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Jacaranda Geoactive 2

NSW AUSTRALIAN CURRICULUM **GEOGRAPHY STAGE 5** FOURTH EDITION

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Jacaranda Geoactive 2

NSW AUSTRALIAN CURRICULUM GEOGRAPHY STAGE 5 FOURTH EDITION

Louise SWANSON

Nicole GRAY

Karen BOWDEN

Adrian HARRISON

Kymberly GOVERS

Steven NEWMAN

CONTRIBUTING AUTHORS

Judy MRAZ

Jill PRICE

Cathy BEDSON

Jeana KRIEWALDT

Denise MILES

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It is recommended that teachers should first preview resources on Indigenous topics in relation to their suitability for the class level or situation. It is also suggested that Indigenous parents or community members be invited to help assess the resources to be shown to Indigenous children. At all times the guidelines laid down by the relevant educational authorities should be followed.

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HOW TO USE THIS RESOURCE

Jacaranda Geoactive 2 NSW Australian Curriculum Geography Stage 5, 4th Edition, consists of your textbook as well as a wealth of online resources. The structure and features of the textbook and eBookPLUS are described here.

'Geographical concepts' is a valuable reference section that covers each of the seven concepts.

Each concept is clearly defined.

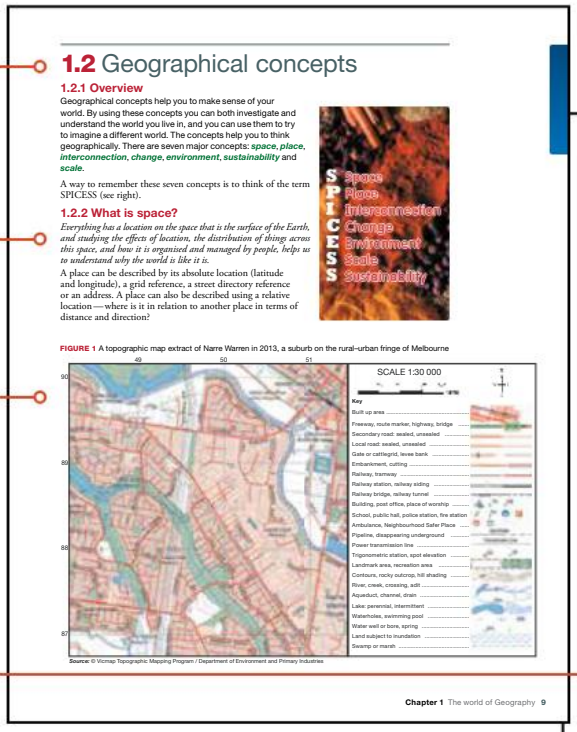
A variety of visual resources support the explanations.

Easily identifiable visual material is referenced in the text and in activities.

myWorld Atlas links extend and deepen your understanding.

Italicised key concepts are applied to the content in the spread.

A series of activities to build and develop your understanding of each concept is provided.



1.2 Geographical concepts

1.2.1 Overview

Geographical concepts help you to make sense of your world. By using these concepts you can both investigate and understand the world you live in, and you can use them to 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***.

A way to remember these seven concepts is to think of the term SPICESS (see right).

1.2.2 What is space?

Everything has a location on the space that is the surface of the Earth, and studying the effects of location, the distribution of things across this space, and how it is organised and managed by people, helps us to understand why the world is like it is.

A place can be described by its absolute location (latitude and longitude), a grid reference, a street directory reference or an address. A place can also be described using a relative location — where is it in relation to another place in terms of distance and direction?

FIGURE 1 A topographic map extract of Narre Warren in 2013, a suburb on the rural–urban fringe of Melbourne

Source: © Vicmap Topographic Mapping Program / Department of Environment and Primary Industries

Chapter 1 The world of Geography 9

Geographers also study how features are distributed across space, the patterns they form and how they interconnect with other characteristics. For example, tropical rainforests are distributed in a broad line across tropical regions of the world, in a similar pattern to the distribution of high rainfall and high temperatures.

ACTIVITIES

1 Using an atlas, give the absolute location for Melbourne, Australia.
Refer to figure 1.
2 Identify the feature at the following locations:
a GR496895 b GR494880.
3 Using the grid references on the topographic map, give the absolute location for:
a Narre Warren station (north-east of map)
b the intersection of Eureka Rd and Pound Rd.
4 Describe the location of Narre Warren station relative to the River Gum Creek Reserve (GR488887). Use distance and direction in your answer.
5 Describe the distribution pattern of creeks and drains in the map area.
6 Explain the influence of the creeks and drains on the distribution of streets and houses.
7 Describe the use of ***space*** shown on this map.

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

FIGURE 2 Inside a greenhouse in Almeria, south-east Spain. Almeria has the largest concentrations of greenhouses in the world and is an important producer of vegetables. Located in Europe's biggest desert biome, the greenhouses cover more than 32 hectares.

Everywhere is a place. Each of the world's biomes — for example, a desert environment — can be considered a place, and within each biome there are different places, such as the Sahara Desert. There can be natural places — an oasis is a good example — or man-made places such as Las Vegas. Places can have different functions and activities — for example, Canberra has a focus as an administration centre, while the MCG is a place for major sporting events and the Great Barrier Reef is a place of great natural beauty and a coral reef biome. People are interconnected to places and people in a wide variety of ways — for example, when we move between places or connect electronically via computers. We are connected to the places that we live in or know well, such as our neighbourhood or favourite holiday destination.

ACTIVITIES

Refer to figure 2.
1 How do you think people have ***changed*** this place by building greenhouses there?
2 What characteristics of a desert biome are being altered in this ***place***?
3 What features might this location have for the production of food?
4 What would be the advantages and disadvantages of greenhouse farming?
5 Suggest the types of crops that would be suitable for greenhouse farming.
6 List ways in which this ***place*** and other ***places*** in Europe may be ***interconnected*** to the greenhouses in Almeria.

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

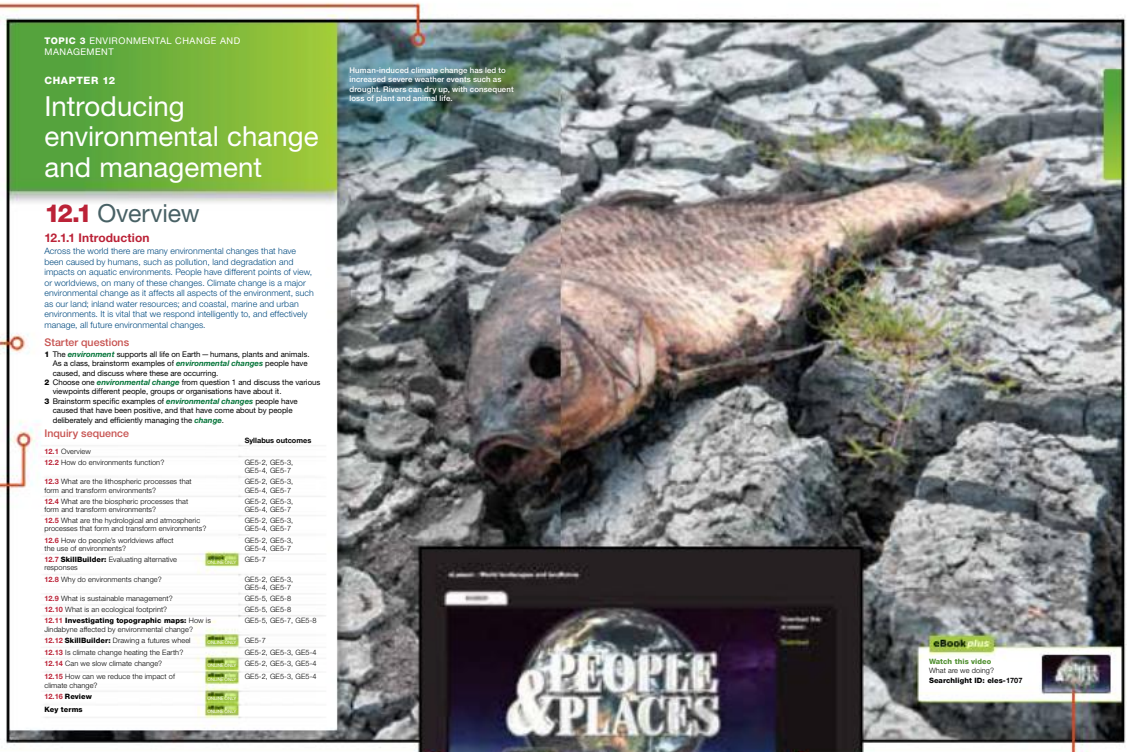
10 Geoactive 2 NSW for the Australian Curriculum Stage 5

Evocative and informative images stimulate interest and discussion.

Starter questions raise issues, link the chapter to your life, and prompt you to think about what you already know and feel about the topic being investigated.

A sequence for your inquiry is provided.

A specially commissioned *People and places* video clip provides an overview of each chapter.



TOPIC 3 ENVIRONMENTAL CHANGE AND MANAGEMENT

CHAPTER 12

Introducing environmental change and management

Human-induced climate change has led to increased severe weather events such as drought. Rivers can dry up, with consequent loss of plant and animal life.

12.1 Overview

12.1.1 Introduction

Across the world there are many environmental changes that have been caused by humans, such as pollution, land degradation and impacts on aquatic environments. People have different points of view, or worldviews, on many of these changes. Climate change is a major environmental change as it affects all aspects of the environment, such as our land; inland water resources; and coastal, marine and urban environments. It is vital that we respond intelligently to, and effectively manage, all future environmental changes.

Starter questions

1 The ***environment*** supports all life on Earth — humans, plants and animals. As a class, brainstorm examples of ***environmental changes*** people have caused, and discuss where these are occurring.
2 Choose one ***environmental change*** from question 1 and discuss the various viewpoints different people, groups or organisations have about it.
3 Brainstorm specific examples of ***environmental changes*** people have caused that have been positive, and that have come about by people deliberately and efficiently managing the ***change***.

Inquiry sequence

	Syllabus outcomes
12.1 Overview	
12.2 How do environments function?	GE5-2, GE5-3, GE5-4, GE5-7
12.3 What are the lithospheric processes that form and transform environments?	GE5-2, GE5-3, GE5-4, GE5-7
12.4 What are the biospheric processes that form and transform environments?	GE5-2, GE5-3, GE5-4, GE5-7
12.5 What are the hydrological and atmospheric processes that form and transform environments?	GE5-2, GE5-3, GE5-4, GE5-7
12.6 How do people's worldviews affect the use of environments?	GE5-2, GE5-3, GE5-4, GE5-7
12.7 **SkillBuilder:** Evaluating alternative responses	GE5-7
12.8 Why do environments change?	GE5-2, GE5-3, GE5-4, GE5-7
12.9 What is sustainable management?	GE5-5, GE5-8
12.10 What is an ecological footprint?	GE5-5, GE5-8
12.11 **Investigating topographic maps:** How is Jindabyne affected by environmental change?	GE5-5, GE5-7, GE5-8
12.12 **SkillBuilder:** Drawing a futures wheel	GE5-7
12.13 Is climate change heating the Earth?	GE5-2, GE5-3, GE5-4
12.14 Can we slow climate change?	GE5-2, GE5-3, GE5-4
12.15 How can we reduce the impact of climate change?	GE5-2, GE5-3, GE5-4
12.16 **Review**	
Key terms	

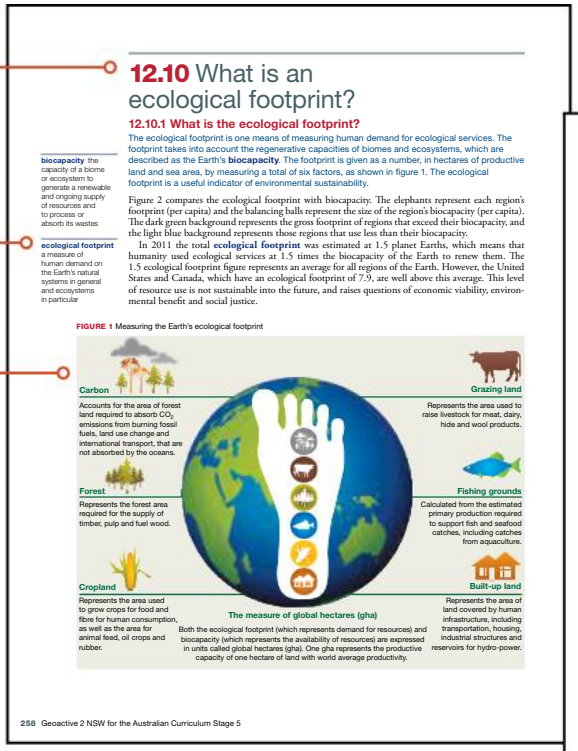
eBookplus
Watch this video
What are we doing?
Searchlight ID: eles-1707

Each section begins with a clearly identifiable spread number and inquiry question.

Key terms are explained.

Engaging and informative visuals promote understanding.

Scaffolding is provided to assist you to write extended written pieces and develop literacy skills.



12.10 What is an ecological footprint?

12.10.1 What is the ecological footprint?

The ecological footprint is one means of measuring human demand for ecological services. The footprint takes into account the regenerative capacities of biomes and ecosystems, which are described as the Earth's **biocapacity**. The footprint is given as a number, in hectares of productive land and sea area, by measuring a total of six factors, as shown in figure 1. The ecological footprint is a useful indicator of environmental sustainability.

biocapacity the capacity of a biome or ecosystem to generate a renewable and ongoing supply of resources and to process or absorb its wastes

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular

Figure 2 compares the ecological footprint with biocapacity. The elephants represent each region's footprint (per capita) and the balancing balls represent the size of the region's biocapacity (per capita). The dark green background represents the gross footprint of regions that exceed their biocapacity, and the light blue background represents those regions that use less than their biocapacity.

In 2011 the total **ecological footprint** was estimated at 1.5 planet Earths, which means that humanity used ecological services at 1.5 times the biocapacity of the Earth to renew them. The 1.5 ecological footprint figure represents an average for all regions of the Earth. However, the United States and Canada, which have an ecological footprint of 7.9, are well above this average. This level of resource use is not sustainable into the future, and raises questions of economic viability, environmental benefit and social justice.

FIGURE 1 Measuring the Earth's ecological footprint

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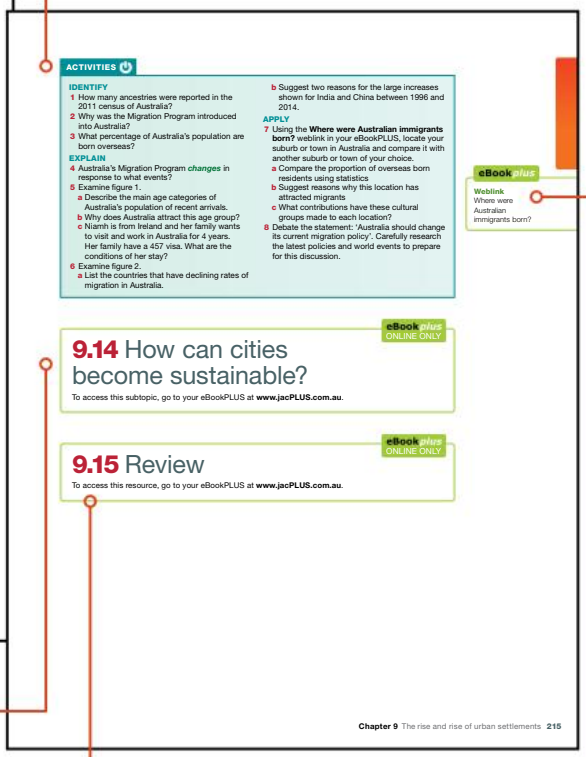
Graded activities address NSW syllabus for the Australian curriculum.



ACTIVITIES

IDENTIFY
1 How many ancestries were reported in the 2011 census of Australia?
2 Why was the Migration Program introduced into Australia?
3 What percentage of Australia's population are born overseas?

EXPLAIN
4 Australia's Migration Program *changes* in response to what events?
5 Examine figure 1.
a Describe the main age categories of Australia's population of recent arrivals.
b Why does Australia attract this age group?
c Niamh is from Ireland and her family wants to visit and work in Australia for 4 years. Her family have a 457 visa. What are the conditions of her stay?
6 Examine figure 2.
a List the countries that have declining rates of migration in Australia.
b Suggest two reasons for the large increases shown for India and China between 1996 and 2014.

APPLY
7 Using the **Where were Australian immigrants born?** weblink in your eBookPLUS, locate your suburb or town in Australia and compare it with another suburb or town of your choice.
a Compare the proportion of overseas born residents using statistics
b Suggest reasons why this location has attracted migrants
c What contributions have these cultural groups made to each location?
8 Debate the statement: 'Australia should change its current migration policy'. Carefully research the latest policies and world events to prepare for this discussion.

eBookplus
Weblink
Where were Australian immigrants born?

eBookplus ONLINE ONLY

9.14 How can cities become sustainable?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

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9.15 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

Chapter 9 The rise and rise of urban settlements 215

References to online material to go to next are provided.

This section includes a range of different activities useful for reviewing the chapter, especially prior to a test.

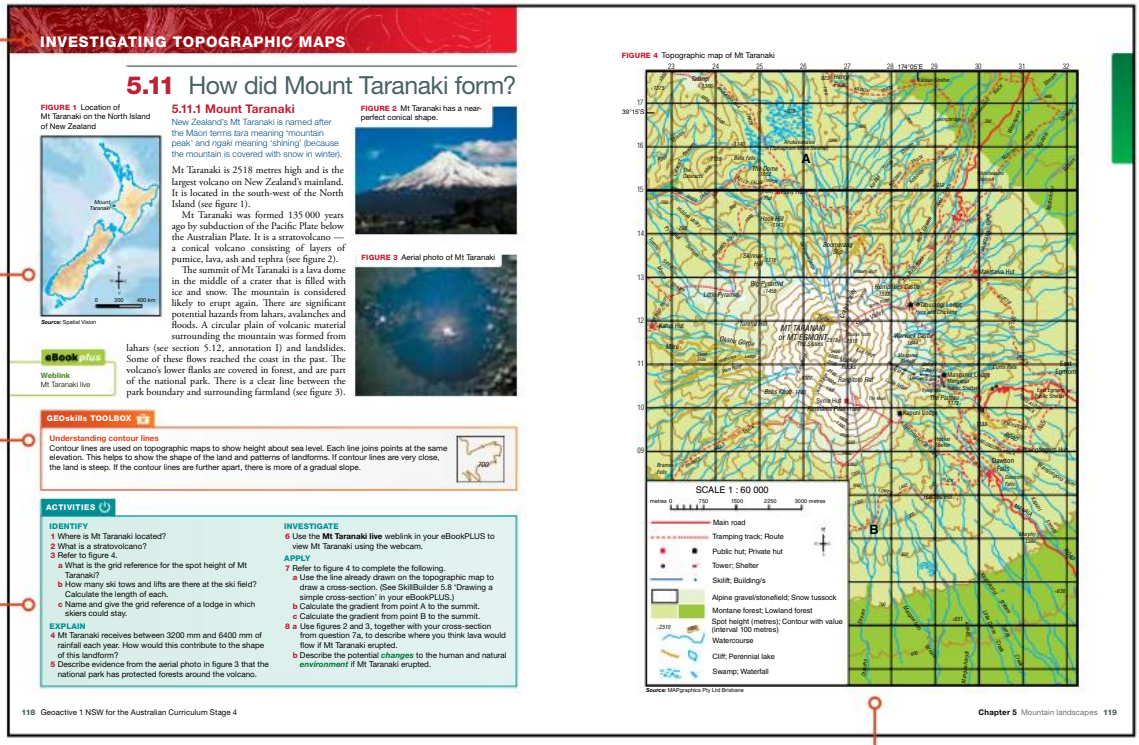
Integrated digital resources reinforce and expand understanding.

Develop your map interpretation skills in the context of the topic you are investigating.

Introductory text, maps and images provide background information.

Succinct summaries of geographical tools are provided.

Graded activities guide analysis of each topographic map extract.



INVESTIGATING TOPOGRAPHIC MAPS

5.11 How did Mount Taranaki form?

FIGURE 1 Location of Mt Taranaki on the North Island of New Zealand

Source: Spatial Vision

5.11.1 Mount Taranaki

New Zealand's Mt Taranaki is named after the Maori terms *tara* meaning 'mountain peak' and *ngaki* meaning 'shining' (because the mountain is covered with snow in winter).

Mt 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).

Mt Taranaki was formed 135 000 years ago by subduction of the Pacific Plate below the Australian Plate. It is a stratovolcano — a conical volcano consisting of layers of pumice, lava, ash and tephra (see figure 2).

The summit of Mt 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, avalanches and floods. A circular plain of volcanic material surrounding the mountain was formed from lahars (see section 5.12, annotation 1) and landslides. Some of these flows reached the coast in the past. 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 (see figure 3).

FIGURE 2 Mt Taranaki has a near-perfect conical shape.

FIGURE 3 Aerial photo of Mt Taranaki

eBookplus
Weblink
Mt Taranaki live

GEOskills TOOLBOX

Understanding contour lines

Contour lines are used on topographic maps to show height about sea level. Each line joins points at the same elevation. This helps to show the shape of the land and patterns of landforms. If contour lines are very close, the land is steep. If the contour lines are further apart, there is more of a gradual slope.

ACTIVITIES

IDENTIFY
1 Where is Mt Taranaki located?
2 What is a stratovolcano?
3 Refer to figure 4.
a What is the grid reference for the spot height of Mt Taranaki?
b How many ski tows and lifts are there at the ski field? Calculate the length of each.
c Name and give the grid reference of a lodge in which skiers could stay.

EXPLAIN
4 Mt Taranaki receives between 3200 mm and 6400 mm of rainfall each year. How would this contribute to the shape of this landform?
5 Describe evidence from the aerial photo in figure 3 that the national park has protected forests around the volcano.

INVESTIGATE
6 Use the **Mt Taranaki live** weblink in your eBookPLUS to view Mt Taranaki using the webcam.

APPLY
7 Refer to figure 4 to complete the following.
a Use the line already drawn on the topographic map to draw a cross-section. (See SkillBuilder 5.8 'Drawing a simple cross-section' in your eBookPLUS.)
b Calculate the gradient from point A to the summit.
c Calculate the gradient from point B to the summit.
8 a Use figures 2 and 3, together with your cross-section from question 7a, to describe where you think lava would flow if Mt Taranaki erupted.
b Describe the potential *changes* to the human and natural *environment* if Mt Taranaki erupted.

FIGURE 4 Topographic map of Mt Taranaki

Source: MAPgraphics Pty Ltd Brisbane

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Chapter 5 Mountain landscapes 119

Clear and custom-designed topographic maps enable development of map interpretation skills.

Integrated digital resources reinforce and expand understanding.

Two SkillBuilder links for each chapter develop and model key geographical skills in context.

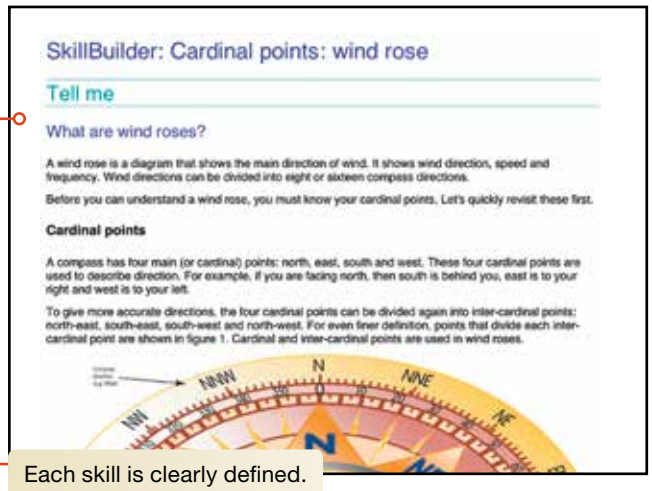
Ideas, information and tips help you collect, process and communicate fieldwork data.

The Geographical Inquiry and Fieldwork Inquiry ProjectsPLUS provide you with an opportunity to develop your inquiry skills in the field and through research.

You are guided through creative online projects using ProjectsPLUS. These are designed to engage students and provide quality assessment support for teachers, with an innovative management system featuring multimedia and project templates.

New worksheets have been designed to consolidate learning for students with learning support needs (including Life Skills students). Each worksheet is mapped to a life skill outcome.

About SkillBuilders


SkillBuilder: Cardinal points: wind rose

Tell me

What are wind roses?

A wind rose is a diagram that shows the main direction of wind. It shows wind direction, speed and frequency. Wind directions can be divided into eight or sixteen compass directions.

Before you can understand a wind rose, you must know your cardinal points. Let's quickly revisit these first.

Cardinal points

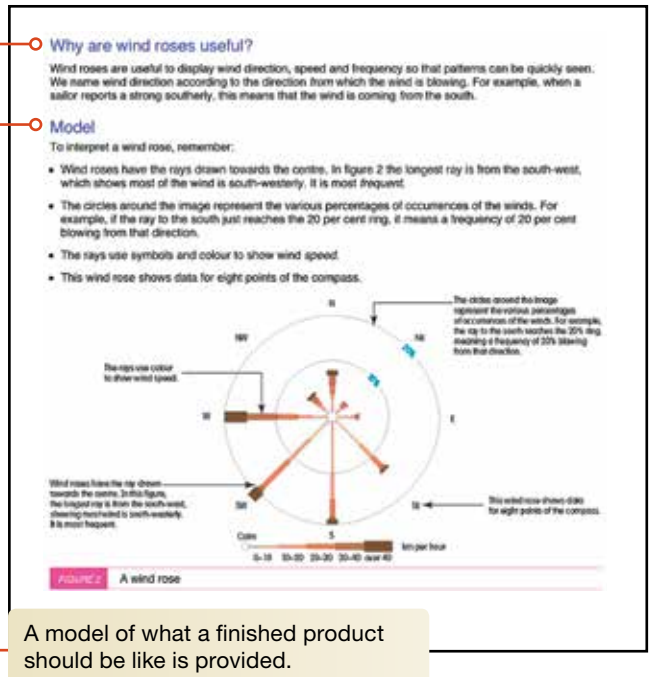
A compass has four main (or cardinal) points: north, east, south and west. These four cardinal points are used to describe direction. For example, if you are facing north, then south is behind you, east is to your right and west is to your left.

To give more accurate directions, the four cardinal points can be divided again into inter-cardinal points: north-east, south-east, south-west and north-west. For even finer definition, points that divide each inter-cardinal point are shown in figure 1. Cardinal and inter-cardinal points are used in wind roses.

Each skill is clearly defined.

eLessons visually explain, and model, the steps in the process for each skill.

The importance of the skill for you as a Geography student is explained.


Why are wind roses useful?

Wind roses are useful to display wind direction, speed and frequency so that patterns can be quickly seen. We name wind direction according to the direction from which the wind is blowing. For example, when a sailor reports a strong southerly, this means that the wind is coming from the south.

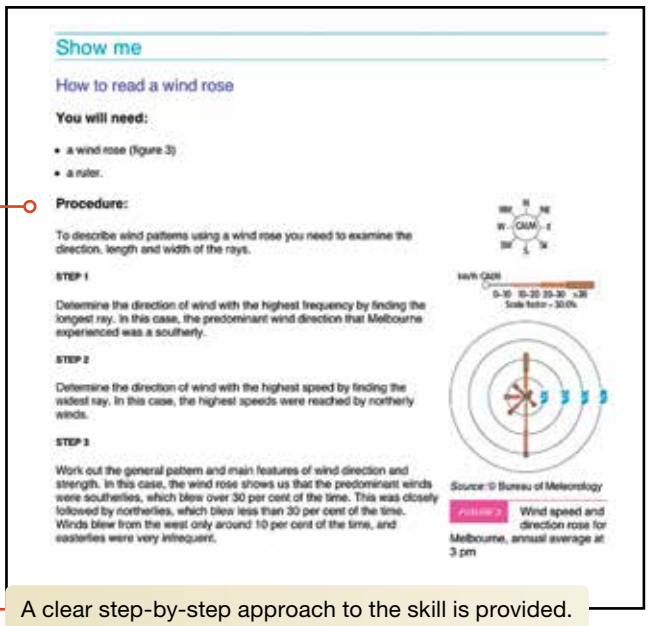
Model

To interpret a wind rose, remember:

- Wind roses have the rays drawn towards the centre. In figure 2 the longest ray is from the south-west, which shows most of the wind is south-westerly. It is most frequent.
- The circles around the image represent the various percentages of occurrences of the winds. For example, if the ray to the south just reaches the 20 per cent ring, it means a frequency of 20 per cent blowing from that direction.
- The rays use symbols and colour to show wind speed.
- This wind rose shows data for eight points of the compass.

A wind rose

A model of what a finished product should be like is provided.


Show me

How to read a wind rose

You will need:

- a wind rose (figure 3)
- a ruler.

Procedure:

To describe wind patterns using a wind rose you need to examine the direction, length and width of the rays.

STEP 1

Determine the direction of wind with the highest frequency by finding the longest ray. In this case, the predominant wind direction that Melbourne experienced was a southerly.

STEP 2

Determine the direction of wind with the highest speed by finding the widest ray. In this case, the highest speeds were reached by northerly winds.

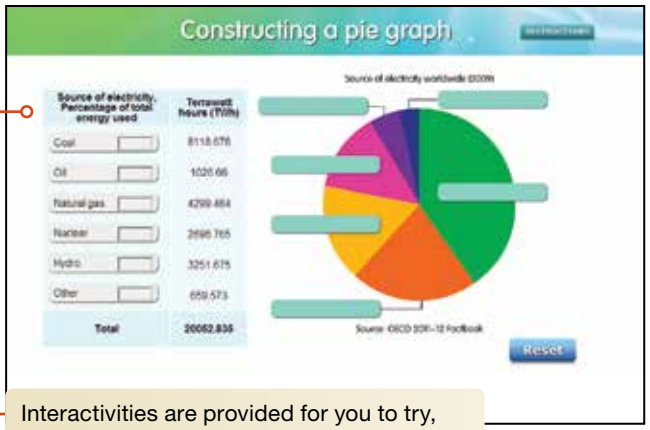
STEP 3

Work out the general pattern and main features of wind direction and strength. In this case, the wind rose shows us that the predominant winds were southerlies, which blew over 30 per cent of the time. This was closely followed by northerlies, which blew less than 30 per cent of the time. Winds blew from the west only around 10 per cent of the time, and easterlies were very infrequent.

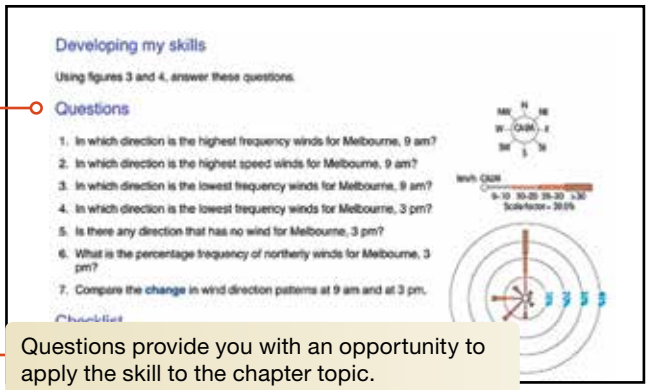
Source: © Bureau of Meteorology

Wind speed and direction rose for Melbourne, annual average at 3 pm

A clear step-by-step approach to the skill is provided.



Interactivities are provided for you to try, focusing on key aspects of each skill.


Developing my skills

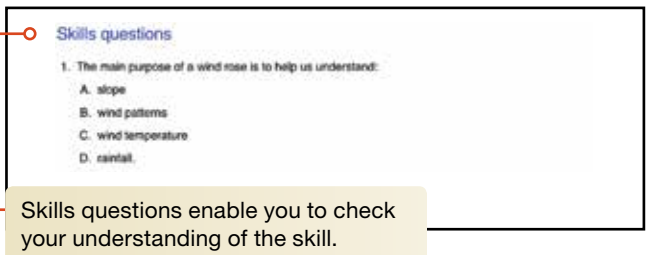
Using figures 3 and 4, answer these questions.

Questions

1. In which direction is the highest frequency winds for Melbourne, 9 am?
2. In which direction is the highest speed winds for Melbourne, 9 am?
3. In which direction is the lowest frequency winds for Melbourne, 9 am?
4. In which direction is the lowest frequency winds for Melbourne, 3 pm?
5. Is there any direction that has no wind for Melbourne, 3 pm?
6. What is the percentage frequency of northerly winds for Melbourne, 3 pm?
7. Compare the change in wind direction patterns at 9 am and at 3 pm.

Checklist

Questions provide you with an opportunity to apply the skill to the chapter topic.


Skills questions

1. The main purpose of a wind rose is to help us understand:
   A. slope
   B. wind patterns
   C. wind temperature
   D. rainfall.

Skills questions enable you to check your understanding of the skill.

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Oquias; **356**/Emma Jones; **359**/bartuchna@yahoo.pl; **368–369**/chungking; **370**/joyfull; **372**/Nataliya Hora; **373**/FCG; **375**/Vladimir Korostyshevskiy; **376**(b)/Ivonne Wierink; **376**(c)/SvedOliver; **376**(d)/Zack Frank; **379**, **423**/Dipak Shelare; **381**/View Factor Images; **390**/William Perugini; **391**/Tim Roberts Photography; **392–393**/Denis Cristo; **394–395**/Travel Stock; **413**(b)/© paul prescott; **414**/Art Berry; **416–417**/Milles Studio; **416–417**/Arthimedes; **419**/Andrei Shumskiy; **420**/Matyas Rehak; **424**/guentermanaus; **424**/NLshop; **425**/GNEs; **428**/meunierd; **429**/mykeyruna; **431**/paul prescott; **432**, **457**(b)/Travel Stock; **432**/zeber; **433**/De Visu; **434**/mohamed zain; **434**/Sean Pavone; **438**/Brisbane; **448**(a)/Macrovector; **449**/rmnoa357; **450**/ingehogenbijl; **452–453**/punghi; **457**(a)/nije salam; **457**(c)/Karve; **457**(d)/Goran Bogicevic; **458**(a)/Monkey Business Images; **458**(b)/Monkey Business Images; **459**/phoelixDE; **462**/Ryszard Stelmachowicz; **465**/Anton_Ivanov; **467**/2xSamara.com • Small Multiples: **213** • Spatial Vision: **4**, **12**, **26**, **36**, **62**, **75**, **83**, **94**, **120**, **160**, **161**, **165**, **171**, **173**, **187**, **191**, **196**, **198**, **202**, **206**, **255**, **261**, **288**, **308**(b), **334**; **5**/Data from World Trade Organization; **14**, **421**, **421**, **421**, **432**/Government of India, Ministry of Home Affairs, Office of Registrar General. 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1.1 Overview

1.1.1 What is a geographical inquiry?

The world around us is made up of interesting places, people, cultures and environments. Geography is the subject that you study at school to learn about different places and how relationships between environments and people shape these places. Geographers question how environments function and why the world is the way it is. They explore geographic issues and challenges facing us today, predict outcomes and come up with possible solutions for the future. Geographers are active and responsible citizens, who are informed about our world and are capable of shaping the future.

FIGURE 1 Our planet is made up of a large variety of fascinating places, peoples, cultures and environments.

Have you ever visited or gone on holidays to a place other than where you live? If so you have probably noticed that some of the features and characteristics of the people and places are similar and some are different. Studying Geography at school provides you with the skills, the knowledge

and the tools to learn about and understand the relationships between the world's people, places and environments.

As a geographer you get to ask questions and then seek to answer them. Geographers use what is called an inquiry approach to help them learn about and understand the world around them. This could involve you working individually, or as part of a group, to discover the answer to a geographical question, using a variety of geographical skills, tools and concepts.

Geographers also look at many interesting issues which face the world today; for example, different people have different viewpoints, or perspectives, about what we should do about climate change. The answer to this question might vary for an individual, a local area, a country or even on a world scale.

1.1.2 What are inquiry skills?

Have you ever noticed that young children ask many questions as they begin to learn because they are curious about the world around them? Below are some examples of questions which we can call *geographical* questions:

- Why are there many different types of landscapes around the world and how are they formed?
- Where is the best place to live?
- How can we look after our water resources so we have enough for the future?
- What are the effects of tourism in different places?

Geographical inquiry skills develop your ability to collect, process and communicate information.

Acquiring geographical information

Acquiring or collecting geographical information needs to be focussed and well planned. Begin a geographical inquiry by developing a problem or issue to investigate. This will be the general theme of your inquiry. Develop a few geographical questions that will help you study your issue or problem. Ensure that your questions are not so broad that they will be difficult to investigate, for example water management in Australia, or so specific that you won't be able to find enough information to support your inquiry.

Think about how you will collect information about your inquiry. You should include both primary geographical data and information from secondary sources. Primary data is information that you have collected yourself using fieldwork. Secondary sources are data that has been collected and processed by someone else, or written by someone else. Secondary sources include websites, books and brochures. Once you have decided on the information you need, plan your investigation and carry out your fieldwork and collate information from secondary sources.

Processing geographical information

Before you begin processing the information you have collected, you should evaluate the sources and techniques you have used to determine whether they are reliable and free from bias. Can you trust the sources of information? Did you carry out your fieldwork techniques thoroughly and with care? Present your information in a range of different forms. This might include graphs, tables, diagrams, sketch maps and annotated photographs. You might also write paragraphs explaining your results. Look at the information you have collected and reflect on your research questions. At this stage you can start to interpret the information. Did you answer your research questions? What are the answers to your research questions? Analyse the findings of your research and draw conclusions.

Communicating geographical information

You can choose to communicate your research findings in a range of ways. Consider who you will be presenting your findings to. Choose methods to communicate your information that are appropriate to your audience. Explain how you undertook your investigation and your findings. Propose actions that you think should be taken to address your problem or issue, and explain why you think this is the right course of action. If possible, take action yourself to address the geographical issue you have chosen.

1.1.3 What are geographical tools?

Geographers use a range of tools to help them collect information during a geographical inquiry. Geographical tools include:

- maps
- fieldwork
- graphs and statistics
- spatial technologies
- visual representations.

Maps

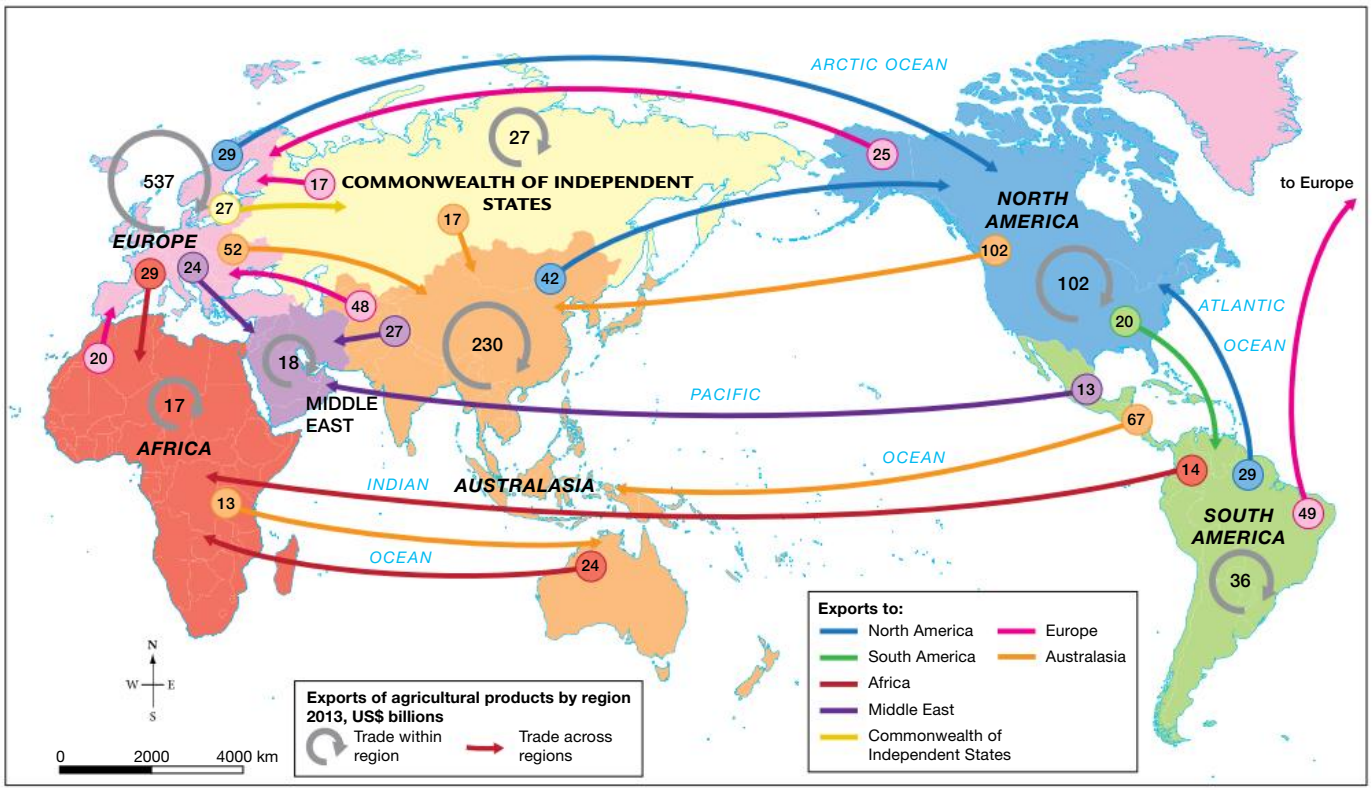
Maps are the most basic tool of the geographer as they are possibly the most effective way to locate, represent, display and record spatial information. These days, geographers are able to use, and create, both digital and non-digital maps.

Political maps are common; they show the boundaries of countries, states and regions, and usually show major cities and bodies of water. Topographic maps and relief maps show the shape of the land on a map. Sketch maps are hand drawn maps which show only the most basic details. Maps can be used to show information about particular themes, such as choropleth maps or flowline maps. Precis maps show a basic summary of information found on a topographic map.

FIGURE 2 A political map of Africa showing the boundaries of countries.

Source: Spatial Vision

FIGURE 3 A flow line map shows the movement of oil trade around the world.



Source: Spatial Vision

It is important for geographers to develop skills in map reading to be able to use all the information found. Mapping skills include being able to determine direction, and use the scale of the map to determine distance between different places. Geographers use lines drawn on maps to determine and communicate the location of different places. On topographic maps, grids are used to determine the area and grid reference of different places. On some maps lines of latitude and longitude are shown to help us locate places.

Fieldwork

There is nothing better than going into an environment, or to visit a place, that you are studying. Seeing something first-hand provides a better understanding than reading about it or looking at it in photographs. That is why fieldwork is such an important, and compulsory, part of your studies.

Fieldwork involves observing, measuring, collecting and recording information and data outside the classroom.

FIGURE 4 Conducting a survey in the field

FIGURE 5 Collecting your own data and information

Fieldwork can be undertaken within the school grounds, around the local neighbouring area or at more distant locations. We can use tools such as weather instruments, identification charts, photographs and measuring devices to collect information about our environment.

Sometimes it may be necessary to use information and communication technology to undertake virtual fieldwork.

Graphs and statistics

Often geographers collect information as numbers. Examples include traffic counts and surveys. These numbers are called statistics. On a field trip you might count the number of pedestrians on a footpath in a given period of time. Statistics which are collected and not processed or analysed yet are called primary data. Statistics which have been processed or analysed by someone are called secondary data.

A simple and effective way geographers present statistics or data is through the use of graphs. There are many different types of graphs that can be used. The most common types of graphs you will use in this resource are column graphs, pie graphs, climate graphs, population profiles and data tables.

Graphs and statistics allow us to easily identify trends and patterns and to make comparisons.

Using statistics helps us to find patterns in the information we have collected. This will help us to draw conclusions about the themes we have investigated.

FIGURE 6 Australia's leading exports of goods and services in A$ million

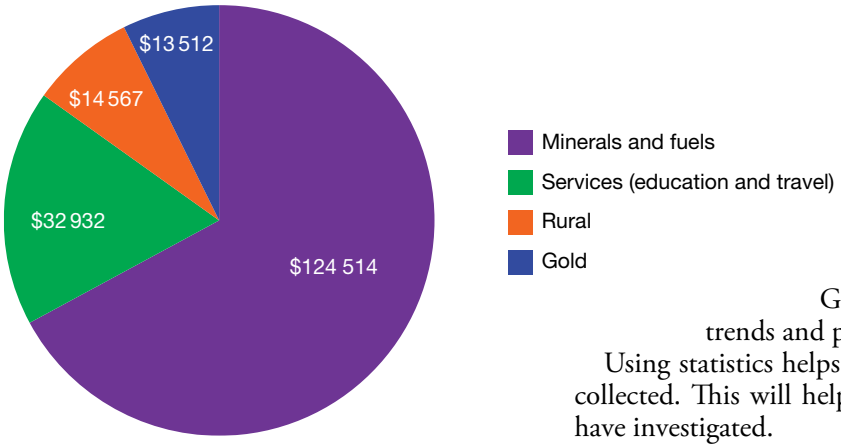
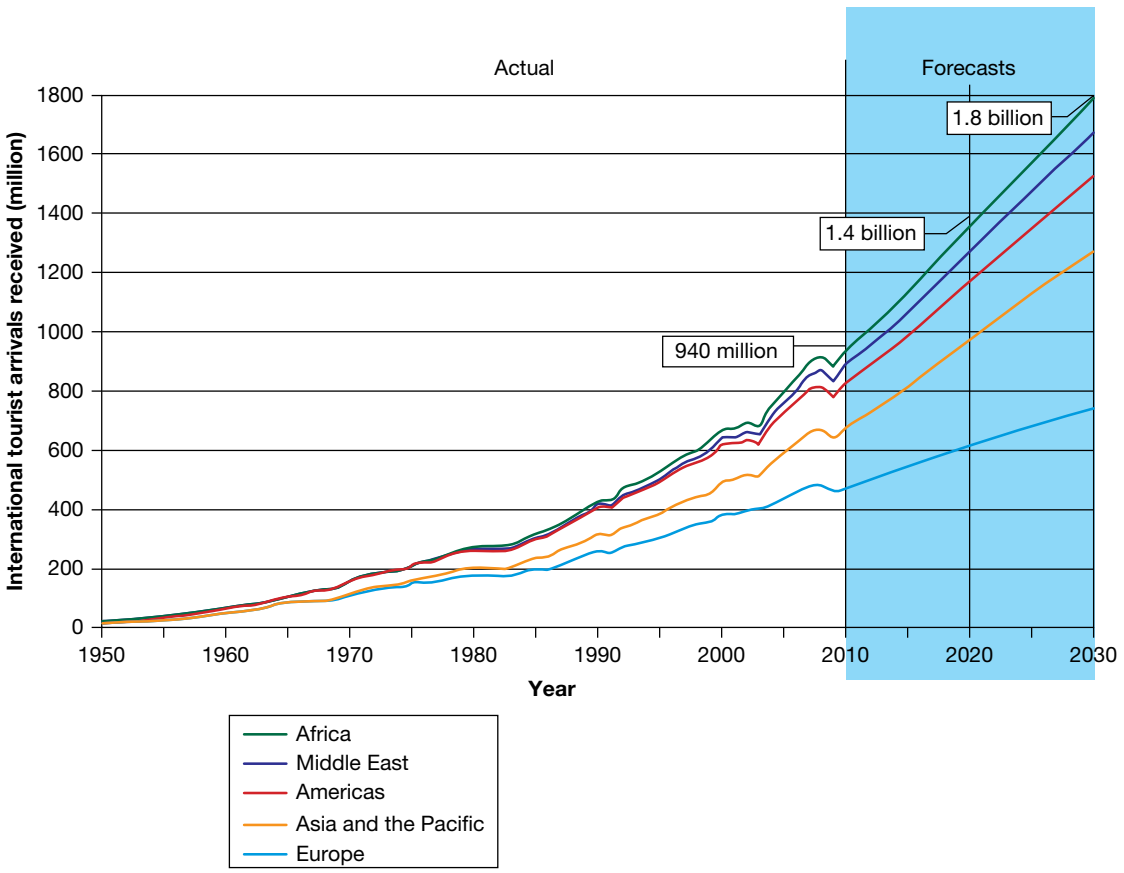


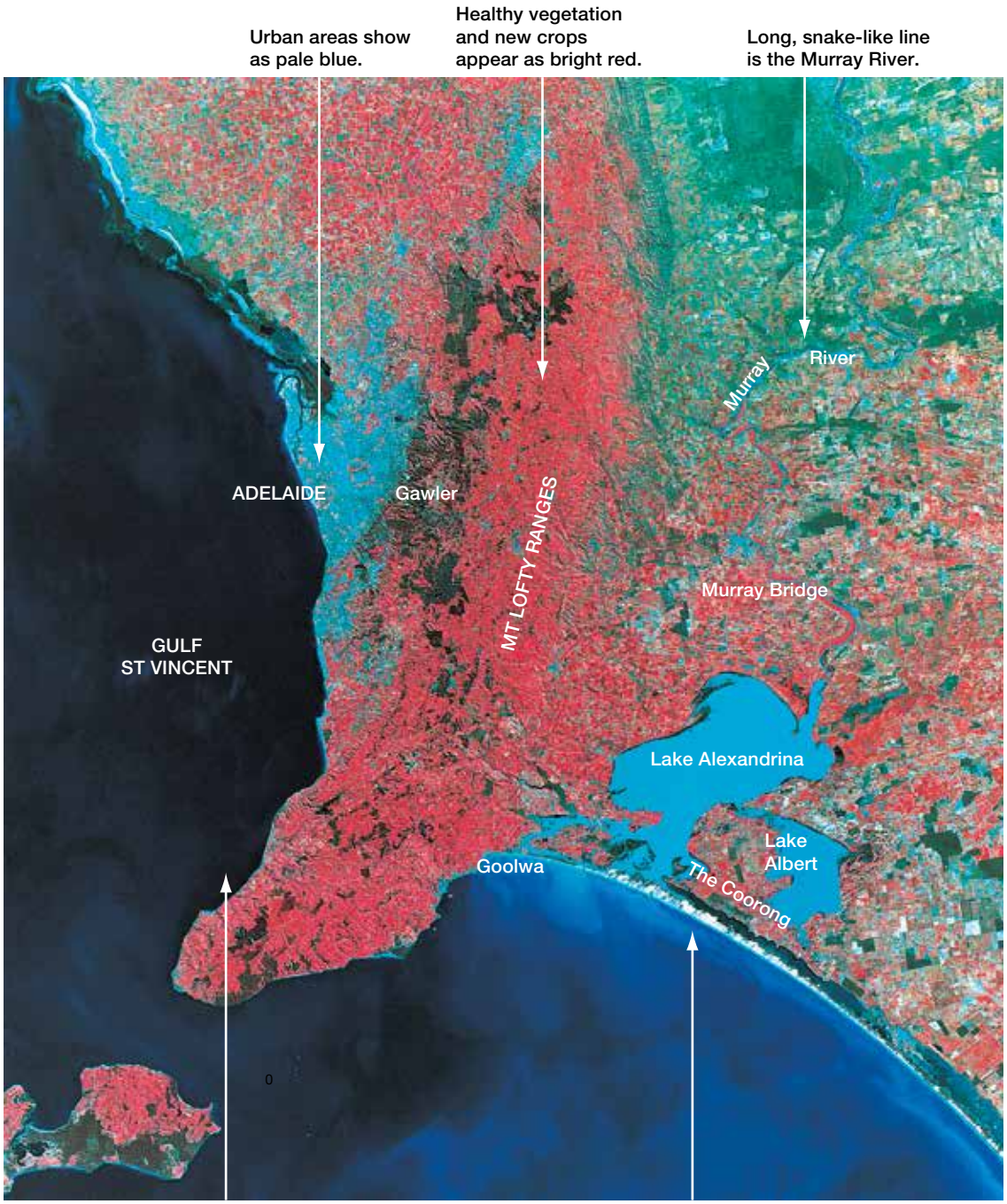
FIGURE 7 Trends and forecasts in tourist arrivals



Spatial technologies

Spatial technologies involve using satellite information and virtual maps to explore and record information. When you use Global Positioning System (GPS) or Google Earth you are using a form of spatial technology. Spatial technologies are any software or hardware that interact with real-world locations. Geographic information systems (GIS) are another commonly used spatial technology. They help us analyse, display and record spatial data.

FIGURE 8 A false-colour satellite image of the Mt Lofty Ranges



Source: © Commonwealth of Australia. Geoscience Australia 1982.

FIGURE 9 Satellite image of Canberra, by GeoEye, 26 September 2011. Satellite images show a realistic view like a photograph, providing a bird's-eye view of a place.

Source: © GeoEye

Visual representations

A visual representation is an effective way of showing complex information using pictures, symbols and diagrams. Examples of visual representations include photographs, field sketches, cartoons and infographics. They are used to display, analyse and communicate geographical data and information.

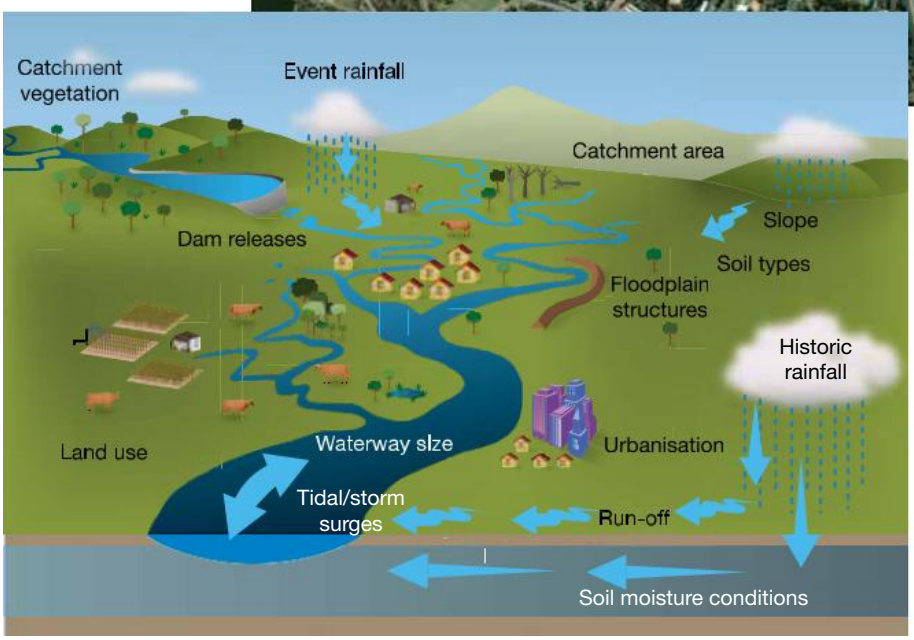


FIGURE 10 This visual representation of the water cycle and factors that affect flooding includes information and images to help you understand geographical processes.

1.2 Geographical concepts

1.2.1 Overview

Geographical concepts help you to make sense of your world. By using these concepts you can both investigate and understand the world you live in, and you can use them to 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***.

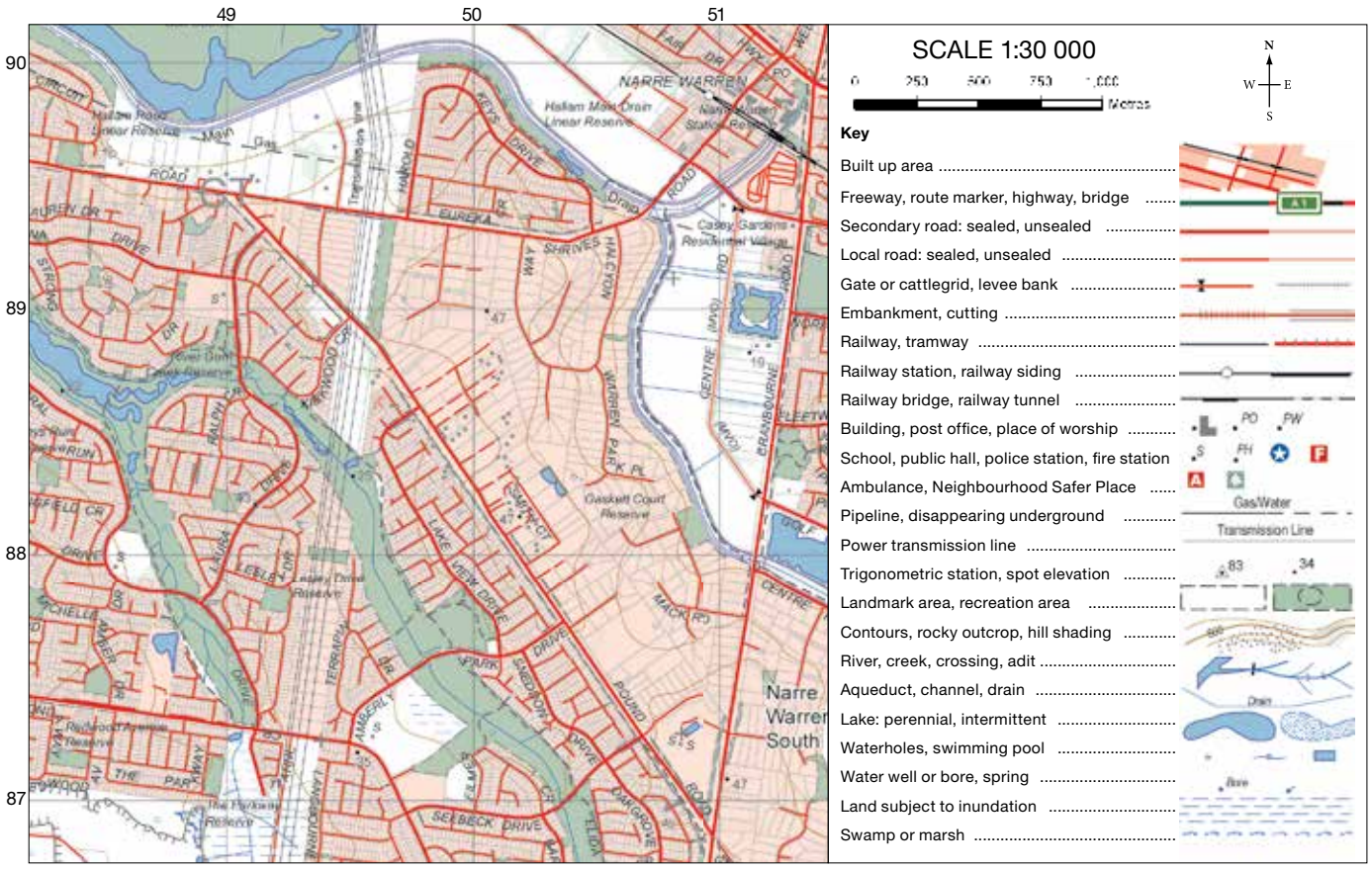
A way to remember these seven concepts is to think of the term SPICESS (see right).

1.2.2 What is space?

Everything has a location on the space that is the surface of the Earth, and studying the effects of location, the distribution of things across this space, and how it is organised and managed by people, helps us to understand why the world is like it is.

A place can be described by its absolute location (latitude and longitude), a grid reference, a street directory reference or an address. A place can also be described using a relative location — where is it in relation to another place in terms of distance and direction?

FIGURE 1 A topographic map extract of Narre Warren in 2013, a suburb on the rural–urban fringe of Melbourne



Source: © Vicmap Topographic Mapping Program / Department of Environment and Primary Industries

Geographers also study how features are distributed across space, the patterns they form and how they interconnect with other characteristics. For example, tropical rainforests are distributed in a broad line across tropical regions of the world, in a similar pattern to the distribution of high rainfall and high temperatures.

ACTIVITIES

1 Using an atlas, give the absolute location for Melbourne, Australia.

Refer to figure 1.

2 Identify the feature at the following locations:
   a GR496895 b GR494880.
3 Using the grid references on the topographic map, give the absolute location for:
   a Narre Warren station (north-east of map)
   b the intersection of Eureka Rd and Pound Rd.
4 Describe the location of Narre Warren station relative to the River Gum Creek Reserve (GR488887). Use distance and direction in your answer.
5 Describe the distribution pattern of creeks and drains in the map area.
6 Explain the influence of the creeks and drains on the distribution of streets and houses.
7 Describe the use of ***space*** shown on this map.

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

FIGURE 2 Inside a greenhouse in Almeria, south-east Spain. Almeria has the largest concentrations of greenhouses in the world and is an important producer of vegetables. Located in Europe's biggest desert biome, the greenhouses cover more than 32 hectares.

Everywhere is a place. Each of the world's biomes — for example, a desert environment — can be considered a place, and within each biome there are different places, such as the Sahara Desert. There can be natural places — an oasis is a good example — or man-made places such as Las Vegas. Places can have different functions and activities — for example, Canberra has a focus as an administration centre, while the MCG is a place for major sporting events and the Great Barrier Reef is a place of great natural beauty and a coral reef biome. People are interconnected to places and people in a wide variety of ways — for example, when we move between places or connect electronically via computers. We are connected to the places that we live in or know well, such as our neighbourhood or favourite holiday destination.

ACTIVITIES

Refer to figure 2.

1 Why do you think people have ***changed*** this place by building greenhouses there?
2 What characteristics of a desert biome are being altered in this ***place***?
3 What features might this location have for the production of food?
4 What would be the advantages and disadvantages of greenhouse farming?
5 Suggest the types of crops that would be suitable for greenhouse farming.
6 List ways in which people living in other ***places*** in Europe may be ***interconnected*** to the greenhouses in Almeria.

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

1.2.4 What is interconnection?

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

The interconnection between people and environments in one place can lead to changes in another location. The damming of a river upstream can significantly alter the river environment downstream and affect the people who depend on it. Similarly, the economic development of a place can influence its population characteristics; for example, an isolated mining town will tend to attract a large percentage of young males, while a coastal town with a mild climate will attract retirees who will require different services. The economies and populations of places are interconnected.

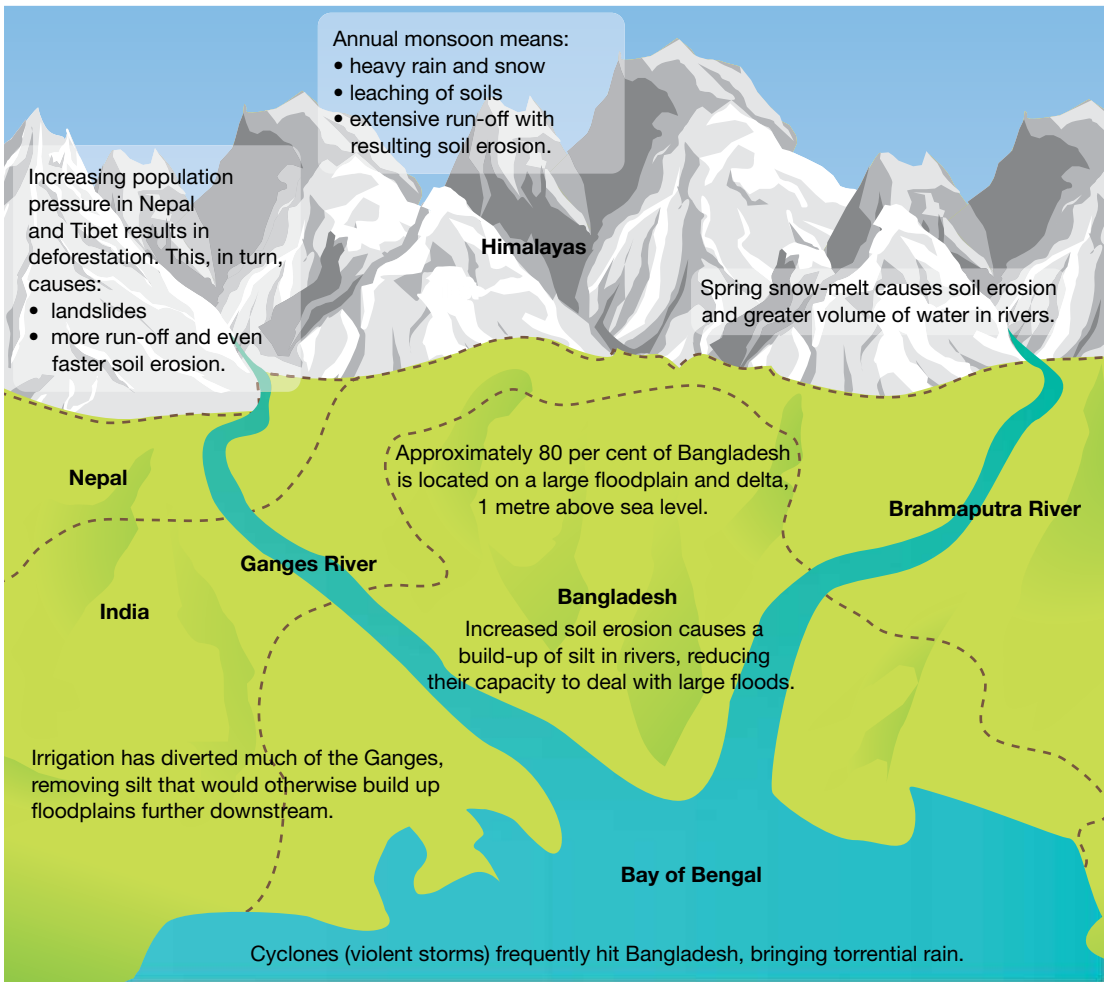


FIGURE 3 Bangladesh is one of the most flood-prone countries in the world. This is due to a number of factors. Firstly, it is largely the floodplain for three major rivers (the Ganges, Brahmaputra and Meghna), which all carry large volumes of water and silt. Secondly, being a floodplain, the topography therefore is very flat, which allows for large-scale flooding. In addition, the country is located at the head of the Bay of Bengal, which is susceptible to typhoons and storm surges. It is expected that sea level rises associated with global warming will increase the flooding threat even further in the future.

ACTIVITIES

Refer to figure 3.

1. What is the ***interconnection*** between the physical characteristics of Bangladesh and its flood risk?
2. What is the ***interconnection*** between human activities and Bangladesh's flood risk?
3. Use information from the figure to construct a flow diagram to show the ***interconnection*** between human activities and natural processes (increased risk of flooding) in Bangladesh.
4. How might an increase in the number and severity of floods affect:
   a. people's wellbeing
   b. economic development in the country?
5. Considering the ***interconnections*** that you have identified, suggest some possible steps that could be taken to reduce the impact of flooding.

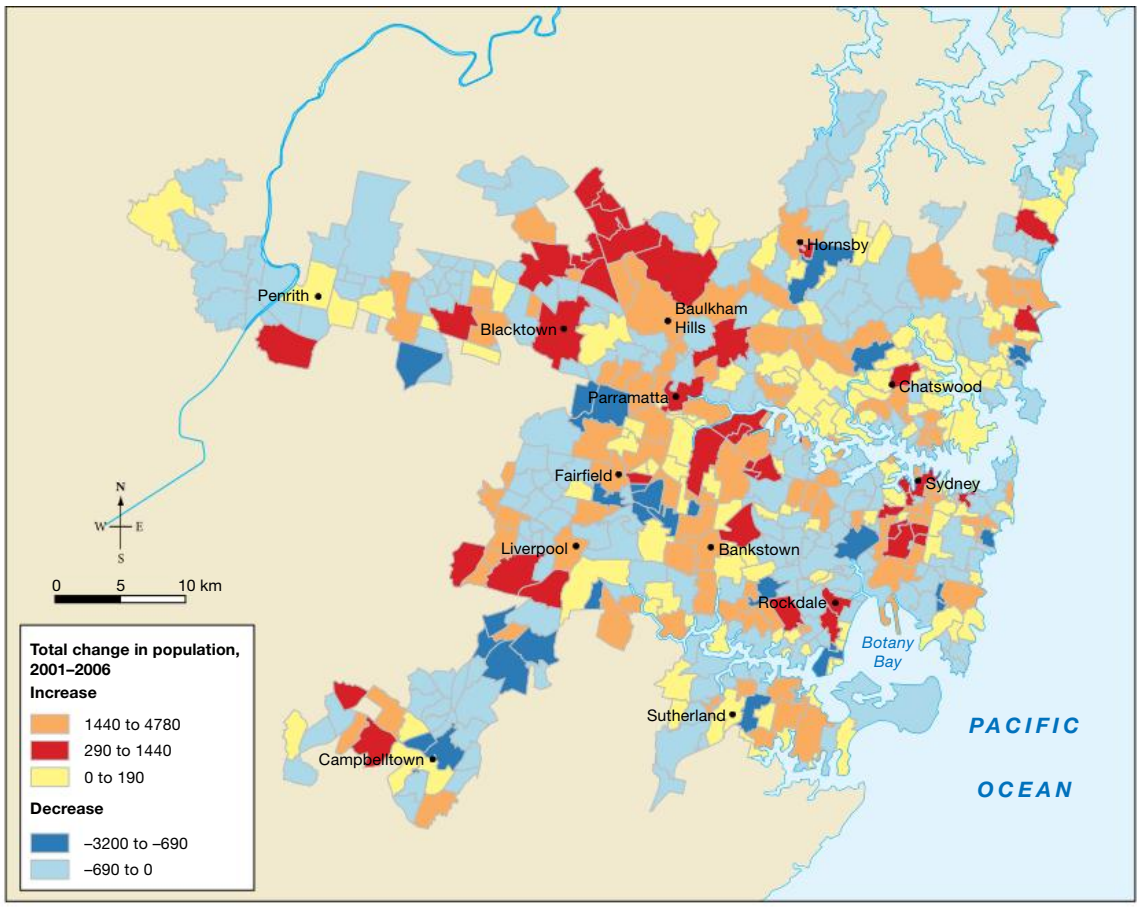
myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › Interconnection

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. Cities, for example, 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.

FIGURE 4 The change in size of the city of Sydney over time



Source: Spatial Vision

FIGURE 5a Landscape before deforestation

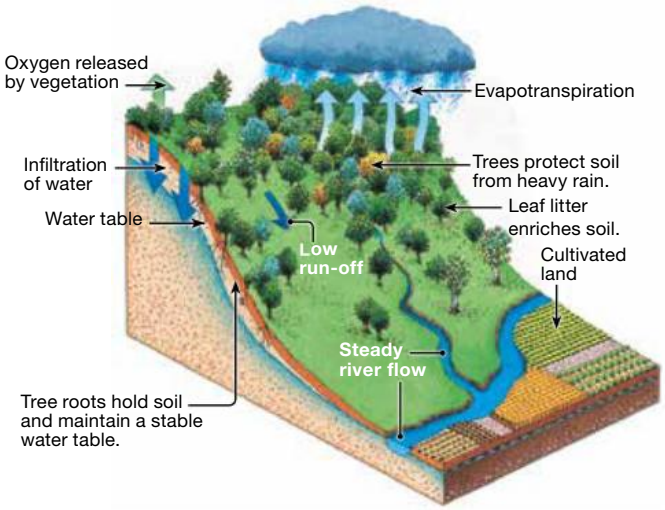
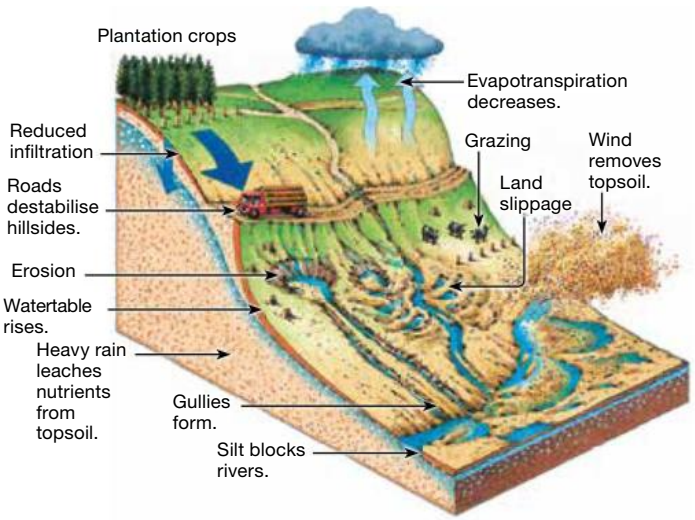


FIGURE 5b Landscape after deforestation



ACTIVITIES

Refer to figure 4.

1. How has Sydney ***changed*** over time? How long has it taken for the city to spread to the furthest areas shown on the map?
2. What main natural feature attracted the earliest settlement?
3. What impact do you think this growth has had on the natural ***environment***?
4. What technological ***changes*** in transport have allowed Sydney to spread and grow over time?

Refer to figures 5a and 5b.

5. List the ***changes*** that would have caused the slippage to occur.
6. What ***interconnections*** are there between:
   - **a** vegetation cover and soil stability
   - **b** vegetation cover and infiltration
   - **c** high run-off and erosion?
7. List all the effects of the landslide on people and the ***environment.***
8. Write a summary statement about the pace of ***change*** and the impact on people and the ***environment*** in these two examples.

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

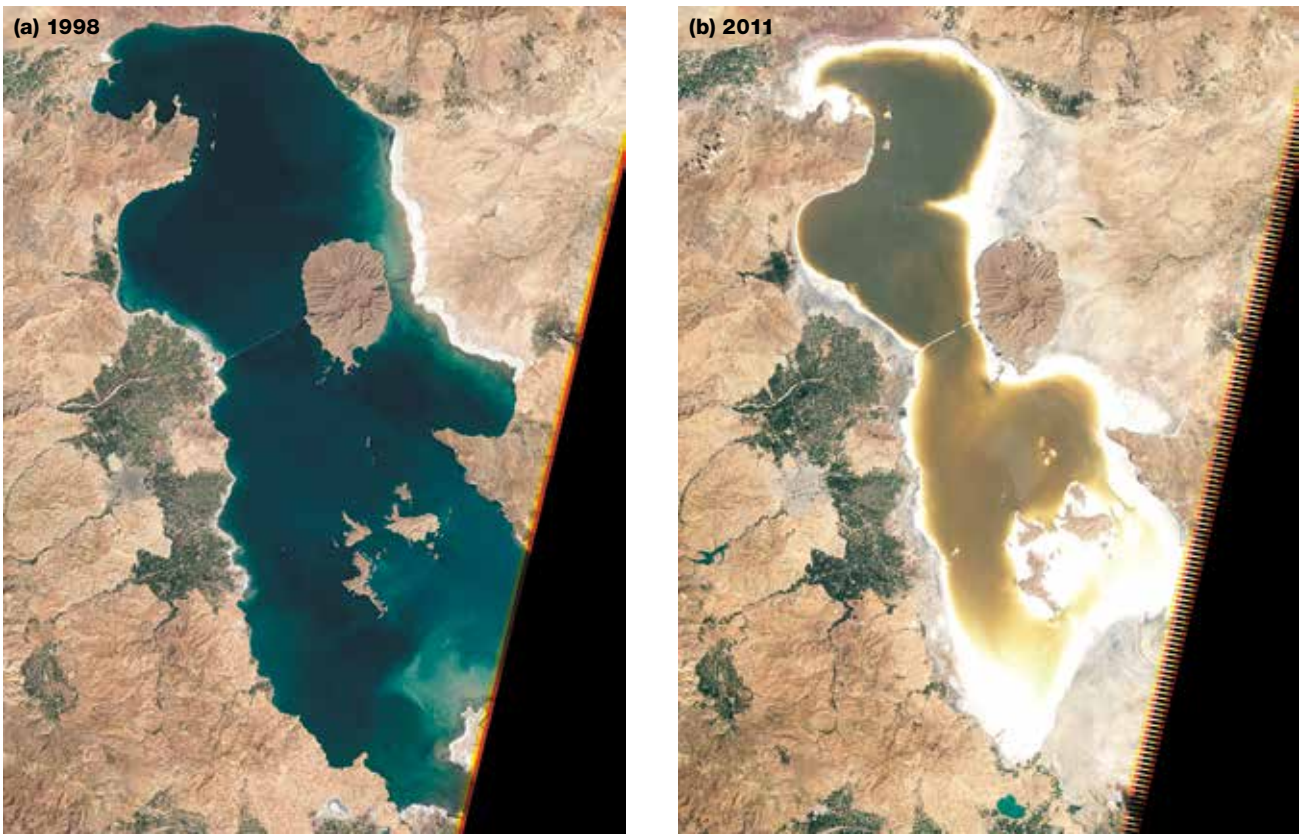
1.2.6 What is environment?

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

There is a strong interrelationship between humans and natural and urban environments. People depend on the environment for the source, sink, spiritual and service functions it provides.

Humans significantly alter environments, causing both positive and negative effects. The building of dams to reduce the risk of flooding, the regular supply of fresh water and the development of large-scale urban environments to improve human wellbeing are examples. On the other hand, mismanagement has created many environmental threats such as soil erosion and global warming, which have the potential to have a negative impact on the quality of life for many people.

FIGURE 6 Lake Urmia is the largest lake in the Middle East and one of the largest landlocked saltwater lakes in the world. Since 2005, the lake has lost over 65 per cent of its surface area due to over-extraction of water for domestic and agricultural needs. The lake and its surrounding wetlands are internationally important as a feeding and breeding ground for migratory birds.



ACTIVITIES

Refer to figure 6.

1 What physical features make up this ***environment***?
2 What features of the natural ***environment*** are consistent across the two images?
3 Describe the changes to this ***environment*** over the time period of 1998 to 2011.
4 Describe the distribution of salt flats around the lake in 1998 compared with their distribution in 2011.
5 How might the loss of water and increase in salt flats affect:
   a people
   b the ***environment*** in the surrounding region?
6 Suggest a possible future scenario for Lake Urmia:
   a if water continues to be extracted and withdrawn
   b if water withdrawals for irrigation are reduced, and water conservation methods are introduced in neighbouring ***places***.

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

1.2.7 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 is a useful tool for examining issues from different perspectives; from the personal to the local, regional, national and global. It is also used to look for explanations or compare outcomes. For example, explaining the changing structure of the population in your local area may require an understanding of migration patterns at a national or even global scale.

FIGURE 7 A map of India showing the distribution of literacy levels (percentage) for 2011

Source: Spatial Vision

ACTIVITIES

Refer to figure 7.

1 At the national ***scale***, what is the average literacy rate for India?
2 At the regional ***scale***, which three states have the lowest literacy levels?
3 What factors might contribute to a state's low literacy level?
4 How might literacy levels affect the wellbeing of people?
5 Data, such as for literacy levels, is collected by governments during a census. How would knowing this sort of information assist a government in planning for future populations?

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

1.2.8 What is sustainability?

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

Sustainability ensures that the source, sink, service and spiritual functions of the environment are maintained and managed carefully to ensure they are available for future generations. There can be variations in how people perceive sustainable use of environments and resources. Some people think that technology will provide solutions, while others believe that sustainable management involves environmental benefits and social justice.

This concept can also be applied to the social and economic sustainability of places and their communities, which may be threatened by changes such as the degradation of the environment. Land degradation in the Sahel region of Africa has often forced people, especially young men, off their land and into cities in search of work.

FIGURE 8 Dust storms are an extreme form of land degradation. Dry, unprotected topsoil is easily picked up and carried large distances by wind before being deposited in other places. Drought, deforestation and poor farming techniques are usually the cause of soil being exposed to the erosional forces of wind and water. It may take thousands of years for a new topsoil layer to form. Therefore, any land practices that lead to a loss of topsoil may be considered unsustainable.

ACTIVITIES

Refer to figure 8.

1 Complete the following table with examples of factors contributing to soil erosion.

Natural factors contributing to soil erosion	Human factors contributing to soil erosion

2 Explain how the ***interconnection*** of human activities and natural processes can contribute to land degradation.

3 Describe the impacts of the dust storm on people living in these two different ***places***:
- **a** rural areas (source of the soil)
- **b** the urban area shown in the image.

4 What are the long-term implications of the ***unsustainable*** use of soil?

5 How can farming be made more ***sustainable*** in terms of soil conservation?

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

1.3 Work and careers in Geography

1.3.1 Geographic skills and future work

Geographic skills will be useful for your future employment. Your understanding of Geography and its application to manage sustainable futures will be pivotal knowledge that will be desirable to future employers. In Geography, students are developing an understanding of the world. The skills you develop in Geography are transferrable to the workplace and can be used as a basis for evaluating strategies for the sustainable use and management of the world's resources.

Skills for work

Geography is a foundational skill for many occupations. Learning to navigate further education and training paths will help you to understand the variety of occupations that the study of Geography can lead to. The study of Geography includes important geospatial and spatial technology skills. These skills underpin the knowledge base of a range of courses and careers. Start your pathways exploration by considering who may use the key geospatial and spatial technologies.

- Geospatial skills – the ability to collect and collate information gathered from fieldwork and observations. Geospatial skills are used in careers such as surveying, meteorology, agricultural scientist and urban planning.
- Spatial technologies – technologies that demonstrate the connections between location, people and activities in digital formats. Jobs in the spatial industry are varied including working in business and government. Spatial technologies apply many techniques such as photogrammetry, remote sensing, and global positioning systems (GPS). Spatial technologies manage information about the environment, transportation and other utility systems.

FIGURE 1 GIS (Geographic Information Systems) being used to manage spaces and plan escape routes during a fire.

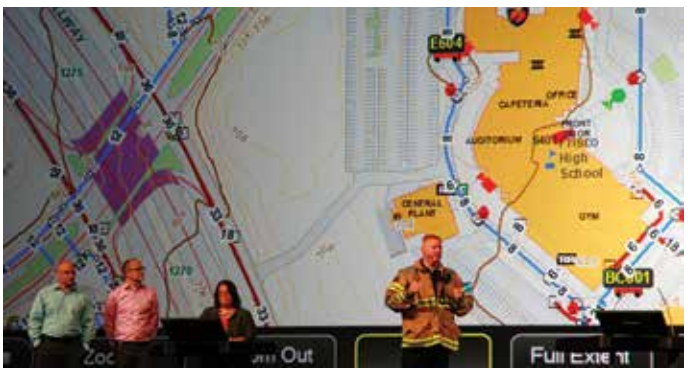
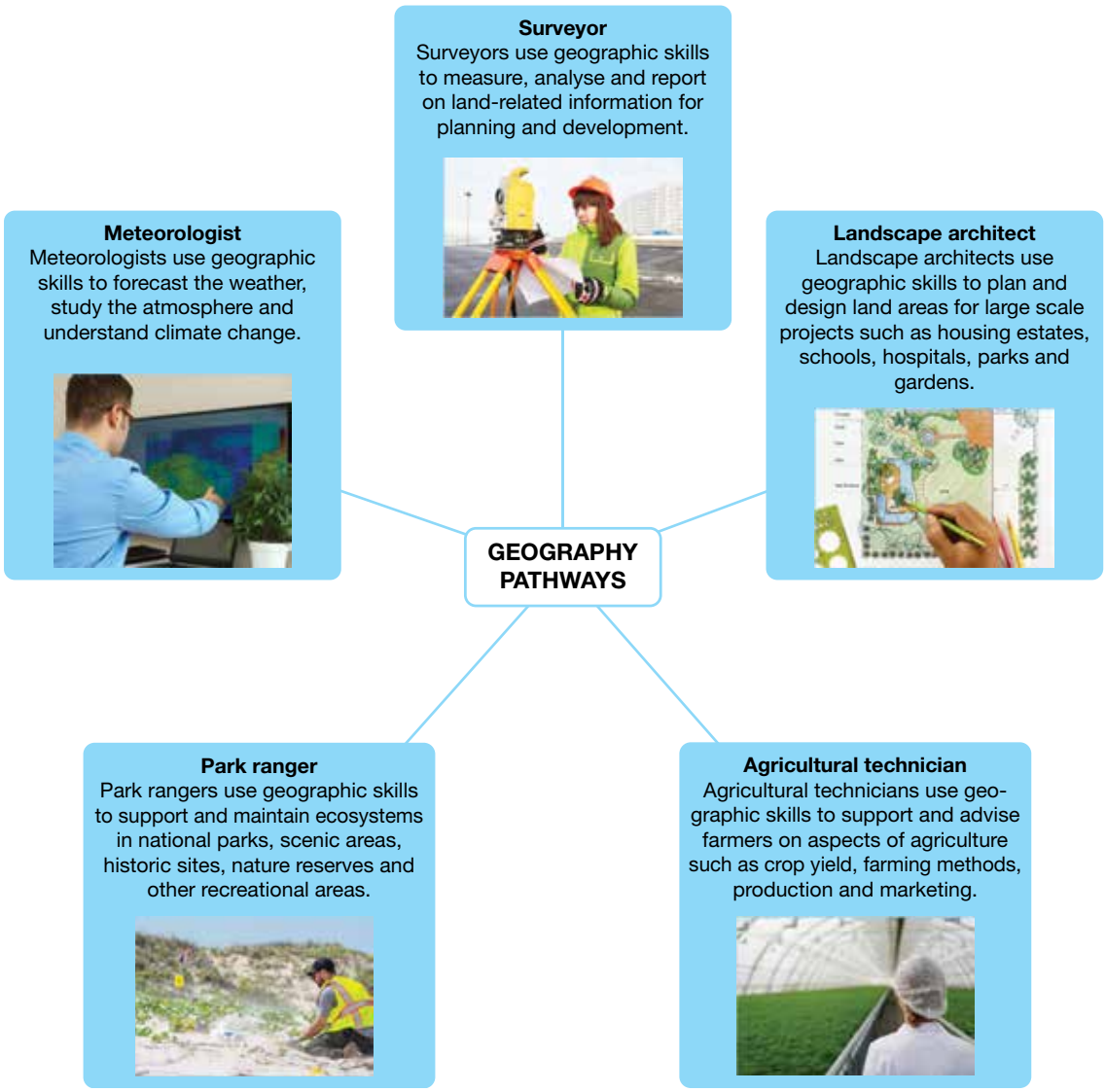


FIGURE 2 Using GPS to survey and record road traffic movements for a local council.

1.3.2 Where can Geography lead?

There are a range of careers that utilise Geography as a foundation skill. As you consider your pathway options for senior studies you may like to research some of the careers that are shown in figure 3.

FIGURE 3 Geography pathways



ACTIVITIES

1. Select an occupational profile that has been presented in figure 3. Use the **Job Outlook** weblink in your eBookPLUS to explore a career that interests you. Job Outlook is a federal government website that provides information on employment in a range of occupations. It also includes information on the training, skills and tools needed for the career that you are researching.
2. Develop a careers profile for your occupation of choice. In your profile include:
   - the geographic skills needed for this job
   - the geographical tools that may be used in this occupation
   - the study and training requirements that lead to this occupation
   - the job prospects for your chosen occupation over the next five years.

   In Australia, there are a range of industries that employ *conservationists, oceanographers or agricultural scientists*. Use the **Job Outlook** weblink in your eBookPLUS to research industries that may deal with land degradation, marine pollution or world food needs. For example, the Agricultural, Forestry and Fishing industries will employ all three occupations and will list a range of technical and professional tasks in their job descriptions.
3. Develop a job description for one of the occupations. Highlight the geographic skills required, the tools they will work with and core skills for work that are essential for the position.

eBookplus

Weblink
Job Outlook

1.3.3 Geography in a changing world

As the world's population increases and the impacts of environmental changes affect living conditions, people and organisations will need to adapt and develop strategies to manage and sustain fragile environments and resources. Land degradation, marine pollution and feeding the future world populations are just three environmental challenges which will be the focus for many occupations in the future. Which careers will be helpful in managing environmental change?

TABLE 1 Careers that use geographic skills to help manage environmental change

Conservationists	Conservationists work to find solutions to land degradation. They may work for governments on policy development in relation to national parks, or with local communities on environmental protection projects.
Oceanographers	Work for oceanographers will mainly involve research and monitoring of the marine environment. They may work for governments providing data and advice on pollution levels or they may work for private or not-for-profit organisations helping to develop and implement solutions to clean up the oceans.
Agricultural scientists	Agricultural scientists will be employed by the government and agriculture and horticulture producers. They may work with farmer groups and agribusiness to do research, and with mining companies on regeneration projects.

Profile of a geographer

Geographers have a love of learning. They are the explorers of the modern world. Geographers are lifelong learners; they expand their knowledge to adapt their skills to the tasks required.

Expansion of knowledge requires a willingness to learn. How many of these skills and attributes have you developed?

- Willingness to learn
- Curious and adaptable
- Active listening
- Good communication
- Critical thinking
- Time management
- Problem solving.

By developing your geographical skills alongside your work attributes you will ensure that as you progress through your career goals the skills that you develop in Geography will be part of your lifelong learning. You can develop your skills and work attributes by undertaking work experience or volunteering activities while you are still at school.

1.3.4 The importance of work experience

Understanding how people are interconnected through the career choices they make will help you build knowledge of occupations and how they work together. The activities you undertake in Geography will prove useful in developing, building and managing your career options. Another way to build your knowledge of geography and the career paths that lead from it is to undertake work experience in the field. Work experience can help you to understand the tasks and training required to specialise in a particular industry. You gain first-hand experience through observation and participating in the day-to-day tasks of workplaces.

Volunteering

Volunteering in your community is a great way to find out about different work environments and what impacts on the delivery of the services or programs. Volunteering your time to support local communities and businesses demonstrates your willingness to learn and support others and it can be a great boost to your self-confidence and skill development.

Learning directly from industry experts through volunteering can help you to consolidate your interests while picking up valuable core skills for work. The core skills for work are considered the most important component of a career portfolio. Geography assists in developing these skills.

Thinking of volunteering? Why not consider …

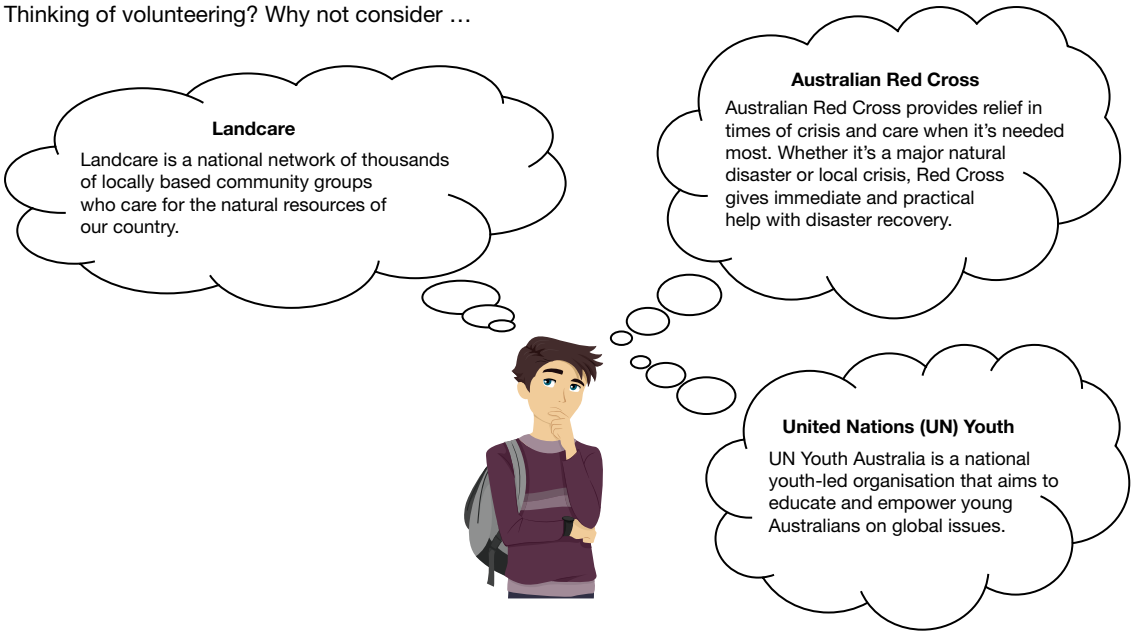
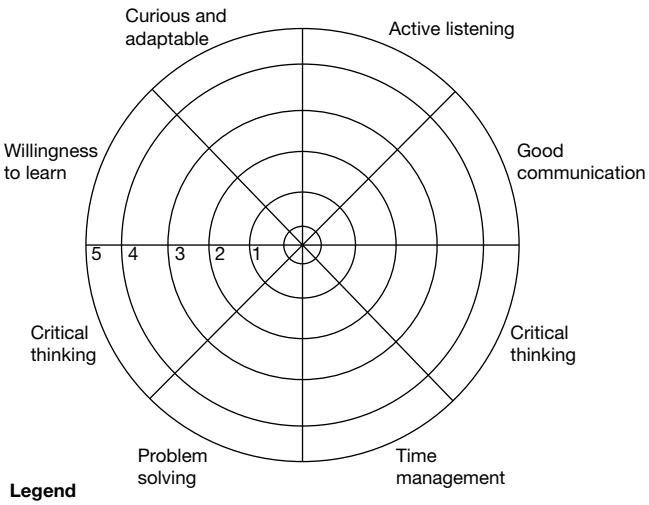


TABLE 2 The core skills for work

Communication	Use effective listening and speaking
Teamwork	Connect and work with others
Learning	Recognise and utilise diverse perspectives
Plan and organise	Ability to develop and see things through to completion
Self-management	Make decisions
Problem solving	Identify and solve problems
Initiative and enterprise	Create and innovate through new ideas
Use technology	Work in a digital world

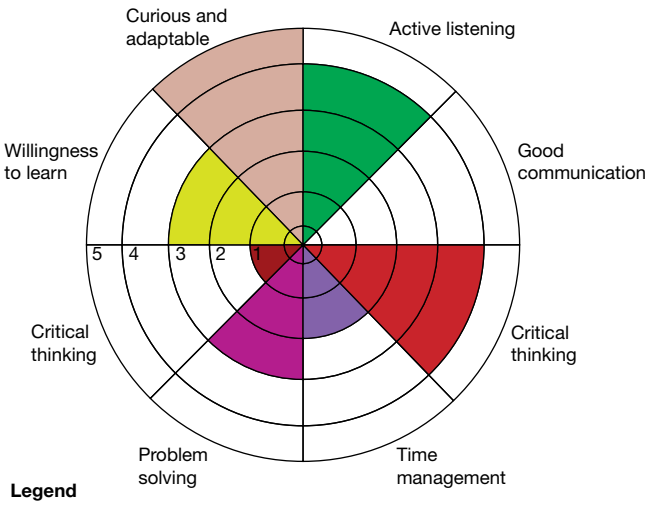
How many core skills for work have you developed? Use figure 4a to help you think about your own skills. You may find you have strengths and areas you need to improve upon. If you do this periodically, you can monitor your progress in this area. Figure 4b is an example of a completed graph.

FIGURE 4a Evaluating my core skills for work



Legend
1 = Poor
2 = Fair
3 = Good
4 = Very good
5 = Excellent

FIGURE 4b Core skills for work — Ashley Green. Semester 1, 2017



Legend
1 = Poor
2 = Fair
3 = Good
4 = Very good
5 = Excellent

1.3.5 Future careers and Geography

Studies in Geography along with other social science subjects and evidence of your work experience or volunteering can demonstrate your adaptability, creativity and enterprise skills for future work.

In the future, the type of work that will be available will change in response to the impact of climate change, population growth and decline and technological innovation. The rapid expansion of world economies will mean that industries will adapt their workforces. Migration and a borderless world will mean that individuals will become global citizens working in large teams around the world. Many of the occupations for this century have yet to be created while others have been imagined and offer a glimpse into the future.

FIGURE 5 Agroecologist: a career of the future

SEEKING AN AGROECOLOGIST…

Agroecologists help restore ecological balance while feeding and fuelling the planet. Agroecologists work with farmers to design and manage agricultural ecosystems whose parts (plants, water, nutrients and insects) work together to create an effective and sustainable means of producing the food and environmentally-friendly biofuel crops of the future.

Agroecologists will also work with Ecosystem Managers to re-introduce native species and biodiversity to repair the damage done by the ecosystem-disruptive farming techniques of the past.

Job Requirements/Skills

You will need an undergraduate degree in agroecology, and be able to demonstrate your knowledge of how plants, soil, insects, animals, nutrients, water and weather interact with one another to create the living systems in which crop-based foods are grown. You'll have an understanding of the technologies and methods involved in growing food in a sustainable way. You will need to be responsive to change, demonstrate adaptability by working in a global team, be creative and enterprising in all elements of the business to ensure that business growth is sustainable.

ACTIVITIES

1 Part time, casual or vacation work are all useful ways to build your core skills for work. Use the **Worksite** weblink in your eBookPLUS to locate information on work experience, volunteering and being ready for your first job.

2 Geographers work in primary, secondary and tertiary industries.
- Provide a definition for each of these industries.
- What is a quaternary industry? Give an example of a quaternary industry career that may use geographical skills (*Hint*: spatial technologies).

3 Over the coming decades, new careers in geography will emerge—jobs such as ecosystem auditor, localiser or rewilder could become commonplace in the future. Exploring these careers today can provide an insight into the type of studies and further training you will need to ensure that are ready for the workforce of tomorrow.

Use the **Careers 2030** weblink in your eBookPLUS and consider the work of an ecosystem auditor, a localiser or a rewilder. Develop a career profile for this emerging career considering:
- a definition for this occupation
- the core skills needed in this field
- the study or training required to undertake the tasks in the job description
- which industries will employ these occupations.

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Weblinks
- Worksite
- Careers 2030

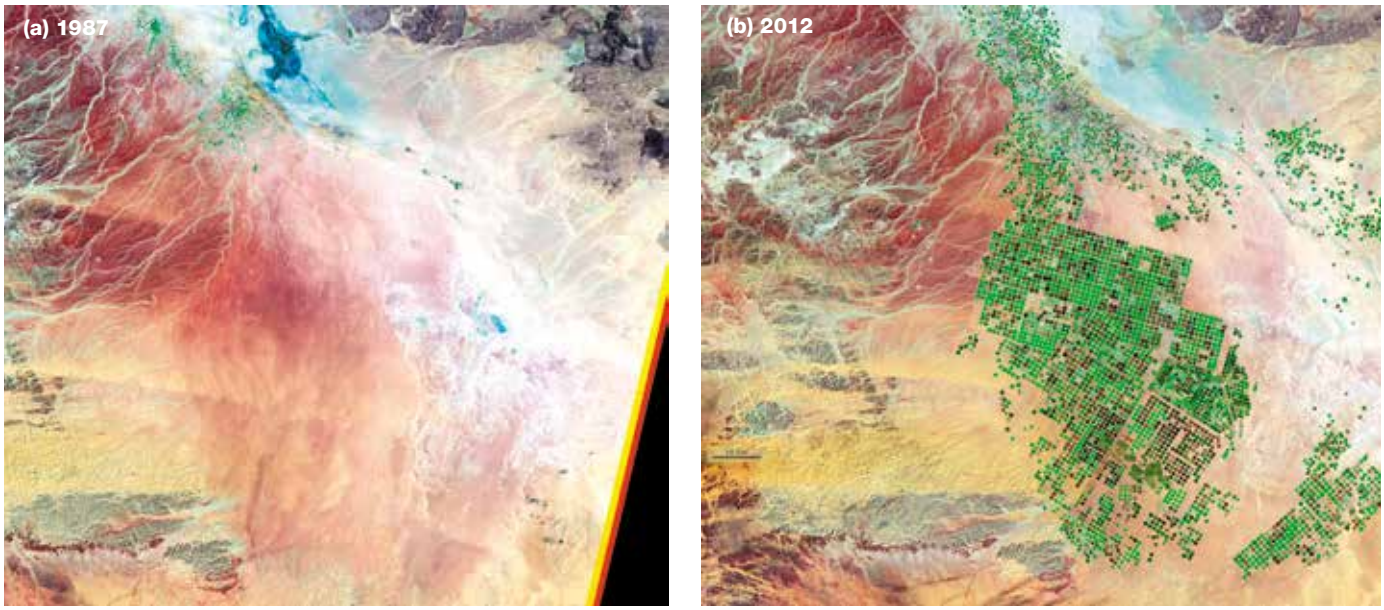
1.4 Review

1.4.1 Applying the concepts

Saudi Arabia is home to extensive desert regions—today, thanks to advances in technology, much of the desert is being transformed into productive farming areas. Fruits, vegetables and grains are the main crops grown, and these help to improve the country's food security. Extensive drilling is tapping into underground aquifers as much as 1000 metres deep to access water for irrigation of water-hungry crops. Large circular sprays, called centre pivots, create a distinctive circular pattern of fields (see figure 1b).

Rainfall in the Wadi As-Sirhan Basin averages only 100–200 mm per year, which is insufficient to recharge underground aquifers. The water that is being pumped to the surface is actually 'fossil' water, possibly up to 20 000 years old. The volume of water that is being used for desert agriculture has more than tripled in just over 25 years.

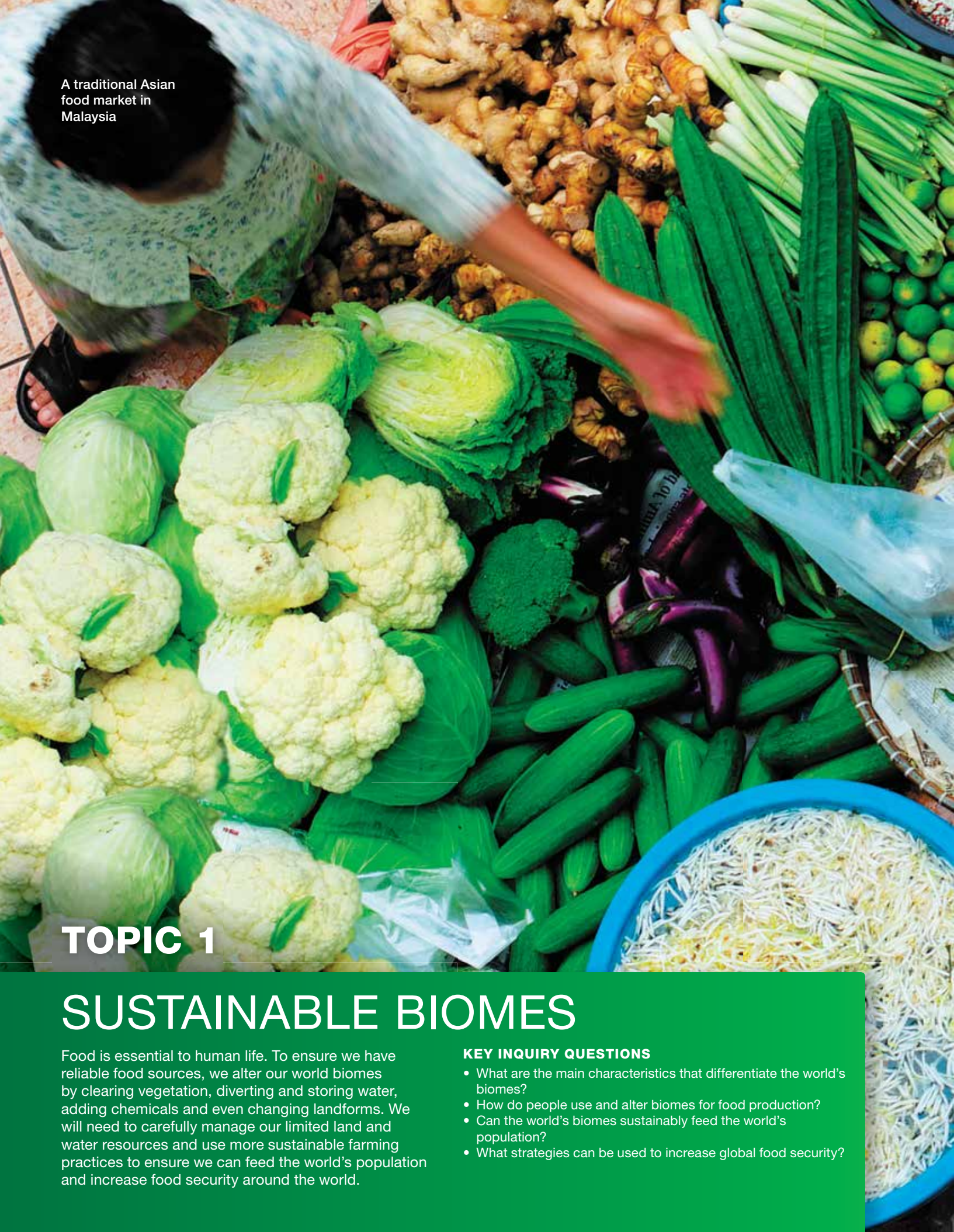
FIGURE 1 Satellite images of the Wadi As-Sirhan Basin in Saudi Arabia. *Note:* Landsat imagery shows new vegetation as bright green, while dry vegetation or land lying fallow is shown as rust-coloured. Dry desert areas are shown as pink and yellow.



ACTIVITIES

1. Where is Saudi Arabia located? (***space***)
2. Looking at figure 1a, how would you describe this ***place***?
3. What do you think the white lines to the north-west of the image are? What does this tell you about the climate in this region? (***environment***, ***space***)
4. Comparing the two images, describe the ***changes*** that irrigation has brought to this ***environment***.
5. Each of the fields in figure 1b is approximately one kilometre wide. What does this indicate about the ***scale*** of this irrigation region?
6. How would the isolation of this irrigation region affect the movement of fresh produce to markets in cities? (***interconnection***)
7. Hydrologists (water engineers) believe that it will be economical to continue pumping water for only another 50 years. Is the use of groundwater ***sustainable*** in the future?

Note: The terms in brackets are intended to help students identify which concept the question is related to.



A traditional Asian food market in Malaysia

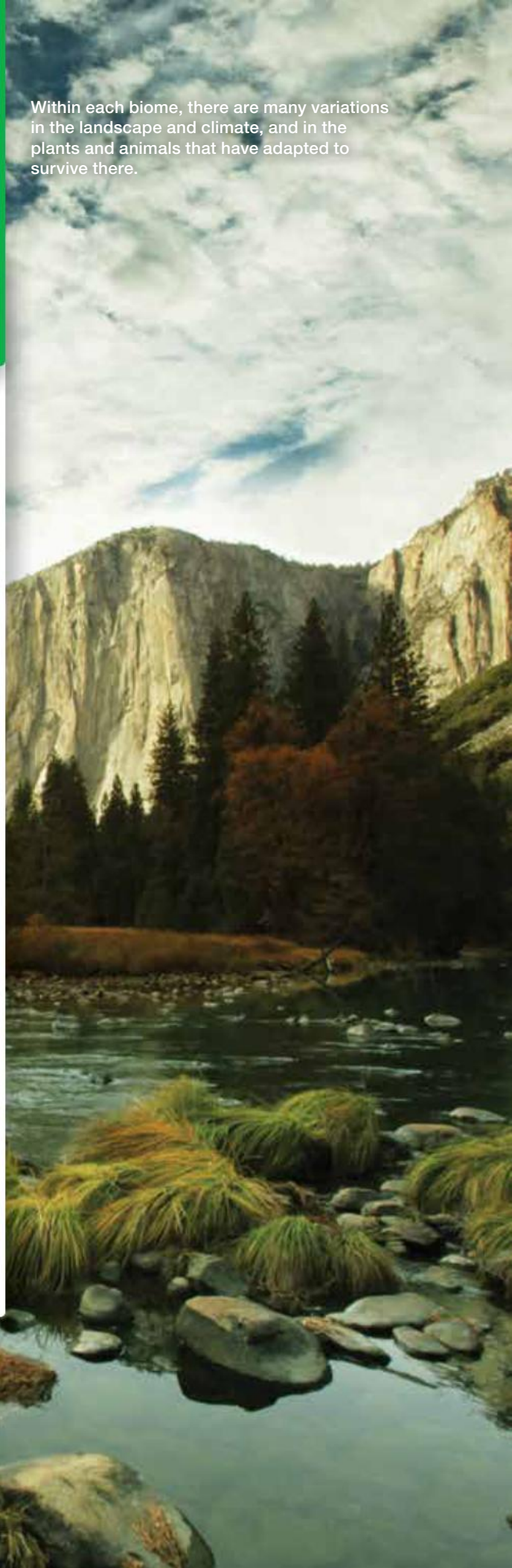
TOPIC 1

SUSTAINABLE BIOMES

Food is essential to human life. To ensure we have reliable food sources, we alter our world biomes by clearing vegetation, diverting and storing water, adding chemicals and even changing landforms. We will need to carefully manage our limited land and water resources and use more sustainable farming practices to ensure we can feed the world's population and increase food security around the world.

KEY INQUIRY QUESTIONS

- What are the main characteristics that differentiate the world's biomes?
- How do people use and alter biomes for food production?
- Can the world's biomes sustainably feed the world's population?
- What strategies can be used to increase global food security?



Within each biome, there are many variations in the landscape and climate, and in the plants and animals that have adapted to survive there.

CHAPTER 2

Biomes

2.1 Overview

2.1.1 Introduction

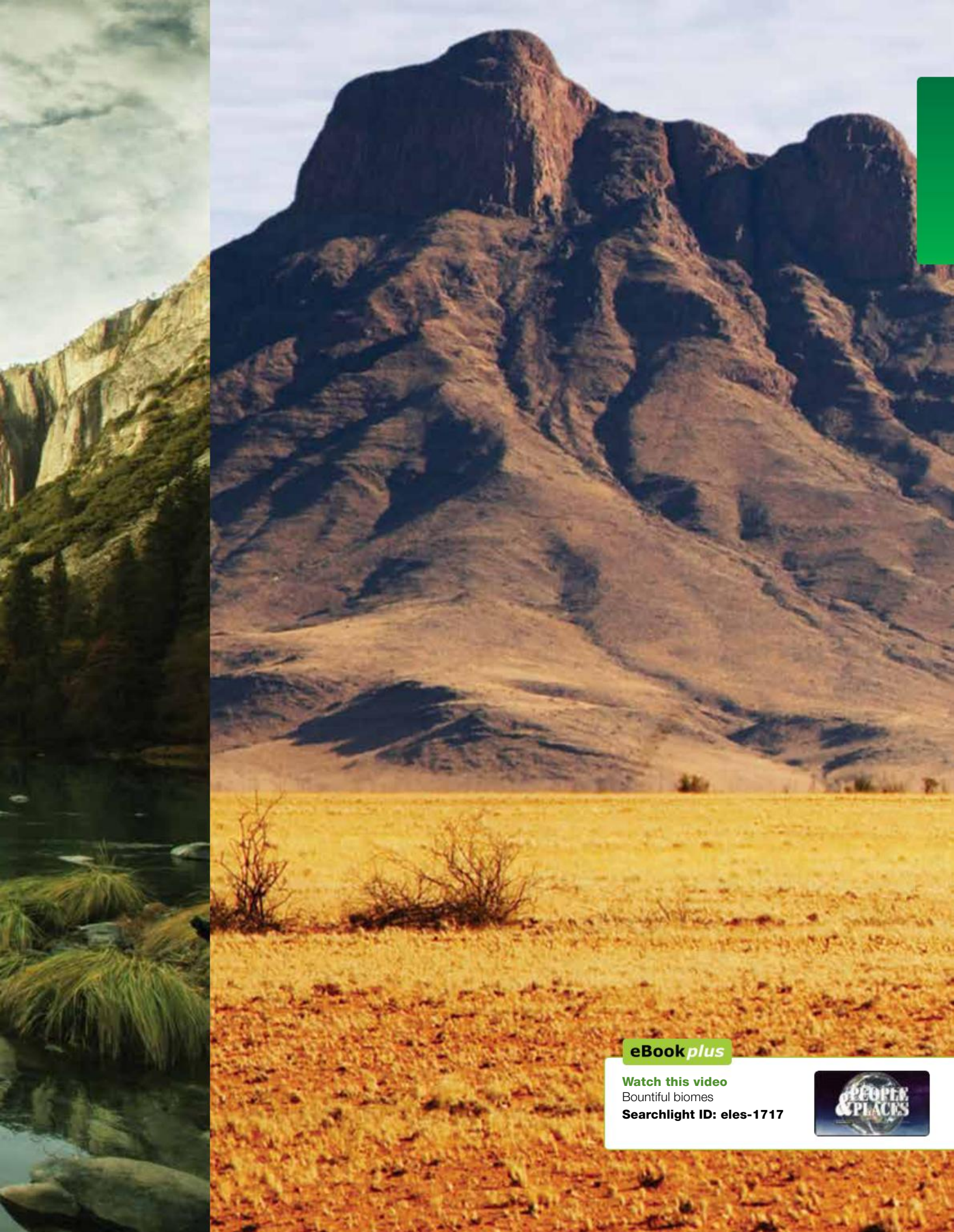
Biomes are communities of plants and animals that extend over large areas. Some are dense forests; some are deserts; some are grasslands, like much of Australia; and so the variations continue. Within each biome, plants and animals have similar adaptations that allow them to survive. Biomes can be terrestrial (land based) or aquatic (water based). Understanding the diversity and functioning of biomes is essential to our survival and wellbeing as they are responsible for the food we eat and the natural products we use on a daily basis.

Starter questions

1. As a class, list words that you think explain what the word *biome* means.
2. What information do the pictures shown here convey about biomes?
3. Create a list of the things you use and consume that come from biomes. Compare your list with other students in your class.

Inquiry sequence

		Syllabus outcomes
2.1 Overview		
2.2 What are biomes?		GE5-1
2.3 Why are biomes different?		GE5-2
2.4 What are Australia's major biomes?		GE5-1
2.5 SkillBuilder Describing spatial relationships in thematic maps	eBook plus ONLINE ONLY	GE5-3 GE5-7
2.6 How do we use the grassland biome?		GE5-1 GE5-2
2.7 Investigating topographic maps: How do coastal wetlands function in Dalywoi Bay?		GE5-1 GE5-2
2.8 SkillBuilder Constructing and describing a transect on a topographic map	eBook plus ONLINE ONLY	GE5-3 GE5-7
2.9 Why are coral reefs unique?		GE5-1 GE5-2
2.10 How do we protect biomes?		GE5-5
2.11 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	



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Bountiful biomes
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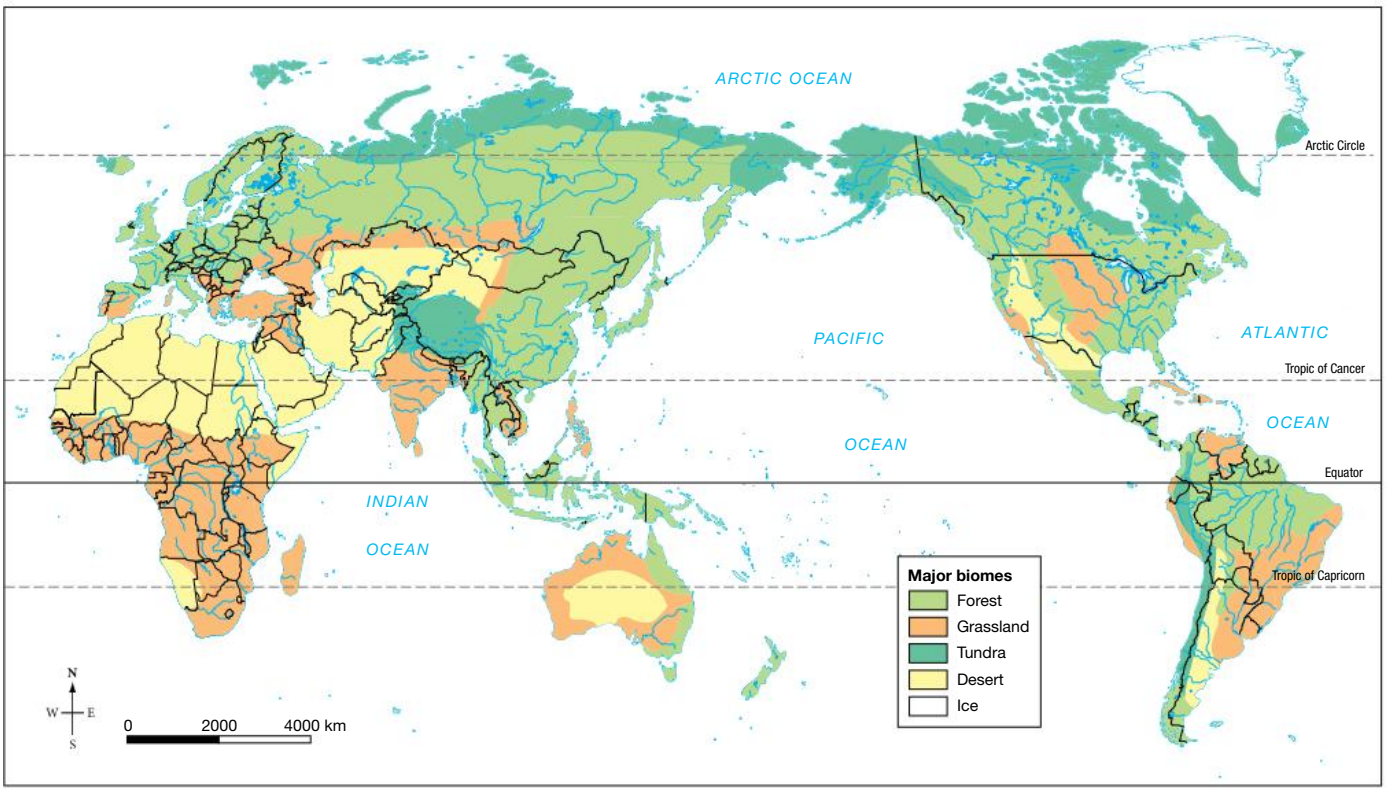
2.2 What are biomes?

2.2.1 What and where are the major biomes?

Biomes are communities of plants and animals that extend over large areas due to similarities of climate within the area of the biome. There are five distinct biomes across the Earth: forest, desert, grassland, tundra and aquatic biomes. Within each major biome there are variations in the visible landscape and in the plants and animals that have adapted to survive in a particular climate.

FIGURE 1 Major biomes of the world



Source: Spatial Vision

Forests

Forests are the most diverse biomes on the Earth. They range from hot and wet tropical rainforests to temperate forests, and have an abundance of both plant and animal life. Over 50 per cent of all known plant and animal species are found in tropical rainforests making them one of the most **biodiverse** places on Earth. Forests are the source of over 7000 modern medicines, and many fruits and nuts originated in this biome. Forests also play an important part in how the planet functions. They regulate global climate by absorbing the sun's energy, plants store and recycle water back into the atmosphere, and importantly they store carbon and convert it into the oxygen we breathe. Forests are under threat from **deforestation**.

biodiversity the variety of living organisms (plant and animal life) within an area

deforestation clearing forests to make way for housing or agricultural development

FIGURE 2 Forest

Deserts

Deserts are places that experience low rainfall and can either be hot or cold, such as the hot deserts in Australia or cold deserts of Central Asia (the Gobi Desert). They are mainly located where the tropic and temperate zones meet. Generally they are places of temperature extremes for example, hot deserts are hot by day and cold by night. Most animals that inhabit deserts are **nocturnal** and desert vegetation is sparse. Desert rain often evaporates before it hits the ground, or else it falls in short, heavy bursts. Following periods of heavy rain, deserts teem with life. Around 300 million people around the world live in desert regions.

FIGURE 3 Desert

Grasslands

Grasslands are biomes dominated by grass and may have small, widely spaced trees or no trees. The two categories of grasslands are tropical grasslands and temperate grasslands, and these are based on climate. Examples include the Sergenti in Tanzania and the Great Plains in North America respectively. The coarseness and height of the grass varies with location. They are mainly inhabited by grazing animals, reptiles and ground-nesting birds, though many other animals can be found in areas with more tree cover. Grasslands have long been prized for livestock grazing, but overgrazing of grasslands is unsustainable and places them at risk of becoming deserts. Over one billion people inhabit the grassland areas of the world.

FIGURE 4 Grassland

Tundra

Tundras are biomes characterised by cold climates and the absence of trees, but they have grasses, dwarf shrubs, mosses and lichens. They are located in the higher latitudes around the polar zones, such as the Arctic Tundra, and at high altitudes, such as the Alti near Siberia. Tundra falls into three distinct categories—Arctic, Antarctic and alpine—but they share the common characteristic of low temperatures. In Arctic regions there is a layer beneath the surface known as **permafrost**. The tundra biome is the most vulnerable to changes in climate, because plants and animals have little tolerance for environmental changes that reduce snow cover.

Aquatic biomes

Water covers about three-quarters of the Earth and can be classified as fresh water or marine. Freshwater biomes contain very little salt and are found on land; these include lakes, rivers and wetlands. Marine biomes are the saltwater regions of the Earth and include oceans, coral reefs and estuaries. Marine environments are teeming with plant and animal life, and are a major food source. Elements taken from the roots of mangroves have been used in the development of cancer remedies. Compounds from other marine life have also been used in cosmetics and toothpaste.

nocturnal active during the night

permafrost permanently frozen ground

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Interactivity
Beautiful biomes
Use this interactivity to further your understanding and recognition of the world's major biomes.
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FIGURE 5 Tundra

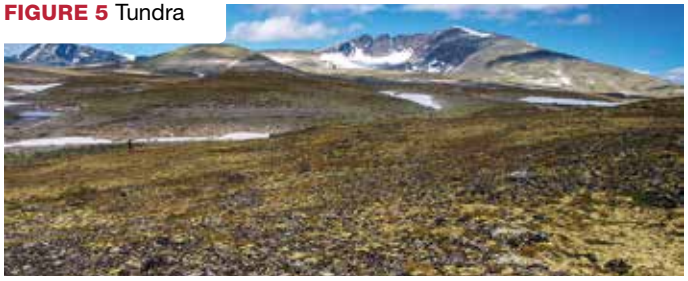


FIGURE 6 Aquatic environment

ACTIVITIES

IDENTIFY

1 Using information in the text and figure 1, create a table that lists the five major biomes, identifies the different types within each of them, and identifies its key characteristics and spatial distribution.

Major biome	Types	Characteristics	Spatial distribution (climate zones)

EXPLAIN

2 Refer to figure 1. Explain why the different biomes would occur in the different climate zones?

INVESTIGATE

3 Tropical rainforests are biodiverse. Use the internet to research the names of some plants and organisms used to make medicines and the diseases they help cure/prevent.

APPLY

4 Select one of the major biomes outlined in this section. Suggest how this biome could be used and ***changed*** by humans and what are some possible impacts of these ***changes***?

2.3 Why are biomes different?

2.3.1 What influences climate?

climate the long-term precipitation and temperature patterns of an area

There is a strong interconnection between **climate** and biomes. A place's climate is influenced by a variety of factors. These include its distance from the equator (latitude) and from the sea, landforms that surround it, its altitude, ocean currents and air movement.

Climate affects the location of biomes and the flora and fauna found within them. This is because of the differences in temperature and precipitation patterns (figure 1). For instance, hot desert biomes have high temperatures but not enough precipitation to sustain an abundance and diversity of life. On the other hand, tropical rainforests have an abundance of heat and precipitation making them plentiful in plant and animal communities.

Latitude

The sun's rays are more direct at the equator. With more energy focused on that region, it heats up more quickly. As you move away from the equator to the mid and higher latitudes, the curvature of the Earth makes the sun's rays travel through more atmosphere and the heat spreads over a larger area. As a result the energy from the sun does not heat up the Earth as effectively, and the closer to the poles you travel the cooler it becomes (figure 2).

FIGURE 1 The interconnection between climate and biomes

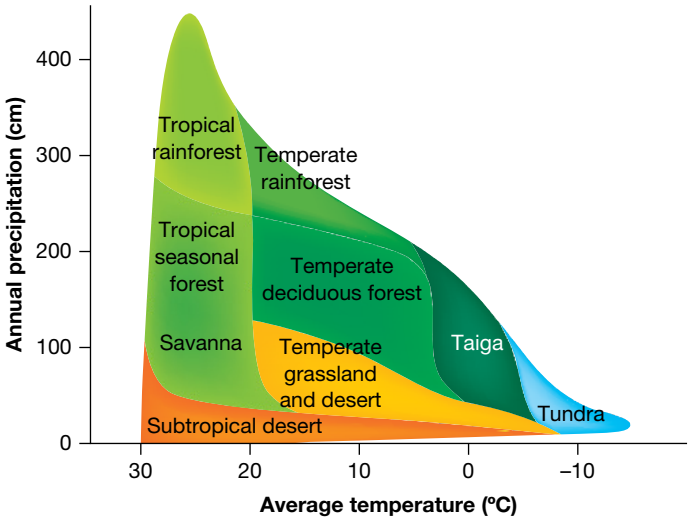
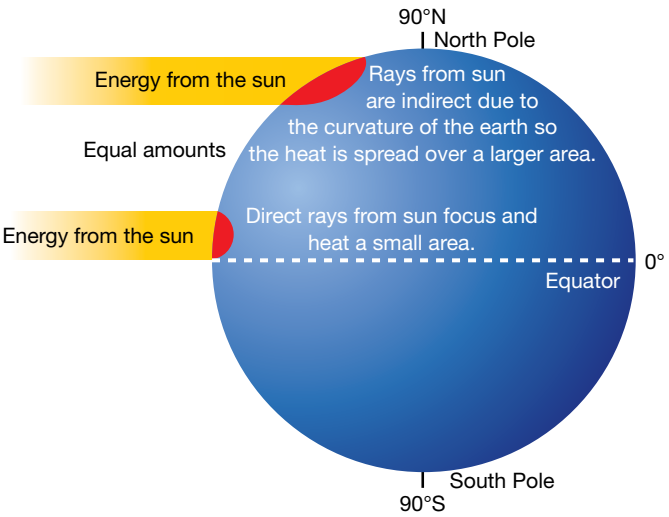


FIGURE 2 The influence of latitude on climate. The rotation of the Earth around the sun and the tilt of the Earth on its axis also influence the seasons.



The tilt of the Earth on its axis also has a part to play. When a hemisphere tilts towards the sun, the sun's rays hit it more directly. This means that a larger space is in more intense sunlight for longer. The days are longer and warmer, and the hemisphere experiences summer. The reverse is true when a hemisphere tilts away from the sun in winter. This has created distinct climate zones based on latitude. There is a relationship between climate zones and the type of biomes located within them (see figure 1).

Altitude and landforms

Altitude also plays a significant role in determining climate. Temperatures fall by 0.65 °C for every 100 metres increase in elevation. This can be illustrated by Mt Kilimanjaro (figure 3), which is located on the border of Tanzania and Kenya, in Africa, approximately 3° latitude from the equator. Towering 5895 metres above sea level, Mt Kilimanjaro is the highest mountain in Africa. Depending on the time of the day, the temperature at the base of the mountain ranges from 21 °C to 27 °C. At the summit, temperatures can plummet to –26 °C. As you move from base to summit, variations occur in the landscape as it transitions from rainforest to alpine desert to desert tundra.

Another, major geographical influence on climate is the location of mountain ranges (figure 4). Whilst the altitude of ranges can affect temperature, the location of mountain ranges affect the amount of precipitation that reaches inland areas. They prevent the moisture laden **prevailing winds** from reaching inland areas by creating a barrier. Rain falls on the **windward** side of a mountain and **rain shadows** form on the **leeward** side of mountains. Desert biomes often form in rain shadows.

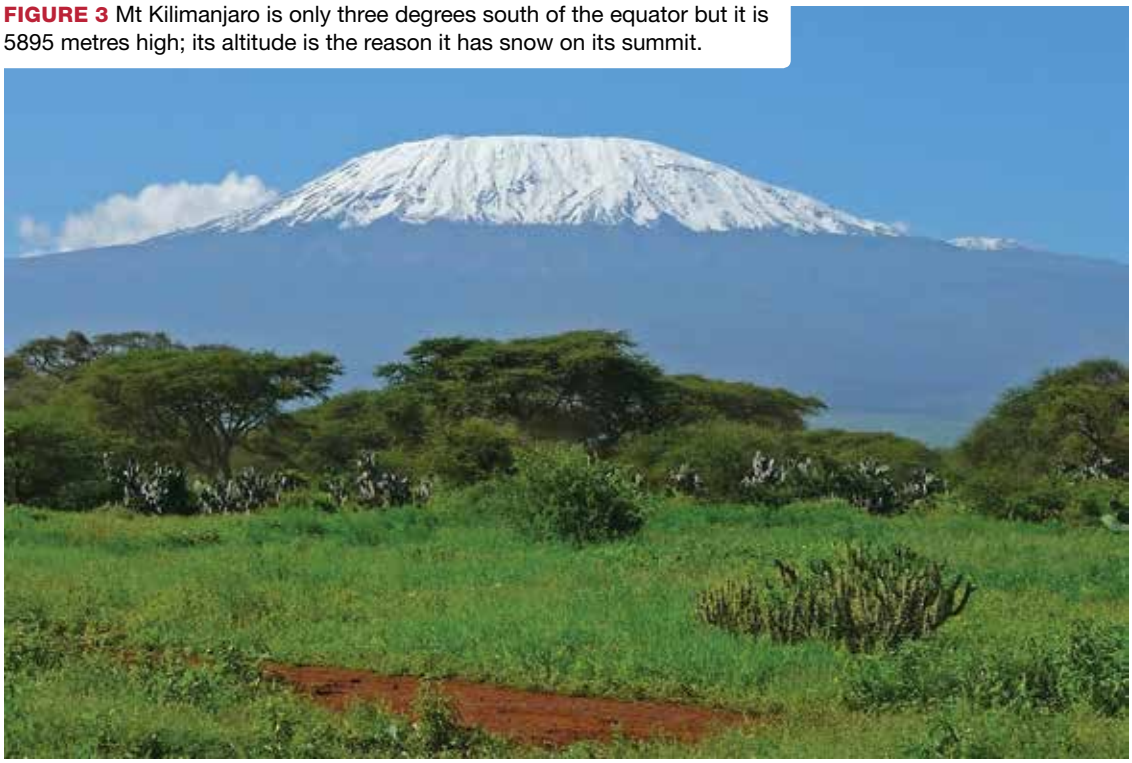
prevailing winds the dominant direction a wind blows from

windward describes the side of the mountain that faces the prevailing winds

rain shadow the dry area on the leeward side of a mountain range

leeward describes the area behind a mountain range, away from the moist prevailing winds

FIGURE 3 Mt Kilimanjaro is only three degrees south of the equator but it is 5895 metres high; its altitude is the reason it has snow on its summit.



Ocean currents and air movement

There are other factors that influence climate and play a role in the development of biomes. Two of these are ocean currents and air movement.

When cold ocean currents flow close to a warm land mass, a desert is more likely to form. This is because cold ocean currents cool the air above, causing less evaporation and making the air drier. As this dry air moves over the warm land, it heatsup, making it less likely to release any moisture it holds making areas it reaches arid. For example, cold ocean currents flow off the coast of Western Australia, while on the East coast of Australia the Pacific Ocean currents are warmer. As a result, Perth on average receives less rainfall than Sydney.

FIGURE 4 The influence of mountains on climate. This illustration shows the pattern typical on the east coast of Australia, where there are warm ocean currents.

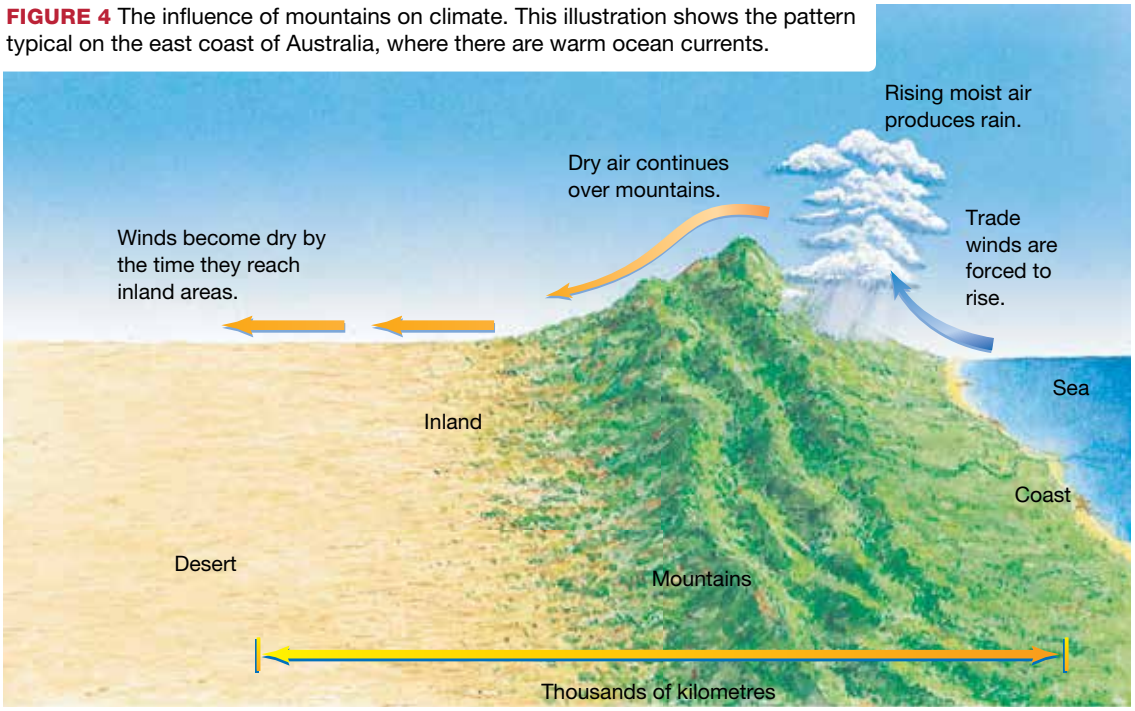
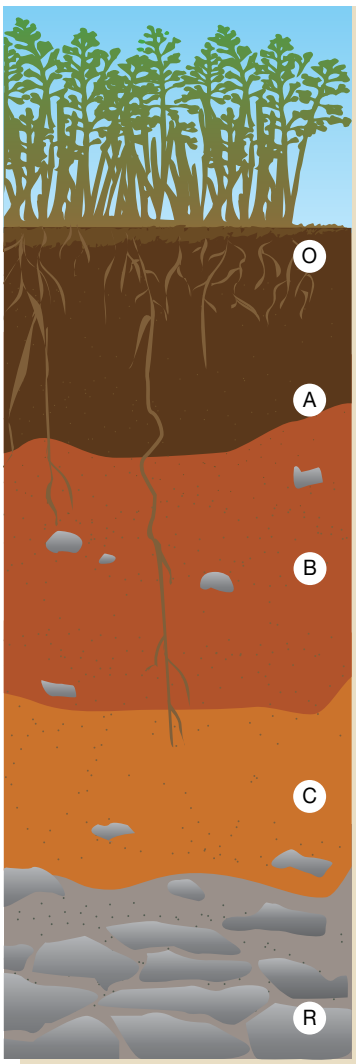


FIGURE 5 A typical soil profile has a number of distinct layers.



Horizon O (organic matter): A thin layer of decomposing matter, humus and material that has not started to decompose, such as leaf litter.

Horizon A (topsoil): The upper layer of soil, nearest the surface. It is rich in nutrients to support plant growth and usually dark in colour. Most plant roots and soil organisms are found in this horizon, which will also contain some minerals. In areas of high rainfall, such as tropical rainforests, minerals will be leached out of this layer. A constant supply of decomposing organic matter is needed to maintain soil fertility.

Horizon B (subsoil): Plant litter is not present in horizon B; as a result, little humus is present. Nutrients leached from horizon A accumulate in this layer, which will be lighter in colour and contain more minerals than the horizon above.

Horizon C (parent material): Weathered rock that has not broken down far enough to be soil. Nutrients leached from horizon A are also found in this layer. It will have a high mineral content; the type is determined by the underlying bedrock.

Horizon R (bedrock): Underlying layer of partly weathered rock.

2.3.2 The role of soil in biomes

Soil is important in determining which plants and animals inhabit a particular biome. Soils not only vary around the world but also within regions. The characteristics of soil are determined by:

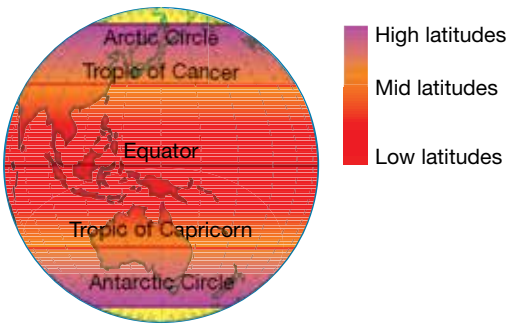
- temperature
- rainfall
- the rocks and minerals that make up the bedrock, which is the basis of soil development.

The amount of vegetation present also plays an important role in determining the quality of the soil. Figure 5 shows a typical soil profile. The different soil layers are referred to as horizons.

Why do soils differ?

Biomes located in the high latitudes (those farthest from the equator) have lower temperatures and less exposure to sunlight than biomes located in the low latitudes (those close to the equator). There are also variations in the amount of precipitation that biomes receive. This is determined partly by their location in relation to the equator (see figure 6).

FIGURE 6 Just as there is a link between climate and latitude, there is also a link between soil, climate and latitude.

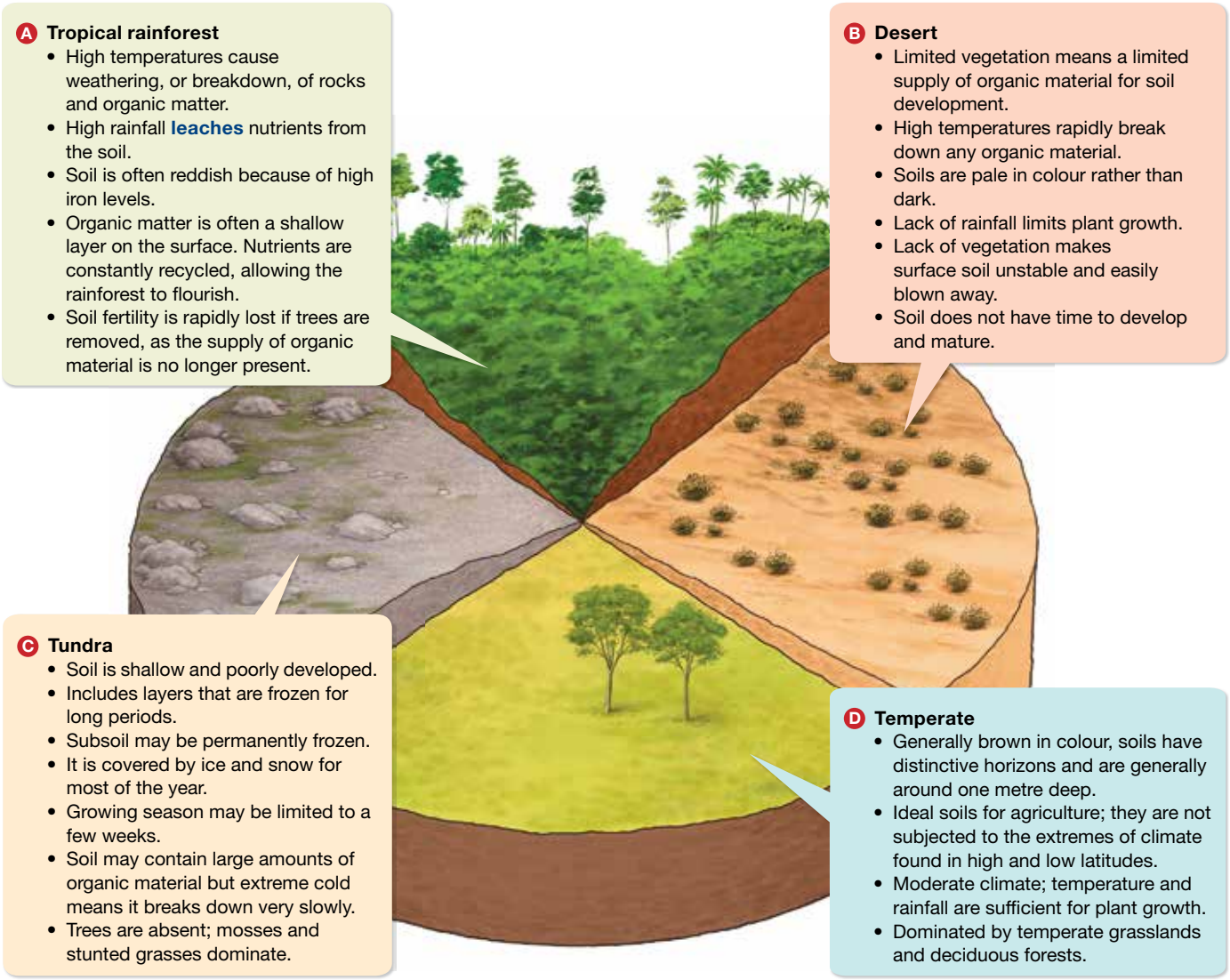


Temperature and precipitation patterns are important factors in determining the rate of soil development. However, soil moisture, its nutrient content and the length of the growing season also play key roles in soil development and, ultimately, the biodiversity of a biome.

Soil is more abundant in biomes that have both high temperatures and high moisture than in cold, dry regions. This is because erosion of bedrock is more rapid when moisture content is high, and organic material decomposes at a faster rate in high temperatures. The decomposition of organic matter provides the nutrients needed for plant growth, which in turn die and decompose in a continuous cycle. This is further demonstrated in figure 7.

leaching the process in which water runs through soil, dissolving minerals and carrying them into the subsoil

FIGURE 7 Different biomes have different soil and vegetation characteristics.



What else is in the soil?

Soil not only supports the plants and animals that we see on the surface of the land; the soil itself is also home to a variety of life forms such as bacteria, fungi, earthworms and algae.

While most soil organisms are too small to be seen, there are others that are visible. For instance, more than 400 000 earthworms can be found on a hectare of land. Regardless of size, all soil organisms play a vital role in maintaining soil quality and fertility. For example, earthworms:

- compost waste and fertilise the soil
- improve drainage and aeration
- bring subsoil to the surface and mix it with topsoil
- secrete nitrogen and chemicals that help bind the soil.

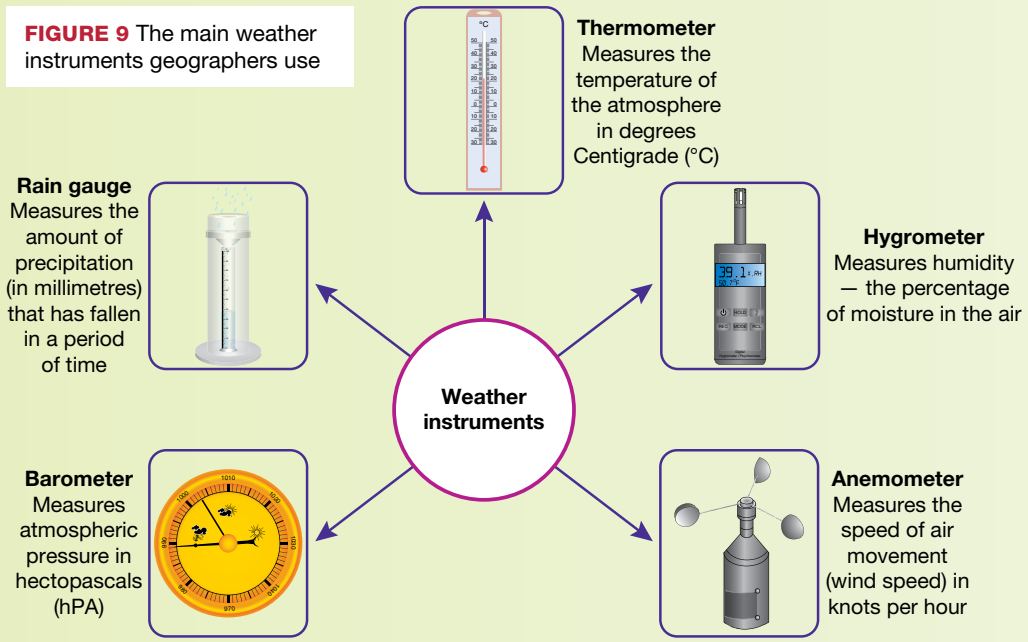
FIGURE 8 There are more microbes in a teaspoon of soil than there are people on Earth.

FOCUS ON FIELDWORK

Weather instruments

Geographers use a variety of instruments to measure weather when out in the field (figure 9).

FIGURE 9 The main weather instruments geographers use



Check with your Science faculty to see if they have many of these instruments. If not there are numerous instructions online to make your own basic instruments.

1 Measure the weather conditions in various parts of your school. For example, record one set of readings in the main quadrangle over concrete and one set of readings on the backfield over grass.
2 Record your measurements in a table like the one below.

Location	Temperature	Humidity	Air pressure	Wind speed	Rain

3 What are some similarities and differences in some of your measurements? Give reasons for these.
4 Use the **Bureau of Meteorology (BOM)** weblink in your eBookPLUS to find the nearest weather station to your school. Compare your measurements to those on the BOM website.

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Weblink
Bureau of Meteorology (BOM)

eBookplus

Interactivity
Why are biomes different?
Use this interactivity to further your understanding of why biomes differ.
Searchlight ID: int-3319

ACTIVITIES

IDENTIFY

1 Refer to figure 1. Name the changes in biomes when there is an increase in temperature and precipitation.
2 Identify the characteristics that affect soils.

EXPLAIN

3 Describe the ***interconnection*** between latitude and climate.
4 Explain why Mt Kilimanjaro has a variety of biomes located on it.
5 Why do deserts usually form on the leeward side of mountains?
6 Explain why soils vary in different biomes.

INVESTIGATE

7 Research the average temperature and average annual precipitation of the area your school is in. Refer to figure 1 and determine what type of biome your school should be in based on the climate data you researched.
8 Use an atlas to locate Rwanda in Central Africa.
  a Describe what you think the climate would be like in this country. Why?
  b What type of biomes would you expect in Rwanda?
  c Use the internet to research Rwanda and test your predictions.

APPLY

9 What impact would deforestation have on soils in forest biomes? What would be the impacts for humans and food?

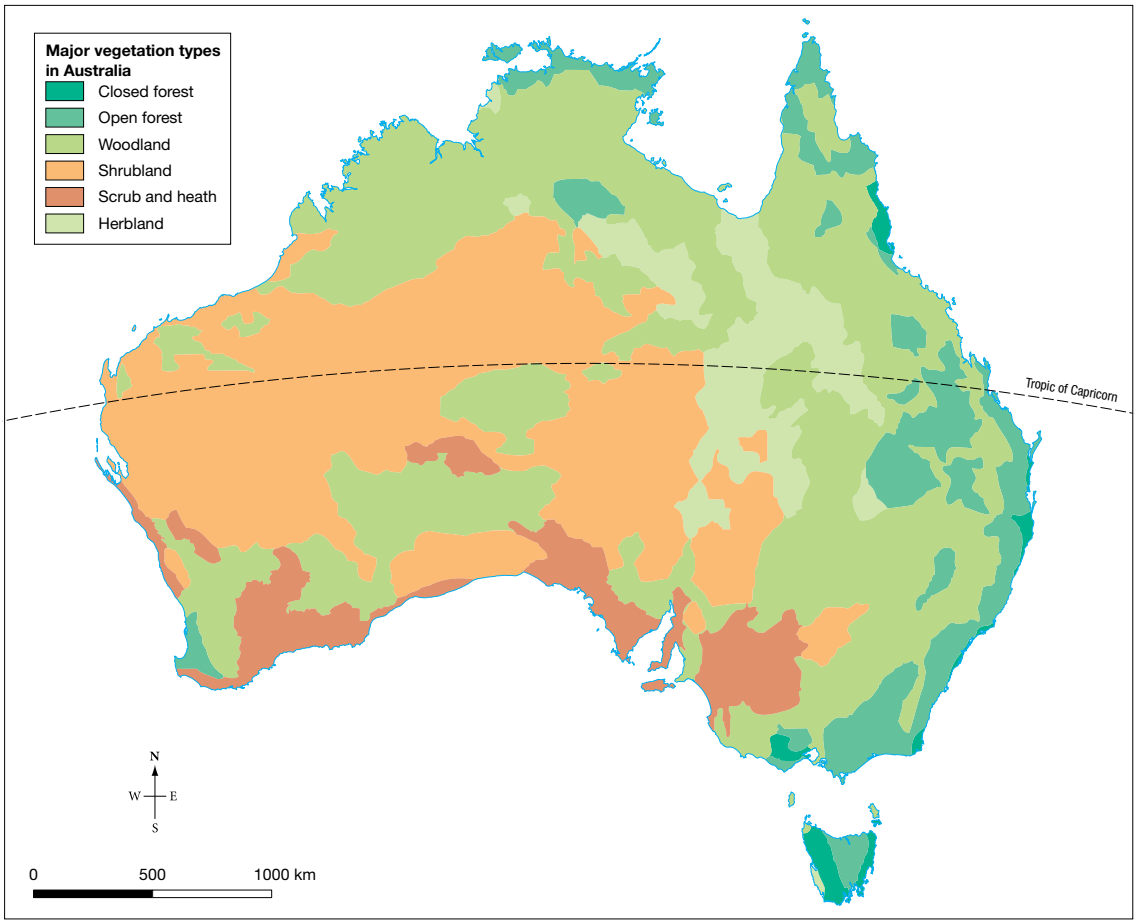
2.4 What are Australia's major biomes?

2.4.1 What factors shape Australian biomes?

Australia is a land of contrasts. In the north are tropical rainforests and savanna grasslands and in the centre is a wide expanse of desert that is second in area only to the Sahara Desert in Africa. In the south, temperate forests and grasslands dominate. It has many of the major biomes located within it. Australia also has vast wetlands and coastal ecosystems.

Australia is a large island continent and is the world's sixth largest country by physical size. It is a large landmass and extends over a number of latitudes from 10° S to 43° S of the equator. As such, it has a variety of climates and biomes (figure 1). The northern part of the continent is within the tropics and the southern areas are located in the temperate zones. The vastness of the continent also impacts precipitation patterns and the mountain ranges on the east coast create rain shadows inland and alpine areas in the higher altitudes.

FIGURE 1 Australia's vastness and latitudinal extent affect the diversity of biomes located on this island continent.



Source: Spatial Vision

However, since European settlement, large-scale land clearing, irrigation of the land through water diversion from rivers, and drainage of wetlands have taken place. Despite the extensive changes made by humans in the past few hundred years, Australia's major biomes are still evident.

FIGURE 2 Wetlands and rivers

FIGURE 3 Grasslands

FIGURE 4 Seagrass meadows

FIGURE 5 Old-growth forest

Wetlands and rivers

In northern Australia, wetlands have been inhabited by Aboriginal peoples for more than 50 000 years. These areas provided them with food and water, and they used wetland plants such as river reeds and lily leaves in making fishing traps. Today, wetlands are still important habitats for native and migratory birds. In many parts of Australia they are under threat because water is diverted from rivers to produce food crops and cotton.

Grasslands

Grasslands are generally flat, having either few trees and shrubs or very open woodland. For many native species, grasslands provide vital habitat and protection from predators. Many grasslands depend on a regular cycle of burning to germinate their seeds and to revive the land. Periodic burning also prevents trees from gaining dominance in the landscape. Before European settlement, Aboriginal peoples hunted the animals in the grasslands. However, since then, grasslands have been used extensively for grazing. These areas often mark the transition between desert and forest, and are a very fragile biome. Without careful management they can quickly change to desert. Less than one per cent of Australia's original native grasslands survive today.

Seagrass meadows

Seagrasses are submerged flowering plants that form colonies off long, sandy ocean beaches, creating dense areas that resemble meadows. Of the 60 known species of seagrass, at least half are found in Australia's tropical and temperate waters. Western Australia alone is home to the largest seagrass meadow in the world. Seagrasses provide important habitats for a wide variety of marine creatures, including rock lobsters, dugongs and sea turtles. They also absorb nutrients from coastal run-off, slow water flow, help stabilise sediment, and keep water clear.

Old-growth forest

An old-growth forest is one in its oldest growth stage. It is multi-layered, and the trees are of mixed ages. Generally, there are few signs of human disturbance. These forests are biologically diverse, often home to rare or endangered species, and show signs of natural regeneration and decomposition. The trees within some old-growth forests have been felled for their timber and to create paper products. **Logging** can reduce biodiversity, affecting not only the forest itself but also the indigenous plant and animal species that rely on the old-growth habitat.

It is estimated that **clearfelling** of Tasmania's old-growth forests would release as much as 650 tonnes of carbon per hectare into the atmosphere. In Victoria, near Melbourne, many old growth forests lie within protected water supply catchments and help maintain the integrity of the city's water supply.

Desert

Australian deserts are places of temperature extremes. During the day, temperatures sometimes exceed 50 °C, but at night this can drop to freezing. Australia's desert regions are often referred to as the outback but they are not all endless plains of sand. Some, such as the Simpson and Great Sandy Deserts, are dominated by sand. The Nullarbor Plain and Barkly Tablelands are mainly smooth and flat, while the Gibson Desert and Sturt Stony Desert contain low rocky hills. In some areas, the landscape is dominated by spinifex and acacia shrubs (as shown in figure 6).

FIGURE 6 Desert

logging the cutting down, processing and removal of trees from an area

clearfelling the removal of all trees in an area

ACTIVITIES

IDENTIFY

1 What latitudes does Australia sit between?
2 Describe the climates in the north of Australia and south of Australia.

EXPLAIN

3 Explain why Australia has a diversity of climates.

APPLY

4 Select one of the biomes covered in this section. Predict what might happen if the biome experienced ***change*** such as draining the wetlands or cutting down old-growth forests. Describe the ***changes*** you consider may occur in this ***environment*** and outline what impacts this would have.

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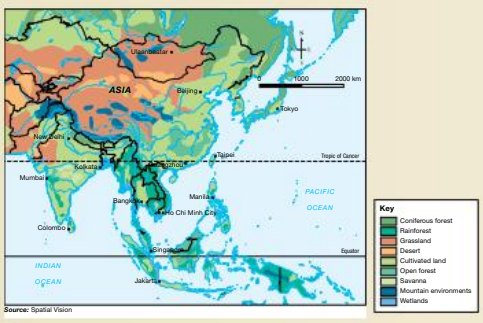
2.5 SkillBuilder: Describing spatial relationships in thematic maps

What are spatial relationships in thematic maps?

A spatial relationship is the interconnection between two or more pieces of information in a thematic map, and the degree to which they influence each other's distribution in space. Describing these relationships helps us understand how one thing affects another.



eLesson

Watch this video to learn how to describe spatial relationships in thematic maps.

Geography SKILLBUILDER

Searchlight ID: eles-1726

Interactivity

Try this interactivity to learn how to describe spatial relationships in thematic maps.

Searchlight ID: int-3344

2.6 How do we use the grassland biome?

2.6.1 What are the characteristics of grasslands?

prairie native grasslands of North America

Grassland, pampas, savanna, chaparral, cerrado, **prairie**, rangeland and steppe all refer to a landscape that is dominated by grass. Once, grasslands occupied about 42 per cent of the Earth's land surface, but today they make up about 25 per cent of its land area. Grasslands are found on every continent except Antarctica (see figure 1).

The grassland biome, as the name suggests, is dominated by grasses, and generally has few or no trees. Grasslands develop in places where there is not enough rain to support a forest but too much rain for a desert; for this reason they are sometimes referred to as a transitional landscape.

Grasslands are found in both temperate and tropical areas where rainfall is between 250 mm and 900 mm per year. In tropical regions, grasslands tend to have a distinct wet and dry season. In temperate regions, the summers tend to be hot and the winters cool. Generally, grasslands in the southern hemisphere receive more rainfall.

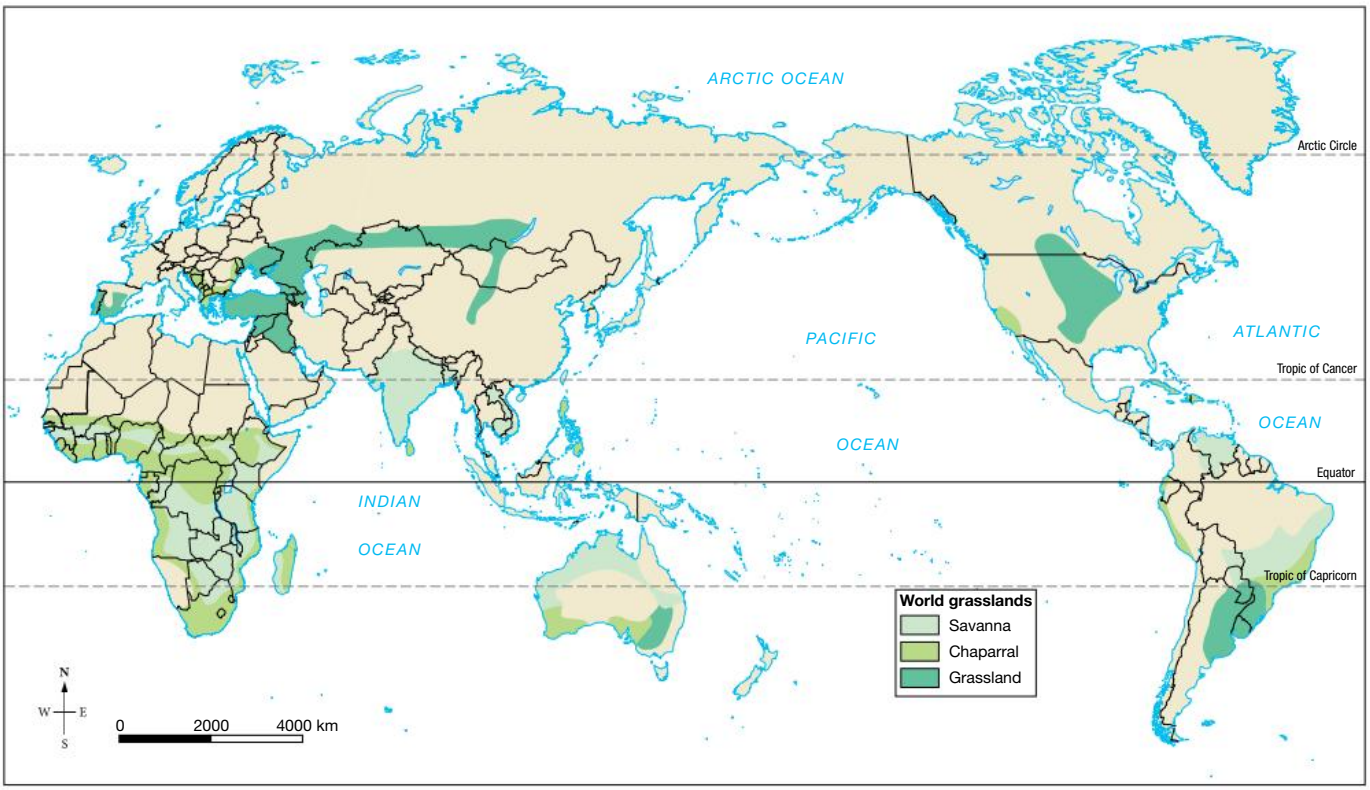
desertification the transformation of land once suitable for agriculture into desert by processes such as climate change or human practices such as deforestation and overgrazing

Grasslands are also one of the most endangered environments and are susceptible to **desertification**. The entire ecosystem depends on its grasses and their annual regeneration. It is almost impossible to re-establish a grassland ecosystem once desert has taken over. Grasslands often depend on fire to germinate their seeds and generate new plant growth. Indigenous populations, such as Australian Aboriginal peoples, used this technique to flush out any wildlife that was hidden by long grass.

Grasslands can occur naturally or as a result of human activity. The presence of large numbers of grazing animals and frequent fires prevent the growth of tree seedlings and promote the spread of grasses. Unlike other plant species, grasses can continue to grow even when they are continually grazed by animals, because their growth points are low, close to the soil. Because grasses are fast-growing plants, they can support a high density of grazing animals, and they regenerate quickly after fire.

Some grasses can be up to two metres in height, with roots extending up to a metre below the soil.

FIGURE 1
Grasslands occupy about a quarter of the Earth's land surface.



Source: Spatial Vision

2.6.2 Why are grasslands important?

Grasslands are the most useful biome for agriculture because the soils are generally deep and fertile. They are ideally suited for growing crops or creating pasture for grazing animals. The prairies of North America, for example, are one of the richest agricultural regions on Earth.

Almost one billion people depend on grasslands for their livelihood or as a food source. Grasslands have been used for livestock grazing and are increasingly under pressure from **urbanisation**. Grasslands have also become popular tourist destinations, because people flock to them to see majestic herds such as wildebeest, caribou and zebra, as well as the migratory birds that periodically inhabit these environments.

urbanisation the social and economic processes whereby an increasing proportion of the population of a country or region live in urban areas

All the major food grains — corn, wheat, oats, barley, millet, rye and sorghum — have their origins in the grassland biome (see figure 2). Wild varieties of these grains are used to help keep cultivated strains disease free. Many native grass species have been used to treat diseases including HIV and cancer. Others have proven to have properties for treating headaches and toothache.

FIGURE 2 Wheat is a type of grass.

Grasslands are also the source of a variety of plants whose fibres can be woven into clothing. The best known and most widely used fibre is cotton. Harvested from the cottonseed, it is used to produce yarn that is then knitted or sewn to make clothing. Lesser known fibres include flax and hemp. Harvested from the stalk of the plant, both fibres are much sturdier and more rigid than cotton but can be woven to produce fabric. Hemp in particular is highly absorbent and has UV blocking qualities.

In Australia today, less than one per cent of native grasslands survive, and they are now considered one of the most threatened Australian habitats. Since European settlement, most native grassland has been removed or changed by farming and other development. Vast areas of grassland were cleared for crops, and introduced grasses were planted for grazing animals, such as sheep and cattle (see figure 3).

FIGURE 3 Grasslands can support a high density of grazing animals. In Australia, we use grasslands for fine wool production.

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Interactivity
Grass, grains and grazing
Use this interactivity to learn more about the relationship between grassland biomes and different types of agriculture.
Searchlight ID: int-3318

ACTIVITIES

IDENTIFY

1 Define grassland.
2 Describe the global distribution of grasslands.
3 Outline why grasslands are an important ***environment***.
4 Describe the major threats to this ***environment***.

EXPLAIN

5 Explain why grasslands are referred to as transitional landscapes.
6 Explain why so little of Australia's grasslands remain.

INVESTIGATE

7 Grasslands are located on six of the Earth's seven continents. Working in teams, investigate one of the grassland biomes. Using ICT, create a presentation (video, prezi, slideshow, etc.) on your chosen biome that covers the following:
- the characteristics of the ***environment***, including climate and types of grasses that dominate this ***place***
- the animals that are commonly found there
- how the ***environment*** is used and ***changed*** for the production of food, fibre and wood products.
- threats to this particular grassland, including the ***scale*** of these threats
- what is being done to manage this grassland ***environment*** in a ***sustainable*** manner.

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

2.7 How do coastal wetlands function in Dalywoi Bay?

2.7.1 What are coastal wetlands?

Wetlands are biomes where the ground is saturated, either permanently or seasonally. They are found on every continent except Antarctica. Wetlands include areas that are commonly referred to as marshes, swamps and bogs. In coastal areas they are often tidal and are flooded for part of the day. In the past they were often considered a 'waste of space', and in developed nations they were sometimes drained for agriculture or the spread of urban settlements.

organic matter decomposing remains of plant or animal matter

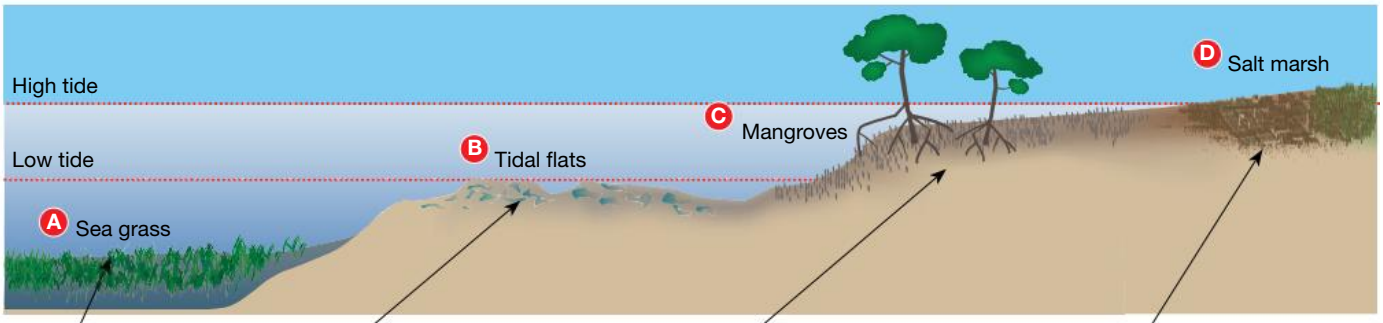
pneumatophores exposed root system of mangroves, which enable them to take in air when the tide is in

2.7.2 Are wetlands important?

Wetlands are a highly productive biome. They provide important habitats and breeding grounds for a variety of marine and freshwater species. In fact, a wide variety of aquatic species that we eat, such as fish, begin their life cycle in the sheltered waters of wetlands. They are also important nesting places for a large number of migratory birds.

Wetlands are also a natural filtering system and help purify water and filter out pollutants before they reach the coast. In addition, they help regulate river flow and stabilise the shoreline. Figure 1 shows a cross-section through a mangrove wetland.

FIGURE 1 Cross-section of a mangrove wetland



A Seagrass meadows:
- are covered by water all the time
- bind the mud and provide shelter for young fish
- produce **organic matter**, which is consumed by marine creatures (see figure 2).

B Tidal flats:
- are covered by tides most of the time
- are exposed for short periods of the day (low tide)
- are formed by silt and sand that has been deposited by tides and rivers
- provide a feeding area for birds and fish.

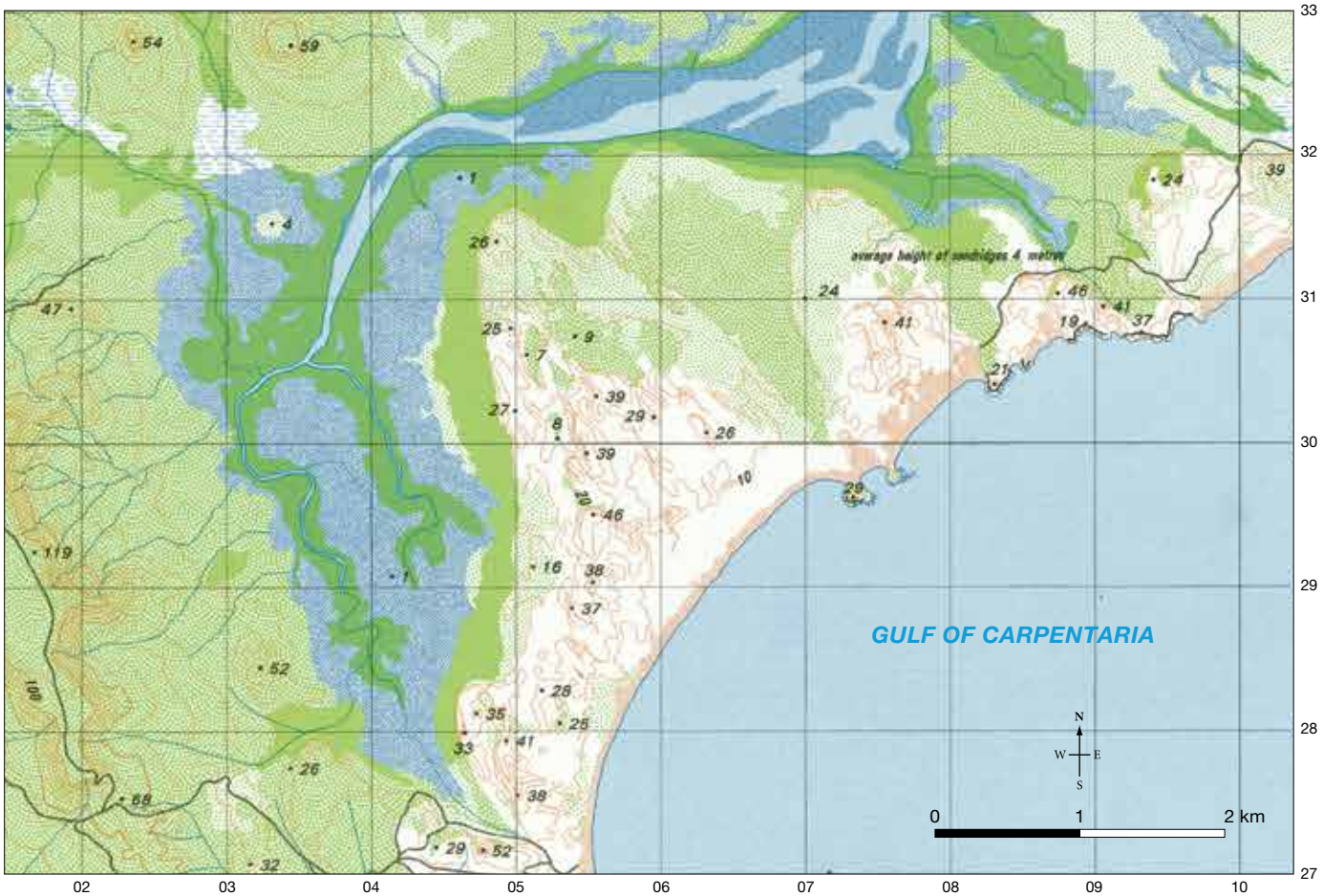
C Mangroves:
- have **pneumatophores** that trap sediment and pollutants from the land and sea (see figure 3)
- change shallow water into swampland
- store water and release it slowly into the ecosystem
- have leaves that decompose and provide a food source for marine life
- provide shelter, breeding grounds and a nursery for marine creatures and birds.

D Salt marshes:
- are covered by water several times per year
- provide decomposing plant matter — an additional food source for marine life
- have high concentrations of salt.

FIGURE 2 Seagrass

FIGURE 3 Pneumatophores

FIGURE 4 Dalywoi Bay, Northern Territory



Source: The Australian Army © Commonwealth of Australia 1999

Key

Vehicle track; Road bridge; Stock grid .....
Mine; Building; Ruin; Church; Windpump; Yard .....
Fence; Horizontal control point; Spot elevation .....
Contour with value and cliff; Pinnacle .....
Depression contours; Sand; Distorted surface .....
Levee; Sandbridge .....
Razorback ridgeline; fault line .....
Vegetation; Dense, medium, scattered; Cleared lane .....
Rain forest; Pine .....
Orchard or vineyard; Line if trees or windbreak .....
Watercourse; Area subject to inundation .....
Swamp; Swamp definite boundary .....
Perennial lake; Watercourse .....
Intermittent lake; Watercourse .....
Mainly dry lake; Watercourse .....
Tank or Small dam; Waterhole .....
Saline coastal flat; Intertidal flat; Rock bare or awash .....
Lighthouse; Intertidal ledge or reef .....
Exposed wreck; Submerged wreck .....
Submerged reef; Submerged rock .....
Indefinite watercourse; Mangrove swamp .....

ACTIVITIES

IDENTIFY

1 What other names are wetlands known by?
2 Describe the natural functions of wetlands in the ***environment***.

EXPLAIN

3 What are seagrass meadows and why are they important?
4 Refer to figure 4 and describe the ***environment*** at the following.
- **a** GR042309
- **b** GR071329
- **c** GR030320
- **d** GR042285

PREDICT

5 Refer to figure 4 and locate the grid square bounded by the following grid references:
030300, 030310, 040030, 040310.
- **a** Describe the natural ***environment*** in this area.
- **b** Describe how this ***environment*** would ***change*** over the course of the day.
- **c** A proposal has been put forward to construct a canal housing estate in this location. It is proposed that the estate will occupy these grid squares and their surrounds. Explain how the ***environment*** may ***change*** if this project goes ahead.

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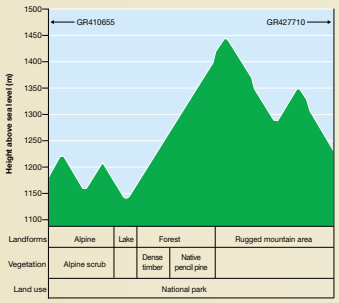
2.8 SkillBuilder: Constructing and describing a transect on a topographic map

What is a transect?

A transect is a cross-section with additional detail, which summarises information about the environment. In addition to the shape of the land, a transect shows what is on the ground, including landforms, vegetation, soil types, settlements and infrastructure.



eLesson

Watch this video to learn how to construct and describe a transect on a topographic map.

Searchlight ID: eles-1727

Interactivity

Try this interactivity to learn how to construct and describe a transect on a topographic map.

Searchlight ID: int-3345

2.9 Why are coral reefs unique?

2.9.1 Formation of coral reefs

Coral reefs are found in spaces around tropical and subtropical shores. They require specific temperatures to develop and sea conditions that are clean, clear and free from sediment. The upper layer is alive, growing on the remains of millions of dead coral. They are one of the oldest ecosystems on Earth and also very vulnerable to human activity.

coral polyp a tube-shaped marine animal that lives in a colony and produces a stony skeleton. Polyps are the living part of a coral reef.

Coral reefs are one of the most biodiverse environments on Earth and are built by polyps that live in groups. A reef is a layer of living tiny animals called **coral polyps** that build and grow on the remains of millions of layers of dead coral. There are many different types of reefs such as inner and outer reefs as well as coral cays (small islands of coral) and coral atolls (see figures 1 and 2).

2.9.2 Benefits of coral reefs

Today, around 500 million people rely on reef systems, either for their livelihood, as a source of food, or as a means of protecting their homes along the coastline. Coral reefs help break up wave action, so waves have less energy when they reach the shoreline, thus reducing coastal erosion.

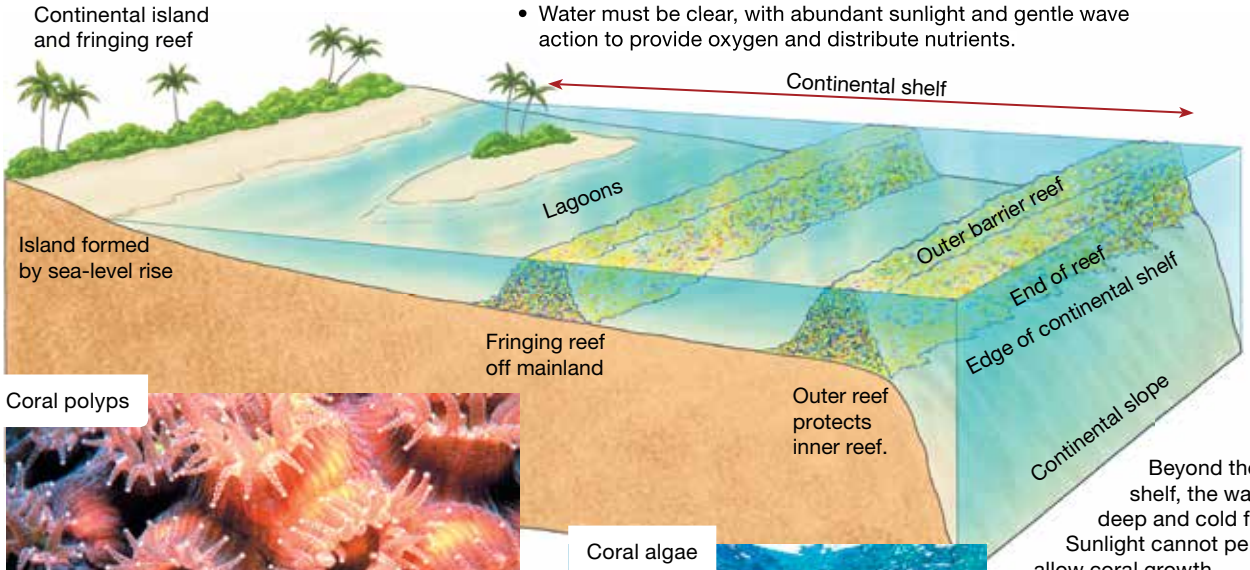
It is estimated that coral reefs contribute $375 billion to the global economy each year. Reefs are important to both the fishing and tourism industries. In 2014, approximately 1.88 million tourists visited Australia's Great Barrier Reef Marine Park alone. Nearly a third of all international tourists who visit Australia also visit the Great Barrier Reef.

Coral reefs have been found to contain compounds vital to the development of new medicines, such as:

- painkillers have been developed from the venom of cone shells
- some cancer treatments come from algae
- treatments for cardiovascular disease and HIV include compounds that were originally found in coral reefs.

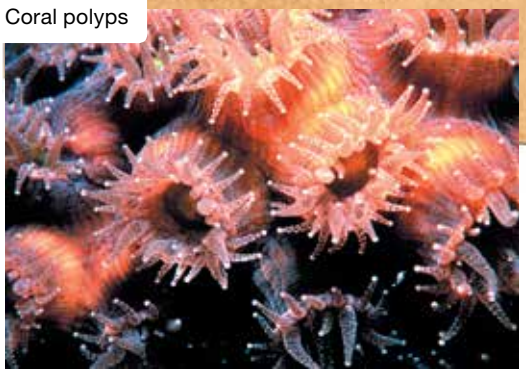
FIGURE 1 Anatomy of a coral reef

- Corals form in warm shallow salt water where the temperature is between 18 °C and 26 °C.
- Water must be clear, with abundant sunlight and gentle wave action to provide oxygen and distribute nutrients.



Beyond the continental shelf, the water is too deep and cold for coral. Sunlight cannot penetrate to allow coral growth.

Coral polyps



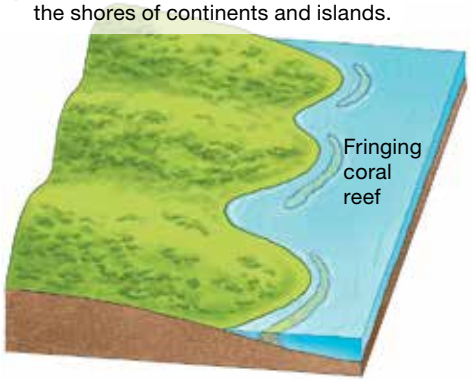
Coral polyps have soft, hollow bodies shaped like a sac with tentacles around the opening. They cover themselves in a limestone skeleton and divide and form new polyps.

Coral algae

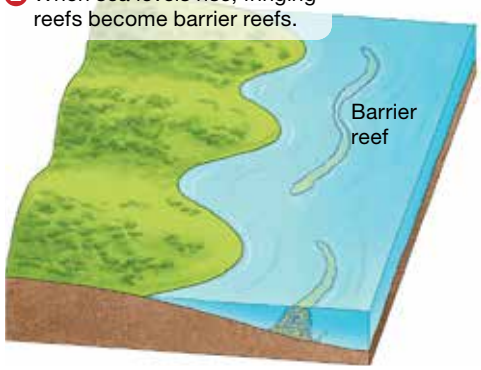
Producers, such as algae, give coral its colour and provide a food source for marine life, such as fish. Coral reefs support at least one-third of all marine species. They are the marine equivalent of the tropical rainforest.

FIGURE 2 The formation of fringing reefs, barrier reefs and coral atolls

1 Fringing coral reefs develop along the shores of continents and islands.

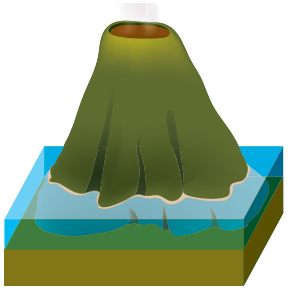


2 When sea levels rise, fringing reefs become barrier reefs.

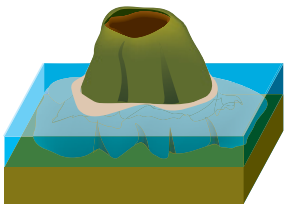


3 Formation of a coral atoll

a Volcanic island

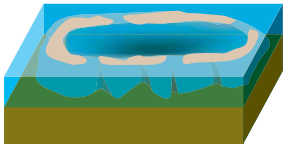


b Eroded volcanic island has been partly submerged by rising sea.



c Sandy island forms on reef from eroded coral and shell.

What was once an island is now completely submerged.



2.9.3 Threats to coral reefs

Reefs also face a variety of threats.

- Urban development requires land clearing and wetland drainage, which increases erosion. Sediment washed into water prevents sunlight penetrating the water.
- Contamination by fossil fuels, chemical waste and agricultural fertilisers pollutes the sea.
- Tourism damages coral through boats dropping anchor or tourists directly removing coral or walking on it.
- Global warming increases water temperature, which bleaches the coral, turning it white and destroying the reef system.
- Predators, such as the crown of thorns starfish, prey on coral polyps, which affects the whole ecosystem.

ACTIVITIES

IDENTIFY

1 Outline what a coral reef is.
2 List the economic and medical benefits of coral reefs.
3 Describe the difference between a fringing reef and a barrier reef.

EXPLAIN

4 Explain how coral reefs are important in protecting coastal communities.

INVESTIGATE

5 Investigate two of the threats to coral reefs and prepare an annotated visual display that outlines:
- the nature of the threat
- the ***changes*** that will occur or have occurred as a result of this threat
- the impact of these ***changes*** on the ***environment***, including references to the rate and ***scale*** of this ***change***
- a strategy for the long-term ***sustainable*** management of the reef ***environment***.

PREDICT

6 Coral reefs are highly susceptible to ***changes*** in the climate. What ***changes*** do you think the coral reef ***environment*** would experience if sea temperatures rise by 2° C?

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › The Great Barrier Reef

2.10 How do we protect biomes?

2.10.1 Can we recreate what has been lost?

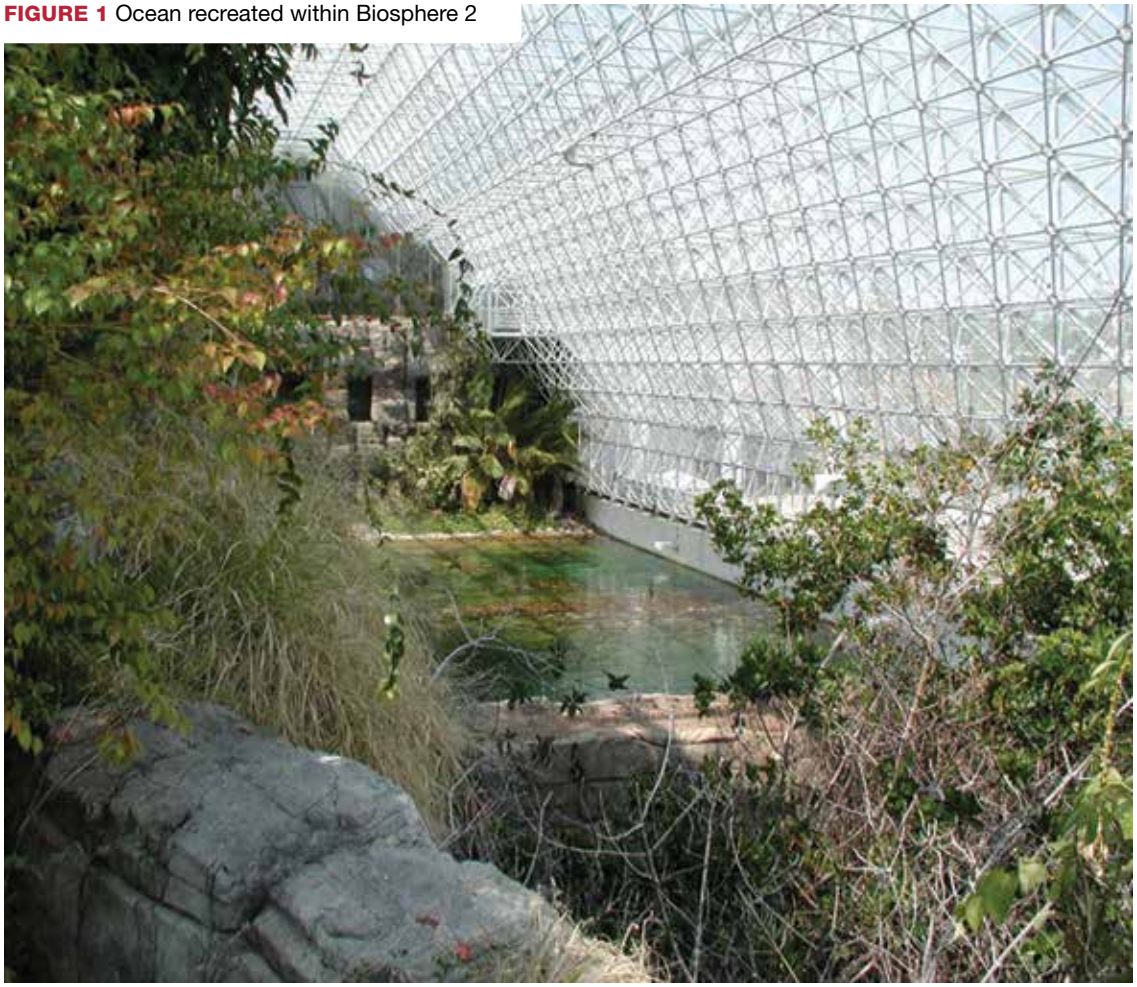
It is important to consider the long-term impact of our actions and ensure that they do not have a negative impact on the environment. In the past, human activity has polluted and degraded the land. People now recognise that there is an urgent need to sustainably look after the biomes that are left on the planet and to repair and conserve damage that has already taken place.

What is Biosphere 2?

Biosphere 2 (see figures 1 and 2) is a research facility in the Arizona Desert, and has been designed to investigate Earth's life systems. Covering an area of 1.5 hectares and standing almost 28 metres at its highest point, Biosphere 2 is the world's largest ecological laboratory. Its mission is to learn more about how the environment connects with us and how we in turn connect with the environment.

Within the confines of Biosphere 2, five natural environments have been recreated: rainforest, desert, savanna, wetland and ocean (including a coral reef). In addition, agricultural and human living spaces have also been created. More than 3000 living organisms are found across the complex. All systems, including oxygen levels, water supply and climate are managed by complex computer systems within the facility.

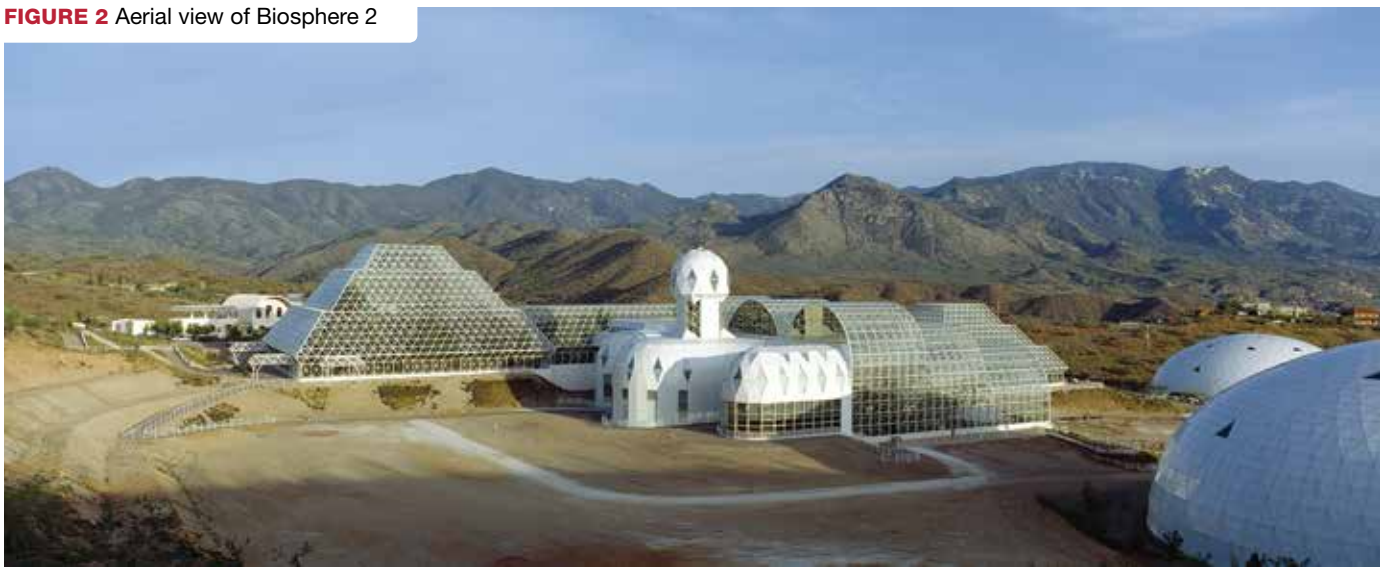
FIGURE 1 Ocean recreated within Biosphere 2



While early experiments focused on our ability to artificially recreate the Earth's biosphere and sustain life within it, the emphasis has now moved to investigating the impact of human activity. Scientists are looking at how increased burning of fossil fuels and the destruction of habitats will affect the natural systems that sustain all life on the planet.

The project has helped demonstrate the complexity of the natural processes that occur on Earth and within particular biomes. Constant work, effort and thought is needed to maintain the natural order.

FIGURE 2 Aerial view of Biosphere 2



land degradation a decline in the quality of land, which makes it less able to support agriculture or native vegetation

salinity the presence of salt on the surface of the land, in soil or rocks, or dissolved in rivers and groundwater

2.10.2 What is Landcare?

Landcare was born in 1986, when a group of farmers near St Arnaud in central Victoria banded together to find sustainable solutions to their common problem: **land degradation**. The idea has since been adopted by the Australian Government and has spread nationwide. Landcare is about communities working together on environmental projects such as:

- cleaning up polluted creeks and waterways
- planting trees
- restoring beach dune systems
- finding workable solutions to problems such as **salinity** in farming communities
- addressing the growing problem of waste disposal and plastic bags.

FIGURE 3 Clean-up Australia — less rubbish was collected this year than last year.

2.10.3 What are the Sustainable Development Goals?

In September 2015, the 193 member states of the United Nations unanimously adopted the Sustainable Development Goals (SDGs) that come in to effect from 2016. It has 17 goals that help guide nations and people for the next 15 years to address the needs of people in developed and developing countries (see figure 4). It focuses on three dimensions they believe will lead to sustainable development; social, economic and environmental. Goals 14 and 15 directly address strategies for biomes (see figure 5).

The SDGs not only guide governments and large organisations to work towards sustainable development, they also encourage citizens to make an effort through individual action, and to work towards a SDG that appeals to them.

Goal 15: Targets

- By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
- By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally
- By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
- By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development
- Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

FIGURE 4 The United Nations' 17 Sustainable Development Goals

- Promote fair and equitable sharing of the benefits arising from the utilisation of genetic resources and promote appropriate access to such resources, as internationally agreed
- Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products
- By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species
- By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
- Mobilise and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
- Mobilise significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation
- Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

FIGURE 5 Goals 14 and 15 from the Sustainable Development Goals address biomes.

Goal 14: Conserve and sustainably use the oceans, seas and marine resources

Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss

ACTIVITIES

EXPLAIN

1 a What is Biosphere 2?
b Describe its location and the ***scale*** of this project.

2 Make a list of advantages and disadvantages of projects such as Biosphere 2.

INVESTIGATE

3 Use the internet to learn more about Biosphere 2 and a similar facility, the Eden Project, in England. Using ICT, create a 'digital story' explaining these ambitious scientific experiments.

4 Use the internet to research the Sustainable Development Goals. In particular, create two fact files for Goals 14 and 15 that outline the targets for these goals.

APPLY

5 Do you think projects such as Biosphere 2 serve a useful purpose? Give reasons for your answer.

6 The Sustainable Development Goals not only focuses on governments and institutions to act sustainably and justly, but also individuals. Look up the Global Goals Campaign to learn about some ways you can participate. What are some ways you and your school could promote Goals 14 and 15 to sustain our biomes?

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2.11 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

2.5 SkillBuilder: Describing spatial relationships in thematic maps

2.5.1 Tell me

What are spatial relationships in thematic maps?

A spatial relationship is the interconnection between two or more pieces of information in a thematic map, and the degree to which they influence each other's distribution in space.

Why are spatial relationships in thematic maps useful?

Spatial relationships between features or information in thematic maps are the links between the distribution of those features. Finding these links can help us to see the world in an organised manner. They are useful in helping you, as a student, to understand how one thing affects another.

They are also used by:

- councils, when determining planning permits
- transport authorities, when determining new freeways, rail links and tunnels
- meteorologists, when predicting the weekly weather.

Model

The maps in figures 1a and 1b show that, across Asia, there is a strong interconnection between climate and biomes. In areas of high rainfall throughout the tropics, rainforest biomes dominate. In western India's hot desert and in the cold mountains, desert biomes exist. In central Asia, the cold deserts and semi-deserts are so dry that desert and grassland biomes dominate the environment. There is no interconnection between climate and the wetland biomes of north-east China and Bangladesh's delta region. Overall though, there is a strong spatial relationship in Asia between biomes and climate.

A description of a spatial relationship in thematic maps:

- clearly identifies which features on thematic maps are linked or interconnected
- points out obvious anomalies, where no linkages or interconnections can be observed
- describes the extent of interconnections (for example, as strong or weak).

2.5.2 Show me

How to find and describe a spatial relationship in thematic maps

You will need:

- two thematic maps that can be compared
- an atlas.

Procedure:

STEP 1

Use an atlas to familiarise yourself with the mapped area. Place names are important to use in your writing. In figure 1, identify places such as India and China.

STEP 2

Identify areas on both maps that have a distinct interconnection by looking for similar patterns in similar parts of the maps. In figure 1, biomes are clearly linked to climate, with temperatures, rainfall and other climatic factors having an important role in determining what will grow in an area. Write a few sentences outlining where these strong interconnections occur. For example: 'In central Asia, the cold deserts and semi-deserts are so dry that desert and grasslands biomes dominate the environment'.

STEP 3

Search the maps carefully and look for any areas where there seem to be no connections between biomes and climate. If necessary, write a few sentences outlining where there are no interconnections. For example: 'The wetland biomes of north-east China and the Bangladesh delta are not linked to climate'.

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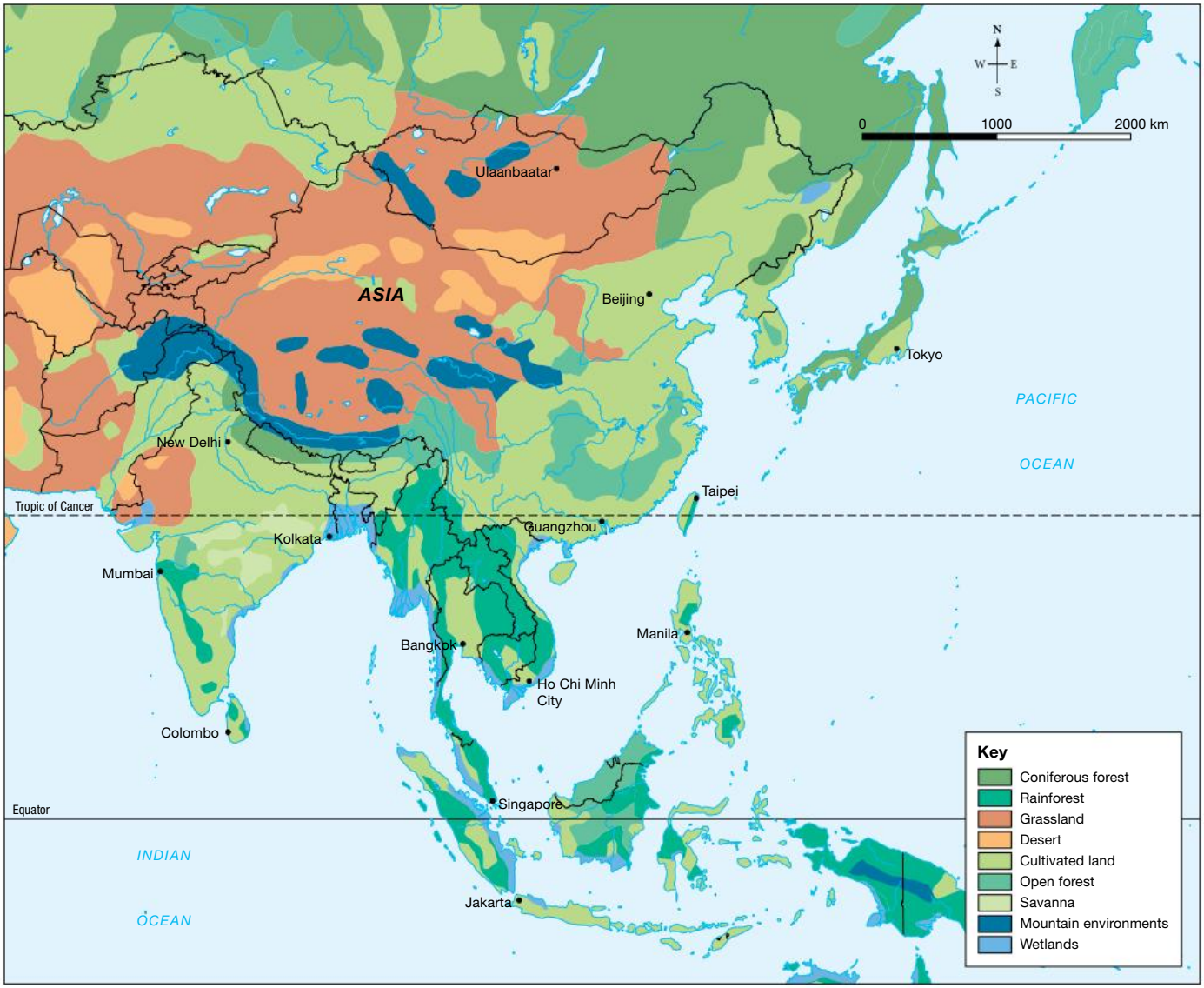
eLesson
Describing spatial relationships in thematic maps
Searchlight ID: eles-1726

FIGURE 1a Thematic map of Asia showing biomes



Source: Spatial Vision

eBookplus

Interactivity
Describing spatial relationships in thematic maps
Searchlight ID: int-3344

STEP 4

Conclude your paragraph with a final statement about spatial relationships. For example: 'In Asia there is a strong spatial relationship between biomes and climate'.

2.5.3 Let me do it

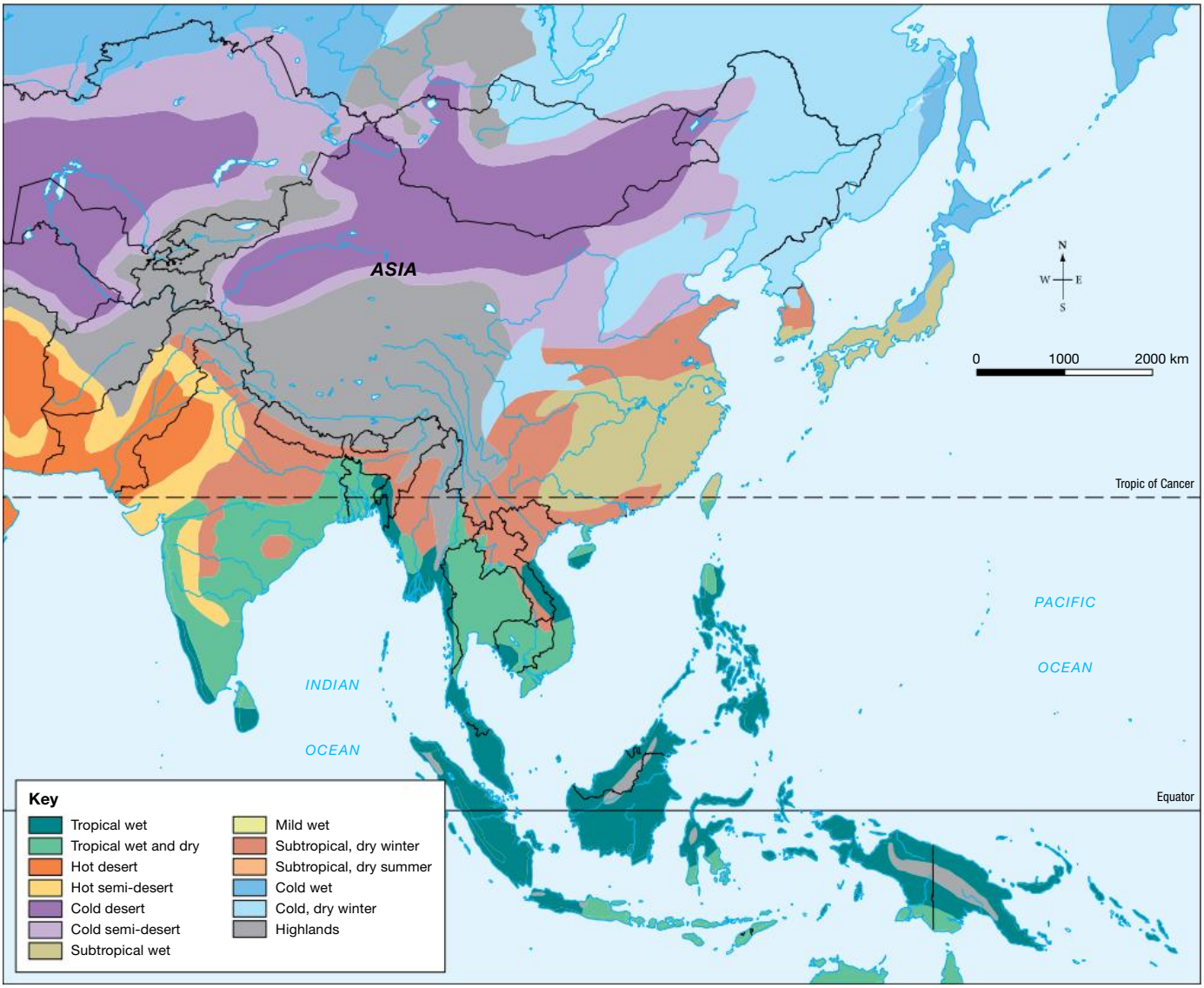
Developing my skills

Use the thematic map for Australia's biomes figure 1 in subtopic 2.4 and locate a climate map of Australia. In a paragraph, describe the spatial relationship between biomes and climate in Australia.

Questions

1. Is there a strong relationship between Australia's arid climates and desert biomes? Explain your answer.
2. Is there a spatial relationship between Australia's tropical rainforests and climate?
3. Is the spatial relationship between climate and the savanna (grassland) biome strong or weak? Explain your answer.
4. Name the main biome found in Tasmania. Why might there be only one biome on the map?
5. Find one biome that does not occur in Australia. Suggest reasons why this is the case.

FIGURE 1b Thematic map of Asia showing climatic zones



Source: Spatial Vision using Natural Earth

Checklist

I have:

- clearly identified which features on thematic maps are linked or interconnected
- pointed out obvious anomalies, where no linkages or interconnections can be observed
- described the extent of interconnections (for example, as strong or weak).

Skills questions

1. Finding the spatial relationships between thematic maps shows:
   a. the interconnection between biomes and climate
   b. the interconnection between features
   c. the importance of a feature
   d. the distribution of a feature.
2. A spatial relationship on a thematic map is about:
   a. slope
   b. rainfall
   c. patterns
   d. colours.
3. Why is it necessary to have two thematic maps when finding interconnections between features?
4. Why do we look for areas where no spatial relationship exists — that is, where there is an anomaly?

2.8 SkillBuilder: Constructing and describing a transect on a topographic map

2.8.1 Tell me

What is a transect?

A transect is a cross-section with additional detail which summarises information about the environment. In addition to the shape of the land, a transect shows what is on the ground, including landforms, vegetation, soil types, settlements and infrastructure.

Why are transects useful?

Transects are useful for showing:

- one or more features that occur along a line between two places
- interconnections between features
- change that occurs along the line.

You can use transects to identify changes in landforms, vegetation and land use. They can also help to show the way certain features, such as landforms, influence other features, such as vegetation. They help us to understand interconnections in the environment.

Transects are used by:

- land developers wanting to explore the key features of an environment
- agronomists seeking to record plant species between two points
- journalists wanting to show differences within a country.

Model

The transect reveals that the main vegetation in the southern areas of the Walls of Jerusalem National Park (where the undulating land reaches 1200 metres) is light alpine scrub. This area contains a lake before the scrub changes to dense timber as the land increases in height. The dense timber gives way to native pencil pines as the land gains further height from 1250 metres to 1400 metres. Where the land rises to 1450 metres, the area is described as rugged mountains. All of this area is designated national parkland.

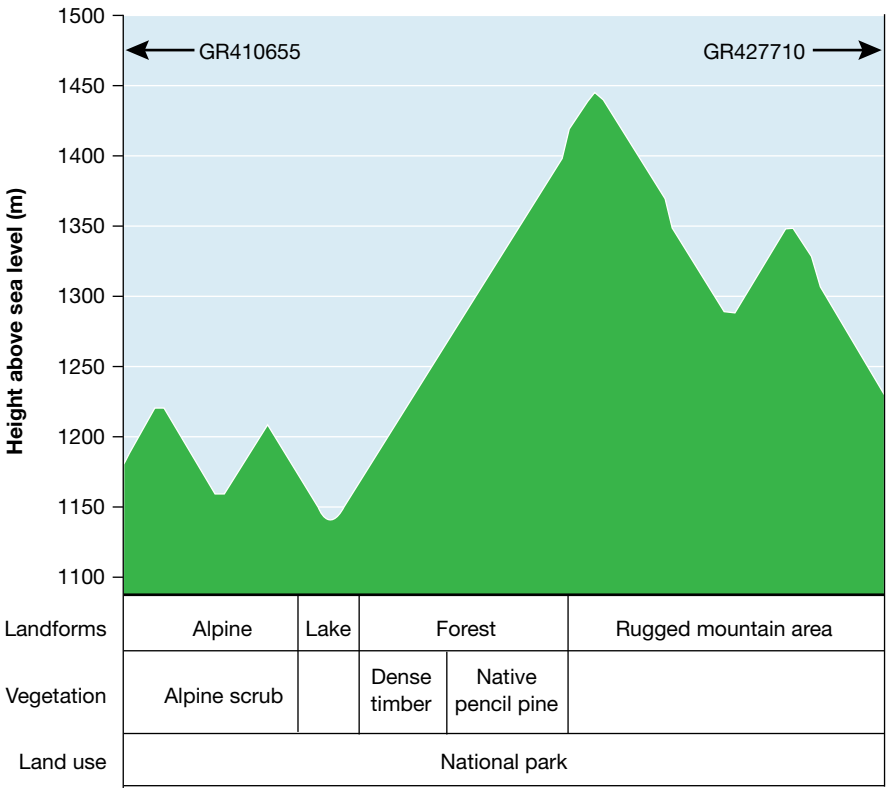
A good transect:

- is drawn in pencil
- has ruled axes
- has labelled axes
- uses small dots
- is drawn with a smooth curve
- identifies key aspects such as slope, landform, vegetation and land use
- includes a title.

A good description of a transect:

- describes the key aspects of slope, landform, vegetation and land use
- identifies interconnections between key features
- notes any anomalies.

FIGURE 1 A transect of the Walls of Jerusalem National Park, Tasmania



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Constructing and describing a transect on a topographic map
Searchlight ID: eles-1727

2.8.2 Show me

How to construct and interpret a transect

You will need:

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

Procedure:

To complete a transect, you must have a topographic map of the place you wish to examine. You then need to choose the area you would like to look at and the two points that will give you the best line through that area. Remember that you will be examining the land's shape and features. In figure 1, the two selected points are grid references 410655 and 427710.

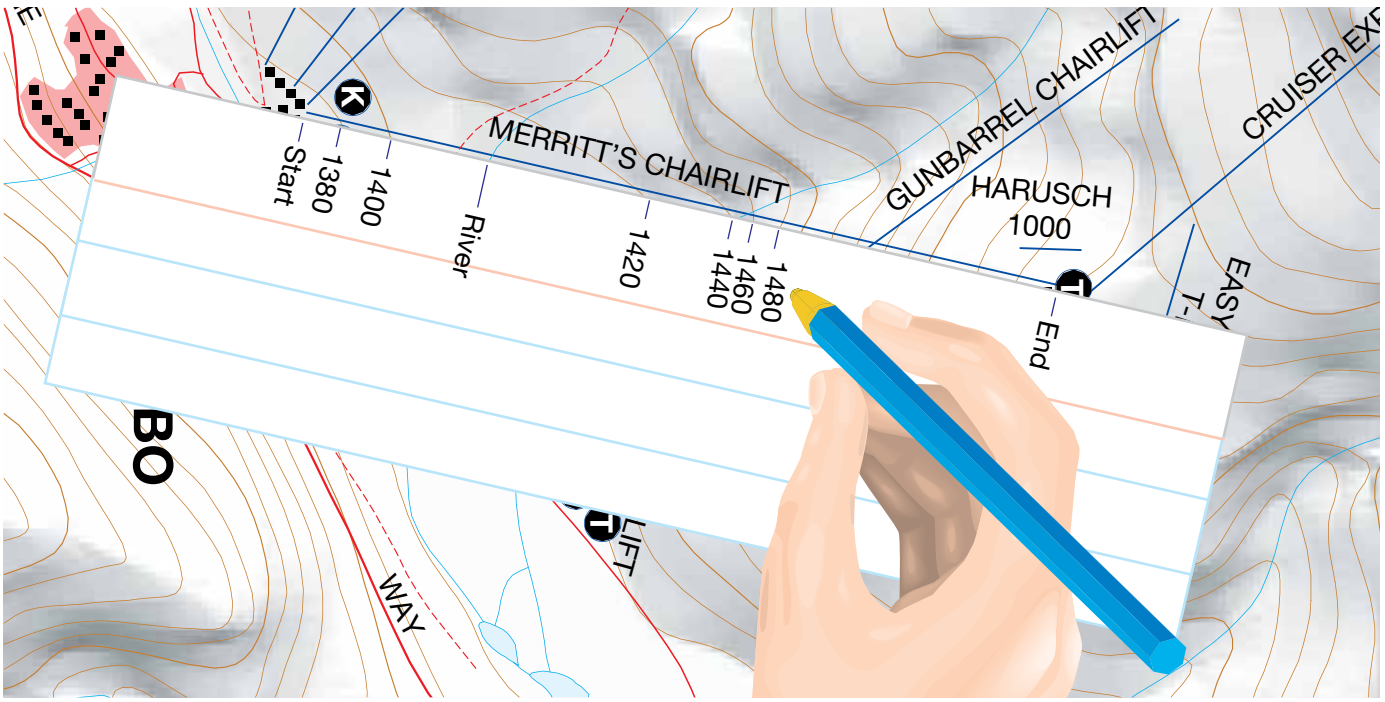
STEP 1

Place the straight edge of a piece of paper between the two points. Mark the two extremities of your transect on the edge. Label these 'Start' and 'Finish' or give them place names or grid references from the map.

STEP 2

Create a mark where each contour line touches the edge of the paper. Beside each mark, write the height of the contour line. (It's a good idea to check the contour interval on the topographic map. This will tell you how many metres the lines increase or decrease by.) It may be necessary to lift the page edge or follow the contour line to find a number. Hold your page firmly and lift the edges to prevent your page moving off the line of the transect. When you have completed all the contour markings, you can lift the page away from the map.

FIGURE 2 Marking the contour lines



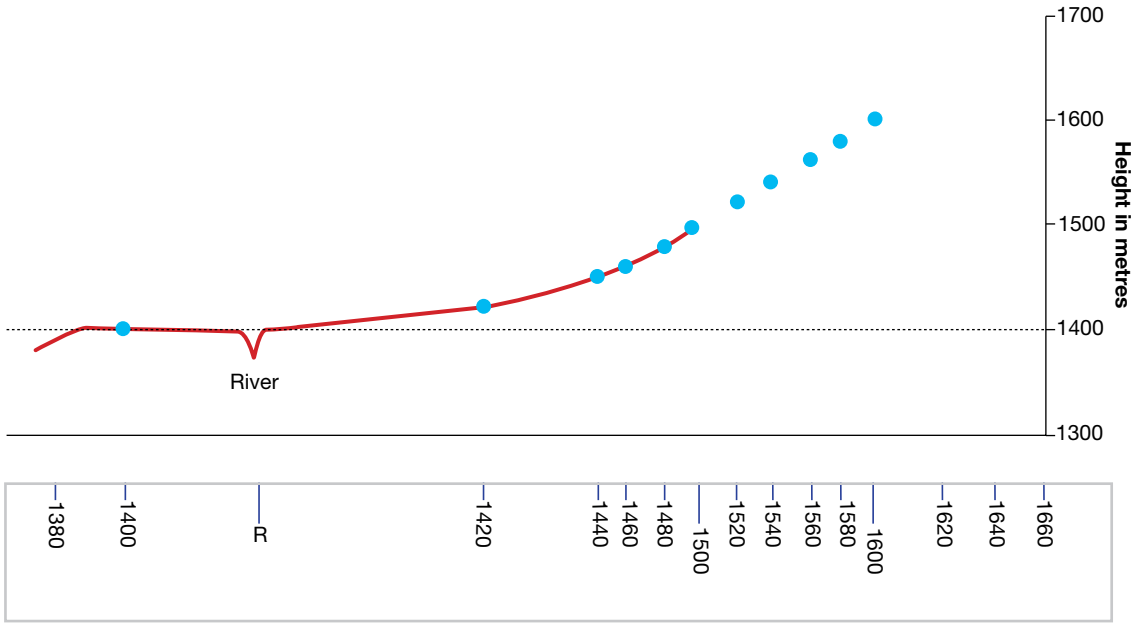
STEP 3

On the other sheet of paper, use your ruler to draw a vertical and a horizontal axis. The horizontal base line should be as long as your cross-section from start to finish. The vertical scale needs to give a realistic impression of the slopes and landforms. If you exaggerate the scale too much, you distort the shape of the land and a hilly area can appear mountainous. Although some vertical exaggeration is acceptable, try to choose a vertical scale carefully. For this exercise, use one centimetre to represent 100 metres.

STEP 4

Place the marked edge of the paper along the horizontal axis. At each contour marking, find the matching height on the vertical scale. Put a small dot directly across from that height and above the contour marked on the edge of the paper.

FIGURE 3 Drawing up the shape of the transect



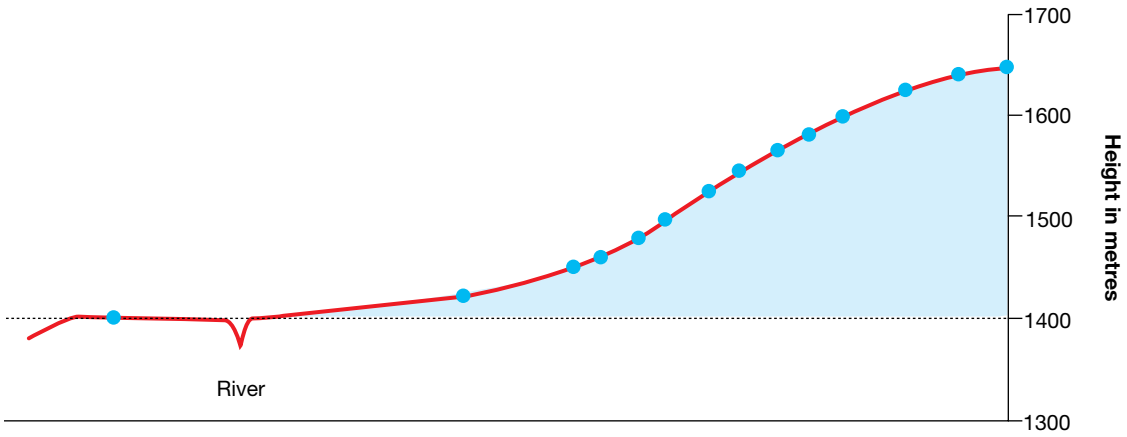
STEP 5

Join the dots with a smooth line to show the slope of the land, as shown in figure 3. Notice that a notch has been used to show a river on the cross-section, and that the river has been labelled. Think about the depth of the river, and keep the notch shallow. Other features can be marked in a similar way when preparing the cross-section.

STEP 6

Complete the cross-section with the geographical conventions of a title and labelled axes. Shade the area below the line of your cross-section.

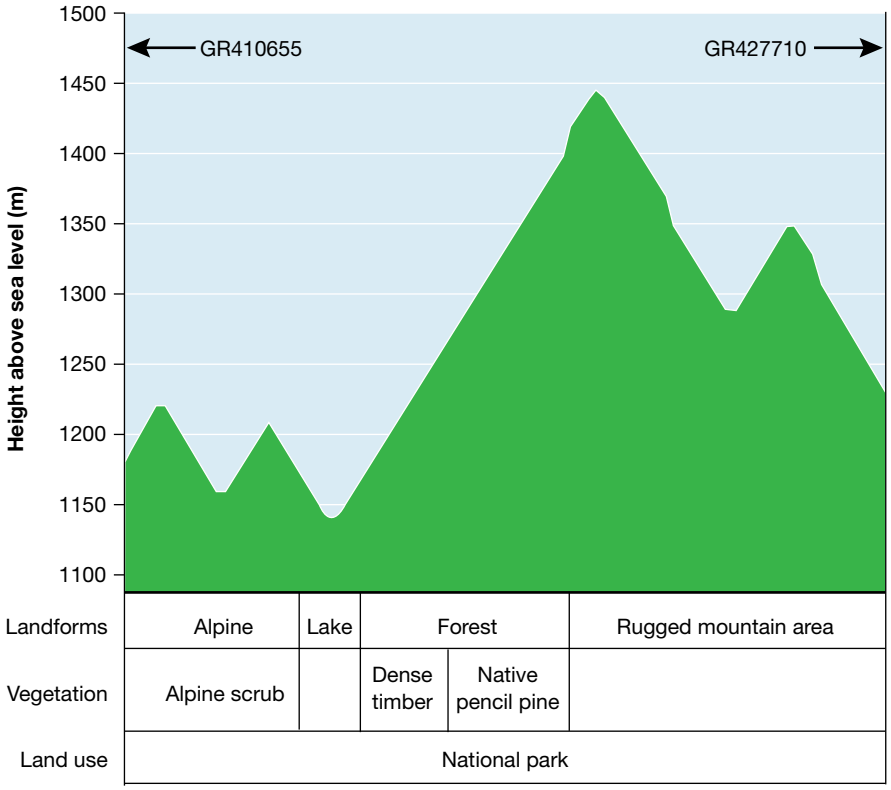
FIGURE 4 The shape of the land is completed.



STEP 7

Beneath your completed cross-section, draw a table, like that in figure 5, to indicate when a feature changes on the transect. Label each category to the left of the vertical axis, as in figure 5. Common categories used here include landforms, vegetation, land use, transport, settlement and sometimes soils, depending on what you would like to show on your transect.

FIGURE 5 A transect of the Walls of Jerusalem National Park, Tasmania



STEP 8

Complete your transect by referring back to the map to determine where a feature occurs, such as native pencil pine in figure 5. Place your paper edge back onto the topographic map to be accurate. Figure 5 shows three categories completed: landforms, vegetation and land use.

STEP 9

Check that the geographical conventions are complete on your transect: include a title and label the axes as 'Height above sea level' and 'Distance'.

STEP 10

Compare your transect with that of a classmate. Are the transects identical shapes? If not, it will be because you have chosen different scales to draw the vertical axis. Land formations can become distorted or misshapen by the choice of scale, and this is referred to as vertical exaggeration. To calculate the vertical exaggeration (VE) of your transect, find the scale bar on your map. In figure 5, the original map had a scale of 1 centimetre to 250 metres, and the transect in figure 5 had a scale of 1 centimetre to approximately 75 metres. The vertical exaggeration of 3.3 is found by dividing the horizontal scale by the vertical scale:

$$VE = 250/75$$
$$= 3.3$$

This VE is reflected in the shape of the transect, which has sharp, high peaks that are not truly representative of the real world. Ideally, vertical exaggeration should not distort the natural shape too much.

eBook*plus*

Interactivity
Constructing and describing a transect on a topographic map
Searchlight ID: int-3345

2.8.3 Let me do it

Developing my skills

Using the topographic map for Dalywoi Bay, figure 4 in subtopic 2.7 of your textbook (doc-20445 in the Resources tab), complete a transect from grid reference 017310 to grid reference 080295. Use the categories of landforms, vegetation and land use. Also calculate the vertical exaggeration of your transect.

Questions

1. List the biomes found on your transect.
2. Using the scale, mark the horizontal distance on your transect where the land is affected by water.
3. How is the vegetation interconnected with the shape of the land?
4. How does the landform affect human activities?
5. If you were to build a house on the land shown in your transect, where would you choose to build, and why?

Checklist

In drawing a transect, I have:

- drawn in pencil
- ruled the axes
- labelled the axes
- used small dots
- drawn with a smooth curve
- identified key aspects such as slope, landform, vegetation and land use
- included a title.

In describing a transect, I have:

- described the key aspects of slope, landforms, vegetation and land use
- identified interconnections between the key features
- noted any anomalies.

Skills questions

1. Transects are used to show:
   a. the height of the land at a place
   b. the shape of the land
   c. the contours of an area
   d. the land's shape and features.
2. A transect is most likely to include information about:
   a. wind
   b. history
   c. vegetation
   d. rainfall.
3. What is the purpose of including information about landforms, vegetation, land use, transport and settlement?
4. Why is it important to understand vertical exaggeration?

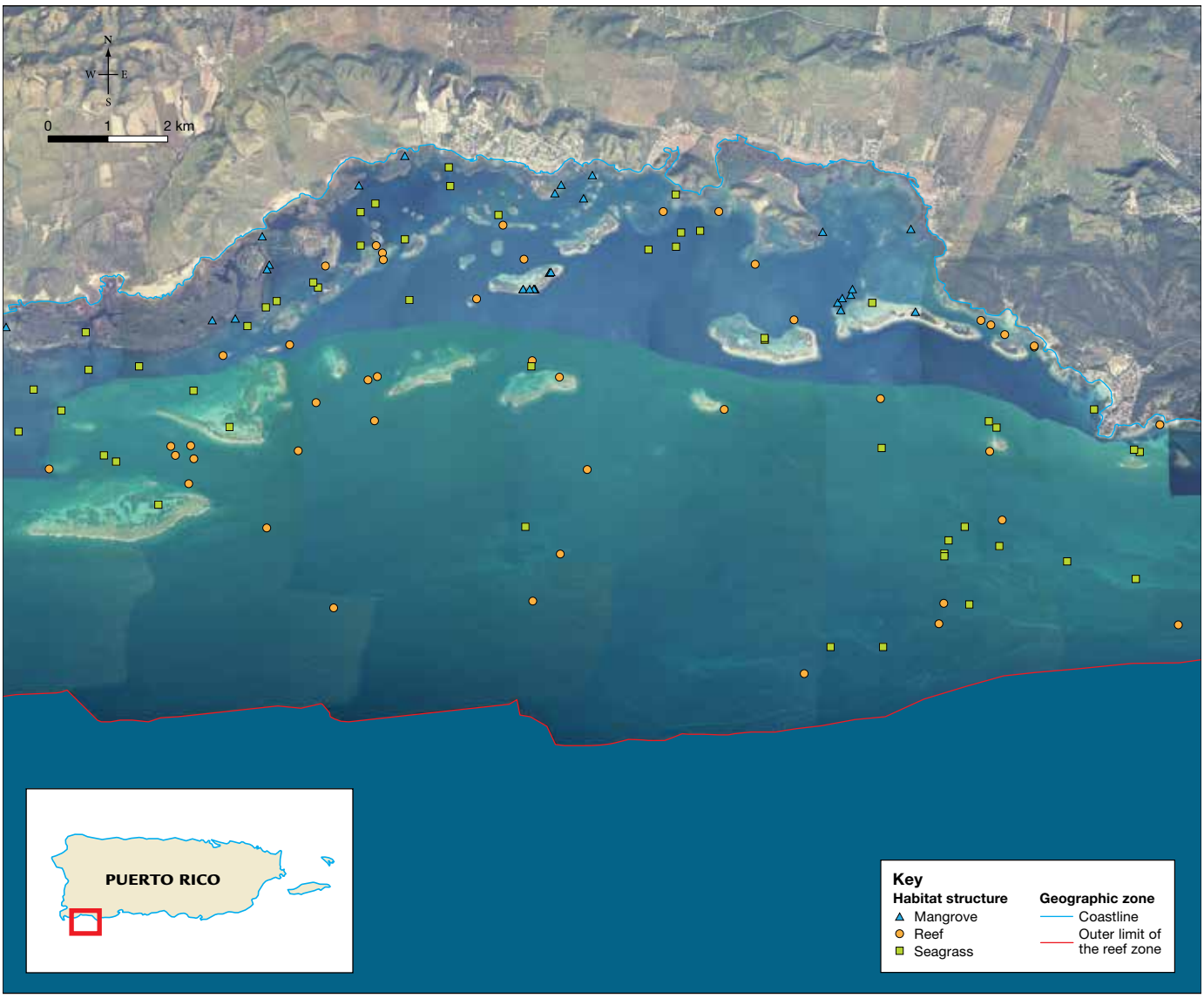
2.11 Review

2.11.1 Review

1. Identify the five major biomes and at least one characteristic that makes each biome unique.
2. In your notebook, draw a circle to represent the Earth, and then annotate it with the following information:
   a. the major lines of latitude
   b. the ***interconnection*** between latitude, climate, vegetation and soil development.
3. a. Make a sketch of the aerial photograph below. Annotate your sketch to show the following features:
   - a coral reef
   - seagrass meadows
   - tidal flats
   - mangroves.

   b. Include additional annotations to explain their function within the coastal environment.

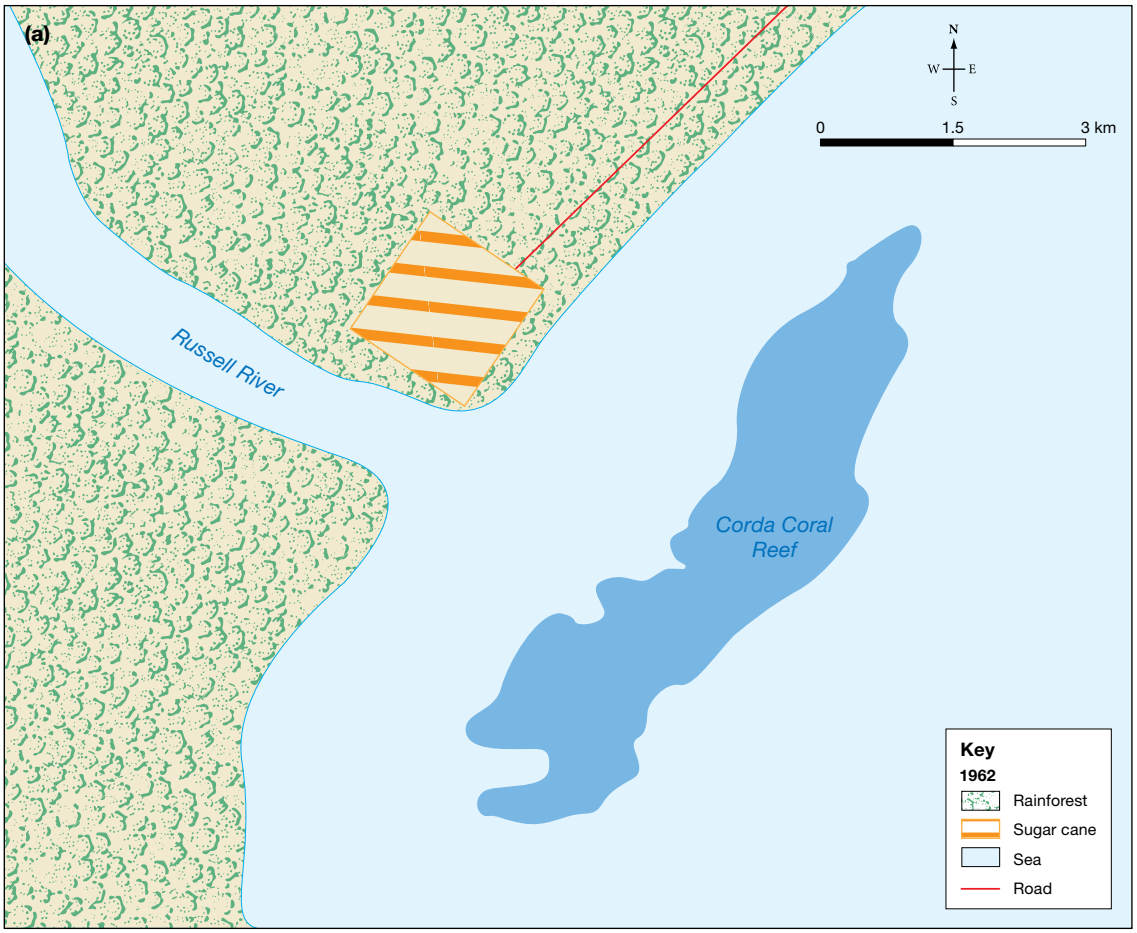
FIGURE 1 Aerial photo and map of the Bay of La Parguera, Puerto Rico



Source: Spatial Vision

4. a. Using a Venn diagram, compare the world biomes of coral reefs and coastal mangroves.
   b. Describe the ***interconnection*** between these two ***environments***.
5. Study the two maps in figure 2 and answer the following questions.
   a. What type of ***environment*** is found in this ***place***?
   b. Describe the ***changes*** that have taken place in this ***environment*** between 1962 and 2013. Include reference to the ***scale*** of this ***change*** in your response.
   c. Explain the ***interconnection*** between human activity and the decline of the coral reef ***environment*** in this ***place***.

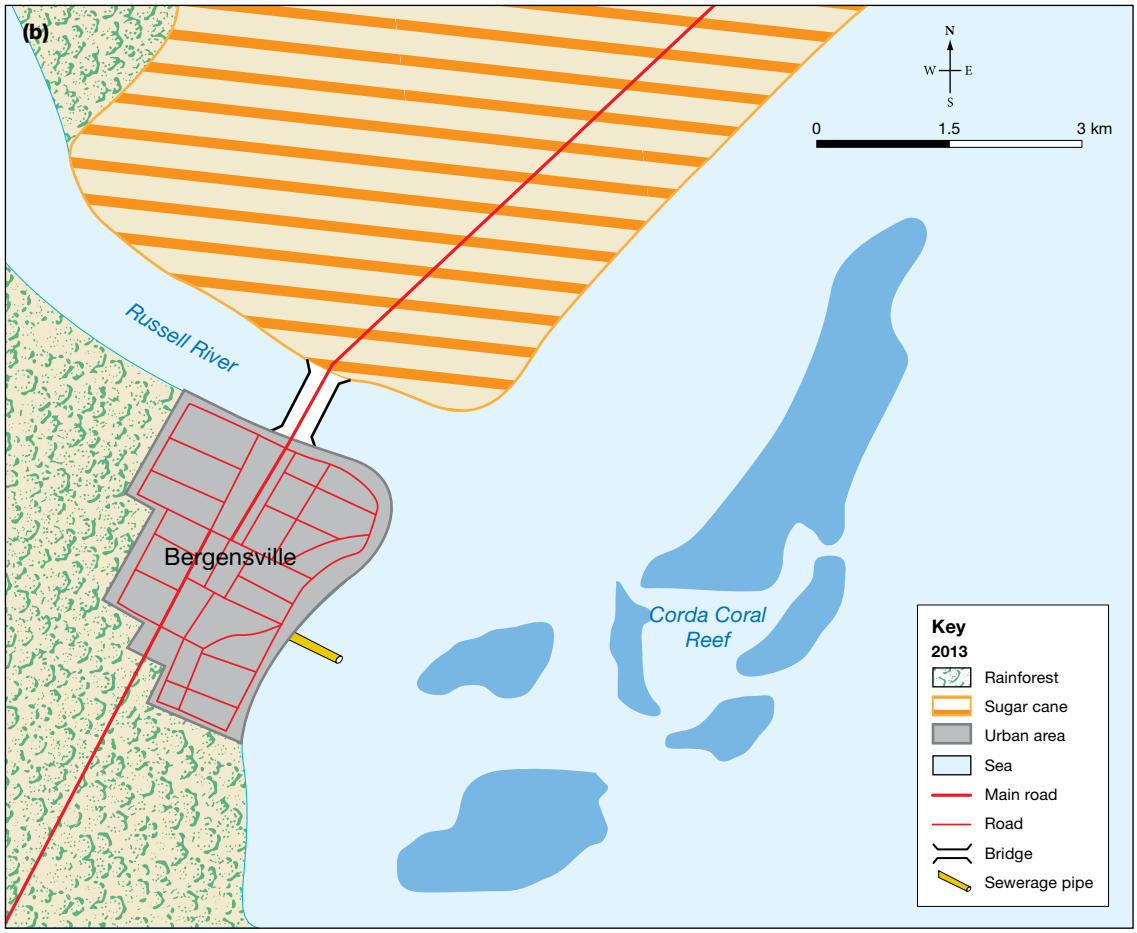
FIGURE 2(a) Map of Sursum district in 1962



Source: Spatial Vision

6. Why would Australia be described as a land of contrasts?
7. a. Explain why grasslands are important.
   b. Why are grasslands considered to be the most endangered biomes?
   c. Where would you find grasslands in Australia?
8. Use the internet to find two photographs or maps of a ***place***. The photos or maps should have been taken or created some time apart. Save your photos or maps and digitally annotate them as follows.
   a. Annotate the first to identify the key features of the ***environment***.
   b. Annotate the second to explain how the ***environment*** has ***changed*** over time.

FIGURE 2(b) Map of Sursum district in 2013



Source: Spatial Vision

2.11.2 Reflect

No soil? No worries

In the eighteenth century it was discovered that plants could be grown without soil, using a system known as hydroponics. A mineral-rich solution dissolved in water provided all that the plants needed to thrive.

In the 1930s, experiments were conducted on Wake Island — a rocky atoll devoid of soil located in the Pacific Ocean north-east of Australia, and used as a refuelling depot. Scientists proved that it was possible to grow vegetables to meet the needs of airline staff and passengers who used the island. Science fiction took the idea a step further in the 1960s, when the Robinson family, in the television series *Lost in Space*, used hydroponics to meet their needs on remote planets.

Today, a 200-square-metre greenhouse provides an average of 113 kilograms of fruit, vegetables and herbs each month — enough to sustain the 230 research workers at McMurdo Station on Ross Island through the winter months. During the summer months, however, when the community can swell to more than 1000 people, the greenhouse acts as a supplement to the fresh produce flown in from New Zealand. It is all done without

FIGURE 3 This greenhouse could be anywhere — climate is no longer a factor in plant growth.

soil, the greenhouse has no glass, and night and day are simulated by artificial lights. Lights can also be used to create the heat that is needed for plant growth, and this heat remains trapped within the greenhouse.

It is essential to ensure that any virus or bacteria found in the greenhouse do not contaminate the Antarctic environment. The whole process must be carefully monitored and, at the earliest sign of problems, the contents of the greenhouse have to be destroyed and the interior 'frozen out' — temperatures inside the greenhouse are allowed to drop so low that ice forms on all surfaces.

Experiments in hydroponics are also underway on the International Space Station, as a first step in paving the way for self-sufficient colonies on the moon — part of NASA's space exploration program.

FIGURE 4 An artist's impression of a greenhouse on the moon

1. What do you understand by the term *hydroponics*?
2. Make a list of the advantages and disadvantages of hydroponics.
3. a. Work with a partner to brainstorm as many products as you can that come from biomes. Include food, fibres and other commodities.
   b. Next to each product, suggest where you think it comes from.
   c. Identify items that you think could not be produced if we did not have a variety of biomes. Select one of these and explain why.
4. Do you think that hydroponics is a ***sustainable*** alternative for meeting our future food needs? Give reasons for your answer.
5. a. Suggest how an ***environment*** might ***change*** if a virus or bacteria that originated in a greenhouse was released into the ***environment***.
   b. What do you think the ***scale*** of this ***change*** might be? Justify your opinion.
   c. Do you think it would be possible to restore or recreate an ***environment***? Why or why not?

6. Are biomes really important? Write a letter to the editor of a newspaper expressing your views on this topic. Make sure you include evidence to support your opinion.
7. Analyse how different values and beliefs contribute to different perspectives on social issues.
8. a. Few people realise that less than 1 per cent of Australia's native grasslands survive. Why does such a significant loss of grassland biomes not attract the same attention as the loss of other biomes such as our tropical rainforest and coral reefs?
   b. How would the following groups of people perceive the value of grassland biomes?
      - graziers (sheep and cattle farmers)
      - city dwellers
      - environmentalists
9. *Biosphere 2 is just like a theme park for scientists: an expensive research facility that does little to protect world biomes*.
   a. Follow these steps:
      - In small groups, choose a leader who will report back to the rest of the class and a scribe who is responsible for taking notes.
      - In your group, discuss the quote and come to a decision on your group's viewpoint.
      - Each leader will present the viewpoint to the class.
   b. Evaluate:
      - your own contribution to the group discussion
      - others' contribution to the group discussion and provide them with feedback
      - the role of the leader and their presentation to the class.

Farmers planting rice in paddy fields near Chiangmai, Thailand

CHAPTER 3

Biomes produce food

3.1 Overview

3.1.1 Introduction

Food dominates every person's life. For many people, what to have for breakfast, lunch and dinner can be a constant thought and sometimes a worry. Food is an essential need for every human as it provides the essential nutrients for the body to sustain and maintain a healthy life. Biomes are key to producing the world's food.

Starter questions

1 Why do you think people around the world eat different kinds of food?
2 Do you think there is enough food in the world for everybody? Why? How do you know?
3 a Is there enough space for your family to grow fruit and vegetables in your home garden, if you had to?
b Does your family have a garden and, if so, does your family grow its own food?
c Conduct a class discussion to establish to what extent people in your class grow food at home.

Inquiry sequence

		Syllabus outcomes
3.1 Overview		
3.2 How can we feed the world?		GE5-3
3.3 What does the world eat?		GE5-3
3.4 SkillBuilder: Constructing ternary graphs	eBook plus ONLINE ONLY	GE5-3, GE5-7
3.5 How does traditional agriculture produce food?		GE5-3, GE5-5
3.6 How have we increased our food?		GE5-2, GE5-3
3.7 How is food produced in Australia?		GE5-2, GE5-3
3.8 Investigating topographic maps: What is a farming area like in Riverina?		GE5-2, GE5-3
3.9 SkillBuilder: Describing patterns and correlations on a topographic map	eBook plus ONLINE ONLY	GE5-3, GE5-7
3.10 Why is rice an important food crop?		GE5-2, GE5-3
3.11 Why is cacao a special food crop?	eBook plus ONLINE ONLY	GE5-2, GE5-3
3.12 Daly River: a sustainable ecosystem?	eBook plus ONLINE ONLY	GE5-2, GE5-3
3.13 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Watch this video
A plate full of biomes
Searchlight ID: eles-1718

3.2 How can we feed the world?

3.2.1 Food production

During the nineteenth century, Thomas Malthus was concerned that the population was growing faster than they could produce food, so he predicted a catastrophe. However, technological advances and the **Green Revolution** allowed humans to produce more food on a larger scale through **monoculture** to feed the growing population. With the Earth's population projected to rise to nine billion people by 2050, what needs to be done to sustainably ensure there is enough food for everyone?

Green Revolution a significant increase in agricultural productivity resulting from the introduction of high-yield varieties of grains, the use of pesticides and improved management

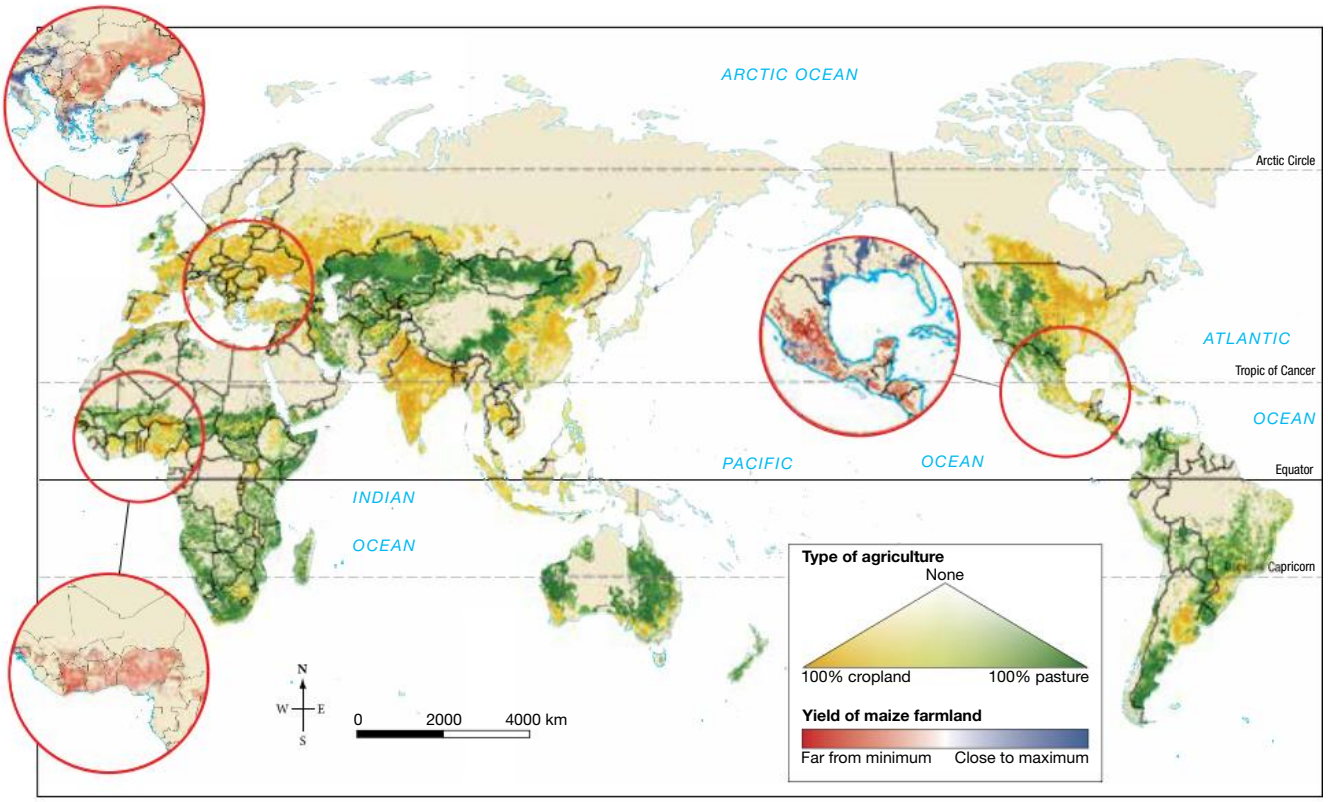
monoculture the cultivation of a single crop on a farm or in a region or country

3.2.2 What are the spatial issues with our food?

The map in figure 1 shows the space that is used for agriculture around the world. With continued population growth, the availability of arable land is of a concern. For instance, there is currently about one-sixth of a hectare of **arable** land per capita in East and South Asia. The population of these regions is expected to experience rapid growth, but very little additional land is available for agricultural expansion. Consequently, arable land per capita will continue to decline in these areas with a potential food crisis.

arable describes land that is suitable for growing crops

FIGURE 1 World distribution of cropland, pasture and maize. More maize, for example, could be grown if improvements were made to seeds, irrigation, fertiliser and markets.



Source: Spatial Vision

3.2.3 Food production increases

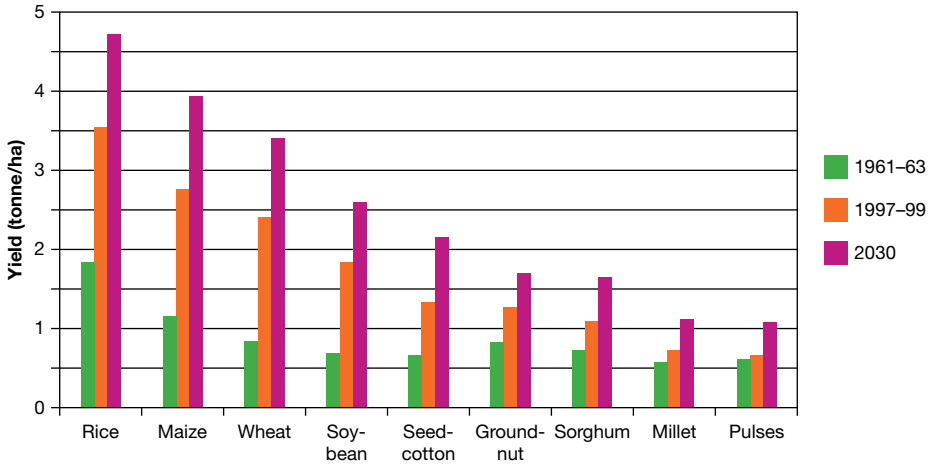
Agricultural **yields** vary widely around the world owing to climate, management practices and the types of crops grown. Globally, 15 million square kilometres of land are used for growing crops—altogether, that's about the size of South America. Approximately 32 million square kilometres of land around the world are used for pasture—an area about the size of Africa. Across the Earth, most land that is suitable for agriculture is already used for that purpose and, in the last 50 years, we have increased our food production.

yield amount of agriculture produced or provided

Current **FAO** projections suggest that cereal demand will increase by almost 50 per cent by 2050 (see figure 2). To meet this demand, either current land will need to increase yields per unit of area, croplands will need to expand by replacing natural habitats, or farmers will need to grow crops more efficiently.

The recent increase in food production has been a result of **innovations** in agriculture. Crop yields have been boosted through advanced seed genetics; agronomy practices (scientific production of food plants), and product innovations that help farmers maximize productivity and quality. In this way, the nutritional content of crops can be increased (see figure 3).

FIGURE 2 Crop yields in developing countries, 1961 to 2030



We could do more

It should be possible to get more food out of the land we are already using. Figure 1 shows the places where maize yields could increase and become more **sustainable** by improving nutrient and water management, seed types and markets.

FIGURE 3 Farmers in a village in Kenya examine information on plant diseases using a laptop at a plant health clinic. They can also consult a plant pathologist and show them samples of their crops.

FAO Food and Agricultural Organization of the United Nations

innovation new and original improvement to something, such as a piece of technology or a variety of plant or seed

sustainable describes the use by people of the Earth's environmental resources at a rate such that the capacity for renewal is ensured

ACTIVITIES

IDENTIFY

1 Why is population an issue for global food production?
2 Outline why there are concerns for food production in East and South Asia.

EXPLAIN

3 Explain how the increasing demand for cereals can be met.
4 Explain the impact on the ***environment*** if agricultural lands were to increase.

INVESTIGATE

5 Research Thomas Malthus and outline his food concerns in the nineteenth century. Are those concerns relevant for the twenty-first century?
6 Figure 1 shows where more crops could be grown. Investigate how Mexico or a country in West Africa or Eastern Europe could improve the ***sustainability*** of their agriculture.

PREDICT

7 With reference to specific ***places***, suggest how increasing population densities might influence future crop production.
8 Figure 1 refers to the potential increase in maize crop yields. Suggest how this could be of benefit to a future world population.

APPLY

9 Should countries in the developed world be supporting those who struggle to produce their own food?
10 Would food production be secure if we grew fewer crops better?
11 Use the **Feed the World** weblink in your eBookPLUS to watch the interactive maps. Describe how the challenge of meeting the needs of a growing and increasingly affluent population can be met.

eBookplus

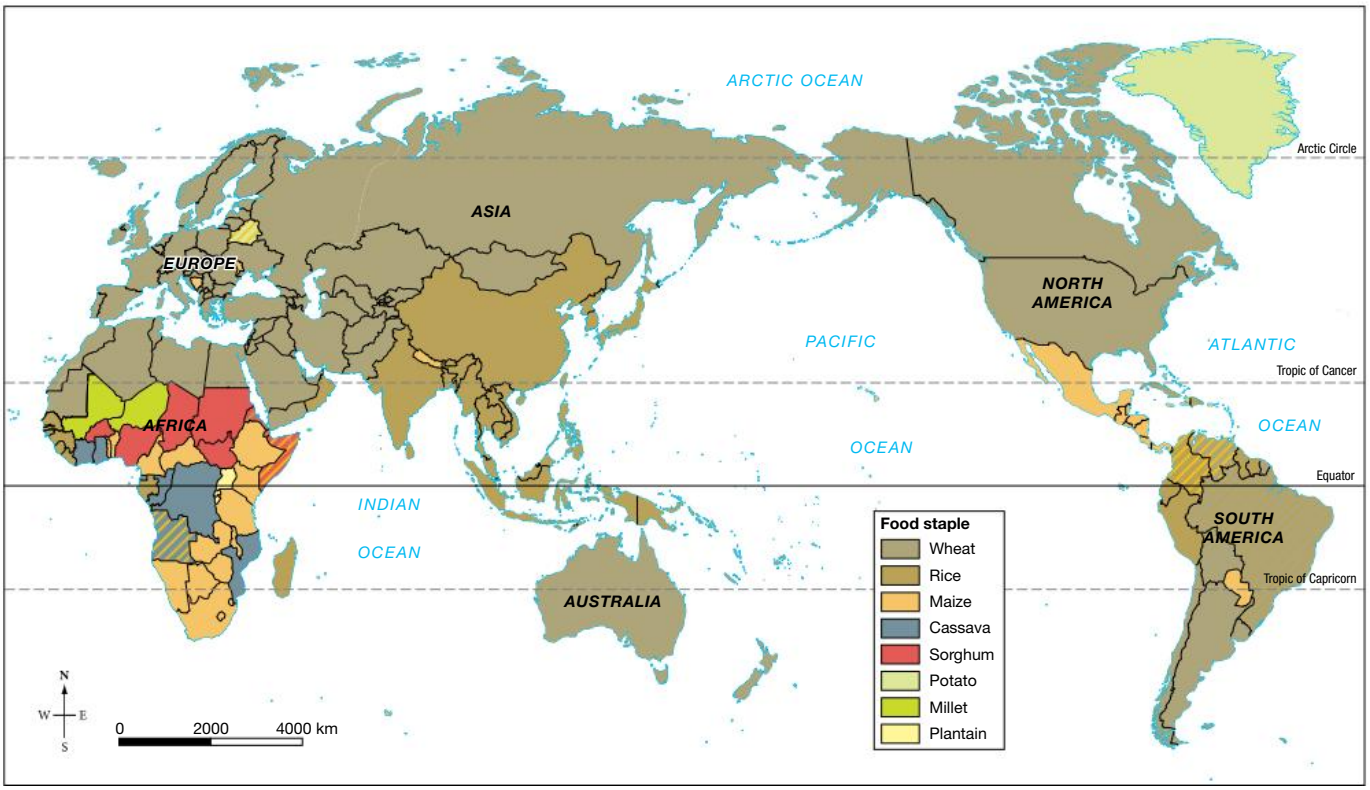
Weblink
Feed the World

3.3 What does the world eat?

3.3.1 The major food staples

Staple foods are those that are eaten regularly and in such quantities that they constitute a dominant portion of a diet. They form part of the normal, everyday meals of the people living in a particular place or country. They are called staples because they are easy to access and are grown or produced locally.

FIGURE 1 Staple foods around the world



Source: Spatial Vision

The world has over 50 000 **edible** plants. **Staple** foods vary from place to place, but are typically inexpensive or readily available. The staple food of an area is normally interconnected to the climate of that area and the type of land.

Most staple foods are cereals, such as wheat, barley, rye, oats, maize and rice, or root vegetables, such as potatoes, yams, taro and cassava. Maize, rice and wheat provide 60 per cent of the world's food energy intake; four billion people rely on them as their staple food.

Other staple foods include legumes, such as soya beans and sago; fruits, such as breadfruit and plantains (a type of banana); and fish.

edible fit to be eaten as food; eatable

staple an important food product or item that people eat or use regularly

Wheat, maize and fish

Wheat is a cereal grain that is cultivated across the world. In 2014, world production of wheat was 729 million tonnes, making it the third most produced cereal with maize being the most produced (1.02 billion tonnes) and rice the second most produced cereal (741 million tonnes). As a main food crop for human consumption, wheat is second to rice in terms of total production tonnage; maize is more extensively used as an animal feed.

Wheat was one of the first crops to be easily cultivated on a large scale, and had the added advantage of yielding a harvest that could be stored for a long time. Wheat covers more land area than any other commercial crop (figure 1), and is the most important staple food for humans (figure 2).

Maize, or corn (figure 3), was originally from the Americas. In the late fifteenth and early sixteenth centuries, explorers and traders brought maize back to Europe and introduced it to other countries. It then spread to the rest of the world, as it was a robust crop with the ability to grow in different environments. Sugar-rich varieties called sweet corn are usually grown for human consumption, while field corn varieties are used for animal feed and **biofuel**. The America's accounted for 51.5 per cent of the world's maize production in 2014, with 361 million metric tonnes grown annually in the United States alone (see table 1).

FIGURE 2 Wheat is used in a wide variety of foods such as breads, biscuits, cakes, breakfast cereals and pasta.

biofuel fuel that has been produced from renewable resources, such as plants and vegetable oils, and treated municipal and industrial wastes

TABLE 1 Top 10 maize producers 2014

Country	Production (tonnes)
United States	361 091 140
China	215 646 300
Brazil	79 877 714
Argentina	33 000 000
Ukraine	28 496 810
India	23 670 000
Mexico	23 273 257
Indonesia	19 008 426
South Africa	14 982 000
Romania	11 988 553
World	1 021 616 584
Australia	390 000

Source: Food and Agriculture Organization of the United Nations, 2014 FAOSTAT, http://faostat3.fao.org/home/index.html

FIGURE 3 Maize, or corn, originated in the Americas and is used as food for humans and animals and as biofuel.

Fish is a staple food in some societies. The oceans provide an irreplaceable, renewable source of food and nutrition essential to good health. According to the United Nations Food and Agriculture

FIGURE 4 Fish haul, Goa

Organization, about 75 per cent of fish caught is used for human consumption. The remainder is converted into fishmeal and oil, used mainly for animal feed and farmed fish (figure 4).

In general, people in developing countries, especially those in coastal areas, are much more dependent on fish as a staple food than those in the developed world. About one billion people rely on fish as their primary source of animal protein.

Use the **United Nations Food and Agriculture Organization** (UN FAO) weblink in your eBookPLUS to find out what is being done to promote sustainable aquatic biomes.

ACTIVITIES

IDENTIFY

1 List the main staple foods of the world and the ***places*** (continents) where they are grown.
2 What is biofuel?

EXPLAIN

3 Explain why plants, rather than animals, dominate as the major staple foods of the world.
4 Australia is a major exporter of wheat. Explain why Australia is able to produce such a surplus.

PREDICT

5 With the increase in world population and greater pressure on fish stocks, what could be done to sustain fish stocks in oceans and lakes?
6 Maize is currently used as a feed for animals, as biofuel and as food for humans. Why might this be an ***unsustainable environmental*** practice in future?

APPLY

7 Although fish may be seen as a staple food for many people, why is it not possible for fish to be a staple food for everyone?
8 Referring to table 1, why do you think countries other than those in the Americas are producing large quantities of maize?

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Weblink
United Nations Food and Agriculture Organization

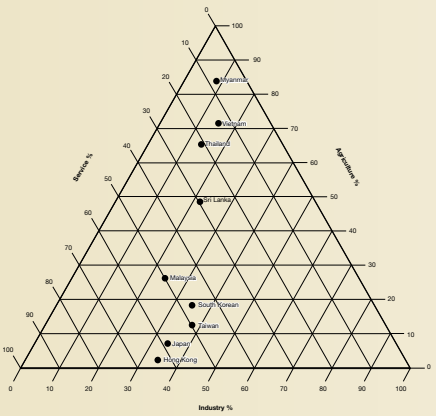
myWorldAtlas Deepen your understanding of this topic with related case studies and questions.
- Rice
- Wheat

eBookplus ONLINE ONLY

3.4 SkillBuilder: Constructing ternary graphs

What are ternary graphs?

Ternary graphs are triangular graphs that show the relationship or interconnection between three features. They are particularly useful when a feature has three components, and the three components add up to 100 per cent. Ternary graphs are most often used to show soil types, employment structures and age structures.



eLesson
Watch this video to learn how to construct a ternary graph.

Searchlight ID: eles-1728

Interactivity
Try this interactivity to learn how to construct a ternary graph.

Searchlight ID: int-3346

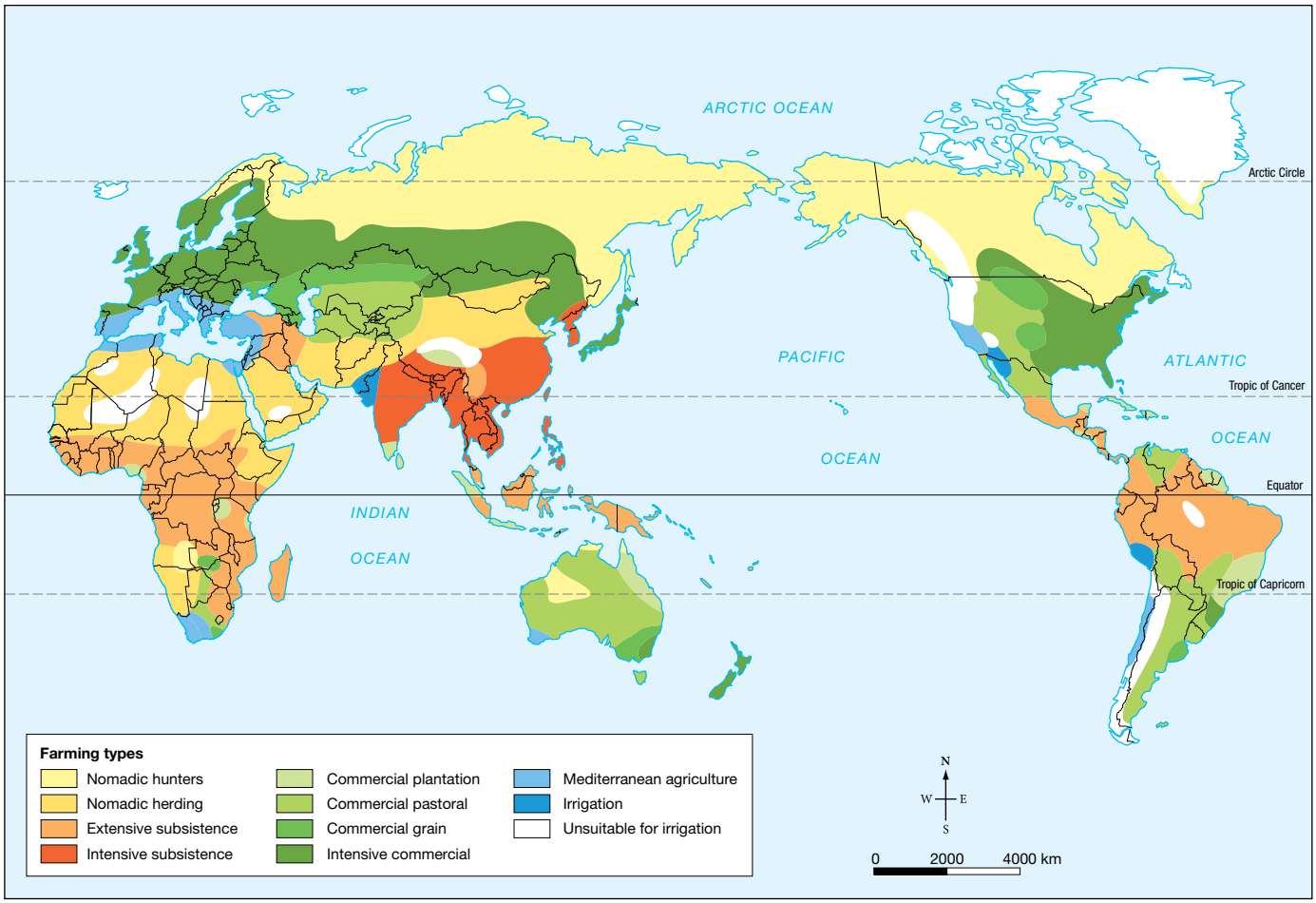
3.5 How does traditional agriculture produce food?

3.5.1 Agriculture

In the more developed countries of the world, large-scale agriculture provides the food for the supermarkets to feed their populations. However, for many people in developing nations, the food produced on their large farms is exported to wealthy nations. To feed themselves they rely on **subsistence** agriculture and local markets to buy and/or exchange food. As seen in figure 1, subsistence-farming practices predominantly occur in and around the tropics.

subsistence describes farming that provides food only for the needs of the farmer's family, leaving little or none to sell

FIGURE 1 World agricultural practices and food production



Source: FAO.

3.5.2 Hunters and gatherers: the San

Today, around 55 500 San (or Kalahari Bushmen) live in the Kalahari Desert in southern Africa. Less than five per cent still live in the traditional way (figure 2).

Traditionally **nomadic** San people travel in small family groups, roaming over regions of up to 1000 square kilometres. They have no pack animals, and carry few possessions — only spears, bows and arrows, bowls and water bags. The Bushmen's clothes are made from animal skins. When needed, they construct dome-shaped shelters of sticks that are thatched with grass.

The San are experts at finding water and tracking animals. The men hunt antelope and wildebeest, while the women hunt small game such as lizards, frogs and tortoises, and gather roots, berries and grubs. When the waterholes are full, empty ostrich shells are filled with water, and buried in the sand for times of drought.

nomadic describes a group of people who have no fixed home and move from place to place according to the seasons, in search of food, water and grazing land

shifting agriculture system in which small parcels of land are used to produce food for a period and abandoned when they become less productive so they can recover naturally, while the farmers move to another plot of land

3.5.3 Nomadic herders: the Bedouin

Bedouins are nomads who live mainly in Syria, Iraq, Jordan, the countries of the Arabian Peninsula, and the Sahara. Some groups are camel herders who live in the inner desert regions. Others herd sheep and goats on the desert fringes, where more water is available. Unless Bedouin tribes find a good piece of grazing land, they rarely stay in one place longer than a week (figure 3).

Bedouin camel-herding families can survive on as few as 15 camels. The camels provide not only transportation but also milk—the main staple of the Bedouin diet. Camel meat is sometimes eaten, and dried camel dung is used as fuel. Camel hair is collected and woven into rugs and tent cloth.

FIGURE 2 A San tribesman

3.5.4 Shifting agriculture: the Huli

The Huli people live in the rainforests of the Papua New Guinea highlands (figure 4). Many still lead a traditional way of life. The land on which they live has steep hillsides and dense rainforest.

The Huli people use a farming system known as **shifting agriculture**. The Huli clear a patch of rainforest and plant crops of sweet potato, sugar cane, corn, taro and green vegetables. When the soil of the garden no longer produces good crops, a new patch of rainforest is cleared, leaving the old one to recover naturally. Huli's individual huts are built next to the gardens and it is the women's responsibility to tend them. The garden crops are supplemented by food that the men have hunted (figure 5). Wild and domesticated pigs are a common source of meat.

FIGURE 3 A Bedouin camp in Saudi Arabia

FIGURE 4 Map showing Huli land, Papua New Guinea

Source: MAPgraphics Pty Ltd, Brisbane

FIGURE 5 Huli tribesman, Papua New Guinea

ACTIVITIES

IDENTIFY

1 What is subsistence agriculture?
2 Name and describe the three types of traditional agriculture production.

EXPLAIN

3 Explain why many people in developing nations need to turn to subsistence agriculture.
4 Explain the shifting agriculture farming system used by the Huli.

INVESTIGATE

5 Refer to figure 1 in subtopic 3.2 and identify the staple food that the San and Huli have in their respective regions. Research if farms in these regions are exporting their food.
6 Name one impact on people and one impact on the natural ***environment*** if rainforests in the world were to ***change*** by deforestation.

PREDICT

7 How might modern technology affect the Huli people in the next 25 years with respect to their traditions and food production practices?
8 What ***changes*** may occur to the way of life of nomadic herders in the future?

APPLY

9 In what ways are traditional agricultural practices considered more ***sustainable*** than modern practices?
10 Referring to figure 1, explain why food production is concentrated in the ***places*** and ***spaces*** bordering the tropical zones.

FOCUS ON FIELDWORK

Soil testing: measuring pH and soil texture

As seen in subtopic 2.3, soil is an important component within biomes. Soil is critical in the growing of plants and as such, determining its texture and its ability to hold nutrients helps humans grow crops more effectively.

Measuring soil pH

Determining a soil's pH identifies how acidic or alkaline it is using a scale from 1 to 14; a pH of 7 is neutral, less than 7 is acid and greater than 7 is alkaline. Excessive pH can interfere with how plants can absorb nutrients therefore affecting growth. The most effective way to test soil pH in the field is by using a soil testing kit (figure 6).

Measuring soil texture

1 Fill a clear jar with a quarter soil and three quarters of water and place a teaspoon of dishwasher powder inside.
2 Place the lid on and tighten then shake the jar to loosen the particles. Store jar until soil particles settle (usually overnight, see figure 7).
3 Once the particles have settled, measure the total height of all the layers. Then measure the height of each layer. Sand, the heaviest and largest particles, will be the bottom layer, silt the second and clay the top layer (figure 8). Calculate what the percentage of each layer is to the total you measured earlier.
4 Refer to the soil ternary graph (figure 9) to determine soil type. (Refer to SkillBuilder 3.4 'Constructing ternary graphs' in your eBookPLUS to help read ternary graphs).

FIGURE 6 A pH soil testing kit from a local garden supplier

FIGURE 7 Leaving soil to settle to see the layers of sand, silt and clay that form

FIGURE 8 Measuring soil texture

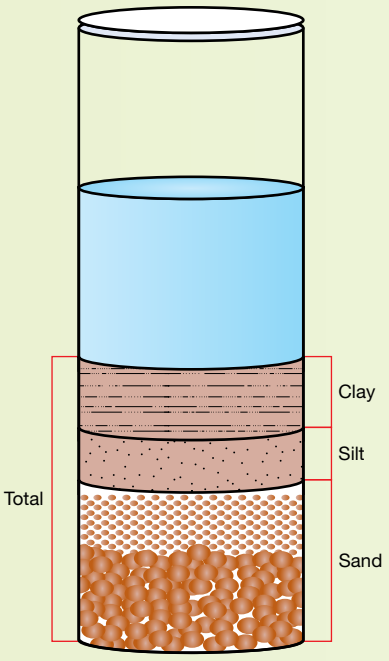
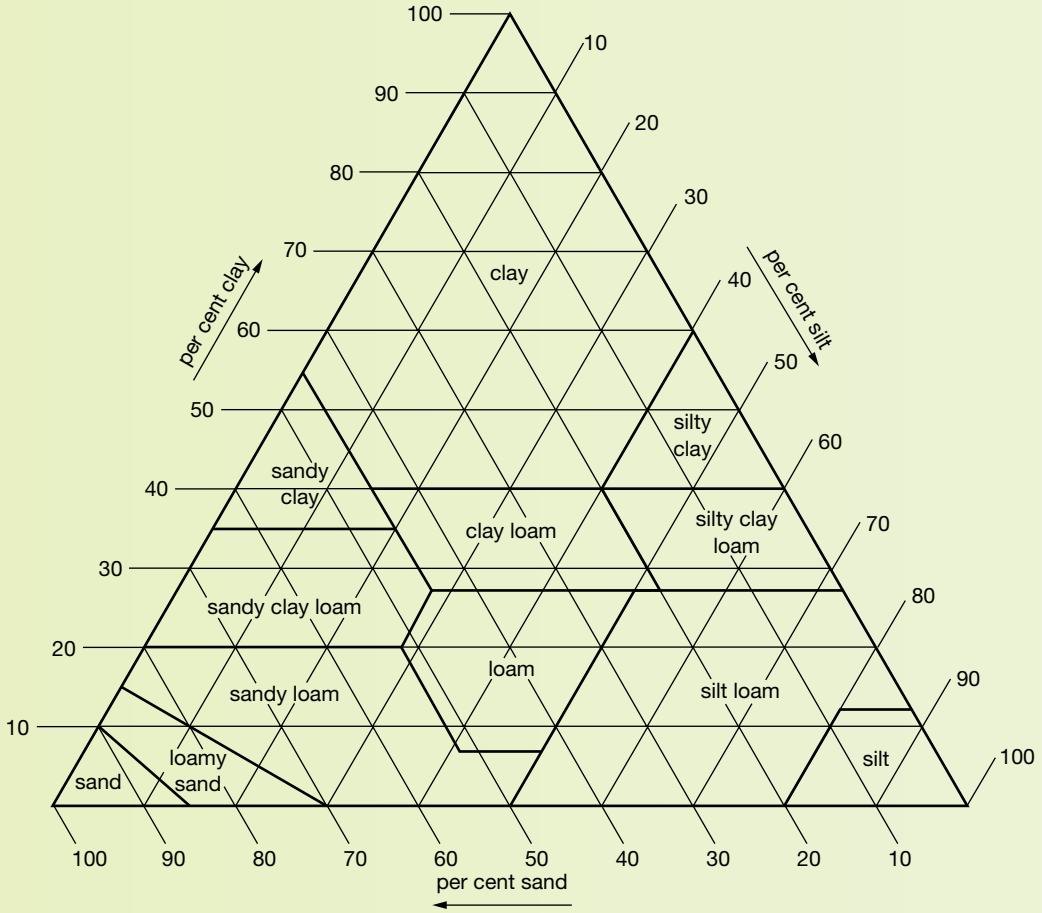


FIGURE 9 Soil classification ternary graph



Fieldwork

1. Collect soil samples from various locations around your school. Mark these locations on a map of your school.
2. Create a table with the headings: Site, pH, and soil type.
   - **a** Determine the pH of each soil sample for each site.
   - **b** Determine the soil type of each sample.
3. Using the information collected and other geographical factors, determine which site would be most suitable for a vegetable garden.

3.6 How have we increased our food?

3.6.1 How did this food increase come about?

World food production has grown substantially in the last century. Increased fertiliser application and more water usage through irrigation have been responsible for over 70 per cent of crop yield increases. The Second Agricultural Revolution in developed countries after World War II, and the Green Revolution in developing countries in the mid 1960s, transformed agricultural practices and raised crop yields dramatically.

per capita
per person (literally 'by head')

Since the 1960s agriculture has been more productive, with world **per capita** agricultural production increasing by 25 per cent in response to a doubling of the world population.

3.6.2 Environmental factors

In the past, growth in food production resulted mainly from increased crop yields per unit of land and to a lesser extent from expansion of cropland. From the early 1960s, total world cropland increased by

only nine per cent, but total agricultural production grew nearly 60 per cent. Increases in yields of crops, such as sweet potatoes and cereals, were brought about by a combination of:

- increased agricultural inputs
- more intensive use of land
- the spread of improved crop varieties.

Figure 1 shows how the increased use of fertilisers, irrigation and pesticides has contributed to improved crop yields.

In some places, such as parts of Africa and South-East Asia, increases in fisheries (areas where boats catch fish) and expansion of cropland areas were the main reasons for the increase in food supply. In addition, cattle herds became larger. In many regions—such as in the savanna grasslands of Africa, the Andes, and the mountains of Central Asia—livestock is a primary factor in food security today.

hybrid plant or animal bred from two or more different species, sub-species, breeds or varieties, usually to attain the best features of the different stocks

3.6.3 Trade factors and economic factors

From the 1960s onward, there has been significant growth of the world trade in food and agriculture. Food imports to developing countries have grown, together with imports of fertilisers, thus reducing the likelihood of developing countries suffering from famine.

3.6.4 What was the Green Revolution?

The Green Revolution was a result of the development and planting of new **hybrids** of rice and wheat, which saw greatly increased yields. There have been a number of green revolutions since the 1950s, including those in:

- the United States, Europe and Australia in the 1950s and 1960s
- New Zealand, Mexico and many Asian countries in the late 1960s, 1970s and 1980s.

With its high-yield varieties of cereals, chemical fertilisers and pesticides, and irrigation, the Green Revolution has had a very positive effect on global food production.

What happened?

The Green Revolution saw a rapid increase in the output of cereal crops—the main source of calories in developing countries. Farmers in Asia and Latin America widely

FIGURE 1 Global trends in fertilisers, irrigated land and pesticides

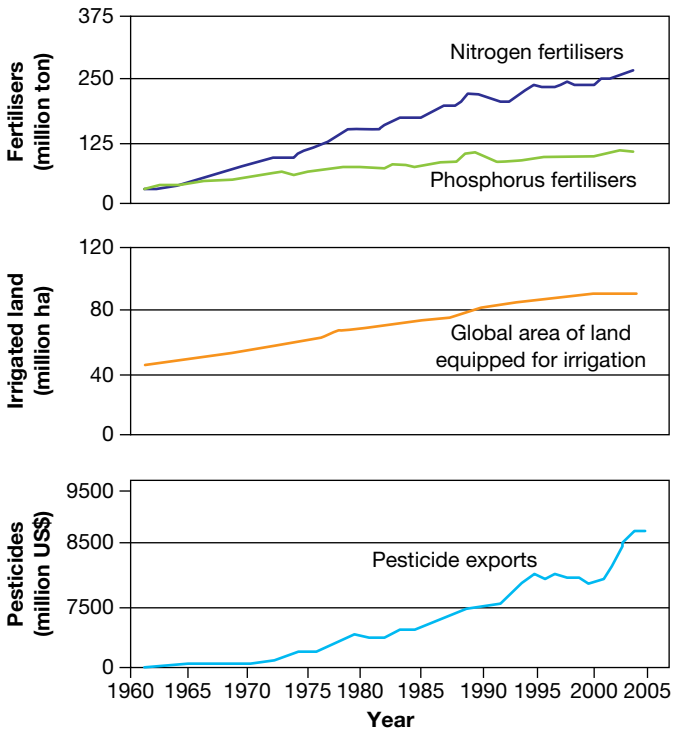


FIGURE 2 Share of crop production increases 1961–99

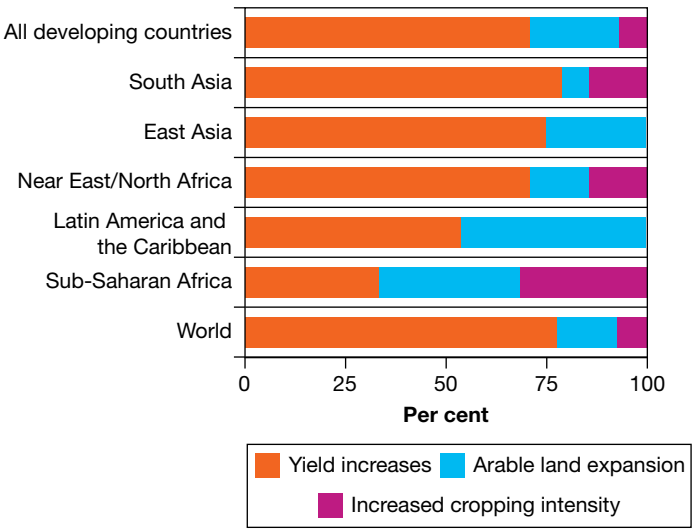


FIGURE 3 Spreading fertiliser in the Punjab, India, during the Green Revolution

adopted high-yielding varieties. Governments, especially in Asia, introduced policies that supported agricultural development. In the 2000s, cereal harvests in developing countries were triple those of 40 years earlier, while the population was a little over twice as large. Yield gains accounted for much of the increase in cereal output and calorie availability. Planting of these varieties coincided with expanded irrigation areas and fertiliser use, as seen in figure 3, where fertiliser is being spread in the Punjab.

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Interactivity
Growing more!
Use this interactivity to further your understanding of how the world has been able to produce more food.
Searchlight ID: int-3320

ACTIVITIES

IDENTIFY
1 In the past, what were the two reasons for the increase in food production?
2 Refer to figure 1. Describe the trends in the use of fertilisers and irrigated land from 1965–2000.

EXPLAIN
3 Explain the significance of trade in food production.
4 Discuss the three reasons for improved crop production.

INVESTIGATE
5 Research the background of the Green Revolution — why it occurred and the key ***places*** involved.
6 Investigate the ***changes*** that came about as a result of the Green Revolution.

PREDICT
7 Some scientists are suggesting that there will be a new Green Revolution. Investigate current thinking and predict the potential ***scale*** of this possible agricultural ***change***.

APPLY
8 Were the ***changes*** brought about during the Green Revolution successful? When explaining your decision, refer to the Punjab and other ***places***.

3.7 How is food produced in Australia?

3.7.1 Farming in Australia

Modern farming in Australia is mainly **commercial** and produces food for local consumption and exports for global markets. Australian farms may produce single crops (monoculture), such as sugar cane, or they may be mixed farms that produce cereal and graze sheep. Many Australian farms have an **agribusiness** approach, are often run by large corporations and use sophisticated technology to help produce higher yields.

commercial
an activity that is concerned with buying and/or selling of goods or services

agribusiness
business set up to support, process and distribute agricultural products

Why are farms found in certain locations?

There is a wide range of types of agriculture in Australia, as shown in figure 1. These types occupy spaces across all biomes found in Australia, from the tropics to the temperate zones.

The location of farms in Australia shows that there is a change in the pattern of farming types, from the well-watered urban coastal regions towards the arid interior. Because much of Australia's inland rainfall is less than 250 millimetres, farm types in these places are limited to open-range cattle and sheep farming.

The pattern of land use and transition of farm types is shown in figure 2. It indicates that **intensive farms**, which produce perishables such as fruit and vegetables, are located on high-cost land close to urban markets. At the other extreme, the **extensive farms**, which manage cattle, sheep and cereals, are found on the less expensive lands distant from the market.

intensive farm
farm that requires a lot of inputs, such as labour, capital, fertiliser and pesticide

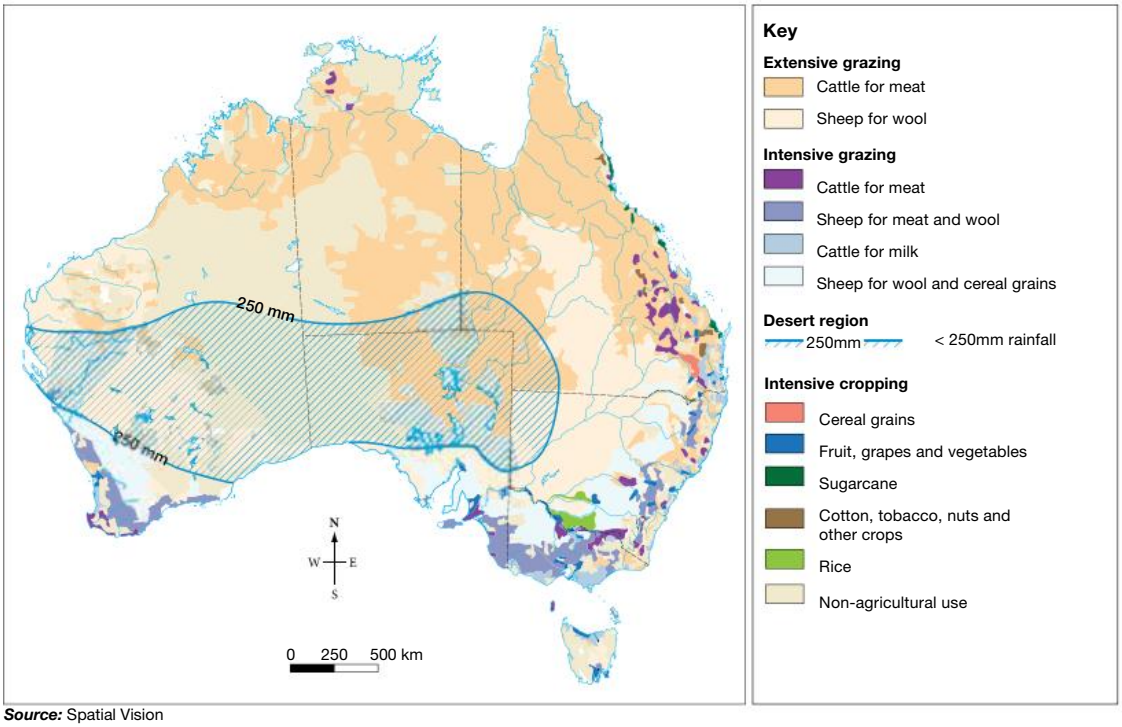
extensive farm
farm that extends over a large area and requires only small inputs of labour, capital, fertiliser and pesticide

Some farm types in Australia

Extensive farming of sheep or cattle

Sometimes known as livestock farming or grazing, these sheep and cattle stations are found in semi-arid and desert grassland biomes, with rainfall of less than 250 millimetres (figure 1). Australia's 90 million sheep and 14 million cattle are found mainly in Queensland and New South Wales. Farms are large in scale, covering hundreds of square kilometres. These days, they have very few employees, and often use helicopters and motor vehicles for mustering (figure 3). Meat and wool products go to both local and overseas markets for cash returns.

FIGURE 1 Types of agriculture in Australia



Source: Spatial Vision

Wheat farms

About 25 000 farms in Australia grow wheat as a major crop, and the average farm size is 910 hectares, or just over nine square kilometres. As in other areas of the world, extensive wheat farming is found in mid latitude temperate climates that have warm summers and cool winters, and annual rainfall of approximately 500 millimetres. In Australia, these conditions occur away from the coast in the semi-arid zone. The biome associated with this form of food production is generally open grassland, **mallee** or savanna that has been cleared for the planting of crops.

Soils can be improved by the application of fertilisers, and crop yields increased by the use of disease-resistant, fast-growing seed varieties. Wheat farms are highly mechanised, using large machinery for ploughing, planting and harvesting (see figure 4). The farm produce, which can amount to two tonnes per hectare, is sold to large corporations on local and international markets.

mallee vegetation areas characterised by small, multitrunked eucalypts found in the semi-arid areas of southern Australia

FIGURE 2 Changes in agricultural land use

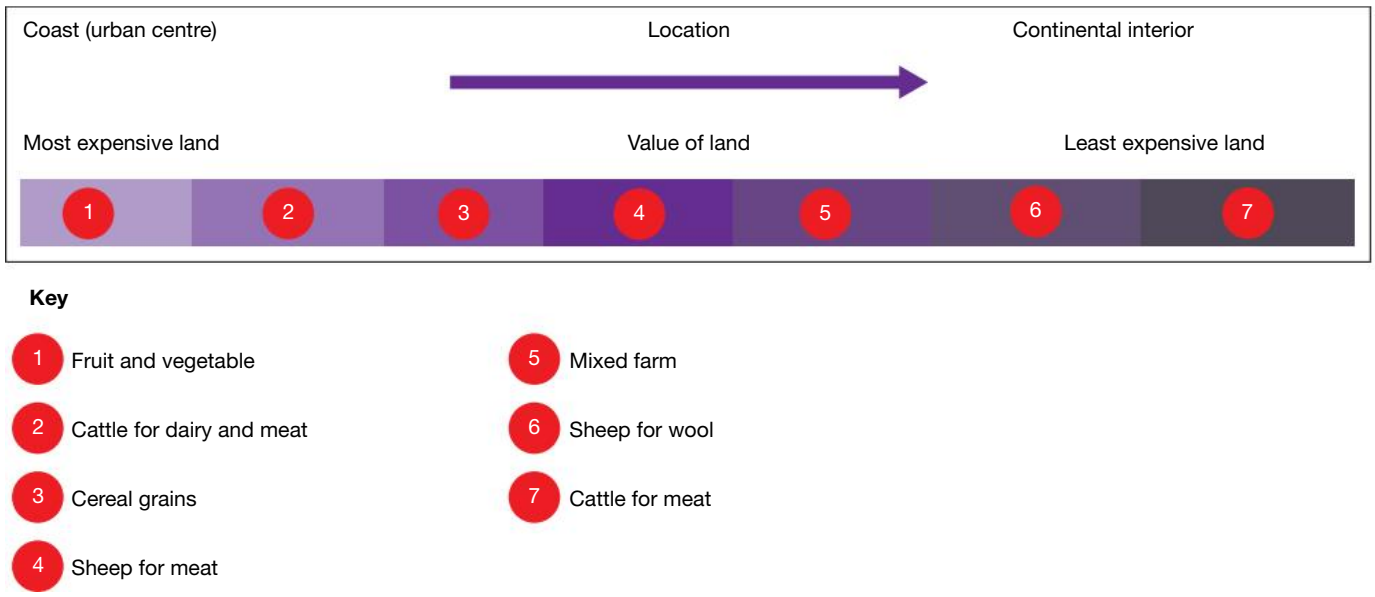


FIGURE 3 Cattle mustering

FIGURE 4 Wheat farming with a combine harvester

Mixed farms

Mixed farms combine both grazing and cropping practices. They are located closer to markets in the wetter areas, and are generally smaller in scale, but operate in much the same way as cattle and sheep farms.

Intensive farming

Intensive farms are close to urban centres, producing dairy, horticulture and market gardening crops (figure 5). They produce milk, fruit, vegetables and flowers, all of which are perishable, sometimes bulky, and expensive to transport. The market gardens are capital- and labour-intensive, because the cost of land near the city is high, and many workers are required for harvesting.

FIGURE 5 Strawberries are typically grown in market gardens.

Plantation farming

This form of agriculture is often found in warm, well-watered tropical places. Plantations produce a wide range of produce such as coffee, sugar cane, cocoa, bananas, rubber, tobacco and palm oil (figure 6). Farm sizes can be 50 hectares or more in size. Although many such farms in Australia are family owned, in other parts of the world they are often operated by large multinational companies. Biomes that contain plantations are mainly tropical forests or savanna, and require large-scale clearing to allow for farming. Cash returns are high, and markets are both local and global.

FIGURE 6 Banana plantation near Carnarvon, Western Australia

ACTIVITIES

IDENTIFY

1 Which type of agricultural land use is closest to urban centres, and which is the furthest away?
2 How does the ***environment*** in the centre of Australia affect farming types?
3 What is the ***interconnection*** between climate and farm type in Australia? (*Hint:* Refer to a climate map in your atlas for other ideas.)

EXPLAIN

4 Explain why extensive, large-***scale*** cattle and sheep farms are typically located in remote and arid regions of Australia.
5 Using the map of farm production in Australia (figure 1), describe and explain the location of:
   a wheat farms
   b dairy farms.

INVESTIGATE

6 Investigate what foods are grown closest to you.
7 Collect information on the percentage of land used for the different forms of farming in Australia, and then show this data in a graph. Comment on the details shown in your graph.
8 Various plantations in Queensland (such as pineapple, sugar cane and banana plantations) are associated with fertiliser run-off, which is affecting the Great Barrier Reef. Find out what effects fertiliser has on these marine ***environments***.

PREDICT

9 What would be the impact of flood or drought on any of the commercial methods of food production?
10 Predict the impact of the growth of Australian capital cities on the ***sustainability*** of surrounding market gardens.

APPLY

11 Why is much of Australia's food production available for export?
12 It used to be said that Australia's economy 'rode on the sheep's back'. What do you think this means, and do you think it is still true today?

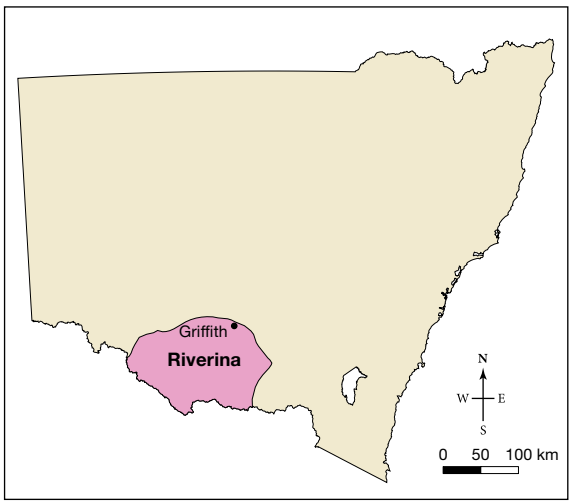
3.8 What is a farming area like in Riverina?

3.8.1 Griffith

Modern-day food production relies heavily on technology to create ideal farming conditions. This may involve reshaping the land to allow for large agricultural machinery and for the even distribution and drainage of water. Uneven or unreliable rainfall can be supplemented by irrigation. As a result of such changes, large areas can become important farmland.

Griffith, located in the Western Riverina of New South Wales Figure 1, is an important agricultural and food-processing centre for the region, generating more than $1.9 billion dollars' worth of food. It is responsible for 60 per cent of the oranges (figure 2), 44 per cent of the rice and 51 per cent of the wine produced in New South Wales.

FIGURE 1 Location map of Riverina and Griffith



Source: Geoscience Australia

FIGURE 2 Oranges being grown in Griffith

The Wiradjuri Nation have lived in this area for thousands of years and are considered the largest Aboriginal and Torres Strait Islander nation in Australia. The first European explorer to the area was John Oxley, who described the region as 'uninhabitable and useless to civilised man'. This was largely due to the lack of a suitable water supply. The construction of irrigation canals in 1906 established a reliable source of water that could be used in food production. The region has become an important food centre owing to the large-scale use of irrigation combined with suitable flat land, fertile soils and a mild climate.

ACTIVITIES

INVESTIGATE

1 Refer to figure 1 in subtopic 2.4, and the location map (figure 1) in this section. What type of ***environment*** would the Wiradjuri have lived in when John Oxley first arrived in the Riverina and Griffith area?
2 Identify and name a possible source for irrigation water on the figure 3 map.
3 How is water moved around this area? (*Hint:* Follow the blue lines.)
4 Using the contour lines and spot heights as a guide, estimate the average elevation of the map area.
5 What is the importance of topography (the shape of the land) to irrigation?
6 What types of farming are found at the following ***places***?
  a GR410195
  b GR413220
7 Approximately what percentage of the visible map area is irrigated?
8 Are orchards and vineyards an example of intensive or extensive farming? Explain.
9 Compare the pattern of irrigation channels and buildings in AR3919 and AR4220. Suggest a reason for the differences you can see.

APPLY

10 Within Griffith there are many factories that process raw materials, such as rice mills, wineries and juice factories. What would be the advantages and disadvantages of locating processing factories close to growing areas?

FIGURE 3 Topographic map extract, Griffith, New South Wales

Source: Commonwealth of Australia (Geoscience Australia).

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3.9 SkillBuilder: Describing patterns and correlations on a topographic map

What are patterns and correlations on a topographic map?

A pattern is the way in which features are distributed or spread. A correlation shows how two or more features are interconnected — that is, the relationship between the features. Patterns and correlations in a topographic map can show us cause-and-effect connections.

eLesson
Watch this video to learn how to describe patterns and correlations on a topographic map.

Searchlight ID: eles-1729

Interactivity
Try this interactivity to learn how to describe patterns and correlations on a topographic map.

Searchlight ID: int-3347

3.10 Why is rice an important food crop?

3.10.1 Factors affecting rice production in Asia

Rice is the seed of a semi-aquatic grass. In warm climates, in more than 100 countries, it is cultivated extensively for its edible grain. Rice is one of the most important staple foods of more than half of the world's population, and it influences the livelihoods and economies of several billion people. In Asia, rice provides about 49 per cent of the calories and 39 per cent of the protein in people's diet. In 2015, approximately 160 million hectares of rice were harvested worldwide, and 101.5 kilograms were produced for each person on Earth.

Figure 1 shows that in 2014 the largest concentration of rice was grown in Asia. Around 163 million hectares are cultivated with this crop, producing 91 per cent of the world's rice. Of this, 48 million hectares and 30 per cent of the global rice crop were in South-East Asia alone.

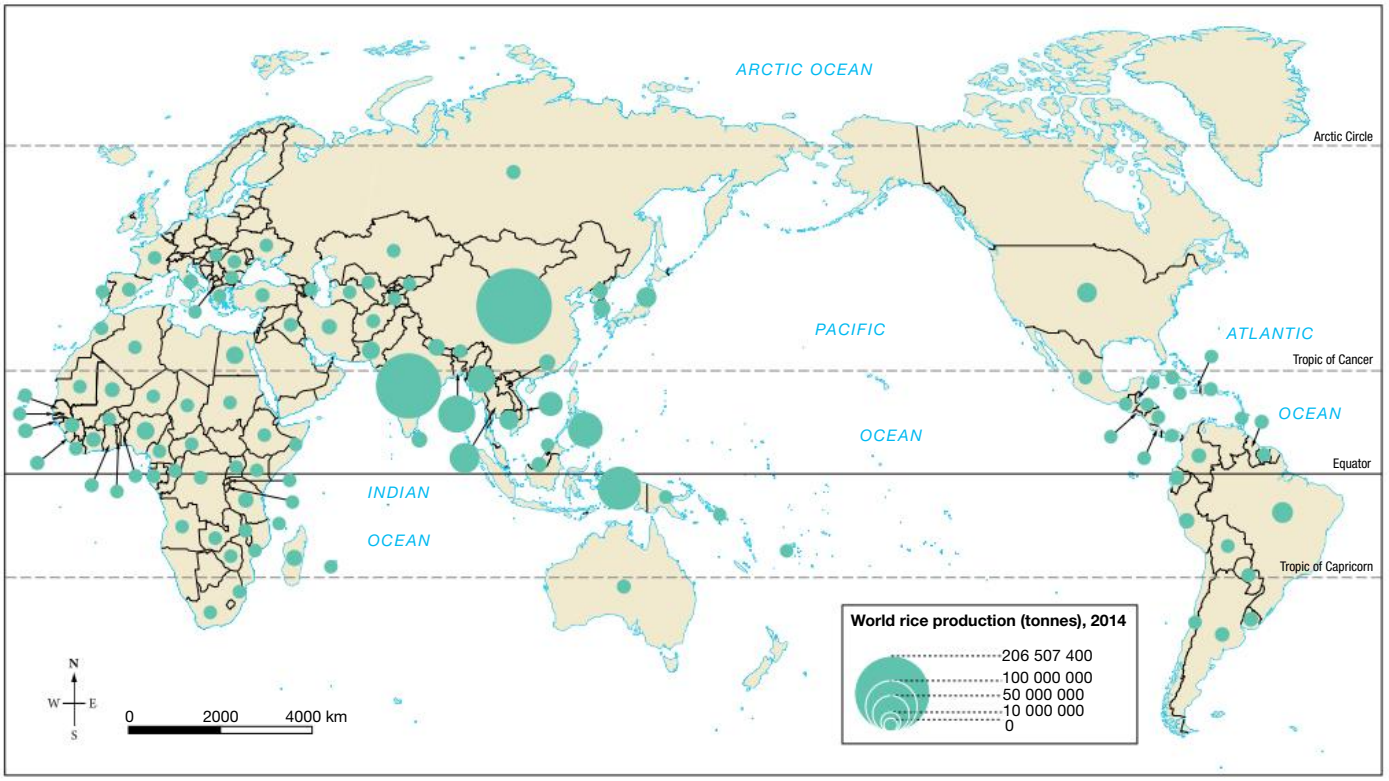
Countries with the largest areas under rice cultivation are India, China, Indonesia, Bangladesh, Thailand, Vietnam, Myanmar and the Philippines, with 80 per cent of the total rice area.

Climate and topography

Rice can be grown in a range of environments that are hot or cool, wet or dry. It can be grown at sea level on coastal plains and at high altitudes in the Himalayas. However, ideal conditions in South-East Asia are high temperatures, large amounts of water, flat land and fertile soil.

In Yunnan Province, China, the mountain slopes have been cultivated in terraced rice paddies by the Hani people for at least 1300 years (see figure 2). The terraces stop erosion and surface run-off and create flat land area for cultivation in otherwise very steep terrain.

FIGURE 1 World rice production, 2014



Source: Food and Agricultural Organization of the United Nations

Irrigation

Traditional rice cultivation involves flooding the paddy fields (*padi* meaning 'rice plant' in Malay) for part of the year. These fields are small, and earth embankments (*bunds*) surround them. Rice farmers usually plant the seeds first in little seedbeds and transfer them into flooded paddy fields, which are already ploughed (see figure 3). Canals carry water to and from the fields. Houses and settlements are often located on embankments or raised islands near the rice fields.

Approximately 45 per cent of the rice area in South-East Asia is irrigated, with the largest areas being found in Indonesia, Vietnam, the Philippines and Thailand. High-yielding areas of irrigated rice can also be found in China, Japan and the Republic of Korea. Because water is available for most of the year in these places, farmers can grow rice all year long. This intensive scale of farming can produce two and sometimes three crops a year.

FIGURE 2 Spectacular rice terraces in Yunnan Province, China. These terraces are at an elevation of 1570 metres.

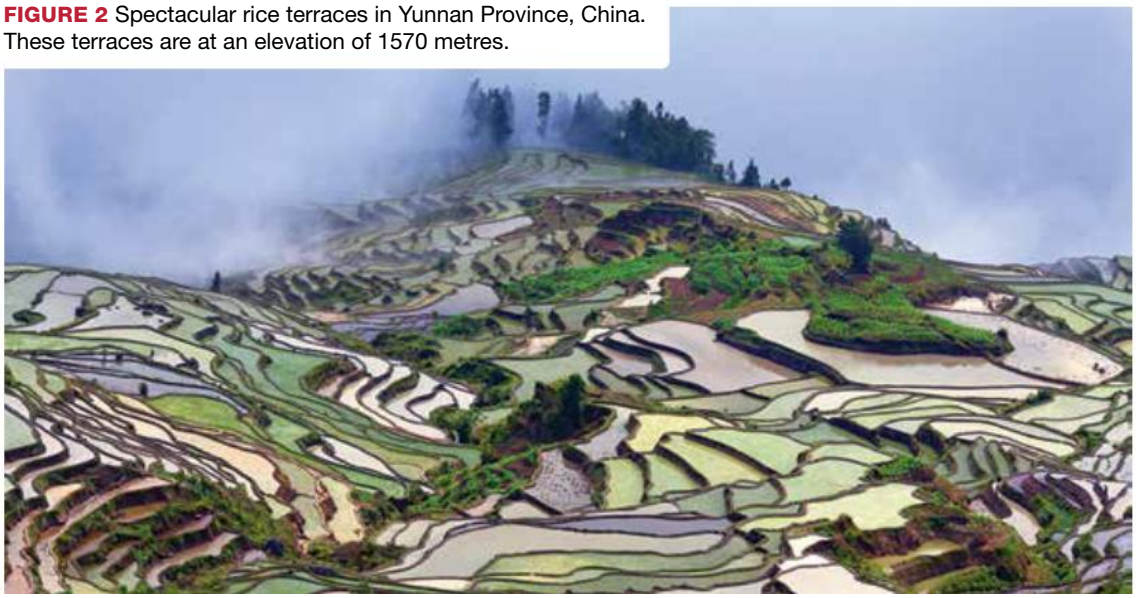


FIGURE 3 Planting rice in paddy fields in north-east Thailand

FIGURE 4 Hybrid rice seeds

Upland rice is grown where there is not enough moisture to nurture the crops; an example of such cultivation takes place in Laos. This method produces fewer rice varieties, since only a small amount of nutrients are available compared to rice grown in paddy fields.

Pests and diseases

Rice yields can be limited if any of the following conditions exist:

- poor production management
- losses caused by weeds (biotic factor)
- pests and diseases (biotic factor)
- inadequate land formation and irrigation water
- inadequate drainage that leads to a build-up of salinity and alkalinity.

Technology

Agricultural biotechnology, especially in China, has produced rice that is resistant to pests. There are also genes for herbicide resistance, disease resistance, salt and drought tolerance, grain quality and photosynthetic efficiency. Genetic engineering may be the way of the future in rice cultivation in some parts of the world (figure 4).

However, in the Philippines, a new strain of rice has been developed that grows well in soils lacking phosphorus. This could change crop yields considerably, and has been a result of cross breeding rather than genetic engineering.

Environmental issues

Increasing temperatures, due to global warming, may be causing a drop in rice production in Asia, where more than 90 per cent of the world's rice is produced and consumed. The Food and Agriculture Organization of the United Nations (FAO) has found that in six of Asia's most important rice-producing countries — China, India, Indonesia, the Philippines, Thailand and Vietnam — rising temperatures over the last 25 years have led to a 10–20 per cent decline in rice output.

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Interactivity
How is rice grown?
Use this interactivity to further your understanding of how rice is cultivated in different places.
Searchlight ID: int-3322

Scientists state that if rice production methods cannot be changed, or if new rice strains able to withstand higher temperatures cannot be developed, there will be a loss in rice production over the next few decades as days and nights get hotter. People may need to turn to a new staple crop.

Rice growing is eco-friendly and has a positive impact on the environment. Rice fields create a wetland habitat for many species of birds, mammals and reptiles. Without rice farming, wetland environments created by flooded rice fields would be vastly reduced.

3.10.2 Factors affecting rice production in Australia

Climate and topography

Eighty per cent of rice produced in Australia consists of temperate varieties that suit climates with high summer temperatures and low humidity. Rice is grown in the Murrumbidgee valleys of New South Wales (figure 5) and the Murray valleys of New South Wales and Victoria. The scale of production is sophisticated.

FIGURE 5 Murrumbidgee irrigation area rice fields

Sowing and irrigation

In Australia, rice grows as an irrigated summer crop from September to March. Most of it is sown by aircraft rather than planted by hand. Experienced agricultural pilots use satellite guidance technology to broadcast seed accurately over the fields.

Before sowing, the seed is soaked for 24 hours and drained for 24 hours, leaving a tiny shoot visible on the seed. Once sown, it slowly settles in the soft mud, and within three to four days each plant develops a substantial root system and leaf shoot. After planting, fresh water is released from irrigation supply channels to flow across each paddy field until the rice plants are well established.

Most countries grow rice as a monoculture, whereas Australian rice grows as part of a unique farming system. Farmers use a **crop rotation** cycle across the whole farm over four to five years. This means that the growers have other agricultural enterprises on the farm as well as rice. This system, designed for efficiency, sustainability and safety, means Australian growers maintain water savings, have increased soil nutrients, higher yields and much healthier crops.

crop rotation a procedure that involves the rotation of crops, so that no bed or plot contains the same crop in successive seasons

Once Australian rice growers harvest their rice (figure 6), they use the subsoil moisture remaining in the soil to plant another crop—either a wheat crop or pasture for animals. This form of rotation is the most efficient in natural resource use and agricultural terms.

Pests and diseases

Rice bays (areas contained by embankments—see figure 5) are treated with a chemical application, which prevents damage by pests and weeds. Without this treatment, crop losses would be extensive. In the last 100 days before harvesting, the rice plant has no chemical applications, so that when it is harvested, it is virtually chemical free.

FIGURE 6 Harvesting rice near Griffith, New South Wales

Technology

Most farms use laser-guided land levelling techniques to prepare the ground for production. This gives farmers precise control over the flow of water on and off the land. Such measurement strategies have contributed to a 60 per cent improvement in water efficiency. Most of the equipment used on rice farms is fitted with computer-aided devices, such as GPS (global positioning systems), CAD (computer-aided design), GIS (geographical information systems) and remote sensing. Australian rice growers are the most efficient and productive in the world.

Environmental issues

biodiversity
the variety of living organisms (plant and animal life) within an area

The rice industry encourages **biodiversity** enhancement and greenhouse gas reduction strategies. Some farms in southern New South Wales are avoiding the use of chemical fertilisers and pesticides by converting farms to biodynamic practices, and have avoided salinity by planting red gums.

ACTIVITIES

IDENTIFY

1. Refer to figure 1. Which countries produce most of the world's rice?
2. What is meant by the term ***monoculture***?

EXPLAIN

3. Explain why ***places*** in Asia are ideally suited to rice growing.
4. Use the **Terraced rice** weblink in your eBookPLUS to explain how the terraced rice fields shown in figure 2 have been formed.
5. Explain the ***environmental*** issues that may affect future rice production.
6. Describe and explain the similarities and differences between the rice cultivation methods in Asia and Australia.

INVESTIGATE

7. Investigate two different rice growing ***places*** in Asia and describe the reasons for the different ***environments***.
8. Investigate an example of an Australian rice farm and outline its yearly rice-growing cycle.
9. Research the ***interconnection*** between rice-growing and the Murray River to ensure a ***sustainable environment***.

PREDICT

10. Predict how technology will influence ***changes*** to rice cultivation in both Asia and Australia.

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Weblink
Terraced rice

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3.13 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

3.4 SkillBuilder: Constructing ternary graphs

3.4.1 Tell me

What are ternary graphs?

Ternary graphs are triangular graphs that show the relationship or interconnection between three features (figure 1). Most graphs you have seen show the relationship between two features, not three.

Why are ternary graphs useful?

Ternary graphs are particularly useful when a feature has three components, and the three components add up to 100 per cent. Ternary graphs are most often used to show soil types, employment structures and age structures. They allow us to clearly see the interconnection between features. For example, with soil types, three different properties can be identified — clay, sand and silt. They can be graphed according to the proportion of each within a soil type, such as clay loam, sandy clay loam or silty clay loam.

Ternary graphs are useful for:

- economists comparing three economic features
- demographers considering population structures
- agriculturalists considering soil types.

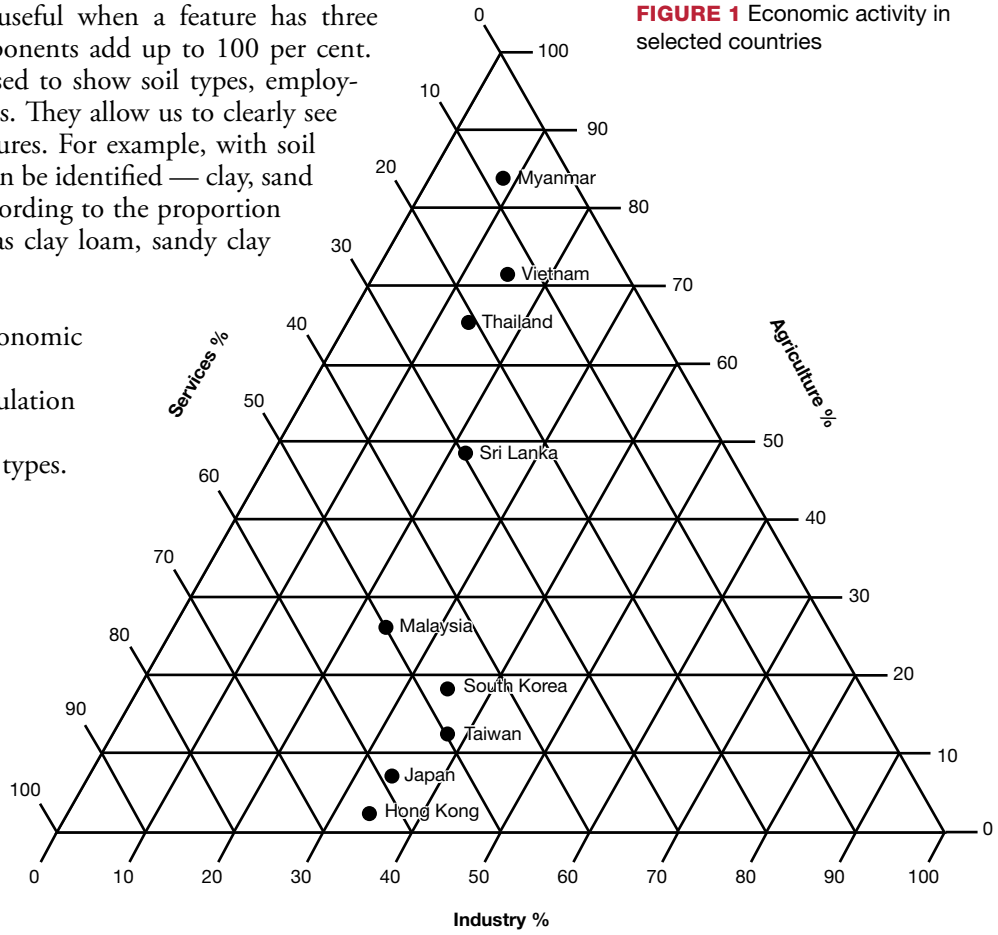

FIGURE 1 Economic activity in selected countries

Model

A good ternary graph:

- is constructed as an equilateral triangle
- has each side of the triangle divided equally into 10
- has lines drawn across the triangle that always total 100 per cent
- contains accurately plotted data
- has labelled axes
- includes a clear title.

3.4.2 Show me

How to construct a ternary graph

You will need:

- data on three features expressed as percentages and totalling 100 per cent
- a pencil
- a ruler
- an eraser.

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eLesson
Constructing ternary graphs
Searchlight ID: eles-1728

Procedure:

STEP 1

First you have to create an equilateral triangle — all three sides are equal and all three internal angles are 60°. Each side of the triangle becomes an axis on the graph. Begin by drawing a 10-centimetre horizontal line, and draw 10 marks that are one centimetre apart. Label these 0 to 10, with 0 on the left-hand side of your line and 100 at the right-hand side. Angle these marks to the left at 60° (figure 2).

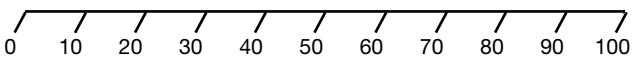
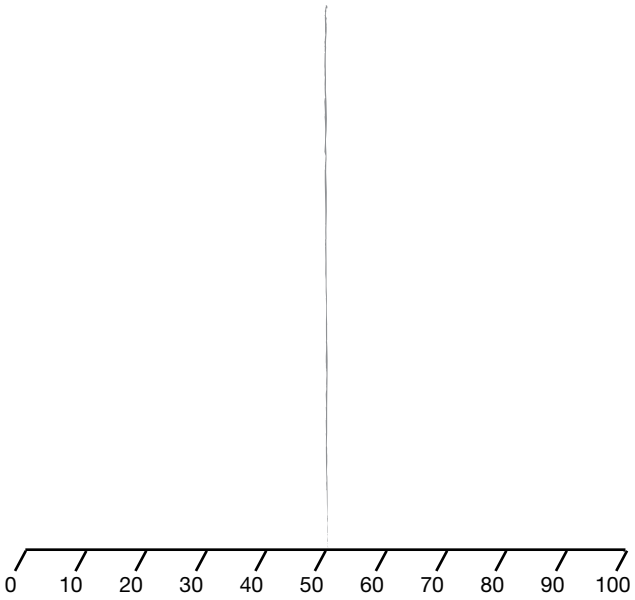


FIGURE 2 Horizontal line with 10 markings 1 centimetre apart

STEP 2

At the 50 per cent point, draw a faint vertical line of about 9 centimetres, which will help you to draw the other two axes (figure 3). Later, you can rub this line out.

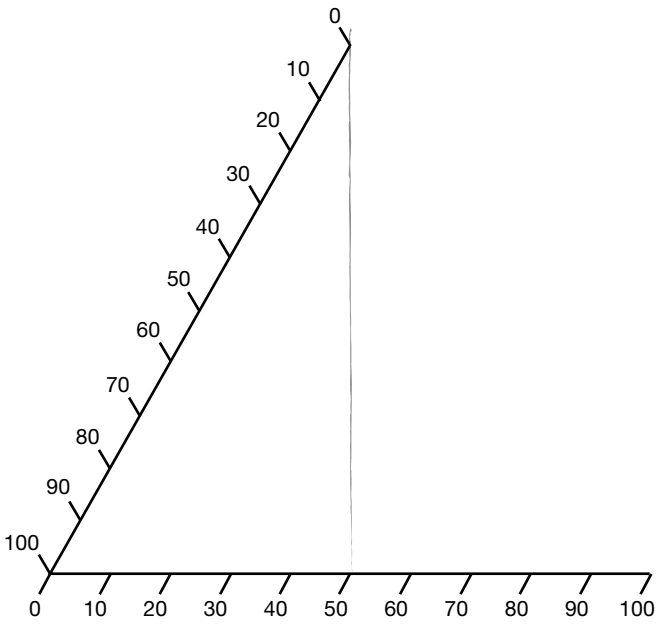
FIGURE 3 Forming the equilateral triangle



STEP 3

Now from the 0 per cent point, draw a diagonal line that is 10 centimetres long and intersects with the vertical line shown in figure 3. (It will intersect a few millimetres below the top of the vertical line; see figure 4.) Draw 10 marks that are one centimetre apart along this diagonal axis. However, this time, mark 100 per cent at the bottom of the line and 0 at the top.

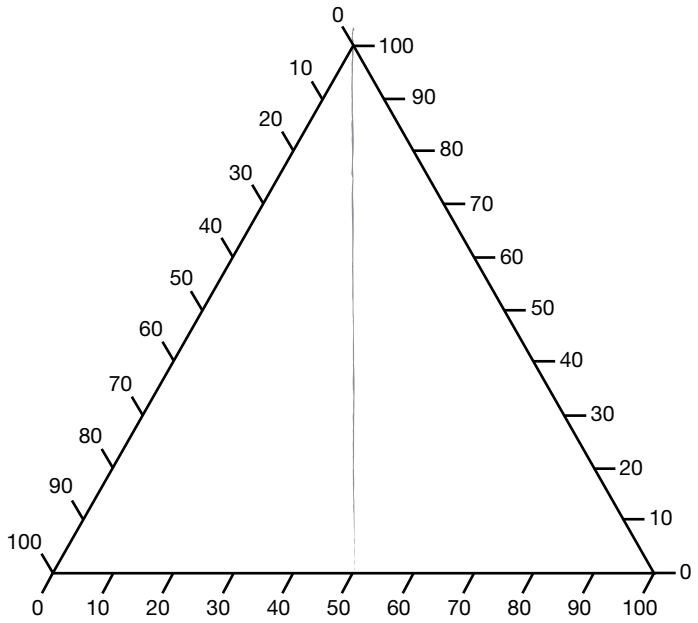
FIGURE 4 Creating a second axis



STEP 4

Repeat this step on the other side of the vertical line to complete the triangle, but reverse the markings, so 0 is at the bottom of the line and 100 is at the top. Your base graph should show a flow of 0 to 100 per cent around the graph, as in figure 5.

FIGURE 5 A ternary graph outline



STEP 5

Erase the vertical line that you drew to centre your graph.

STEP 6

Now you need to use a ruler and carefully join points across the triangle that add to 100 per cent. This will provide a grid on which you can plot data.

STEP 7

Label the axes with the three features that you are going to plot. For figure 1, this is Services, Industry and Agriculture. Put the percentage symbol (%) after each label (figure 6).

FIGURE 6 A ternary graph with its grid completed and axes labelled

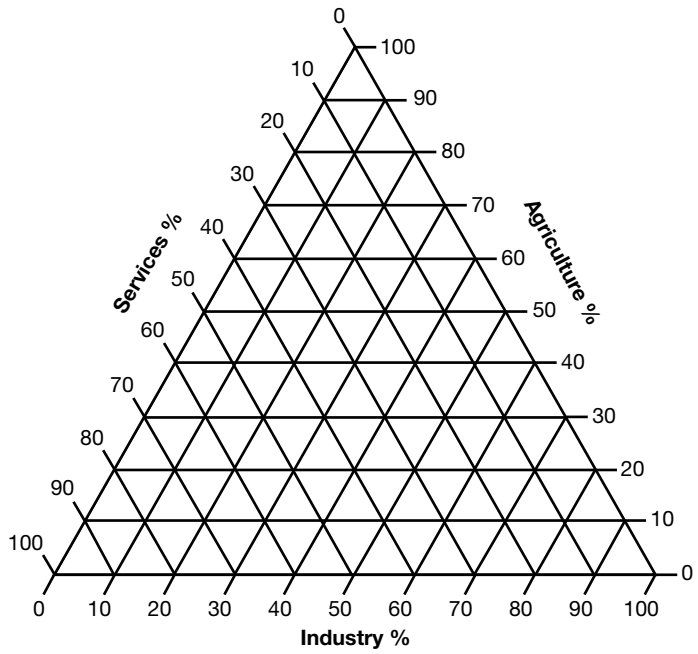
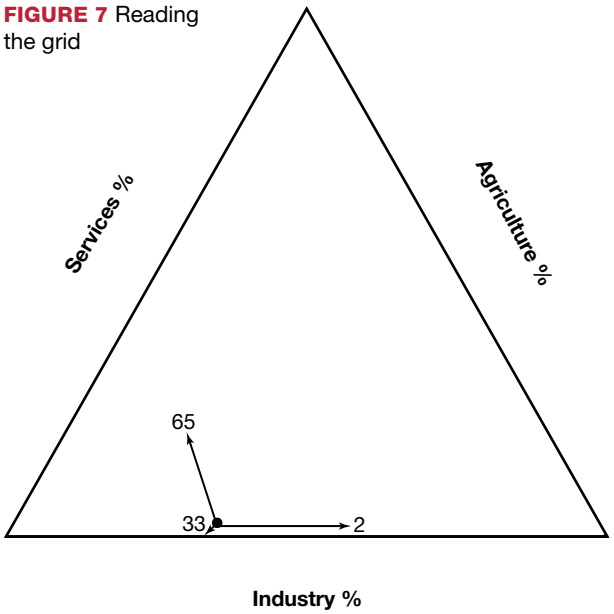


FIGURE 7 Reading the grid



STEP 8

Sample data for figure 1 would appear in a table like the one below.

TABLE 1 Sample data on economic activity for selected countries in figure 1

Country	Agriculture %	Industry %	Services %
Hong Kong	2	33	65
Myanmar	84	8	8
Sri Lanka	49	21	30

To plot data, you need to find the point where the percentages for the three features intersect.

Plotting and reading ternary graphs needs concentration. You need to follow the diagonal lines sloping down from left to right (\) from the left-hand axis, the diagonal lines sloping up from left to right (/) from the bottom axis, and the horizontal lines from the right-hand axis. Look at the patterns outlined in figure 7 to make sure you read the grid in the correct manner. (Correctly angling the markers that fall outside the triangle will help you in plotting and reading the graph.)

When plotting country data, find the spot represented by the three sets of data and draw a small dot. Label it with the country name. Check that you can find the three countries in table 1 on your ternary graph.

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Constructing ternary graphs
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STEP 9

Complete the graph with an appropriate title. In this case, the graph shows economic activity in selected countries.

3.4.3 Let me do it

Developing my skills

Use the following set of data to construct a ternary graph on labour force by occupation, 2011–12, in selected countries.

TABLE 2 Labour force by occupation, 2011–12, selected countries

Country	Agriculture %	Manufacturing %	Services %
Australia	4	21	75
Colombia	18	14	68
Finland	4	24	74
Germany	2	24	74
India	53	19	28
Indonesia	38	13	49
Italy	4	28	68
Sri Lanka	32	26	42
South Korea	6	24	70
Thailand	41	13	46
Venezuela	7	22	71
Vietnam	48	22	30

Questions

1. Which country has the greatest percentage of its population employed in agriculture?
2. Which country has the greatest percentage of its people employed in services?
3. Which countries have the lowest percentage of people employed in manufacturing?
4. Which country has the most even distribution across the three areas of employment?
5. Onto your graph, plot where you think the following countries would be placed: the United States, Gambia and Argentina. Explain your answer.

Checklist

I have:

- constructed an equilateral triangle
- divided each side of the triangle into 10
- drawn lines across the triangle that always total 100 per cent
- accurately plotted the data
- labelled the axes
- provided a clear title.

Skills questions

1. Ternary graphs are used to show:
   a. the interconnection between features
   b. cause and effect
   c. the distribution of one aspect
   d. the pattern of features.
2. Ternary graphs show the percentages of:
   a. one component
   b. two components
   c. three components
   d. four components.
3. Why is 100 per cent a key element of the ternary graph?
4. Why is care required when reading a ternary graph?

3.9 SkillBuilder: Describing patterns and correlations on a topographic map

3.9.1 Tell me

What are patterns and correlations on a topographic map?

A pattern is the way in which features are distributed or spread. A correlation shows how two or more features are interconnected — that is, the relationship between the features.

Why are patterns and correlations in topographic maps useful?

Patterns and correlations in a topographic map can show us cause-and-effect connections. A feature may be seen to occur at a place on a map and, when we ask why, other features on the topographic map help to explain the answer.

Topographic maps are useful for showing:

- landforms and land use connections
- water features and flooding for emergency services
- vegetation cover and slopes for fire authorities
- landforms and settlements for urban developers.

Model

In the environs of the township of Clare, South Australia, the eastern ridge slopes are used extensively for grape growing. Roads run parallel to the ridge and, owing to the steepness of the land, it is possible to drive over the ridge at only a few points, such as at Hughes Park (GR 800405). Settlements follow the ridge road along North Road. Streams that have their source on the ridge tend to flow west and form larger streams. Those streams flowing to the east are often dammed. Windmills throughout the flatter areas suggest water is needed for animal pasture in the drier months of the year. Spring Gully Conservation Park is a treed area on the steepest part of the ridge. The vineyards to the north at White Hut and Stanley Flat are not on sloped land, suggesting that the types of grapes grown there differ from those across most of the area. The Clare Valley region (figure 1) is an important vineyard area, adding significantly to the agricultural output of South Australia.

A good description of patterns and correlations in a topographic map:

- uses place names
- mentions distances
- identifies regions
- identifies connections
- notes anomalies
- is written in paragraphs, and includes an introduction that identifies the place and a conclusion that summarises the key findings.

3.9.2 Show me

How to describe patterns and correlations in a topographic map

You will need:

- a topographic map of the place being considered.

Procedure:

STEP 1

Take the time to carefully analyse the topographic map, particularly its legend. Visualise the landforms and land use of the mapped place.

STEP 2

Now systematically look for connections between features, beginning with places that have strong connections. Try this list of connections that can be applied to most topographic maps:

- landforms and water or drainage
- landforms and vegetation types

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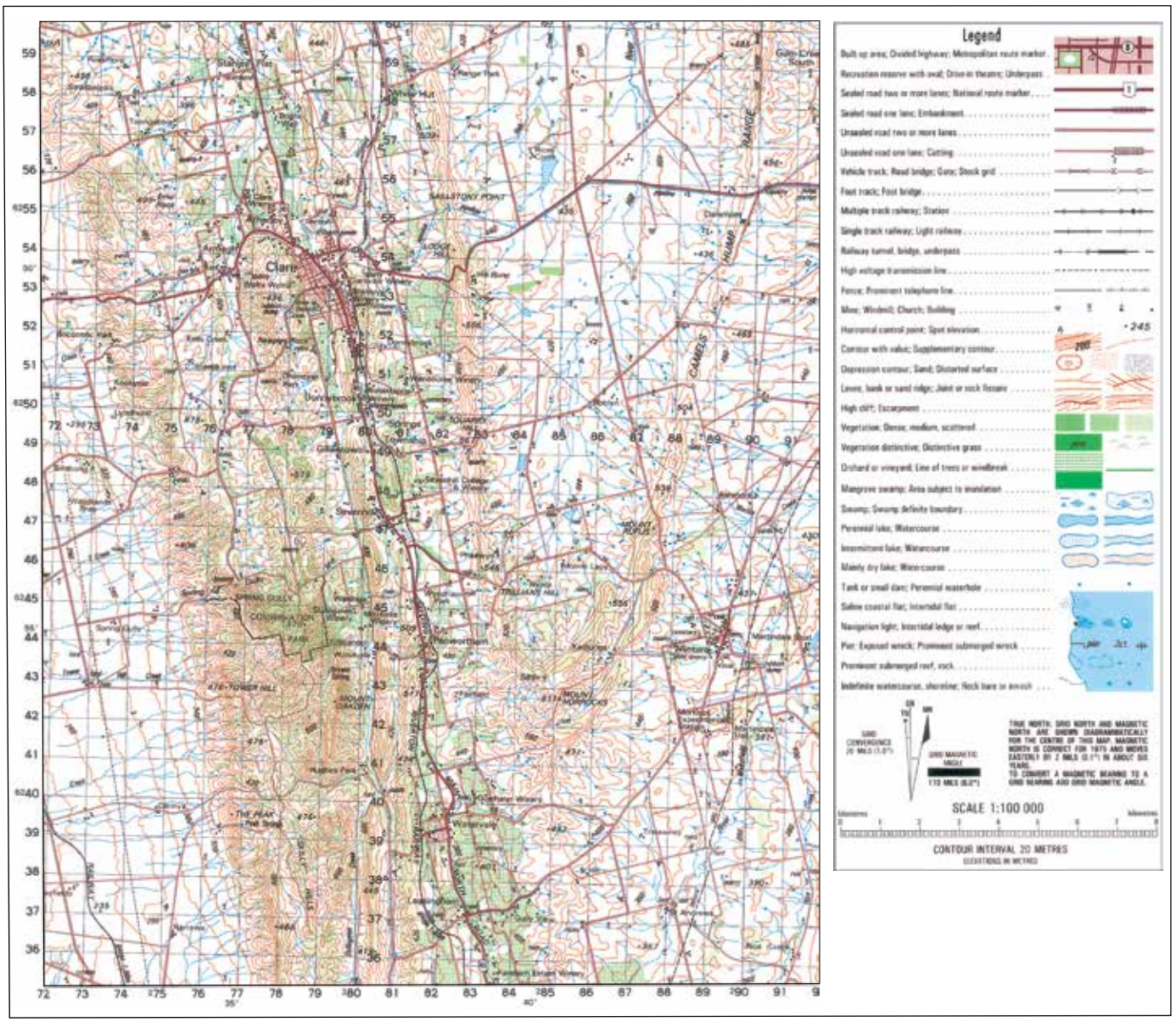
- landforms and settlement
- landforms and agricultural use
- water and vegetation
- settlement and agricultural uses.

FIGURE 1 Topographic map extract showing the Clare Valley, South Australia



Source: Spatial Vision

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Interactivity
Describing patterns and correlations on a topographic map
Searchlight ID: int-3347

After you have identified these connections, write a few sentences describing any connections that are obvious. Begin by introducing the place being discussed, as in the paragraph under the heading 'Model' in section 3.9.1, which opens with 'In the environs of the township of Clare, South Australia …' An example of a connection found in figure 1 is that there is a strong link between land slope and vineyards.

STEP 3

Now systematically look for any anomalies that are evident. You are looking for things that seem unusual or show no connections. For example, in figure 1, the wineries at White Hut and Stanley Flat are not on east-facing slopes.

STEP 4

Complete your description with a concluding statement about the place. The paragraph under the heading 'Model' in section 3.9.1 concludes with the statement: 'The Clare Valley region is an important vineyard area, adding significantly to the agricultural output of South Australia.'

3.9.3 Let me do it

Developing my skills

Using the topographic map of the Griffith area, figure 3 in subtopic 3.8 (doc-20446 in the Resources tab), write a paragraph identifying any patterns and correlations that are evident.

Questions

1. Why are the water channels straight? Is there an interconnection between slope and water resources? Explain your answer.
2. To what extent is there a correlation between orchards and slope? Explain your answer.
3. Describe the direction of development of Griffith township. Suggest why it has developed in this way.
4. How do we know that the irrigated orchards are smallholdings?
5. Is there a correlation between land slope and agricultural land use?

Checklist

I have:

- used place names
- mentioned distances
- identified regions
- identified connections
- noted anomalies
- written in paragraphs and included an introduction that identifies the place and a conclusion that summarises the key findings.

Skills questions

1. Patterns and correlations in topographic maps are used to show:
   a. the shape of the land between two places
   b. cause and effect
   c. the distribution of one aspect
   d. types of animals.
2. Patterns and correlations in topographic maps do not include information about:
   a. settlements
   b. numbers of cattle
   c. slope
   d. landforms.
3. Why should you include a statement of the location?
4. Why is it important to conclude your paragraph of writing?

3.11 Why is cacao a special food crop?

3.11.1 Where is cacao grown?

Where does chocolate come from? Chocolate is made from the beans of the cacao plant (see figure 2). The chocolate that is produced from these beans might come from cacao grown in Ghana, Mexico, Malaysia or Indonesia. Look on the wrapper next time you eat a chocolate bar!

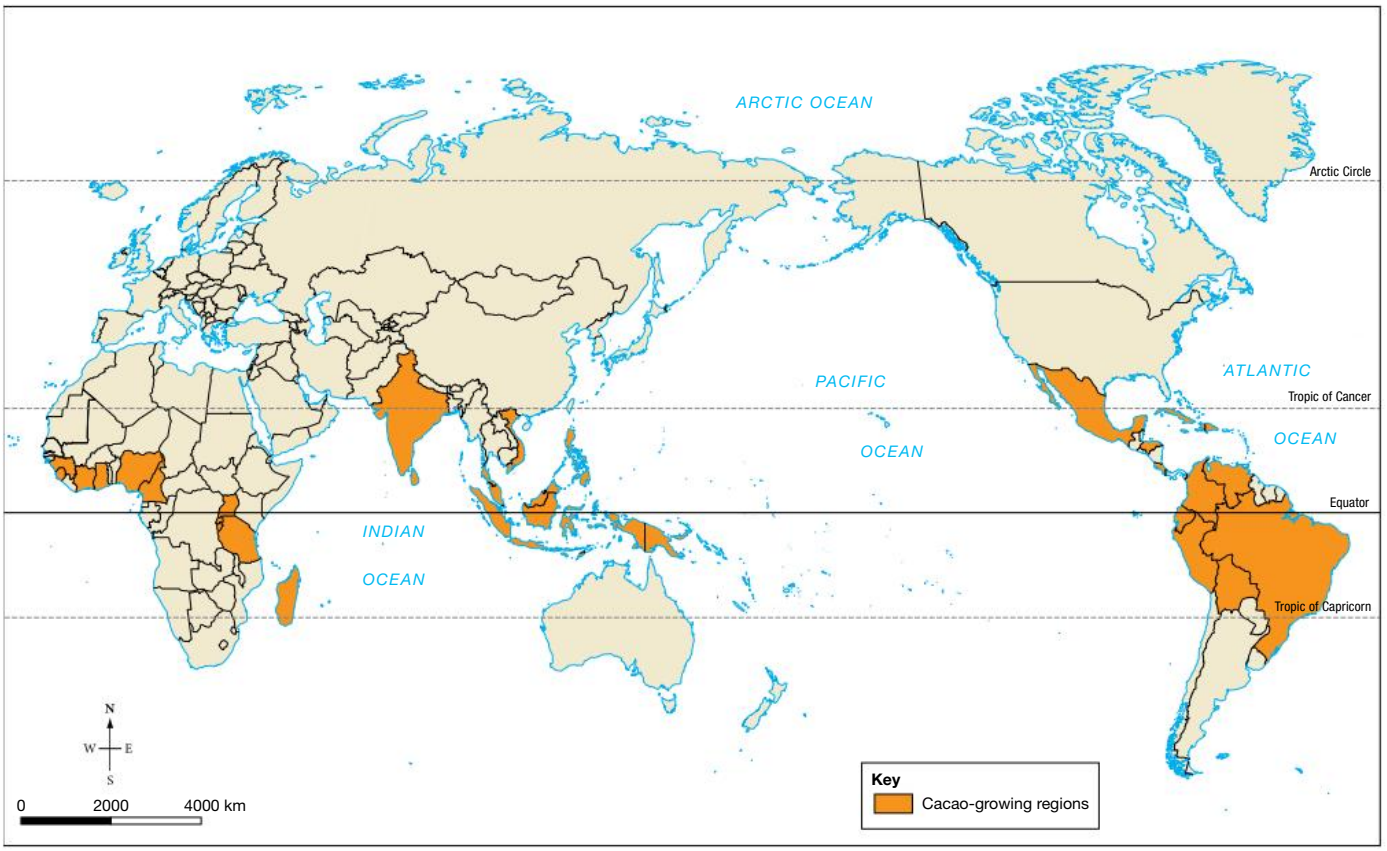
Chocolate has been eaten or drunk by people for 4000 years. A recent study showed that today, 91 per cent of females and 87 per cent of males consume chocolate products in places such as Great Britain, Australia, Switzerland, China and the United States. However, rising disposable incomes and changing tastes will continue to change the scale of production, both overseas and locally; people in India and China are now eating more chocolate.

The cacao tree is a native of the Amazon Basin and other tropical areas of South and Central America, where wild varieties still grow in the forests. Many countries now grow cacao, but the main places are:

- West Africa — Ghana, Nigeria and Cote D'Ivoire
- South America — Brazil and Ecuador
- Asia — Malaysia and Indonesia.

Malaysia and Indonesia, where cacao is a relatively new crop, are becoming increasingly important growing areas (see figure 1).

FIGURE 1 The main cacao-growing regions of the world



Source: Spatial Vision

3.11.2 What influences the growth and production of chocolate?

Environmental factors

Most of the world's cacao is grown in a narrow belt between 10 degrees north and 10 degrees south of the equator (figure 1). Cacao trees grow well in humid tropical climates with regular rainfall and a short dry season. The trees need temperatures between 21° and 23° C and rainfall of 1000 to 2500 millimetres per year. The soil must drain well but have good moisture-holding capacity. The trees cannot tolerate tropical sun and must be grown in the shade of other trees, such as banana trees, palms and rubber plants. Although cacao plants can reach a height of 12 metres, most are only six to seven metres tall. Growth is very fast, and the plant can flower and fruit two to three years after planting.

FIGURE 2 A cacao bean and seeds

Economic factors

Around the world, six million cacao farmers — and 40 million to 50 million people in total — depend on cacao for their livelihood. For the past century, demand has grown by three per cent per year.

Cacao beans are an important export for West African nations such as Ghana and the Cote d'Ivoire and are an important source of income for local communities (figure 3). These countries are the source of more than 70 per cent of the world's cocoa.

Cacao beans are traded on the world market and their price can change daily, depending on supply and demand around the world. For example, too many beans on the world market can cause prices to drop, leaving farmers without the cash they need to cultivate their crops, and this ultimately lowers the supply. Adverse weather or tree disease can shrink supply as well.

Cacao is a **cash crop**, grown mostly in an **agroforestry** system, allowing for biodiversity and **income diversity** for families.

cash crop a crop grown to be sold so that a profit can be made, as opposed to a subsistence

agroforestry the use of trees and shrubs on farms for profit or conservation? the management of trees for forest products

income diversity income that comes from many sources

Labour

Cacao is one of the world's most labour-intensive crops. Much of the work is done by hand on a daily basis. The flowers are often pollinated by hand and defective pods are removed to allow the plant to put more energy into good ones.

Cultural factors

In Australia, chocolate Santas and Easter bunnies feature on special occasions. In many cacao-farming villages in other countries, drying the beans is done as a collective effort, with farming families gathering to turn the beans and visit with one another. In Oaxaca, Mexico, traditional healers called *curanderos* give chocolate drinks to cure bronchitis. They also plant cacao beans in the

FIGURE 3 A cacao farmer from Ghana carrying cacao pods

earth to ward off evil forces and heal those who have *espanto* — sickness caused by fright. Children drink chocolate for breakfast to ward off stings from scorpions or bees.

What is the future for chocolate?

Consumer demand for chocolate is on the rise, but the cacao tree is under threat from pests, fungal infections, climate change, and farmers' lack of access to fertilisers and other products that enhance yields. In West Africa, there are efforts to train farmers in organic, sustainable farming practices.

Global consumption is increasing, especially for darker, more cocoa-heavy varieties. Research is underway to develop hardier trees that can produce bigger yields while still making tasty chocolate. Fairtrade arrangements are improving the lives of farmers, increasing their income and helping them replace old trees and equipment.

ACTIVITIES

IDENTIFY

1 On a world map, label and name the ***places*** where cacao is grown.
2 What ***environmental*** factors suit cacao growing in the Daintree region of North Queensland?

EXPLAIN

3 Explain how world cacao bean prices can affect a cacao farmer's income.
4 Explain the significance of chocolate in different cultures throughout the world.

INVESTIGATE

5 Research an example of a ***sustainable*** growing method, such as shade cacao farming.
6 Investigate the industry assistance being given to cacao farmers, such as the Farmer Field Schools and the Cocoa Livelihoods Program.
7 Research the phenomenon of Fairtrade and how this operation has enabled the ***sustainability*** of cacao in many ***places*** in the world.

APPLY

8 Open Google Earth and select the Fairtrade Certified checkbox within the Global Awareness layer.
   a Investigate a number of cocoa cooperatives on different continents.
   b Describe the ***scale*** of these cooperatives and their importance to their countries. Where is their cocoa sold?
   c The idea of Fair Trade can benefit both farmers and the ***environment*** by promoting ***sustainable*** farming. After reading about the work of the cooperatives, consider whether the prices that farmers sell their cocoa for are fair.
9 Should money be spent on research to produce hardier cacao trees with bigger yields just to satisfy the chocolate desires of the Western world? It has been suggested that there could be a crisis in chocolate production by 2020, with chocolate becoming rare and very expensive. Should money be spent on other types of agriculture?

3.12 Daly River: a sustainable ecosystem?

3.12.1 Contrasting approaches to the land

In pre-European times, Aboriginal and Torres Strait Islander people occupied the whole of Australia. Their perception of the land was that it provided sufficient resources to ensure their survival and wellbeing. Apart from fire-stick farming, their interaction with the environment had a relatively low impact on the various biomes and associated ecosystems, and was sustainable over thousands of years of occupancy.

When Europeans arrived in Australia, they thought that much of the continent was uninhabitable. They considered the land to be barren, hostile and unable to provide enough resources to ensure adequate food supplies and human survival.

Traditional Aboriginal people were nomadic, wandering over very large areas in small groups, although in coastal and well-watered regions, where food supplies were more abundant, a more sedentary lifestyle was adopted. They carried very little — usually just weapons and a few tools made of wood, stone or bone. They would seek shade under trees during the hottest part of the day and used campfires and blankets of tree bark to keep warm at night. Their hunting and gathering skills ensured an abundant supply of food and water. Aboriginal people divided their year into seasons that were determined by the weather and the available food resources associated with that weather. Use the **Daly River food calendar** weblink in the Resources tab to learn more about how Aboriginal people managed food supplies based on seasonally available resources in the Daly River area of the Northern Territory.

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Weblink
Daly River food calendar

The Daly River area

Before European settlement, the Malak Malak Aboriginal people used Daly River as a traditional meeting place for trade and ceremonies. The Malak Malak were strong defenders of their country and hunted and gathered across the whole area.

Contact with the non-Aboriginal world came late to this region when attempts were made in the 1880s to establish agriculture, pastoralism and mining.

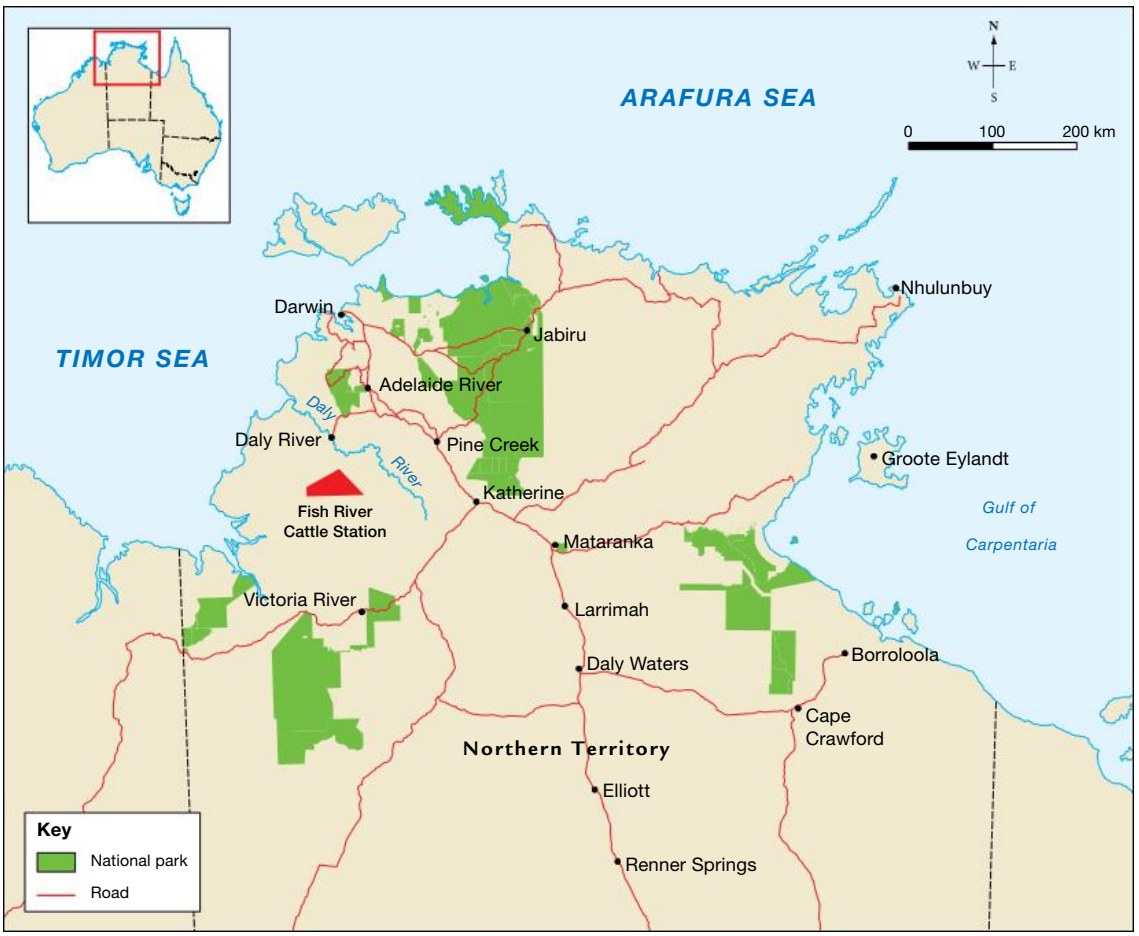
FIGURE 1 Daly River in the wet season

However, by the 1920s, the vision of crops of peanuts and tobacco came to nothing, owing to pests, native grasses, acidic soil and flooding in the wet season (figure 1), all of which made farming impossible. This was compounded by poor communication links and transport, and the fact that farm labourers were difficult to secure, unreliable and inexperienced. In 1967, the Tipperary Land Corporation cleared large tracts of land around the settlement and started growing sorghum, but their plans also came to nothing, with the whole operation being closed down in 1973. Most Aboriginal people were attached to particular farms and worked as labourers or in fishing and crocodile-shooting enterprises. Many moved to nearby towns and communities or combined their traditional lifestyle with modern technology.

Fish River Station

The Fish River cattle station (180 000 hectares) is on the Northern Territory's Daly River. Its isolation had previously made ranching difficult, and the local biomes, habitats and ecosystems were largely untouched (figure 2).

FIGURE 2 Daly River is the name of a river and a town in the Northern Territory.



Source: Spatial Vision

The station has recently been handed back to the traditional owners by the Indigenous Land Council and the Pew Environment Group to foster cultural and sustainable economic development. The Indigenous owners will be able to generate income through programs such as fencing, cultural site protection, weed eradication, plant and animal surveys, feral animal eradication, soil conservation, and regeneration of threatened flora and fauna species. The plan will combine science with traditional knowledge (figure 3) to encourage biodiversity and will find ways to pass this knowledge to future generations.

FIGURE 3 Fish River Station rangers Desmond Daly and Jeff Long patrol 178 000 hectares of land.

ACTIVITIES

IDENTIFY

1 When was significant contact with Europeans established in the Daly River area of the Northern Territory?
2 Why was the Fish River Station given back to the traditional Aboriginal owners?

EXPLAIN

3 Describe the traditional nomadic way of life of Australian Aboriginal people. How does it differ from yours?
4 Why would the seasonal ***changes*** in availability of food be an important part of traditional Aboriginal knowledge of their land and its food supplies?

INVESTIGATE

5 What are the features of the biomes found in the Daly River area? Describe some of their characteristics.
6 Litchfield National Park is close to the Daly River. Find out why this park has been set up in that area.

PREDICT

7 How might the re-establishment of native flora and fauna improve the ecosystems of the Daly River area and enhance their ***sustainability***?
8 How could tourism on the Fish River Station help with its economic development?

APPLY

9 Use the **Daly River food calendar** weblink in the Resources tab. What are the similarities and differences between modern food consumption and that shown in the Daly River seasonal calendar?
10 The United Nations has established a body called the Food and Agriculture Organization. Explain why this organisation would be important in managing agriculture now and in the future.
11 Find out more about the Indigenous Land Corporation, Northern Land Council and the Pew Environment Group.
12 Use the **Food and Agriculture Organization** weblink in the Resources tab to investigate the idea of biodiversity through sustainable food production.

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Weblink

- Daly River food calendar
- Food and Agriculture Organization

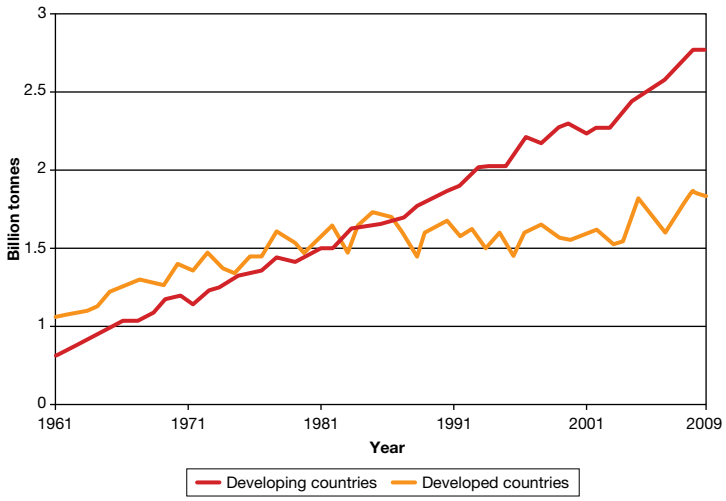
3.13 Review

3.13.1 Review

Global food crops

1. Refer to figure 1. Describe how the production of food crops has ***changed*** over time for developing and developed countries in the world. What reasons can you suggest for the difference between the two regions?
2. a. What was the 'Green Revolution'?
   b. How has the 'Green Revolution' intensified crop production, especially in the developed world?
3. Why have some types of crops been able to ***sustainably*** increase their yield but use less land to grow?
4. Rice can be grown under a number of ***environmental*** conditions. What reasons can you give for it not being grown around the world to the same levels of production in Asian regions?
5. a. What regions of the world grow cacao?
   b. What are the economic benefits of growing cacao in developing countries?
   c. The ***environmental*** conditions in north Queensland are ideal to grow cacao. If Queensland farmers decided to increase their production of cacao what would be the impacts for farmers in other countries?
6. Cacao trees must be grown in the shade of other trees, such as banana trees, palms and rubber plants. What might be the advantages and disadvantages of this to a cacao farmer?
7. Explain why, with a choice of 50 000 edible plants, people have come to rely on only a small group of staple food crops. Refer to subtopic 3.3 to help you.
8. Keep a diary of the food that you have eaten for a week and identify where these food items might have been grown in Australia. Refer to subtopic 3.7 for additional information about farm types in Australia.

FIGURE 1 World production of major crops, 1961–2009



Source: Food and Agriculture Organization of the United Nations, 2011, *Save and grow: A policymaker's guide to the sustainable intensification of smallholder crop production*, http://www.fao.org/ag/save-and-grow/en/1/index.html.

Griffith case study

Refer to subtopic 3.8 to answer the following questions.

9. What aspects of the Australian ***environment*** would John Oxley have found different from the English countryside?
10. What has been the key to the agricultural success of the Griffith region?
11. Refer to figure 3 in subtopic 3.8 (see doc-20446 in the Resources tab). In what ways has the environment been modified for farming in this area?
    a. What is the highest point on this map? Give the grid reference and elevation.
    b. What is the main land use at higher elevations?
    c. Why is this area not used for farming?
12. What are the requirements needed for growing (a) grapes and (b) oranges? Conduct research to find the types of irrigation methods used and why.
13. Why is the Griffith region suitable for rice farming?

3.13.2 Reflect

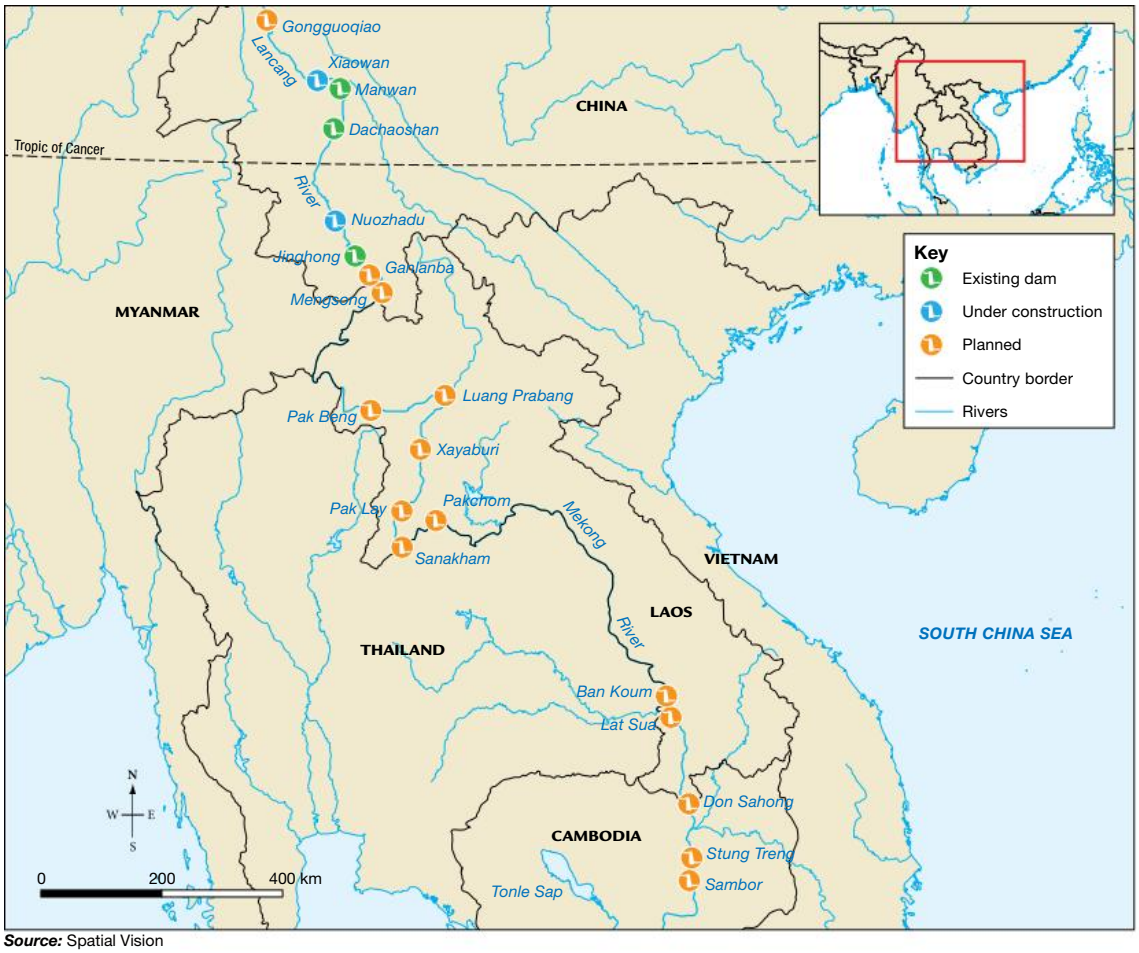
Tonle Sap lake and floodplains

Tonle Sap of Cambodia is classified as a Biosphere Reserve, and is the largest freshwater body in South-East Asia. It is home to one of the world's largest freshwater fisheries and, when combined with associated rice fields, it provides most of the staple food of Cambodia. The lake produces over 400 000 tonnes of fish — two-thirds of Cambodia's annual fish catch. Rich biodiversity, abundant

sediments and nutrient inflows from the Mekong River makes Tonle Sap and its floodplain biome one of the most productive inland fisheries and rice-producing areas in the world.

However, in the past decade, the fish catch at Tonle Sap has dwindled significantly. It is feared that the lake is losing its attributes due to overfishing and changes to the river floodplain biome. Over 70 per cent of Tonle Sap's water comes from the Mekong River, and it is possible that this inflow is being compromised by the construction of dams (see figure 2).

FIGURE 2 Dams on the Mekong River



Source: Spatial Vision

FIGURE 3 Manwan Dam, China

14. A number of dams have been planned or have already been built on the Mekong River as shown in figures 2 and 3. Use the **International Rivers** and **Mekong Times** weblinks in the Resources tab to find out more about the dams on the Mekong River and answer the following questions.
    a. Locate Tonle Sap on the map in figure 2. What are some changes you can predict for this biome from the additional dams planned along the Mekong River?
    b. What are some ways in which the damming of the Mekong can potentially affect food production?
    c. Why might Cambodia and Vietnam have the 'worst deal' in gaining water from the Mekong River?
15. Study the diagram in figure 4, showing the Tonle Sap floodplain biome, ecosystem and general ***environment***.
    a. Describe the vegetation and crop structure from the lake to the evergreen/dry forest, and give reasons for the location of the settlements and the rice fields.
    b. The floodplain adjacent to the lake is an important breeding ground for fish and crustaceans in the wet season. What ***changes*** occur to the breeding grounds for fish and to the rice-producing areas when waters from the Mekong River arrive? How would this ***change*** or help in the production of food sources from fisheries and rice crops?
    c. What parts of the Tonle Sap floodplain biome would ***change*** if water from the Mekong River was lost due to dam construction? How would this affect seasonal production from rice fields and fisheries and their general ***sustainability*** as a form of agriculture?

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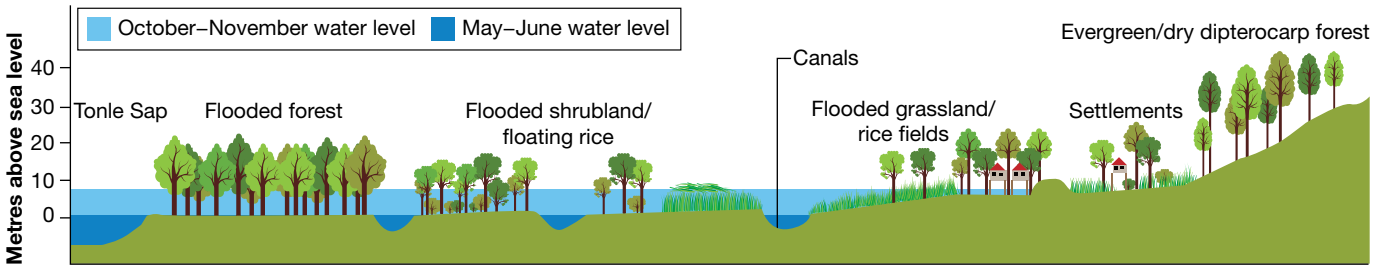
Weblink
- International Rivers
- Mekong Times

FIGURE 4 Diagram illustrating the Tonle Sap floodplain



Global food crops

16. Should we be concerned about future food crop supplies, or is this a problem for future generations?
17. Should farmers planting food crops be concerned about the ***sustainability*** of the ***environment***, or only about economic factors?
18. *The Green Revolution was responsible for producing higher-yielding varieties of wheat, rice and maize. It relied on crops being grown with high levels of irrigation, fertilisers and pesticides. These often replaced natural resources; for example, fertilisers replaced soil quality management, while herbicides provided an alternative to crop rotations as a means of controlling weeds.*
    Evaluate these ideas, suggesting whether these strategies would be implemented if the Green Revolution had been introduced in the twenty-first century.
19. In the cacao industry, children often contribute positively to the household income by helping out on the family farm in appropriate work that does not jeopardise their health or education. Unfortunately, also, child labour remains widespread in the cacao sector, with a quarter of children aged between 5 and 17 living in cacao-growing regions involved in its production, mainly on family farms or working with parents. Most of these children are exposed to hazardous conditions, using dangerous tools and carrying heavy loads, with 51 per cent reporting injuries while at work. Should we, in Australia, be concerned about this? What could we do? How is Fairtrade helping to ***change*** this child labour market?
20. Is it the duty of nations with food surplus to be responsible for feeding the world? Think carefully about the consequences if food aid to nations with food shortages does not occur.
21. What can we learn from the agricultural practices of indigenous people around the world in the way they produce their food (for example: Aborigines and Torres Strait Islanders, the San and Bedouins)?

The fertile Scarca Valley in the Italian Alps, modified for agriculture

CHAPTER 4

Changing biomes

4.1 Overview

4.1.1 Introduction

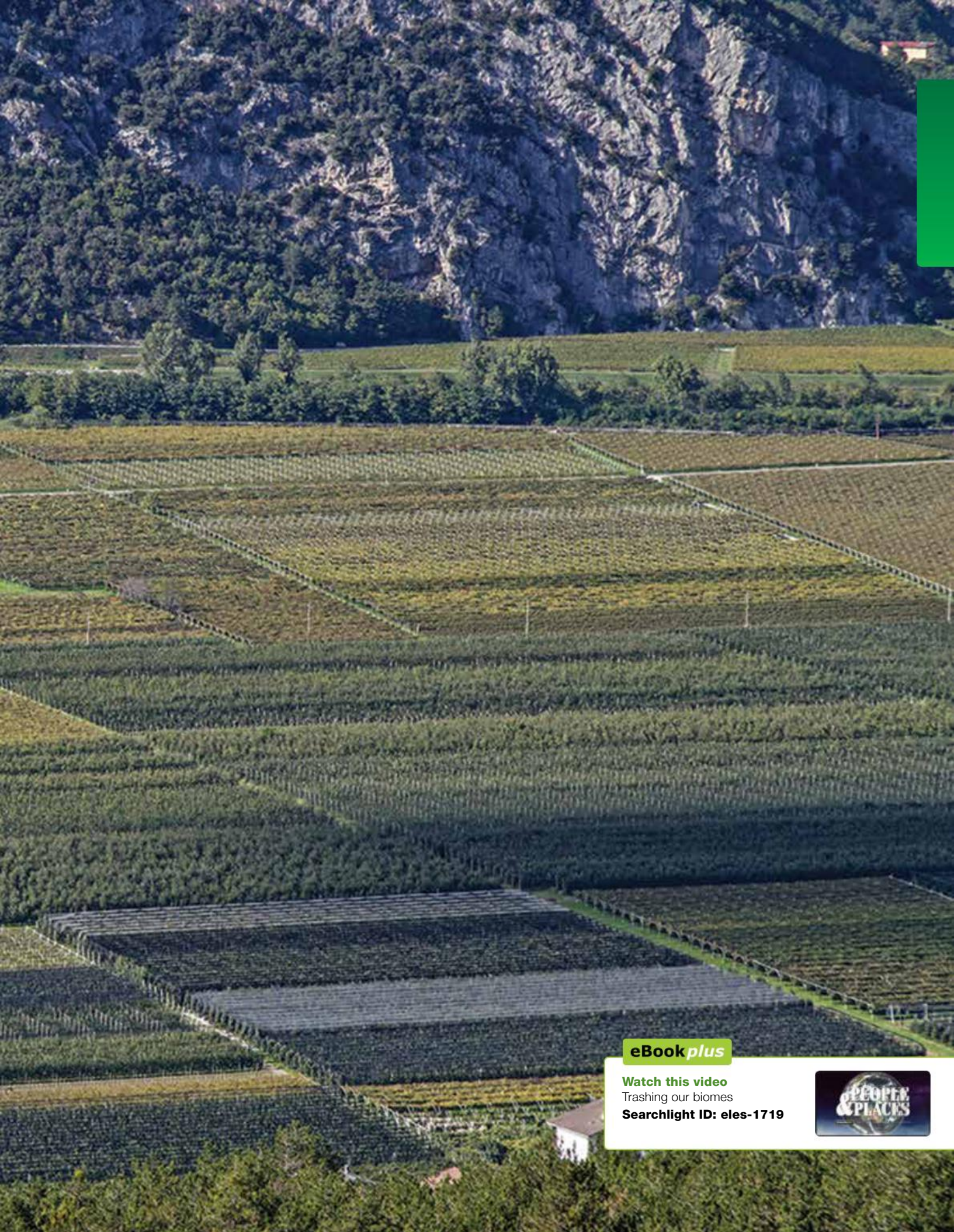
Food is essential to human life, and over the past centuries we have been able to produce more food to feed our growing population. While technology has enabled us to increase production, it has come at a price. Large-scale clearing of our forests, the overfishing of our oceans, and the constant overuse of soils has resulted in a significant decline in our biophysical world.

Starter questions

1. How can feeding the world be destroying the world?
2. Do you know where your food comes from?
3. What food items do you eat most of within a typical day? Are they animal-based, plant-based or fish-based?
4. Do you or your family grow any of your own food?
5. Use an online mapping program such as Google maps, and choose the satellite view over Mackay, Queensland. Discuss with your class what has happened to the ***environment*** around Mackay. What is the main crop being grown in this region?

Inquiry sequence

	Syllabus outcomes
4.1 Overview	
4.2 How does producing food affect biomes?	GE5-2
4.3 How are biomes modified for agriculture?	GE5-2
4.4 Where have all the trees gone?	GE5-2
4.5 Investigating topographic maps: How has the Riverina region been changed to produce food?	GE5-2, GE5-7
4.6 SkillBuilder: GIS – deconstructing a map eBook plus ONLINE ONLY	GE5-3, GE5-7
4.7 Paper profits, global losses?	GE5-2
4.8 Should we farm fish?	GE5-2
4.9 SkillBuilder: Interpreting a geographical cartoon eBook plus ONLINE ONLY	GE5-3, GE5-7
4.10 What impacts does farming have on the lithosphere?	GE5-2
4.11 How does irrigation change the environment?	GE5-2
4.12 How is the hydrosphere altered by farming?	GE5-2
4.13 How does agriculture diminish biodiversity in biomes?	GE5-2
4.14 What impact does farming have on the atmosphere?	GE5-2
4.15 Review eBook plus ONLINE ONLY	
Key terms eBook plus ONLINE ONLY	



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Watch this video
Trashing our biomes
Searchlight ID: eles-1719

4.2 How does producing food affect biomes?

4.2.1 What is our biophysical world?

Biomes are created by the interactions of the four spheres of the **biophysical environment**. A change in any of the spheres will impact the others at varying levels. The large-scale production of food requires modifications to the environment and as a consequence, biomes have been impacted.

biophysical environment all elements or features of the natural or physical and the human or urban environment including the interaction of these elements; made up of the Earth's four spheres — the atmosphere, biosphere, lithosphere and hydrosphere

Planet Earth is made up of four spheres: the atmosphere, lithosphere, hydrosphere and biosphere (see figure 1).

All these spheres are interconnected and make up our biophysical or natural environment. For example, rain falling from a cloud (atmosphere) may soak into the soil (lithosphere) or flow into a river (hydrosphere) before being taken up by a plant or animal (biosphere) where it may be evaporated and returned to the atmosphere.

Natural events, such as storms or earthquakes, or human activities can create changes to one or all of these spheres. The production of food, whether from the land or sea, has the potential to change the natural environment and, in doing so, increases the likelihood of food insecurity. Table 1 shows how food production can affect the biophysical world.

FIGURE 1 The Earth's four spheres

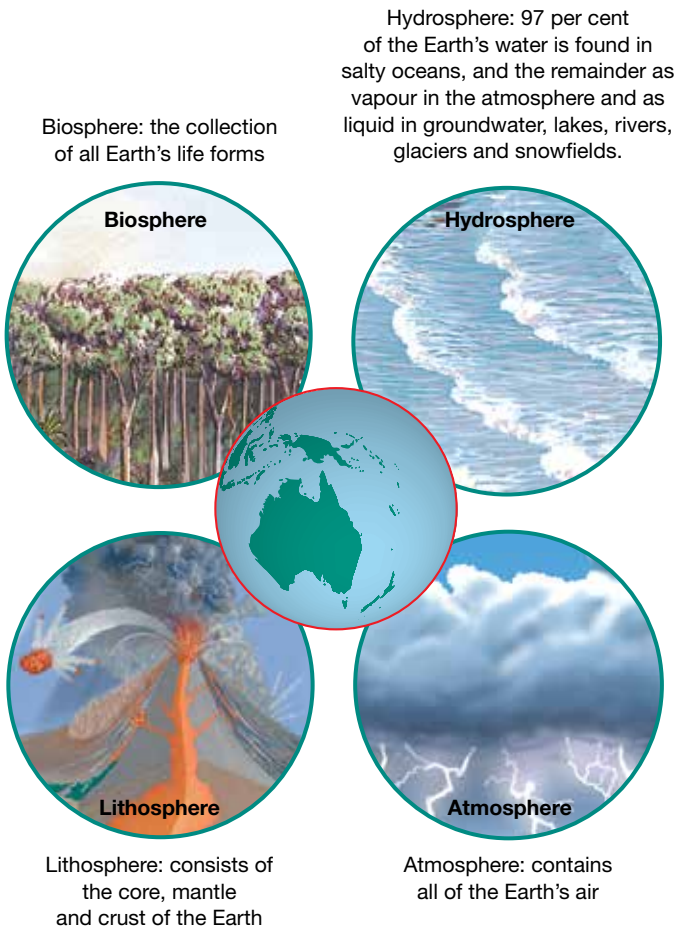


TABLE 1 How food production affects the biophysical world

Activities	Atmosphere	Lithosphere	Biosphere	Hydrosphere
Clearing of native vegetation for agriculture	x	x	x	x
Overgrazing animals		x	x	x
Overusing irrigation water, causing saline soils		x	x	x
Burning forests to clear land for cultivation	x	x	x	x
Run-off of pesticides and fertilisers into streams		x	x	x
Producing greenhouse gases by grazing animals and rice farming	x			
Changing from native vegetation to cropping		x	x	x
Withdrawing water from rivers and lakes for irrigation	x	x	x	x
Overcropping soils		x	x	x
Overfishing some species			x	

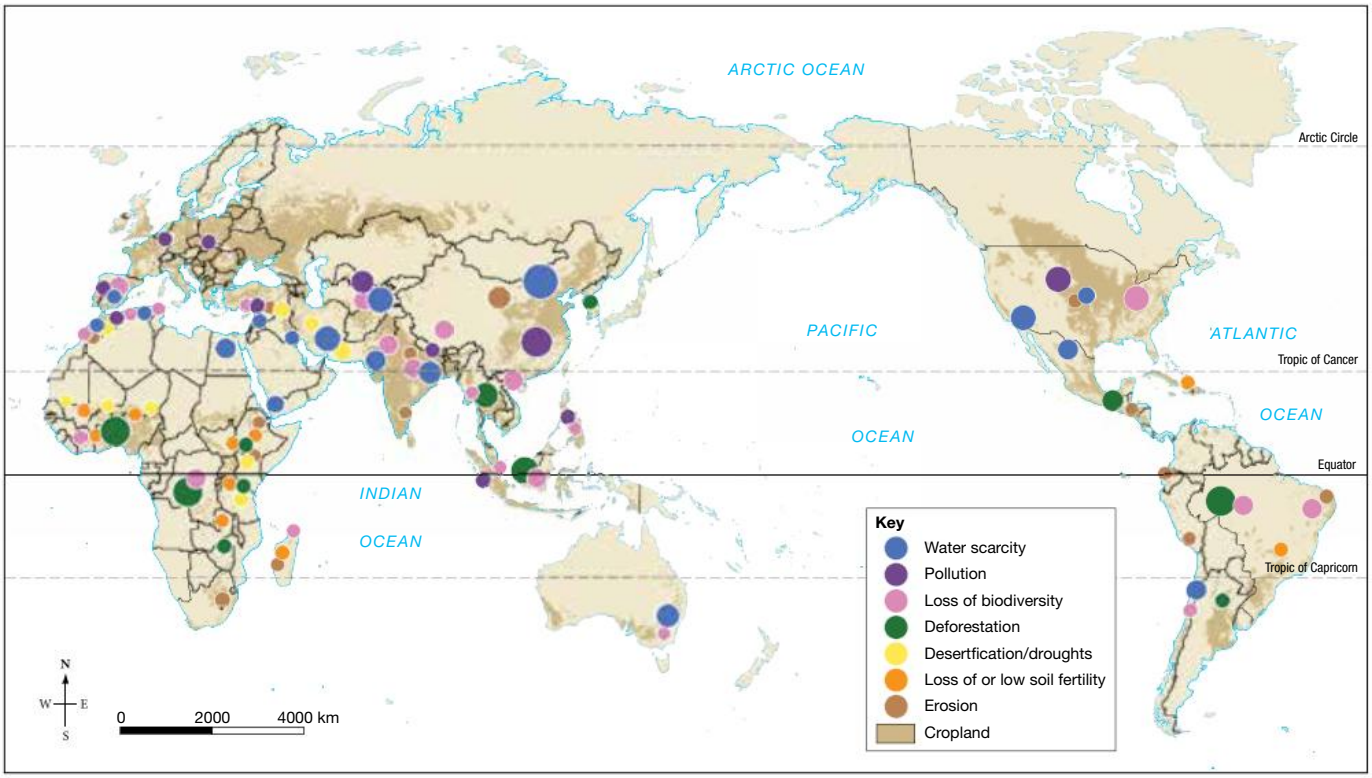
4.2.2 What has happened to our biophysical world?

Between 1961 and 2008, the world's population increased by 117 per cent, or by 3.5 billion, while food production increased by 179 per cent. This has been the result of improved farming methods; the increased use of fertilisers and pesticides; large-scale irrigation; and the development of new technologies, ranging from farm machinery to better quality seeds.

There have been many benefits associated with this change, especially in terms of human well-being and economic development. However, at the same time, humans have changed the Earth's biomes more rapidly and more extensively than in any other time period. The loss of biodiversity and **degradation** of land and water (which are essential to agriculture) are not sustainable. With an expected population of nine billion in 2050, it has been estimated that food production will need to increase by approximately 70 per cent. The global distribution of environmental risks associated with food production can be seen in figure 2.

degradation deterioration in the quality of land and water resources caused by excessive exploitation

FIGURE 2 State of the world's land and water resources for food and agriculture



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 Describe the spheres of the biophysical ***environment***.
2 Why has food production increased so rapidly over time?

EXPLAIN

3 Referring to figure 1, explain how ***change*** in one sphere of the biophysical ***environment*** could impact the other spheres.
4 Select one example from table 1. Describe how human activity can ***change*** the biophysical world.
5 Refer to figure 2 and your atlas.
  a What are the main ***environmental*** issues facing Australia's food production?
  b In which ***places*** in the world is deforestation a major concern?
  c Which continents suffer from water scarcity?
  d What do you notice about the location and distribution of regions that do not have ***environmental*** problems relating to food production?

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Interactivity
Degrading our farmland
Use this interactivity to investigate impacts of agriculture around the world.
Searchlight ID: int-3323

INVESTIGATE

6 Select one agricultural product in Australia and conduct research to find data on how much is produced and how this has ***changed*** over time.

APPLY

7 Use the following labels to create a flow diagram showing how the clearing of native vegetation can affect all four of the Earth's spheres.

- Soil left bare and exposed to wind and water erosion
- Less evaporation of water from vegetation
- Loss of habitat for birds, animals and insects
- Increased water runs off from exposed land
- Increased sediment builds up in streams

4.3 How are biomes modified for agriculture?

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Interactivity
Changing nature
Use this interactivity to further your understanding of how we change environments to produce food.
Searchlight ID: int-3321

4.3.1 How do we use technology for food production?

Throughout the twentieth century rapid population growth and the development of new technologies allowed for larger scale agriculture to occur. To accommodate the increase in size and amount of farms to grow crops and graze animals, biomes were altered to meet the higher production demands. In general, the focus of agriculture is to modify water, climate, soils, land and crops.

4.3.2 How do we modify climate?

Irrigation is the artificial application of water to the land or soil to supplement natural rainfall. It is used to assist in the growing of agricultural crops to increase food production in dry areas and during periods of inadequate rainfall.

In flood irrigation, water is applied and distributed over the soil surface by gravity. It is by far the most common form of irrigation throughout the world, and has been practised in many areas, virtually unchanged, for thousands of years.

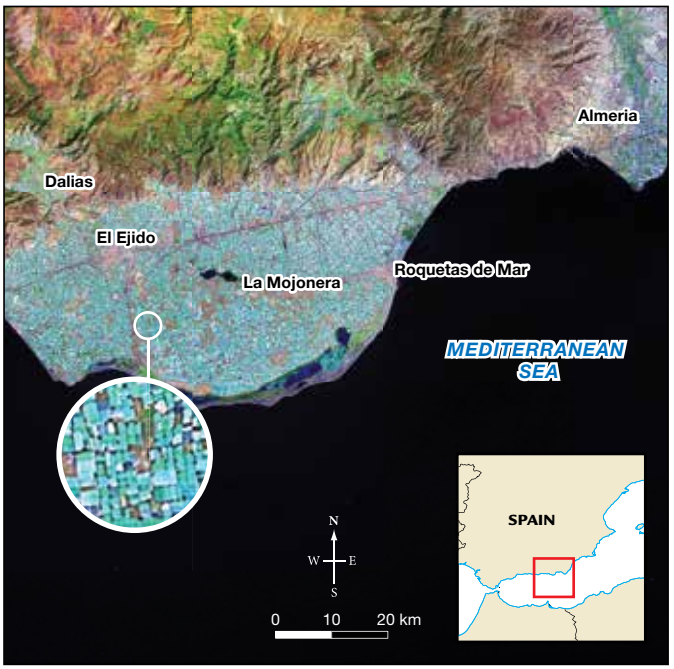
Modern irrigation methods include computer-controlled drip systems that deliver precise amounts of water to a plant's root zone.

Another way of modifying climate is with the use of greenhouses (or glasshouses) used for growing flowers, vegetables, fruits and tobacco (see figure 2). Greenhouses provide an artificial biotic environment to protect crops from heat and cold and to keep out pests. Light and temperature control allows greenhouses to turn non-arable land into arable land, thereby improving food production in marginal environments. Greenhouses allow crops to be grown throughout the year, making them especially important in high-latitude countries.

The largest expanse of plastic greenhouses in the world is around Almeria, in south-east Spain. Here, since the 1970s, semi-arid pasture land has been replaced by greenhouse **horticulture** (see figures 1 and 2). Today, Almeria has become Europe's market garden. To grow food all year round, the region has around 26 000 hectares of greenhouses.

horticulture the practice of growing fruit and vegetables

FIGURE 1 False-colour satellite image of greenhouses in the Almeria region.



Source: American Geophysical Union and Google Maps.

FIGURE 2 Inside an Almerian greenhouse

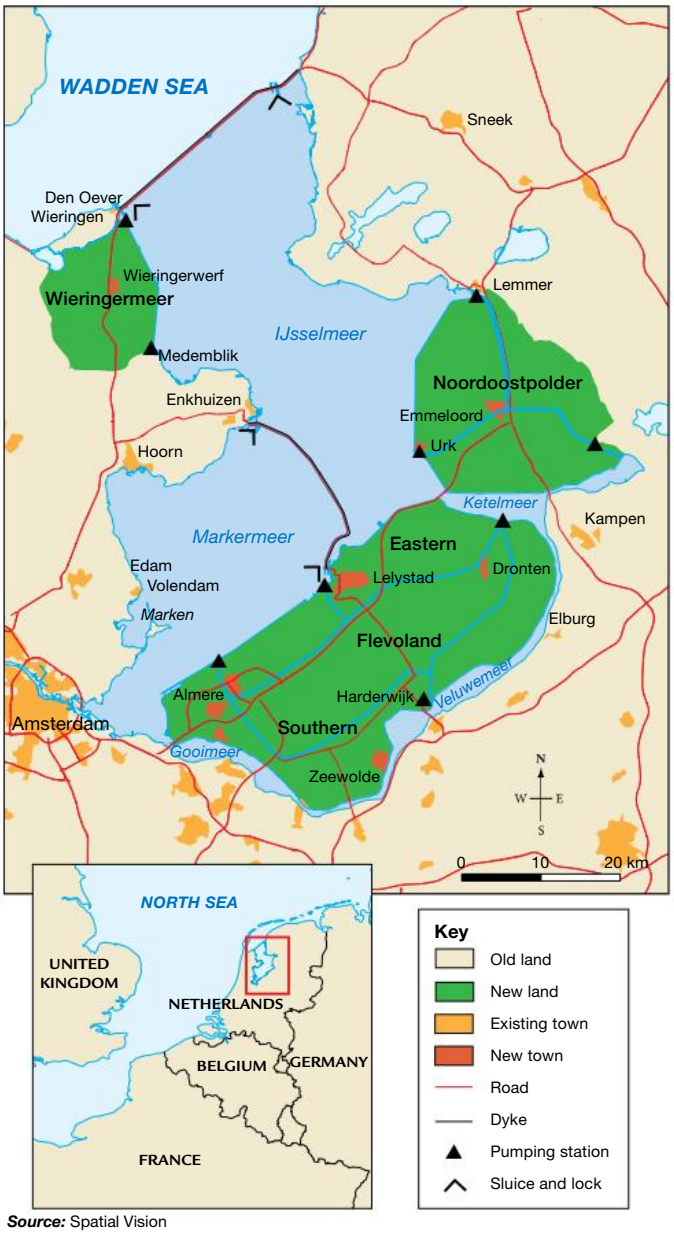
4.3.3 How do we modify soils?

Fertilisers are organic or inorganic materials that are added to soils to supply one or more essential plant nutrients. Fertilisers are essential for high-yield harvests, and it is estimated that about 40 to 60 per cent of crop yields are due to fertiliser use. It is estimated that almost half the people on Earth are currently fed as a result of adding fertiliser to food crops.

4.3.4 How do we modify landscapes?

People change landscapes in order to produce food. **Undulating** land can be flattened, steep slopes terraced, or stepped, and wetlands drained. Land reclamation is the process of creating new land from seas, rivers or lakes. In addition, it can involve turning previously unfarmed land, or degraded land, into arable land by fixing major deficiencies in the soil's structure, drainage or fertility.

In the Netherlands, the Dutch have tackled huge reclamation schemes to add land area to their country. One such scheme is the IJsselmeer (see figure 3), where four large areas (*polders*) have been reclaimed from the sea, adding an extra 1650 square kilometres for cultivation. This has increased the food supply in the Netherlands and created an overspill town for Amsterdam.



Source: Spatial Vision

FIGURE 3 Land reclamation in the Netherlands

undulating describes an area with gentle hills

ACTIVITIES

IDENTIFY

1 Describe irrigation and how it is an agricultural method that modifies climate.

2 Describe how soils are modified and how undulating land is ***changed*** for agriculture.

EXPLAIN

3 Explain how land reclamation affects aquatic biomes.

INVESTIGATE

4 Research the land reclamation project in Ijsselmeer (Zuiderzee Works) and create a report that outlines the scope of the project.

PREDICT

5 Refer to figures 1 and 2. How do greenhouses modify ***spaces*** and ***places*** on the Earth's surface?

6 Refer to figure 3. What might be the purpose of the pumping station?

APPLY

7 Refer to figure 3. Use the ***scale*** to calculate the approximate area of new land created in Flevoland.

4.4 Where have all the trees gone?

4.4.1 Why are forests important?

Thirty per cent of the world's land surface is covered in forest. This is nearly one-third less than existed in prehistoric times, when humans did not have the technology to fell trees in large numbers. Large-scale deforestation has occurred as the need for timber products and land for food has increased over time. In the decade from 2000 to 2010, over 13 million hectares of forest were cleared each year. Cultivated land now covers one quarter of the Earth's land surface.

Forest biomes offer us many goods and services, ranging from wood and food products, to supporting biological diversity. They provide habitat for a wide range of animals, plants and insects. Forests contribute to soil and water conservation, and they absorb greenhouse gases.

4.4.2 Why do we clear forests?

By clearing forests, valuable trees can be harvested for timber and paper production, while mining ores and minerals can be accessed below the Earth's surface. Sometimes, forests are flooded rather than cleared in order to construct dams for hydroelectricity. Forests may also be cleared for food production, such as small-scale **subsistence** farming, large-scale cattle grazing, for **plantations** and crop cultivation. Figure 1 illustrates the main causes of **deforestation** in the Amazon rainforest.

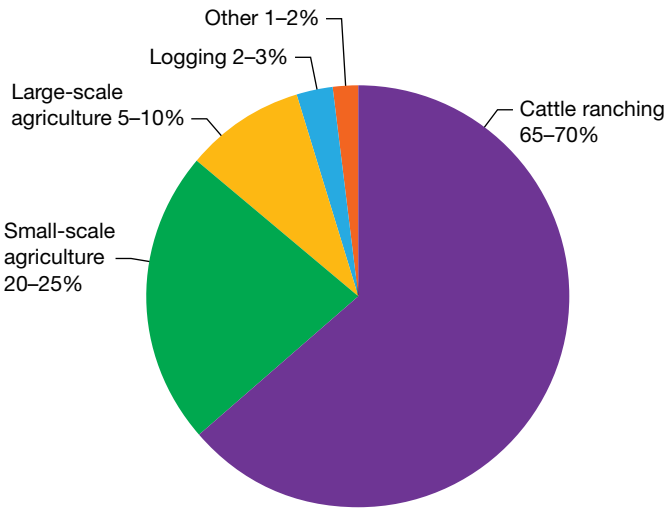
subsistence describes farming that provides food only for the needs of the farmer's family, leaving little or none to sell

plantation an area in which trees or other large crops have been planted for commercial purposes

deforestation clearing forests to make way for housing or agricultural development

Road construction, usually funded by governments, also plays a part in changing rainforest environments (see figure 2). Roads help to improve access and make more land available, especially to the landless poor. They also reduce population pressures elsewhere by encouraging people to move to new places. At the same time, businesses benefit from improved access to mine resources and forest timbers, and are better able to establish large cattle ranches and farms.

FIGURE 1 Main causes of deforestation in the Brazilian Amazon, 2000–05

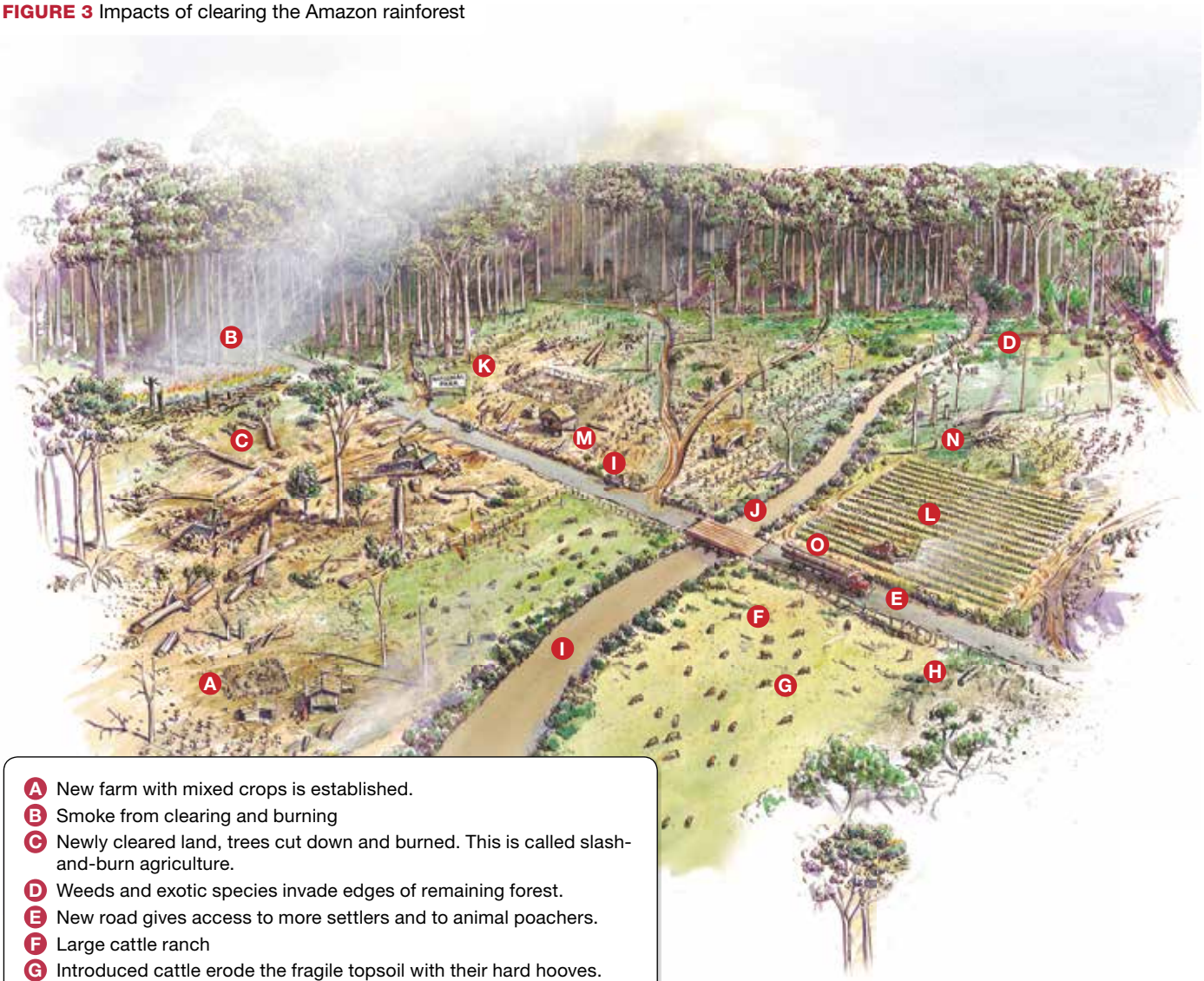


4.4.3 What happens when forests are cleared?

Figure 3 illustrates some changes that forest clearing in the Amazon can have on the environment.

FIGURE 2 The effects of road building in the Amazon. Settlements tend to follow a linear pattern along the roads and then gradually move inland, opening up the forests.

FIGURE 3 Impacts of clearing the Amazon rainforest



- A New farm with mixed crops is established.
- B Smoke from clearing and burning
- C Newly cleared land, trees cut down and burned. This is called slash-and-burn agriculture.
- D Weeds and exotic species invade edges of remaining forest.
- E New road gives access to more settlers and to animal poachers.
- F Large cattle ranch
- G Introduced cattle erode the fragile topsoil with their hard hooves.
- H Erosion of topsoil increases, caused by rain on exposed soils.
- I The river carries more sediment as soil is washed into streams.
- J Flooding increases as stream channel is clogged with sediment.
- K Fences stop movement of rainforest animals in search of food.
- L Pesticides and fertilisers wash into river.
- M Farm is abandoned as soil fertility is lost.
- N Weeds and other species dominate bare land.
- O Harvesting of timber reduces forest biodiversity.

FOCUS ON FIELDWORK

Remote sensing

Remote sensing is a high-tech and sophisticated method of collecting data by geographers, in which data is collected without their being physically present in the field. Common forms of remote sensing equipment that geographers utilise are weather instruments, satellites or aircraft, which scan the Earth to collect information about it (figure 4).

Remote sensors are classified as passive or active. Passive sensors collect data from external energy, such as heat or light, which is reflected off various surfaces. Many satellite images, such as Landsat images, are passive as they respond to light frequencies that reflect off Earth. This sensor detects the different light waves that are emitted from vegetation, so geographers can observe changes in vegetation. They use a false-colour image to show an object in colours that are different from the true-colour image in a photograph. Figure 5 shows a Landsat image that uses false colours; cleared land is in the false colour of violet.

FIGURE 4 Remote sensing satellites and aircraft

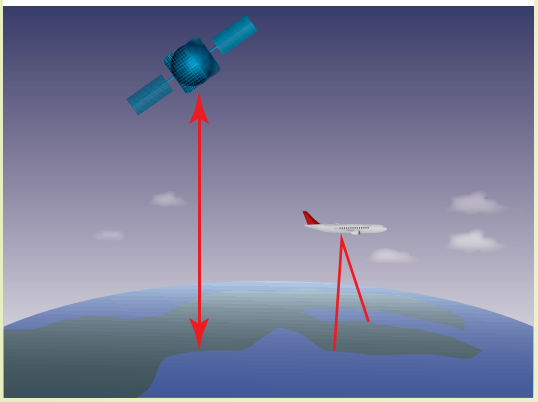
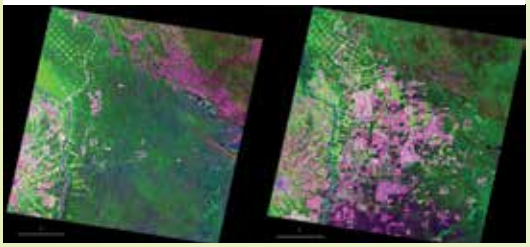


FIGURE 5 Bolivia Deforestation II Sensor: L5 TM acquisition date: July 2, 1986 and June 22, 2000. These images show the progression of deforestation in Bolivia from 1986 to 2000, caused by resettling people and agricultural development.



Active sensors, on the other hand, send energy, sound or light to the surface to collect data about Earth. Light Detection and Ranging (LIDAR) sends a laser beam to the surface of Earth and measures the time for the laser to reflect back to the sensor. This type of sensor is often used to measure the topography of an area (figure 6).

In more recent times, geographers have used drones with remote sensing equipment on board

FIGURE 6 LIDAR is a remote sensing device to detect the topography of an area.

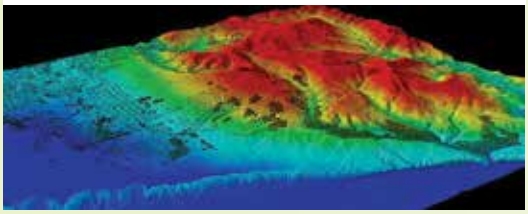


FIGURE 7 Drones are a more cost effective way for geographers to collect data in the field with remote sensing equipment.

to collect data. While still expensive, it is more cost effective than launching a satellite or using aircraft that carry people in them.

As a high-school student, access to remote sensing equipment is difficult to come by. However, Google Earth's *Historical Imaging* feature allows you to collect data about a space remotely.

1. Open Google Earth; in the View tab, make sure *Historical Imagery* is ticked. Compare satellite images of your suburb or town using the slider.
2. Identify and note any changes that are evident between the images.
3. Search for the Amazon rainforest. Compare satellite images at the edges of the forest. What changes are evident?

ACTIVITIES

IDENTIFY

1. Refer to figure 1. Describe the three main causes of deforestation in the Amazon.
2. Outline the advantages and disadvantages of road building in the Amazon.

EXPLAIN

3. Why would subsistence farming in the Amazon be referred to as 'slash-and-burn' farming?
4. Refer to figure 3. Identify two impacts of land clearing in the Amazon and explain what ***changes*** they make to the ***environment***.

INVESTIGATE

5. Research soya bean farming in the Amazon. How ***sustainable*** is it compared to cattle ranching?

PREDICT

6. Examine the illustration of rainforest destruction shown in figure 3. Draw a sketch of what you predict the area will look like in ten years' time. Use labels and arrows to show important features.

APPLY

7. Opening up the rainforest with roads can lead to fragmentation of the forest. How might this affect native animals?

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › Forest environments

4.5 How has the Riverina region been changed to produce food?

4.5.1 The Murrumbidgee Irrigation Area (MIA)

The Murrumbidgee Irrigation Area (MIA) is located within the Riverina region of New South Wales. The climate in this area is semi-arid (warm, with unreliable rainfall). The land only became productive after irrigation was available. The MIA was established in 1912 to control and divert water from local rivers and creeks to produce food. An elaborate series of weirs, canals and holding ponds, fed by upstream rivers and dams, have been established throughout the region. Today approximately a quarter of the area of MIA's 660 000 hectares is irrigated.

Irrigation water is used to produce much of the rice, citrus, walnuts, livestock, vegetables, wine, cereal crops, pulses and oilseeds in the MIA which contributes over Aus$5 billion annually to the Australian economy.

Prior to 1912, Barren Box swamp (also known as Barren Box Storage and Wetlands) was only filled with water for short periods following rain or flooding from Mirrool Creek. Once irrigation commenced, the swamp received irrigation drainage water. Excess water arriving at Willow Dam was diverted into the swamp for storage. This irrigation water was later used downstream. Today, it is the main irrigation and urban drainage water recycling point for the Murrumbidgee Irrigation Area (MIA).

FIGURE 1 Irrigation water used for grape production.

ACTIVITIES

IDENTIFY

1 Name the river which is located in the southern part of the map, near 400175.
2 Name the creek at 425203.
3 Name the swamp located at 393220.
4 Identify the types of farming at the following locations.
  a GR410200
  b GR410195
5 Identify the feature that has been constructed at the following locations to help produce food.
  a GR400215
  b GR416194
  c GR391215
  d GR400193
6 a What is the height of the land at the following locations?
  i GR425206
  ii GR420179
  iii GR399196
  b What is the lowest spot elevation on the map?
  c What is the highest spot elevation on the map?
  d How is the elevation of the land in the north-east corner of the map different from the elevation for the rest of the region?
  e How would you describe the steepness of the land shown in the majority of the area displayed on the map?

EXPLAIN

7 How is the pattern of irrigation channels and buildings in AR3919 different to the pattern of irrigation channels and buildings in AR4220?
8 How have people overcome the low and unreliable water availability in the MIA region?
9 How has the ***environmental*** factor of topography of the region been an advantage for food production in this region?
10 How has the Barren Swamp been ***changed*** to provide water for food production?

FIGURE 2 Topographic map of Griffith, New South Wales

Source: Commonwealth of Australia (Geoscience Australia).

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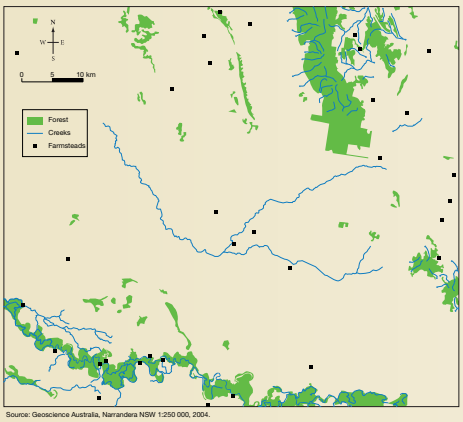
4.6 SkillBuilder: GIS — deconstructing a map

What is GIS?

A geographical information system (GIS) is a storage system for information or data, which is stored as numbers, words or pictures. GIS allows multiple series of information to be displayed in a succession of map layers. The spatial distribution of the data and the relationship to other data may be compared.



eLesson

Watch this video to learn how to understand GIS.

Searchlight ID: eles-1730

Interactivity

Try this interactivity to learn how to understand GIS.

Searchlight ID: int-3348

4.7 Paper profits, global losses?

4.7.1 How do we use paper?

pulp the fibrous material extracted from wood or other plant material to be used for making paper

Biomes enable us to produce the food we eat and they also supply many of the raw materials for manufacturing, such as minerals, ores and fibres. We are able to make cloth from cotton and wool using grassland biomes, while forest biomes give us wood for construction and **pulp** for making paper products. There are thousands of everyday items made from paper, ranging from toilet paper to disposable nappies, packaging, money, tickets and writing paper (see figure 1).

FIGURE 1 Different paper products

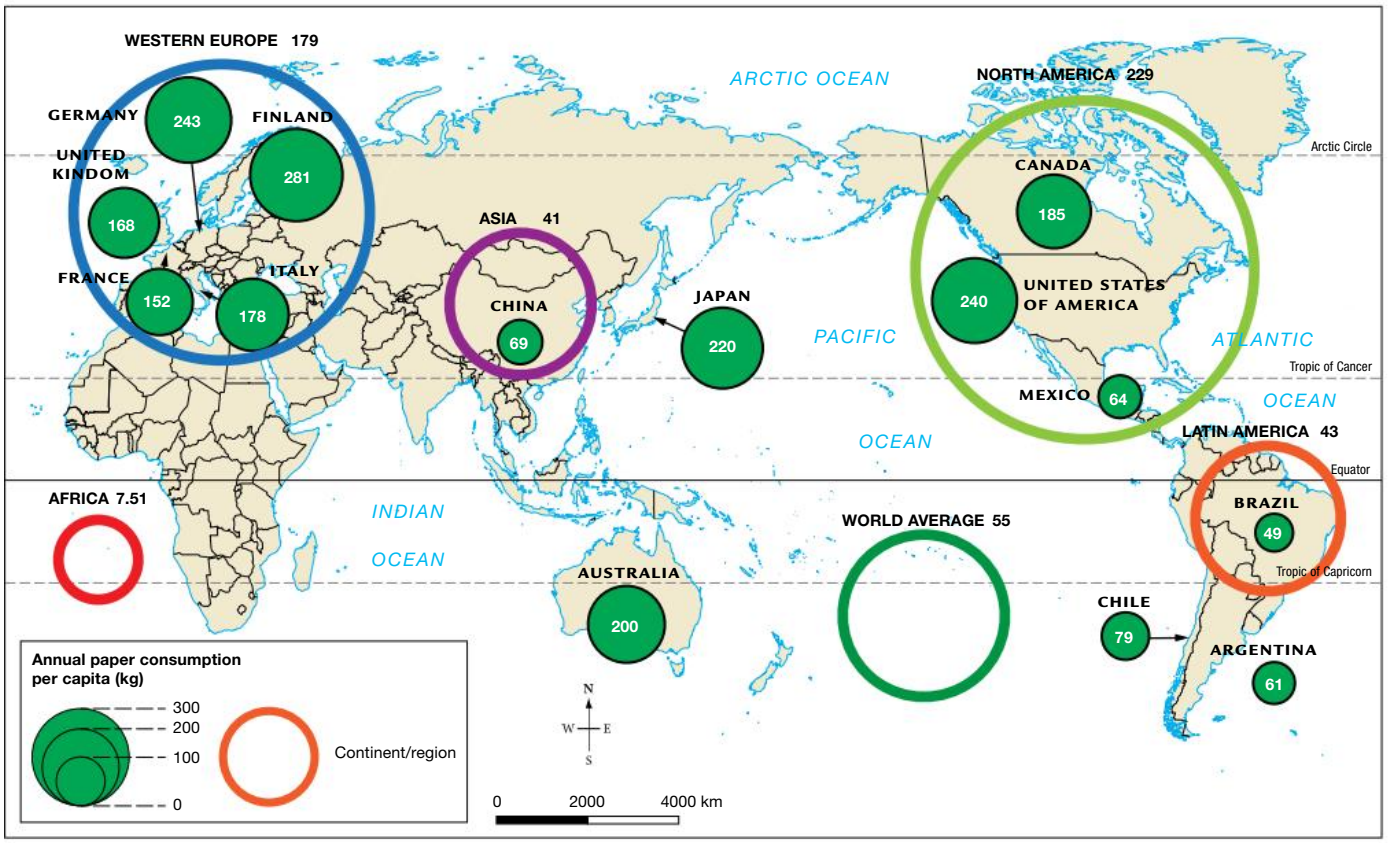
4.7.2 Are we a paperless society?

Traditionally, paper has provided us with the means to record ideas, news, knowledge and even works of art. Paper is interconnected with social development as it aids in literacy and communication. Despite the invention of modern electronic communication, plastic bags and the 'paperless office', paper still remains an essential part of our homes and workplaces.

Modern society has become very dependent upon paper products. Until recently 402.6 million tonnes of paper and cardboard was produced worldwide with China producing over 105 million tonnes (26 per cent). China consumed 100 million tonnes of paper and the USA consumed 72 million tonnes in the same year. However, per capita, the USA consumed 240 kilograms per person, whereas China consumed only 69 kilograms per person, making the United States the largest consumer of paper in the world — with five times the global average consumption (see figure 2). Australia consumed over 3.2 million tonnes of paper and cardboard and is set to increase by another 4.9 per cent by 2020.

With technological advancements, paper has now become a cheap, disposable product. This has resulted in a high level of use and waste.

FIGURE 2 Global paper footprints and annual consumption of paper



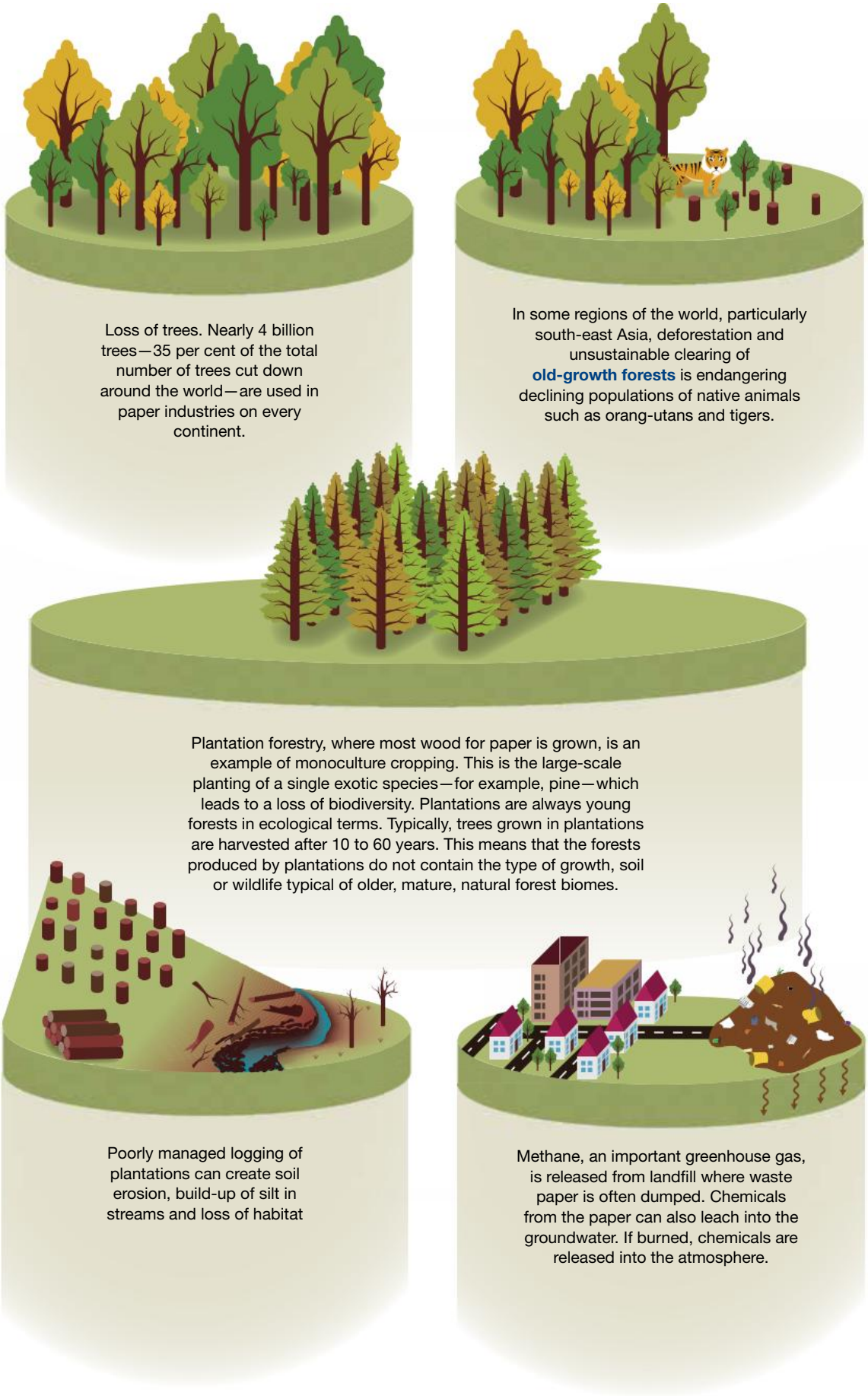
Source: Spatial Vision

4.7.3 How does making and using paper affect biomes?

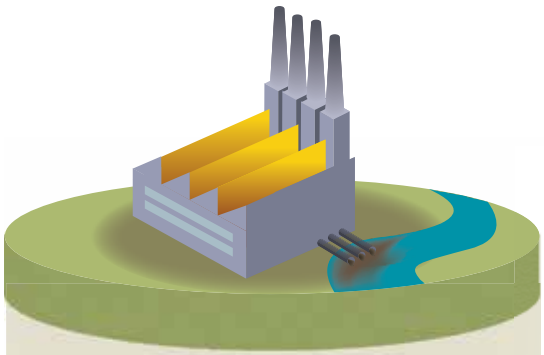
Pulp and paper production has been ranked as one of the most resource-intensive and highly polluting of all manufacturing industries. Besides wood fibre, the main inputs into the paper-making process are water, energy and chemicals needed for breaking down fibres and bleaching to create clean, white paper. The paper industry uses more water to produce one tonne of product than any other industry. It takes 10 litres of water to produce just one A4 sheet of paper.

Pulp and paper is the third largest industrial polluter of air, land and water in both Canada and the United States, releasing over 100 million kilograms of toxic waste each year. Paper's impact on biomes starts at the forest stage with the activity of logging the timber, and continues with the conversion of the timber to pulp and paper. Environmental impacts continue even after paper has been used and discarded. Today, more than 34 per cent of municipal waste in the United States is made up of paper and cardboard. Figure 3 illustrates how biomes are affected by paper production.

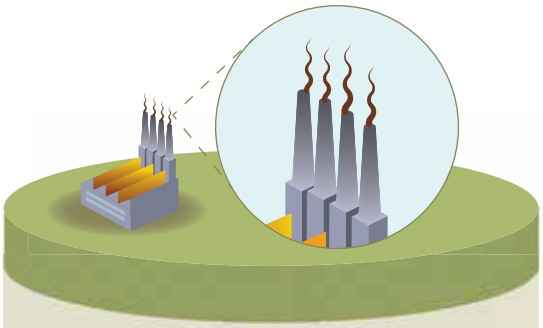
FIGURE 3
Environmental consequences of paper production



old-growth forests natural forests that have developed over a long period of time, generally at least 120 years, and have had minimal unnatural disturbance such as logging or clearing



Waste water generated from the production process includes high concentrations of chemicals such as hydrochloric acid and chlorine dioxide.



Paper production releases nitrogen dioxide and sulphur dioxide, both major contributors to acid rain, and carbon dioxide, a greenhouse gas.

FIGURE 4 Environmental effects of harvesting plantation timber

4.7.4 Is there a sustainable future for paper?

There has been an increase in environmental awareness and government legislation in recent years — this is helping to make the paper industry and people's use of paper more environmentally friendly, thus reducing the negative impacts on biomes. The Australian timber industry follows the Forest Code of Practice, which sets out rules and regulations regarding logging on slopes and protecting streams and habitat trees.

There has been considerable research conducted into the use of non-wood products, for example bamboo, sugarcane, hemp and **kenaf**, to provide fibre for paper. Currently, these non-wood products make up 7 per cent of the fibre used in paper-making globally.

kenaf plant in the hibiscus family that has long fibres useful for making paper, rope and coarse cloth

In some places, tree plantations are able to grow on land that is unsuitable for other forms of agriculture or is badly degraded, in which case there is likely to be an *increase* in habitat and biodiversity.

For the paper industry, the goals are to reduce fuel and energy requirements and reduce emissions. China, with its relatively new paper industry, is leading the way in this field. For everyday citizens, it is about making sensible choices, reducing our use of paper and recycling (see figure 5). Products made from recycled paper can include masking tape, hospital gowns, bandages, egg cartons and even lampshades. However, paper can be recycled only 5 to 7 times, after which the fibres become too short and weak to bond together.

FIGURE 5 Paper recycling factory

For every tonne of paper *not* consumed, the following savings are made;

- 18 trees
- 67 500 litres of water
- 9500 kilowatt hours of power
- 3300 kilograms of greenhouse gas emissions.

How can you and your classmates reduce your paper consumption?

eBookplus

Weblink
Paper production

ACTIVITIES

IDENTIFY

1 a Construct a list of the 10 most important paper items in your daily life.
b What are the similarities and differences?
c Using an online word cloud generator, create a class word cloud from everybody's lists to see what the most common answers are.
2 Refer to figure 2. List the top six, per capita, paper consumers in the world.
3 Refer to figure 4. List the ***environmental*** effects of clearing a pine plantation that you can see in this photograph.

EXPLAIN

4 Refer to figure 2. Compare the paper consumption of countries in Europe with that of countries in Asia. Use figures in your answer.
5 To what extent is there a link between a country's level of development and its consumption of paper? Note, you may wish to consult the World Statistics in your atlas.
6 What is old-growth forest? Why is it important to protect these types of biomes from being cleared?
7 How might the structure and biodiversity be different in an old-growth forest compared with a tree plantation?

INVESTIGATE

8 Use the **Paper production** weblink in your eBookPLUS and study the interactive map. Create a list of some of the ***environmental*** concerns of paper production in Asia, Latin America and Russia.

APPLY

9 Is there such a thing as a paperless society? What are some ways this could be achieved?
10 Does your school have a paper recycling program? How effective do you think it is? Suggest ways in which it could be improved.

4.8 Should we farm fish?

4.8.1 Why are we overfishing?

The ocean biome has always been seen as an unlimited resource of food for humans. In fact, overfishing is causing the collapse of many of our most important marine ecosystems, and threatens the main source of protein for over one billion people worldwide. Aquaculture is a possible solution but, at the same time, it contributes to the decline in fish stocks.

Overfishing is simply catching fish at a rate higher than the fish species can replace themselves. It is an unsustainable use of our oceans and freshwater biomes.

Massive improvements in technology have enabled fish to be located and caught in larger numbers and from deeper, more inaccessible waters. The use of spotter planes, radar and factory ships ensure that fish can be caught, processed and frozen while still at sea.

Globally, fish is the most important animal protein consumed (see figure 1). A lack of conservation and management of fisheries, combined with rising demand for fish products, has seen a 'boom and bust' mentality (see figure 2). The larger fish species are targeted and exploited and, after their populations are decimated, the next species are fished. Examples of this include blue whales, Atlantic cod and bluefin tuna.

4.8.2 What happens when we overfish?

- With overfishing there are often large quantities of **by-catch**. This means that juvenile fish and other animals, such as dolphins and sea birds, are swept up in nets or baited on hooks before being killed and discarded. For every kilogram of shrimp caught in the wild, five kilograms of by-catch is wasted (see figure 3).
- Destructive fishing practices such as cyanide poisoning, dynamiting of coral reefs and bottom trawling (which literally scrapes the ocean floor) cause continual destruction to local ecosystems.

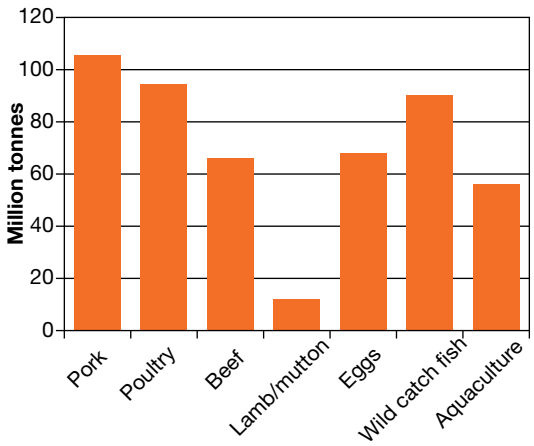


FIGURE 1 Global animal protein production, 2010

by-catch marine species that are unintentionally caught while targeting/catching other marine species

FIGURE 2 Unsustainable fishing

FIGURE 3 Up to 80 per cent of some fish catches is by-catch.

- A large quantity of fish, which could have been consumed by people, is converted to fishmeal to feed the aquaculture industry, as well as to fatten up pigs, chickens and to feed pet cats (see figure 4).
- Coastal habitats are under pressure. Coral reefs, mangrove wetlands and seagrass meadows, all critical habitats for fish breeding, are being reduced through coastal development, overfishing and pollution.

FIGURE 4 In Australia, the average cat eats 13.7 kilograms of fish a year compared with the average Australian, who eats 11 kilograms a year.

Shark attack!

Many species of shark are now threatened with extinction owing to excessive overfishing. Their fins are often used to make shark fin soup, a Chinese delicacy and status symbol. A single bowl of soup can cost up to $1000 in Hong Kong. When sharks are caught, the fins are removed and the sharks thrown overboard, a process known as finning.

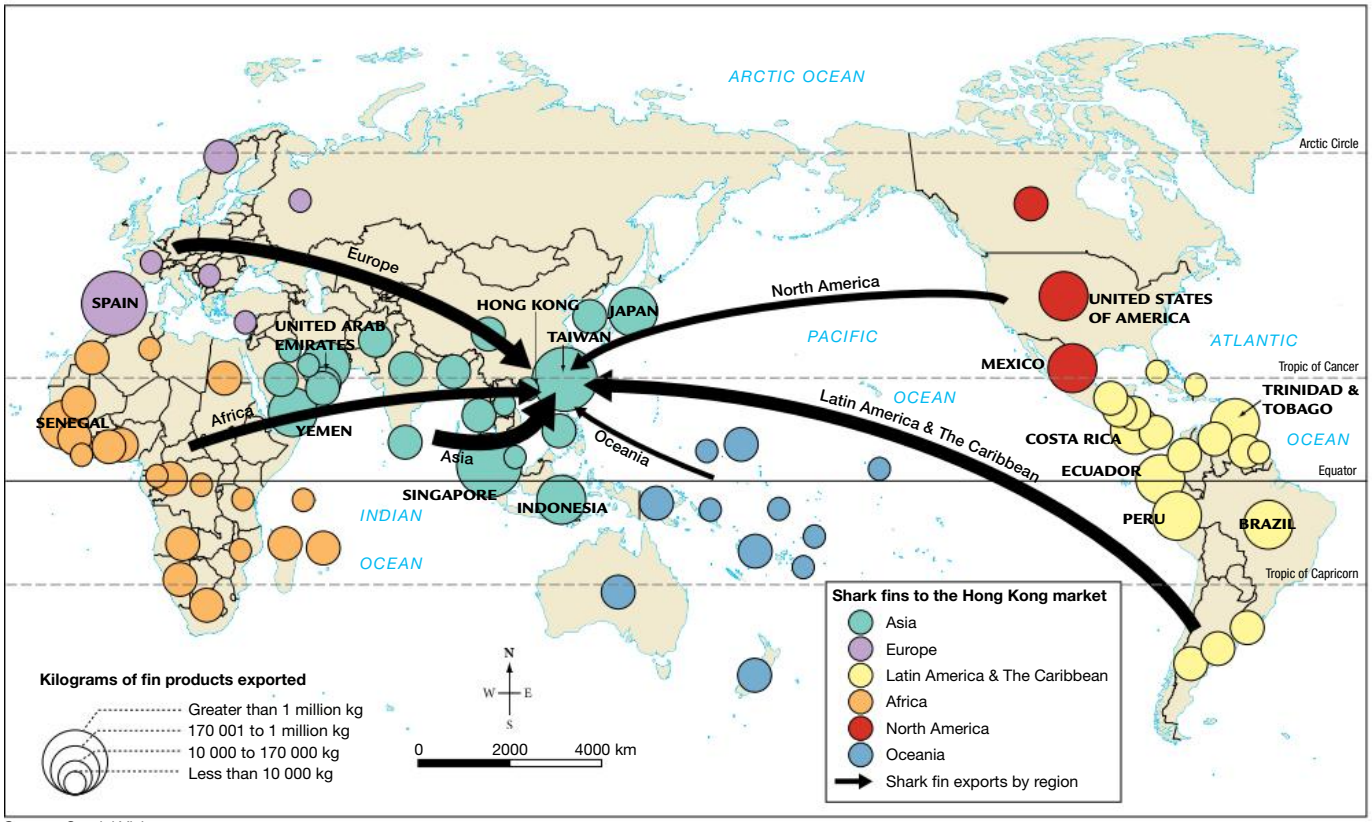
This practice is banned in countries such as the United States, where the sharks must be brought back to shore before the fins are removed and the bodies discarded. This limits the size of catches due to space availability on the boat.

Fishing for fins is a global industry, with Hong Kong being the main import centre (see figure 5). The United Nations Environment Programme estimates that up to 73 million sharks are killed each year to support the global fin market.

Sharks are prone to overfishing because they tend to grow and mature slowly and produce relatively few young. They are often caught up in tuna fishing nets. Some populations of hammerhead sharks have declined by 99 per cent in heavily fished regions such as the Mediterranean and northwest Atlantic.

In Australia, 178 tonnes of fin are exported each year, in an industry worth $124 million. Laws on live finning are inconsistent across the country and not well controlled. Currently, there are no international limits on shark catches. Palau, a small country of 22 000 people and 200 islands located 800 kilometres east of the Philippines, has become the first nation in the world to create a shark sanctuary.

FIGURE 5 Imports of shark fins into Hong Kong



Source: Spatial Vision

4.8.3 Is fish farming the solution?

Aquaculture is one of the fastest growing food industries, providing fish for domestic and export markets. It brings economic benefits and increased food security (see figure 6).

Over 47 per cent of fish consumed by people comes from aquaculture. While aquaculture is often seen as a sustainable and eco-friendly solution to overfishing, its rapid growth and poor management in many places has created large-scale environmental change. Some of these changes are described below.

- *Pollution*. Many fish species are fed a diet of artificial food in dry pellets (see figure 7). Chemicals in the feed, and the massive waste generated by fish farms, can pollute the surrounding waters.
- *Loss of fish stock*. Food pellets are usually made of fish meal and oils. Much of this comes from by-catch, but the issue is still that we are catching fish to feed fish. It can take two to five kilograms of wild fish to produce one kilogram of farmed salmon. Other ingredients in the food pellets include soybeans and peanut meal — products that are suitable for human consumption and grown on valuable farmland.

aquaculture the farming of aquatic plants and aquatic animals such as fish, crustaceans and molluscs; also called fish farming

FIGURE 6 Aquaculture and wild fish capture, 2000–2024

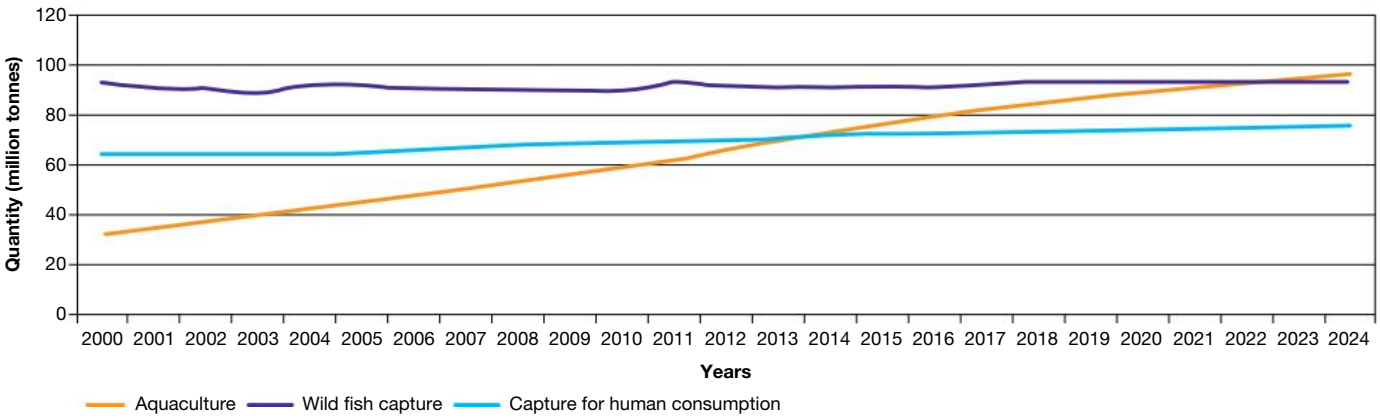


FIGURE 7 Feeding fish in pens, Thailand

- *Loss of biodiversity*. Many of the fish species farmed are selectively bred to improve growth rates. If accidentally released into the wild, they can breed with native species and so change their genetic makeup. This can lead to a loss of biodiversity. Capture of small ocean fish, such as anchovies, depletes food for wild fish and creates an imbalance in the food chain.
- *Loss of wetlands*. Possibly the greatest impact of aquaculture is in the loss of valuable coastal wetlands. In Asia, over 400 000 hectares of mangroves have been converted into shrimp farms. Coastal wetlands provide important ecological functions, such as protecting the shoreline from erosion and providing breeding grounds for native fish.

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Interactivity
Hook, line and sinker
Use this interactivity to further your understanding of the development of aquaculture around the world.
Searchlight ID: int-3324

ACTIVITIES

IDENTIFY

1 Refer to figure 1. How important is fish, both wild catch and aquaculture, as a source of protein compared with other sources? Use figures in your answer.
2 **a** Why is by-catch a concern for ***sustainability***?
b Examine closely the photograph in figure 3, and describe the by-catch that you see.
3 Refer to figure 6. Using this data, compare the predicted growth of wild capture and aquaculture production to 2024.
4 Who are the three major exporters of shark fins to Hong Kong? Use figures in your answer.

EXPLAIN

5 Explain how overfishing can lead to a loss of biodiversity.
6 Refer to table 1 Australia's fisheries production:

TABLE 1 Australian fisheries production 2009–10 (tonnes)

	Fishing	Aquaculture	Total
Fin fish	115 012	47 595	162 607
Crustaceans	37 261	5564	42 825
Molluscs	14 447	18 723	33 670
Other	361	1660	2021
Total	**167 458**	**73 542**	**241 123**

a What reasons can you suggest for the similarity of figures for fishing for molluscs and aquaculture of molluscs? (Molluscs include abalone, scallops and oysters.)
b Why are the figures for fin fish so different from fishing and aquaculture sources? (Fin fish include tuna, salmon and trout.)

INVESTIGATE

7 Investigate and write a newspaper article on the collapse of the Atlantic cod-fishing industry in Newfoundland. What lessons in the ***sustainability*** of fishing can be learned from the case of the Atlantic cod?
8 Collect photographs and other information to create an annotated poster showing one of the destructive fishing practices mentioned above.

PREDICT

9 What do you think the future of aquaculture might be? Why?

APPLY

10 Create a pros and cons table on the topic 'Should we farm fish?' Are there more positives or negatives? Discuss your ideas with a classmate.

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4.9 SkillBuilder: Interpreting a geographical cartoon

What are geographical cartoons?

Geographical cartoons are humorous or satirical drawings on topical geographical issues, social trends and events. A cartoon conveys the artist's perspective on a topic, generally simplifying the issue. Your response to geographical cartoons encourages discussion and evaluation of alternative responses as you take in other people's viewpoints and perspectives.

eLesson

Watch this video to learn how to interpret a geographical cartoon.

Searchlight ID: eles-1731

Interactivity

Try this interactivity to learn how to interpret a geographical cartoon.

Searchlight ID: int-3349

4.10 What impacts does farming have on the lithosphere?

4.10.1 What is land degradation?

The land, or lithosphere, is one of our most basic resources and is often taken for granted. In our quest to produce as much as possible from any one area of land, we have often failed to manage it sustainably. Land degradation is the result of such poor management.

Land degradation is a decline in the quality of the land to the point where it is no longer productive. Land degradation covers such things as soil **erosion**, invasive plants and animals, salinity and desertification. Degraded land is less able to produce crops, feed animals or renew native vegetation. There is also a loss in soil fertility because the top layers, rich in **humus**, can be easily eroded by wind or water. In Australia, it can take up to 1000 years to produce just three centimetres of soil, which can be lost in minutes in a dust storm.

Globally, degradation has caused the loss of more than 350 million square kilometres of the Earth's surface. In Australia, of the five million square kilometres of land used for agriculture, more than half has been affected by, or is in danger of, degradation.

erosion the wearing down of rocks and soils on the Earth's surface by the action of water, ice, wind, waves, glaciers and other processes

humus organic substance in the soil that is formed by the decomposition of leaves and other plant and animal material

What are the causes of land degradation?

Land degradation is common to both the developed and developing world, and results from both human and natural causes.

Human causes

Human causes of land degradation involve unsustainable land management practices, such as:

- land clearance — deforestation or excessive clearing of protective vegetation cover
- overgrazing of animals — plants are eaten down or totally removed, exposing bare soil, and hard-hoofed animals such as cows and sheep compact the soil (see figure 1)

eBookplus

Interactivity
Losing land

Use this interactivity to further your understanding of the types and impacts of land degradation.

Searchlight ID: int-3325

- excessive irrigation — can cause watertables to rise, bringing naturally occurring salts to the surface, which pollute the soil
- introduction of exotic species — animals such as rabbits and plants such as blackberries become the dominant species
- decline in soil fertility — caused by continual planting of a single crop over a large area, a practice known as monoculture
- farming on marginal land — takes place on areas such as steep slopes, which are unsuited to ordinary farming methods.

FIGURE 1 Soil erosion as a result of overgrazing in Australia

Biophysical causes

Natural processes such as prolonged drought can also lead to land degradation. However, land can also sometimes recover after a drought period. Topography and the degree of slope can also influence soil erosion. A steep slope will be more prone to erosion than flat land.

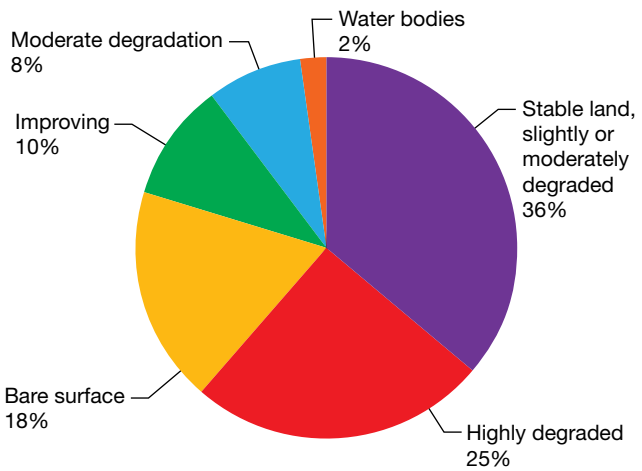
What are the impacts of land degradation?

As land becomes degraded, productivity, or the amount of food it can produce, is lost. Some countries in sub-Saharan Africa have lost up to 40 per cent productivity in croplands over two decades, while population has doubled in the same time period. Farmers may choose to abandon the land, try to restore the land or, if the pressure to produce food is too great, they may have no choice but to continue using the land. Unproductive land will be exposed to continual erosion or weed invasion.

If extra fertilisers are applied to try to improve fertility, the excessive nutrients can create pollution and algae build-up in nearby streams. Airborne dust creates further hazards for both people and air travel. Land degradation is a classic example of human impact on all spheres of the environment — atmosphere, biosphere, lithosphere and hydrosphere.

Figure 2 shows the total amount of land across the Earth's surface (not just farmland) and the extent of land degradation. About 40 per cent of degraded lands are found in places that experience widespread poverty, which is a contributing factor to food insecurity. Poor farmers with degraded land and few resources often have little choice but to continue to work the land.

FIGURE 2 State of the world's land resources



Source: Food and Agriculture Organization of the United Nations, 2011.

Are we turning drylands into deserts?

Desertification is an extreme form of land degradation. It usually occurs in semi-arid regions of the world, and the result gives the appearance of spreading deserts. Desert biomes, or arid regions, are harsh, dry environments where few people live. In contrast, semi-arid regions, or drylands, occupy 41 per cent of the Earth's surface and support over two billion people, 90 per cent of whom live in developing nations. While traditional grazing and cropping has taken place in dryland regions for centuries, population growth and the demand for food has put enormous pressure on land resources. Overclearing of vegetation, overgrazing and overcultivation are a recipe for desertification.

ACTIVITIES

IDENTIFY

1 List two human and two natural causes of land degradation.
2 Refer to figure 2. What percentage of the world's land resources are classified as moderately to highly degraded?
3 Which biome supports more life: desert or drylands? Why?

EXPLAIN

4 Create an annotated sketch to show the ***interconnection*** between plants and soil. Use the following points as labels on your sketch.
- Plant roots help hold soil together.
- Decomposing plants add nutrients to the soil.
- Plants shade the topsoil and reduce evaporation.
- Plants reduce the speed of wind passing over the ground.

5 Explain how land degraded by drought may recover, whereas land degraded by cultivation may not.
6 Study the photograph in figure 1. Why would it be difficult to either graze animals or grow crops on this land?

INVESTIGATE

7 Investigate an area in your state that has been ***changed*** by land degradation. Identify the location, causes and impacts of the degradation. Are any steps being taken to reduce the impacts?

APPLY

8 Examine the photograph in figure 1 again. If this was your property and your livelihood, what steps would you take to reduce the erosion problem?

4.11 How does irrigation change the environment?

4.11.1 What is the purpose of irrigation?

Food production and security is directly related to water availability. As the population increases, so too does demand for water. Moreover, there are always competing demands for water from the domestic, industrial and environmental sectors. In many places in the world, water is becoming increasingly scarce. Consequently, the development of water resources is becoming more expensive and, in some cases, environmentally destructive.

Most of the world's food production is rain-fed; that is, dependent on naturally occurring rainfall. Only a small proportion of agricultural land is irrigated, yet **irrigation** is now the biggest user of water in the world, consuming 70 per cent of the world's freshwater resources. Irrigation brings many benefits, such as:

- supplementing or replacing rain, especially in places where rainfall is low or unreliable. In many parts of the world, it is not possible to produce food without irrigation (see figure 1).
- increasing crop yields, up to three times higher than rain-fed crops. Only 20 per cent of the world's farmland is irrigated but it produces over 40 per cent of our food.
- enabling a wide variety of food to be grown, especially those with high water needs, such as rice, or with high value, such as fruit and wine grapes
- flexibility, being used at different times according to crop needs; for example, during planting and growing or close to harvest time.

irrigation the supply of water by artificial means to agricultural areas where there is a shortage

FIGURE 1 Irrigation allows for pasture to be grown in times of drought. Compare the irrigated to non-irrigated paddocks.

4.11.2 What are the impacts of irrigation on the environment?

The benefits of irrigation have resulted in increased food production and greater food security. But irrigation has created major changes to the biomes where it is used. Irrigation changes the natural environment by extracting water from rivers and lakes and building structures to store, transfer and dispose of water. The topography or shape of the land is often changed too, as occurs when terraces are built for paddy fields. In addition, irrigation water is often applied to the land in much larger quantities than naturally occurs, which can then change soil composition and cause **waterlogging** and **salinity** problems.

waterlogging saturation of the soil with groundwater so that it hinders plant growth

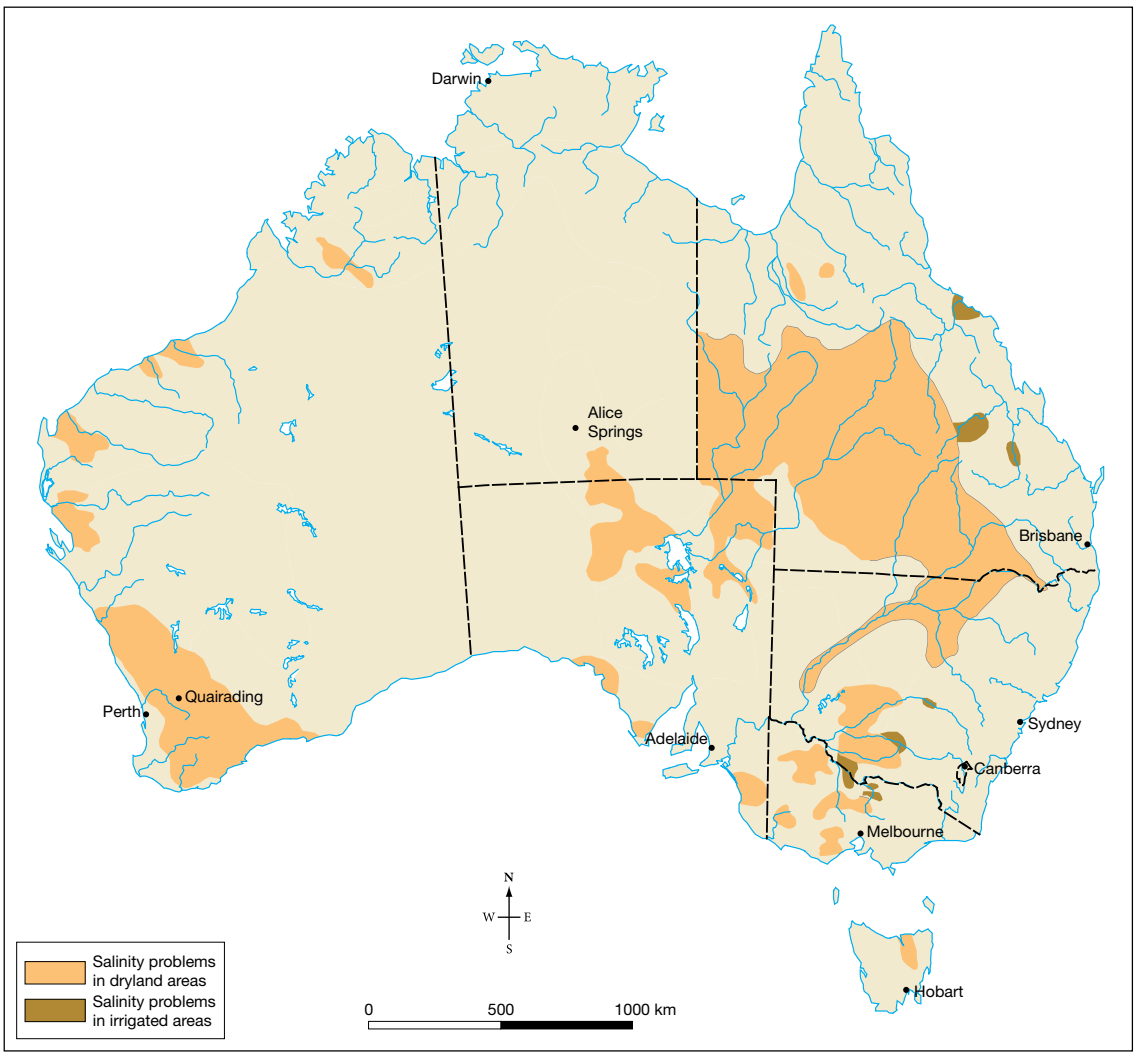
salinity the presence of salt on the surface of the land, in soil or rocks, or dissolved in rivers and groundwater

How does irrigation create salinity problems?

On irrigated land, salinity is the major cause of land being lost to production, which is in the order of 2 to 3 million hectares per year across the world. It is also a major cause of land degradation in Australia (see figure 2).

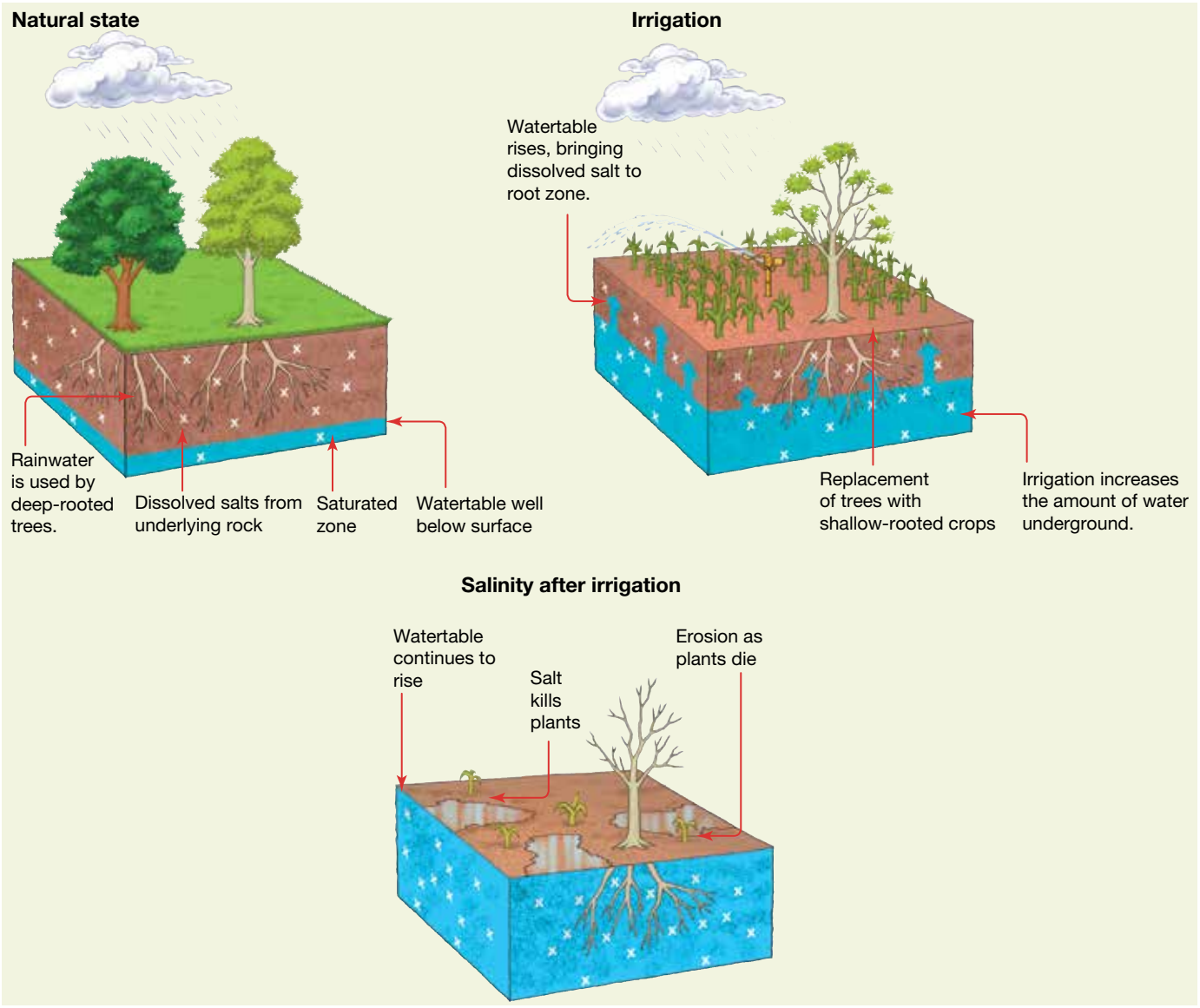
Overwatering of shallow-rooted crops adds excess water to the watertable, causing it to rise (see figure 3). If the subsoils are naturally salty, much of this salt can be drawn to the surface. Most crops and pasture will not grow in salty soils, so the land becomes useless for farming. Land that is affected by salinity is also more prone to wind and water erosion.

FIGURE 2 Distribution of salinity in Australia



Source: MAPgraphics Pty Ltd, Brisbane.

FIGURE 3 The development of irrigation salinity



ACTIVITIES

IDENTIFY

1 Outline the need for irrigation.
2 Identify two impacts of applying water in larger quantities that occur naturally.
3 What percentage of the world's fresh water is consumed by irrigation? What would be the other main uses of water?

EXPLAIN

4 Referring to figure 3, explain how irrigation causes salinity.
5 What ***changes*** to the ***environment*** are needed in order to irrigate a large region?

INVESTIGATE

6 **a** Research dryland salinity. Explain its natural and human causes.
b Refer to figure 2, why do you think dryland salinity covers a larger area than irrigation salinity?

APPLY

7 Study the map in figure 2, showing the distribution of salinity in Australia. Estimate the approximate percentage of each state affected by salinity.
8 Can we feed the world without irrigation? Write a paragraph expressing your viewpoint.

4.12 How is the hydrosphere altered by farming?

4.12.1 What happens if we divert too much water?

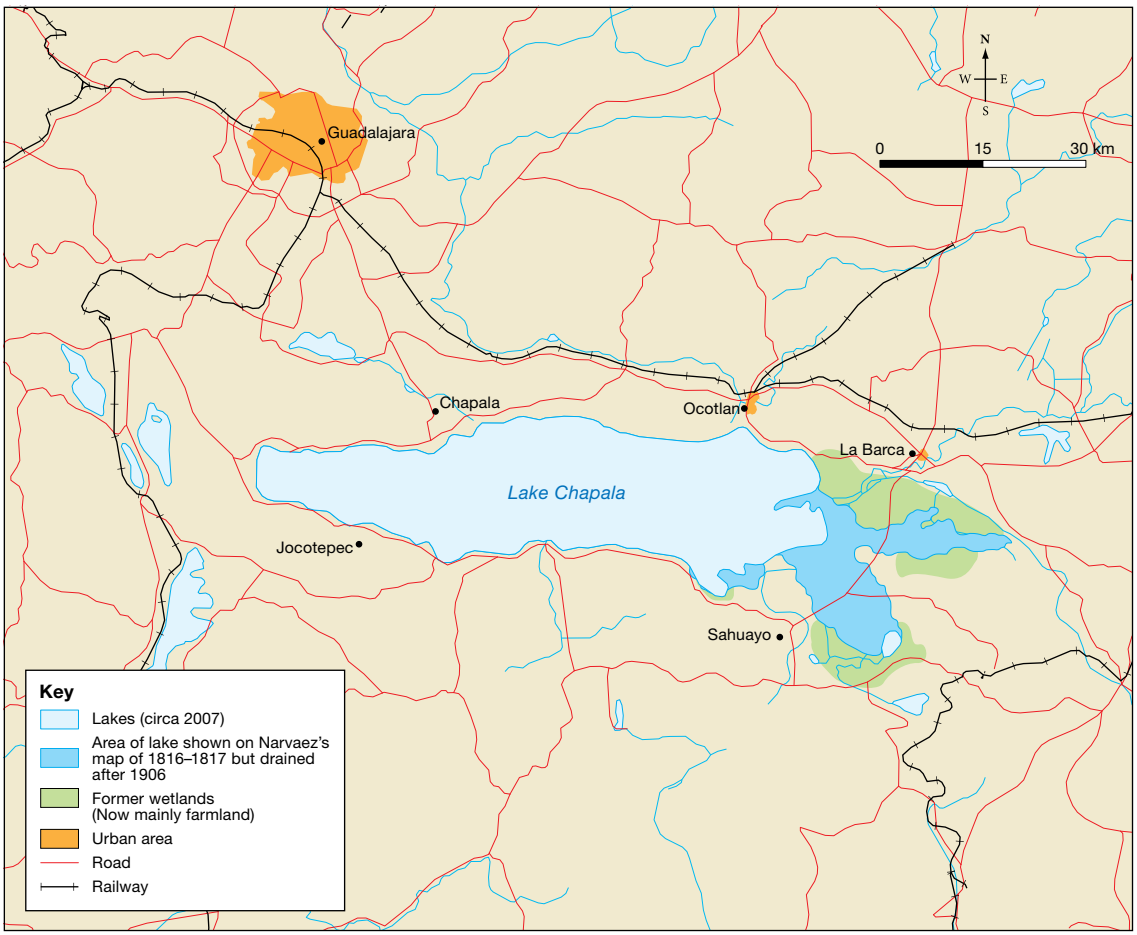
The hydrosphere is part of the biophysical environment where water flows and is stored on our planet. Although there is plenty of water in the world, fresh water is finite and not always located where people are concentrated or where food is grown. Therefore, we often have to draw water from natural storages such as lakes, rivers and ponds, and underground storages called **aquifers**. Growing populations and increased food production means water is being used at a faster rate than it can be replenished; making current practices unsustainable. For countries that have rapid population growth and limited access to water resources, water deficits and food insecurity are a growing concern.

aquifer a body of permeable rock below the Earth's surface, which contains water, known as groundwater

For thousands of years, farmers have diverted water from rivers, lakes and wetlands for watering crops and pastures in dry areas. Large-scale irrigation schemes can effectively 'water' our deserts but, if too much water is used, wetlands can dry out, rivers cease to flow and lakes dry up. It is estimated that between three and six times more water is held in reservoirs around the world than exists in natural rivers. It is possible that the level of water extraction will nearly double by 2050.

Lake Chapala, Mexico's largest lake is shrinking (see figure 1). The amount of water lost through irrigation and domestic use, combined with high evaporation rates, has seen the volume of the lake decrease by 50 per cent.

FIGURE 1 Map of Lake Chapala, Mexico. Note the area of land drained for farmland.



Source: Data from Tony Burton. All rights reserved.

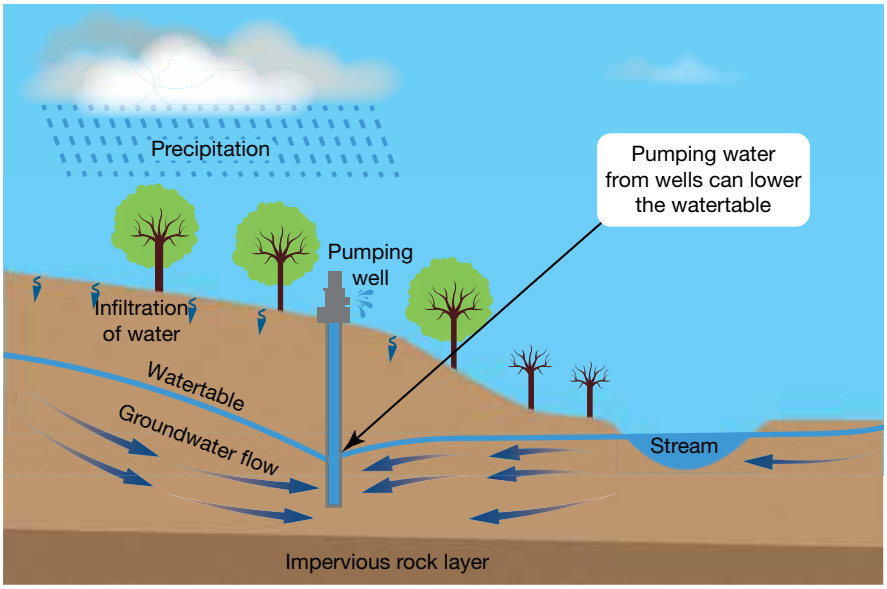
4.12.2 What happens if we extract too much water?

As surface water resources become fully exploited, people turn to underground water sources. Improvements in technology have also enabled farmers to pump water from aquifers deep underground (see figure 2).

Groundwater levels do not respond to changes in the weather as rapidly as rivers and lakes do. If the water is removed unsustainably (at a rate that is faster than the rate of replenishment by rainfall, run-off or underground flow), then **watertables** fall. Water then becomes harder and more expensive to extract. Water stored in aquifers can take thousands of years to replenish. Over-extraction of groundwater can result in wells running dry, reduced stream flow, and even land subsidence (sinking).

The High Plains region of the central United States (see figure 3) is the leading irrigation area in the western hemisphere, producing over $20 billion worth of food and fibre per year. In all, 5.5 million hectares of semi-arid land is irrigated using water pumped from the huge Ogallala Aquifer.

FIGURE 2 Diagram showing the use of groundwater as a water source in farming



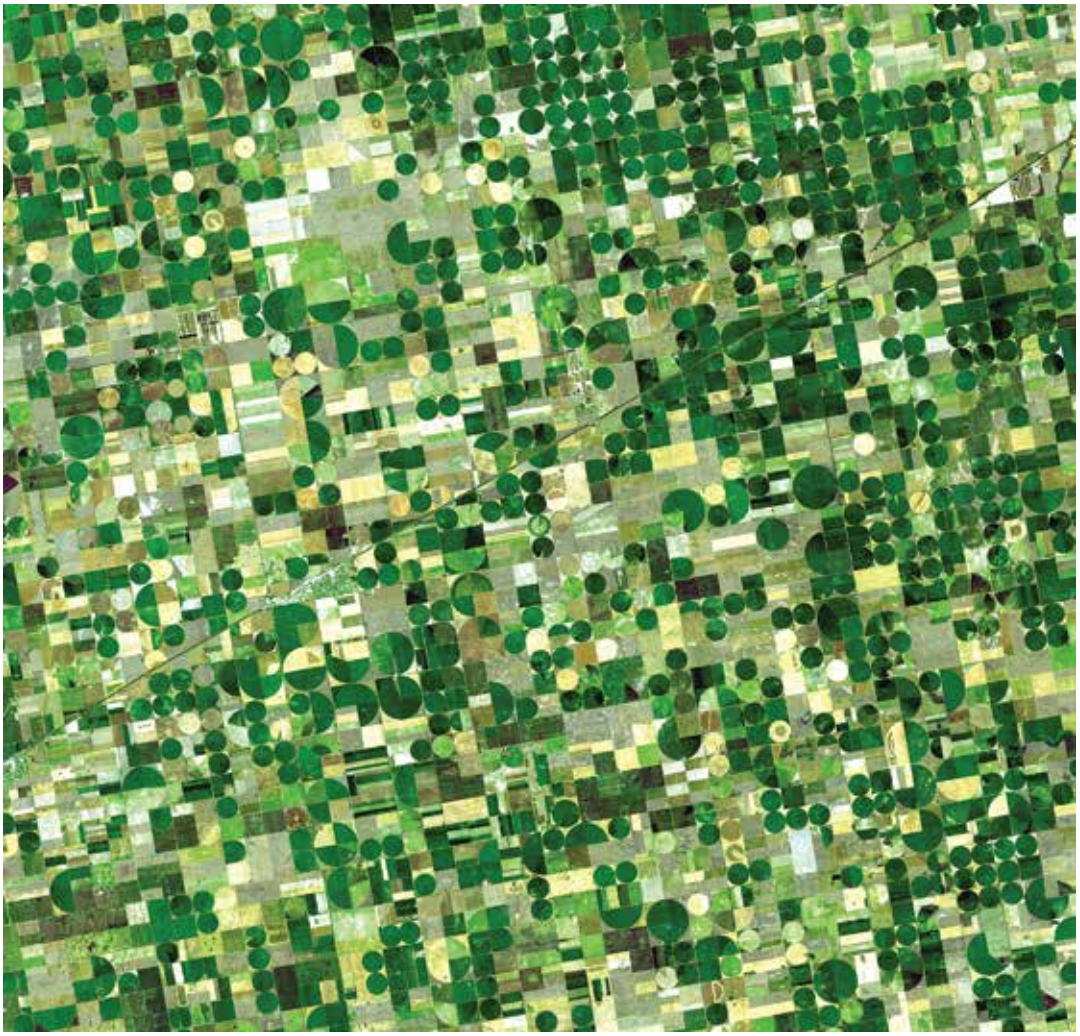
watertable upper level of groundwater, below which all pores in the soils and rock layers are saturated with water

FIGURE 3 The size of the Ogallala Aquifer

Source: Data from the USGS.

Since large-scale irrigation was developed in the 1940s, groundwater levels have dropped by more than 30 metres. Pesticides and other pollutants from farming have also infiltrated the groundwater. Scientists estimate that if the aquifer was pumped dry, it would take over 6000 years to refill it naturally.

FIGURE 4 Irrigated cropland relies heavily on water from the Ogallala Aquifer.



ACTIVITIES

IDENTIFY

1 List the different types of water resources that can be used to supply water for food production.
2 Identify one natural and one human factor that has contributed to the ***change*** in water levels in Lake Chapala.

EXPLAIN

3 Study figure 2. Explain how pumping groundwater can lower watertables.
4 Explain what the likely effects are of draining wetlands for farmland, as evident around Lake Chapala, Mexico in figure 1.
5 Explain why natural water storages are depleting at a faster rate than they can replenish.

INVESTIGATE

6 Research the Great Artesian Basin in Australia. Write a report that:
- includes a location map and shows its extent and other images
- describes and explains key facts about the water storage
- explains how it is used for agriculture
- identifies issues that are affecting its use.

APPLY

7 Refer to figure 3. Using the scale bar, work out the approximate area covered by the Ogallala Aquifer.
8 If the Ogallala Aquifer was to run dangerously low, and irrigation was no longer possible, what would be the short- and long-term consequences?

4.13 How does agriculture diminish biodiversity in biomes?

4.13.1 Is biodiversity diminishing?

The last few centuries have seen the greatest rate of species extinction in the history of the planet (see figure 1). The population of most species is decreasing, and genetic diversity is declining, especially among species that are cultivated for human use. Six of the world's most important land biomes have now had more than 50 per cent of their area converted to agriculture (see figure 2).

In those places where there has been very little industrial-scale farming, a huge variety of crops are still grown. In Peru, for example, over 3000 different potatoes are still cultivated. Elsewhere, biodiversity as well as agricultural biodiversity (biodiversity that is specifically related to food items) is in decline. In Europe, 50 per cent of all breeds of domestic animals have become extinct, and in the USA, 6000 of the original 7000 varieties of apple no longer exist. How has this happened?

- Converting natural habitats to cropland and other uses replaces systems that are rich in biodiversity with **monoculture** systems that are poor in diversity (see figure 3).
- Industrial-scale farming and new high-yielding, genetically uniform crops replaces thousands of different traditional species. Two new rice varieties in the Philippines account for 98 per cent of cropland.
- Uniform crops are vulnerable to pests and diseases, which then require large inputs of chemicals that ultimately pollute the soil and water. Traditional ecosystems have many natural enemies to combat pest species.
- The introduction of modern breeds of animals has displaced indigenous breeds. In the space of 30 years, India has lost 50 per cent of its native goat breeds, 30 per cent of sheep breeds and 20 per cent of indigenous cattle breeds.

monoculture the cultivation of a single crop on a farm or in a region or country

FIGURE 1 Extinctions per thousand species per millennium

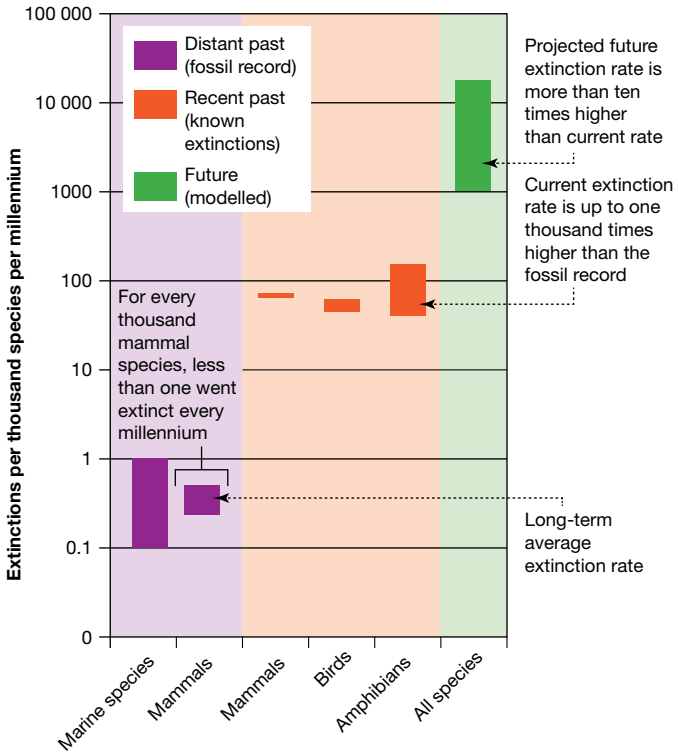


FIGURE 2 Percentage of biomes converted to agriculture over time

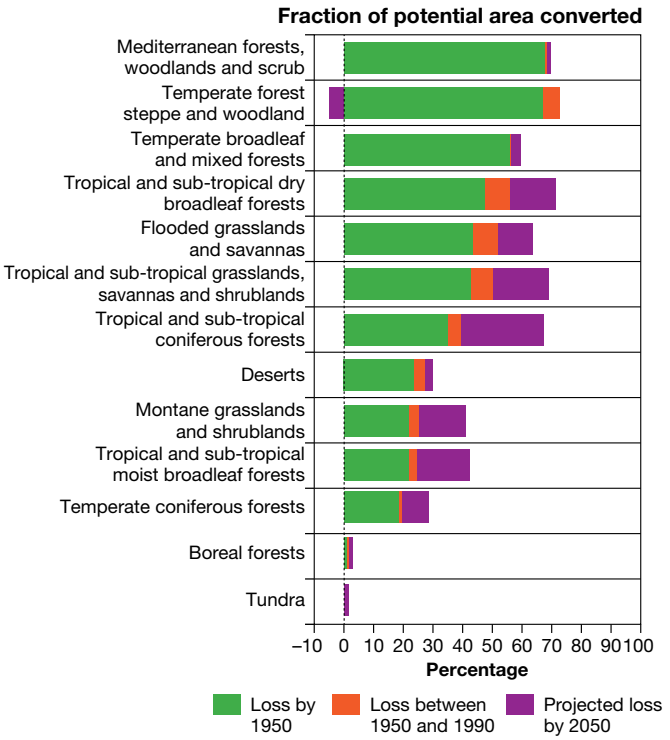
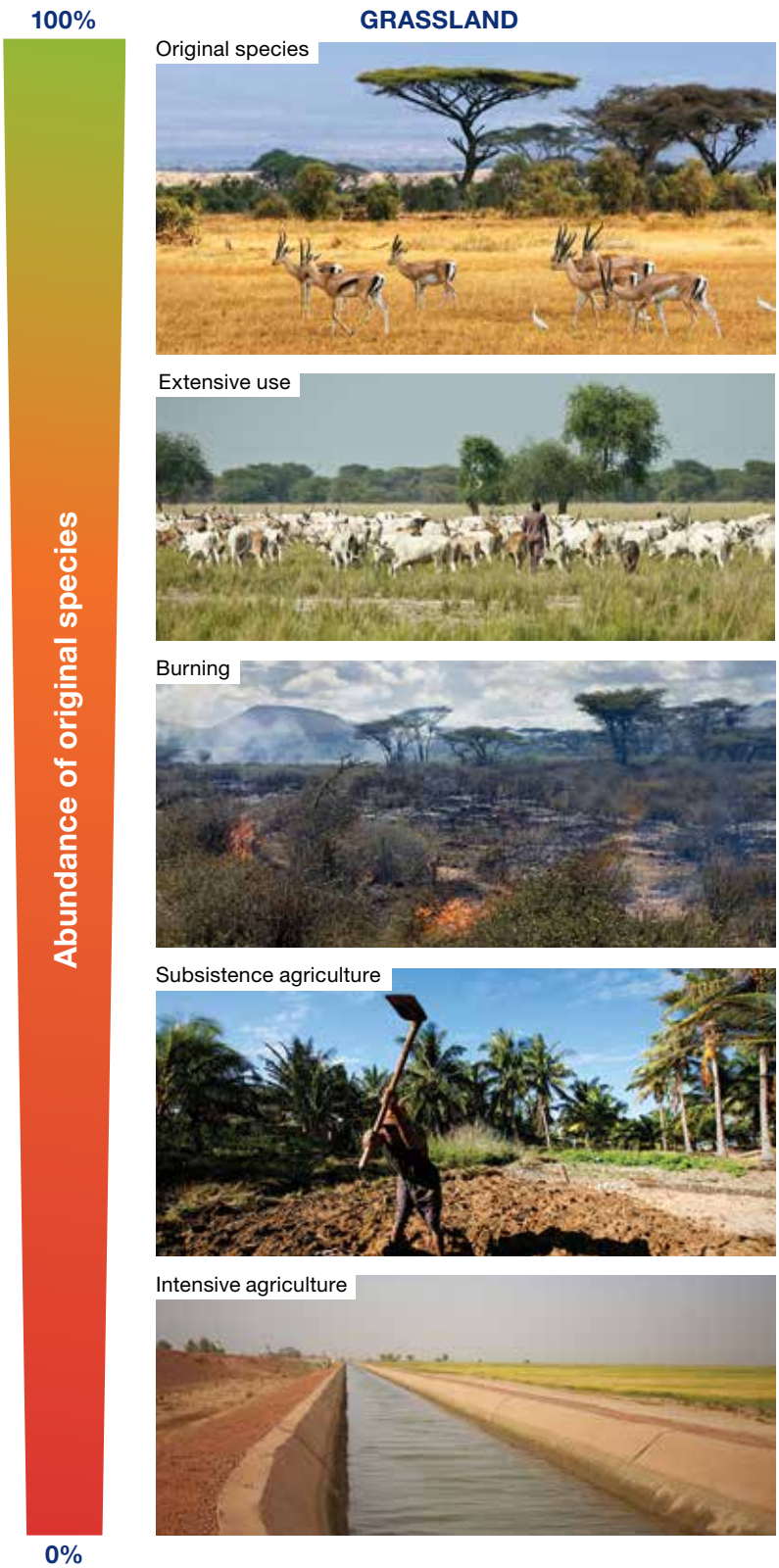


FIGURE 3 Changes to percentage of original species according to changes in biomes for food production



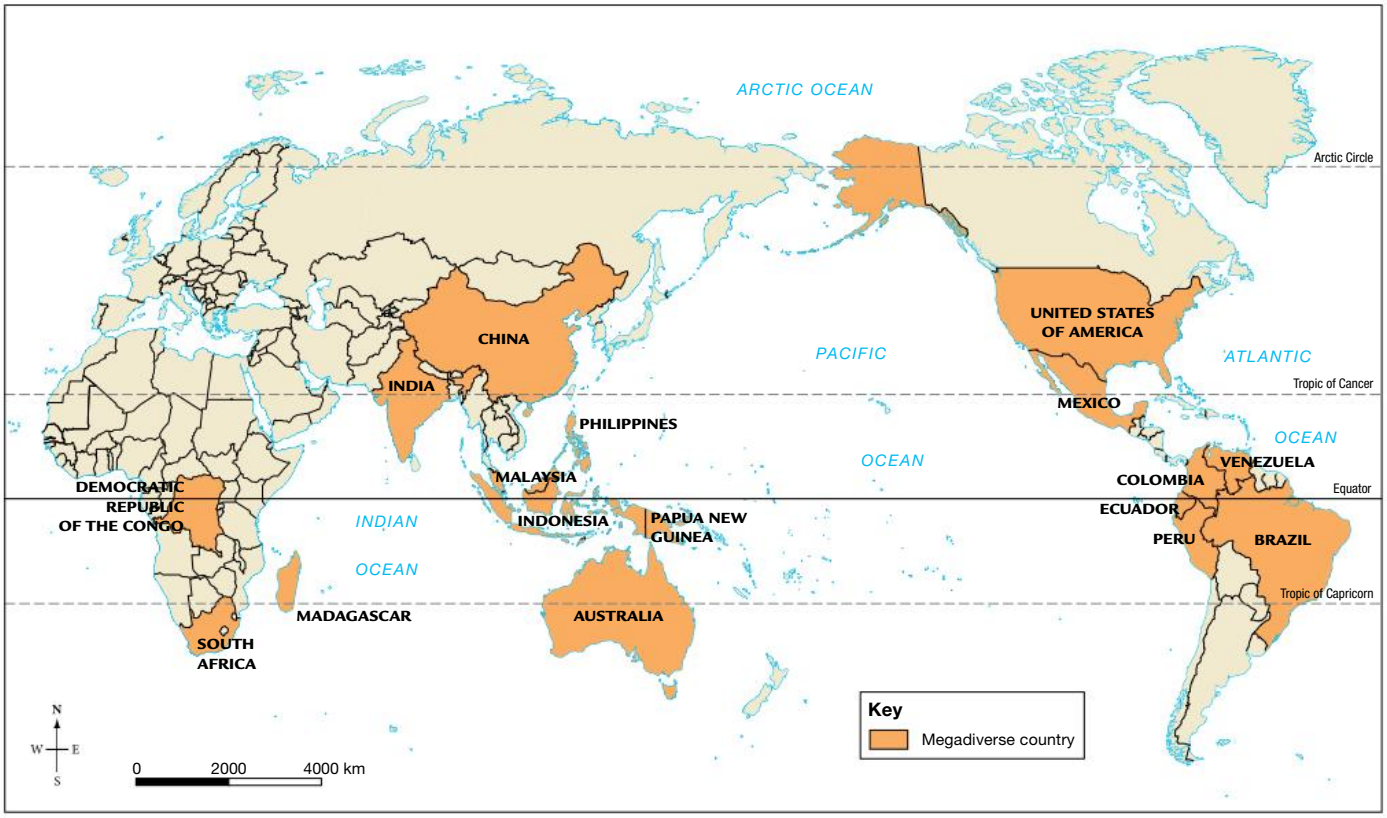
endemic describes species that occur naturally in only one region

4.13.2 Australia's biodiversity

Australia has a high number of **endemic** species, and has seven per cent of the world's total species of plants, animals and micro-organisms. That makes Australia one of only 17 countries in the world that are classified as megadiverse — having high levels of biodiversity. These 17 nations combined contain 75 per cent of the Earth's total biodiversity (see figure 4). Australia's unique biodiversity is due to its 140 million years of geographic isolation. However, Australia has experienced the largest documented decline in biodiversity of any continent over the past 200 years. It is thought that 50 species of animals (27 mammal species and 23 bird species) and 48 plant species are now extinct.

Farming practices, such as land clearing by European settlers, have played a part in the habitat loss and reduction in biodiversity in Australia. In 2014–15, agriculture was worth 54 billion dollars to the Australian economy. While farming is important economically and for providing food to feed the population, 30 million hectares of farming land is being protected by farmers to conserve native vegetation, and in turn the habitats of many animals. Farmers are using strategies such as excluding or reducing access to livestock, managing pests and feral animals, managing weeds, planting seeds of native vegetation, and retaining existing native vegetation. Farmers have been able to achieve this through working closely with the government and other organisations such as Landcare.

FIGURE 4 Distribution of megadiverse countries



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 Describe the ways in which human activities can lead to a loss in biodiversity.

2 What is a megadiverse country? Why is Australia considered a megadiverse country?

EXPLAIN

3 **a** Study figure 2. Which three biomes have seen the greatest percentage ***change*** in areas converted to cultivation? Use figures in your answer.

b Suggest why these three have had the most ***change***.

4 Study the information in figure 3. Describe each scenario for the grassland biome and explain its relationship with biodiversity as it changes for food production.

5 Research the importance of genetic diversity. Write an opinion piece for a newspaper that outlines the importance of genetic diversity and food security.

APPLY

6 In what ways would the traditional Aboriginal nomadic way of life have helped maintain biodiversity before European settlement?

myWorldAtlas

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

- **World species**
- **Endangered species in Australia**
- **Introduced species in Australia**
- **Tasmanian devil**

4.14 What impact does farming have on the atmosphere?

4.14.1 How can farming affect the climate?

Agriculture's dependence on the atmosphere, in particular climate, is evident by the interconnection of rain and temperature patterns, and where food can be grown. However, as the climate changes, so will what can be grown and where. As agriculture has grown globally and made significant modifications to many global biomes, there is evidence to suggest that agriculture has contributed to climate change.

greenhouse gas
a gas that absorbs infrared radiation which contributes to the greenhouse effect

It has been observed that the Earth's climate is experiencing changes that have been influenced by human activities. In particular, the Earth's temperature is warming, partly due to increases in **greenhouse gases** such as water vapour, carbon dioxide, methane and nitrous oxide, which are entering the atmosphere. These increases in greenhouse gases have been attributed to human activities and agriculture has had a significant part to play. Food production has contributed to changes in the climate in two ways:

FIGURE 1 A cartoonist's view of livestock and global warming

- Grazing animals and flooded rice paddies produce the greenhouse gas methane. Methane is 20 times more effective at warming the planet than CO_2. Livestock are thought to be responsible for 29 percent of the world's methane output. The next largest sources, in order, are oil and gas, landfill, rice paddies and wastewater treatment systems.
- Food production changes the surface of the Earth, which then alters the planet's ability to absorb or reflect heat and light. Large-scale deforestation and desertification can significantly alter the microclimate of a region. Around 80 per cent of global deforestation is caused by clearing the land for agriculture such as grazing, slash and burn farming and cropping.

4.14.2 Which are the biggest polluters?

Cows emit large quantities of methane through belching and flatulence (caused by digestive gases). The gas is produced by bacteria digesting grass in one of the four stomachs that cows have. It has been estimated that one cow could produce somewhere between 100 and 500 litres of methane per day (see figure 2). This amount is similar to the pollution produced by one car in one day. When you consider there are over 1.5 billion cows in the world, this equates to a lot of gas. Scientists today are working on 'fuel-efficient cows' — cows that convert feed more efficiently into milk rather than methane.

Rice farming is one of the biggest sources of human-produced methane, averaging between 50 and 100 million tonnes per year. The gas is produced in the warm, waterlogged soils of the rice paddies (see figure 3).

FIGURE 2 Argentine scientists are strapping plastic tanks to the backs of cows to assess how much methane they produce.

FIGURE 3 Methane is released from rice paddies.

The practice of **factory farming**, in which a very high number of animals are concentrated in the one place, produces an unmanageable amount of waste (see figure 4). On a sustainable farm, animal manure can be used as a natural fertiliser but on a factory farm the large quantity becomes a source of methane, because the waste is often mixed with water and stored in large ponds or lagoons. An additional problem can occur if these ponds leak, as they create soil and water pollution. The use of nitrogen-based fertilisers on farms also releases nitrous oxide, another greenhouse gas.

FIGURE 4 Factory farming produces large quantities of waste products.

factory farming a highly-intensive system of farming that confines animals or poultry to small, confined, and strictly controlled spaces for the sole purpose of food production

4.14.3 How does deforestation contribute to changes in climate?

Trees are 50 per cent carbon, so when they are burned or felled, the CO_2 they store is released back into the atmosphere. On average, 13 million hectares of the world's forests are lost each year, mostly in tropical regions of South-East Asia, Latin America and Africa. Deforestation accounts for 30 per cent of greenhouse gases released into the atmosphere each year. Forests also act as carbon sinks, the most effective way of storing carbon. Large areas of cleared land absorb more heat than native vegetation, which can lead to changes in local weather conditions.

ACTIVITIES

IDENTIFY

1 Name the three main greenhouse gases.
2 Describe the two ways in which deforestation can contribute to ***changes*** in greenhouse gases.
3 What is the biggest global emitter of methane: livestock, cars or rice paddies?

EXPLAIN

4 Study figure 4. Compare and contrast factory farming to traditional farming methods. Draw up a table of two columns, one headed 'Key features of a traditional dairy farm' and one headed 'Key features of a factory farm'. List the features of both styles of farming and then compare your lists.
5 Is factory farming a ***sustainable*** form of food production? Give reasons for your answer.
6 The building of large-***scale*** dams and subsequent flooding of forests in the Amazon is also contributing to increases in greenhouse gas emissions. Explain the reason for this.

INVESTIGATE

7 Research the sources of methane gas and find out what percentage each contributes to world methane output. Construct a pie or bar graph to display your information. Is the biggest source natural or human?
8 Assess whether climate ***change*** will affect agriculture. Do some online research to investigate some of the possible effects of climate ***change*** on food production.

APPLY

9 If one cow produces 16 kWh energy equivalent per day, how many cows would be needed to power your own home per day? You will need to check your household electricity bill.
10 With another member of the class, discuss different ideas for reducing agriculture's contribution to greenhouse gas emissions.

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4.15 Review

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4.6 SkillBuilder: GIS — deconstructing a map

4.6.1 Tell me

What is GIS?

A geographical information system (GIS) is a storage system for information or data, which is stored as numbers, words or pictures. The data has the location attached so that it may be viewed as a map or as an image. GIS can process huge amounts of information to produce maps that would take a long time to draw by hand. Specialised computer programs produce maps from the data.

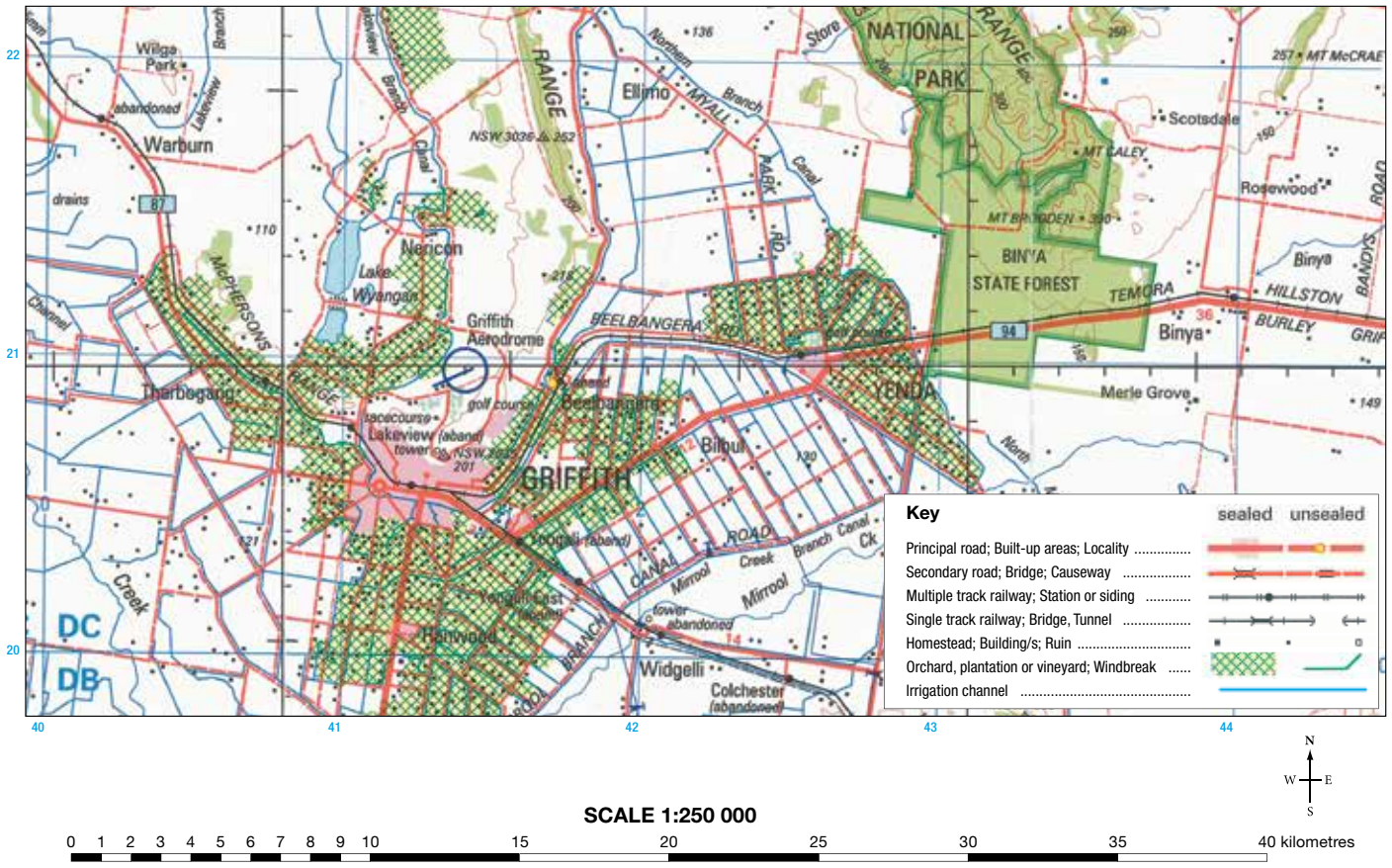
In this SkillBuilder, map layers will be created in a similar way to that used by cartographers and GIS specialists when making digital maps, but with much simpler tools and processes.

Why is GIS useful?

Analysing large amounts of information using a computer is much faster than doing it manually, and provides a much deeper understanding of the information. GIS allows multiple series of information to be displayed in a succession of map layers. The spatial distribution of the data and the relationship to other data may be compared. GIS is used in many professions wherever maps are required, such as in urban planning, logistics, resource management, the police force and public health.

Model

FIGURE 1 Example of a section of a topographic map



Source: Commonwealth of Australia (Geoscience Australia).

FIGURE 2 Example of a satellite image (called a raster image in GIS). This shows a section of the area that appears in figure 1.

Source: © Geoscience Australia

A GIS stores data in three ways: as points, lines or polygons (called vector data); as tables (called tabular data); and as pixels in an image (called raster data). A satellite image, for example, would be called a raster image in GIS (figure 2). A GIS program:

- stores similar information together
- stores data attached to points, lines and polygons in separate files
- stores the location of each point, line or polygon digitally
- includes tables of data in which each row is linked to a location and each column stores information as numbers or words
- includes information about the source of the data — known as metadata.

A breakdown of maps such as a GIS:

- traces each set of point, line and polygon data onto three pieces of tracing paper
- uses appropriate colours for the features
- layers the features, with points on top, lines underneath and polygons on the bottom
- includes BOLTSS.

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eLesson
GIS — deconstructing a map
Searchlight ID: eles-1730

4.6.2 Show me

How to deconstruct maps to build a simple GIS

You will need:

- a topographic map
- three pieces of tracing paper
- coloured pencils.

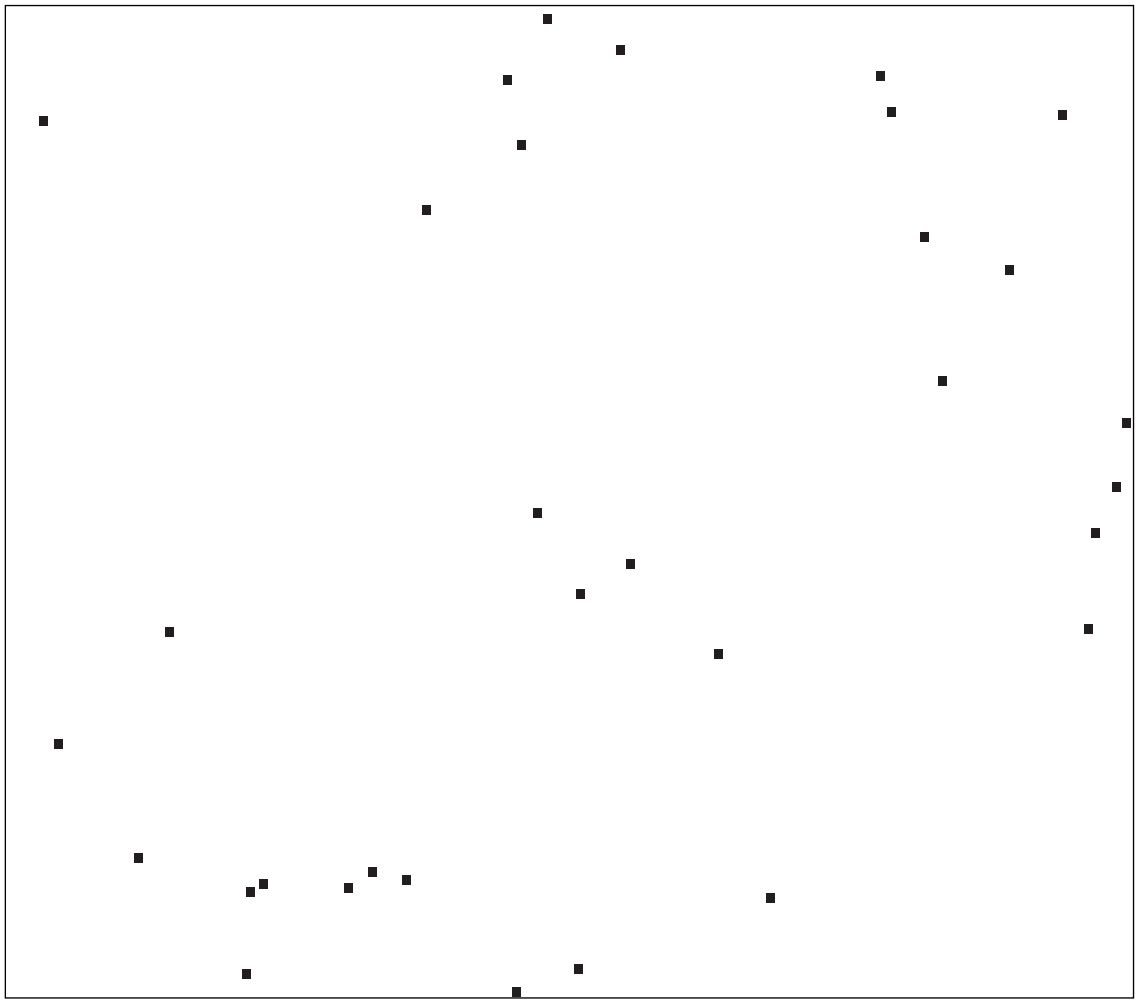
Procedure

STEP 1

Point features on the map have a location that may be defined using either a grid reference or latitude and longitude. The map of Griffith shown in figure 1 (doc-20446 in the Resources tab) has many point features, such as spot elevation (height), bores, wells, buildings, gates and stock grids.

Overlay one piece of tracing paper on the topographic map and, using an appropriate colour, mark the homesteads (point data) on the tracing paper (figure 3).

FIGURE 3 Point features marked on the first layer of tracing paper

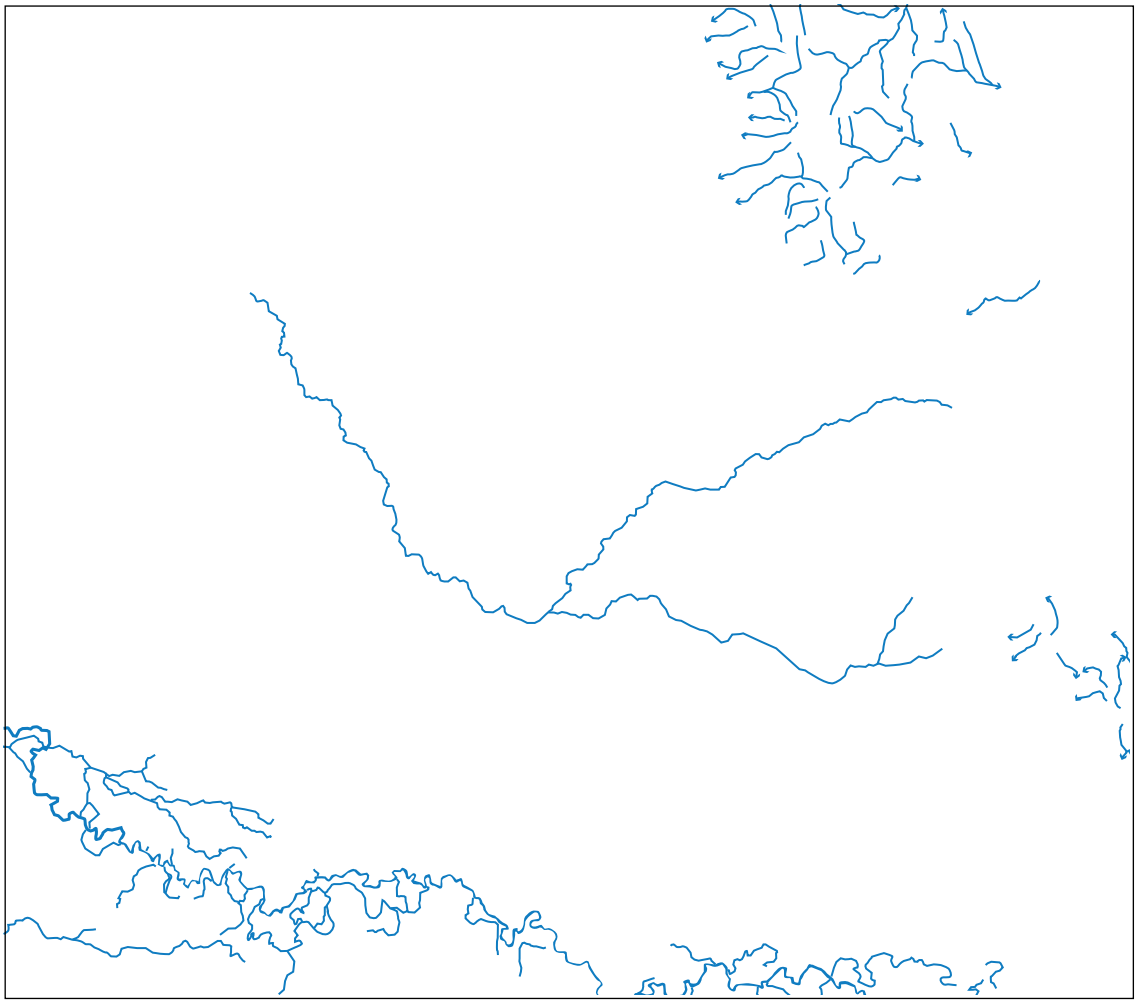


STEP 2

Line features on the map may be straight or winding. Their location is determined by joining multiple points. Figure 1 has many line features, such as roads, railway lines, rivers and creeks, irrigation channels and power lines.

Overlay a second piece of tracing paper on the topographic map and, with an appropriate colour, trace the rivers and creeks (line features; figure 4).

FIGURE 4 Line features of rivers and creeks are traced onto a second piece of tracing paper.



STEP 3

A polygon is a shape that has many sides. Its location on the map is determined by joining multiple points. Figure 1 has many polygon features, such as orchards, vineyards, national parks, lagoons, swamps and forested areas.

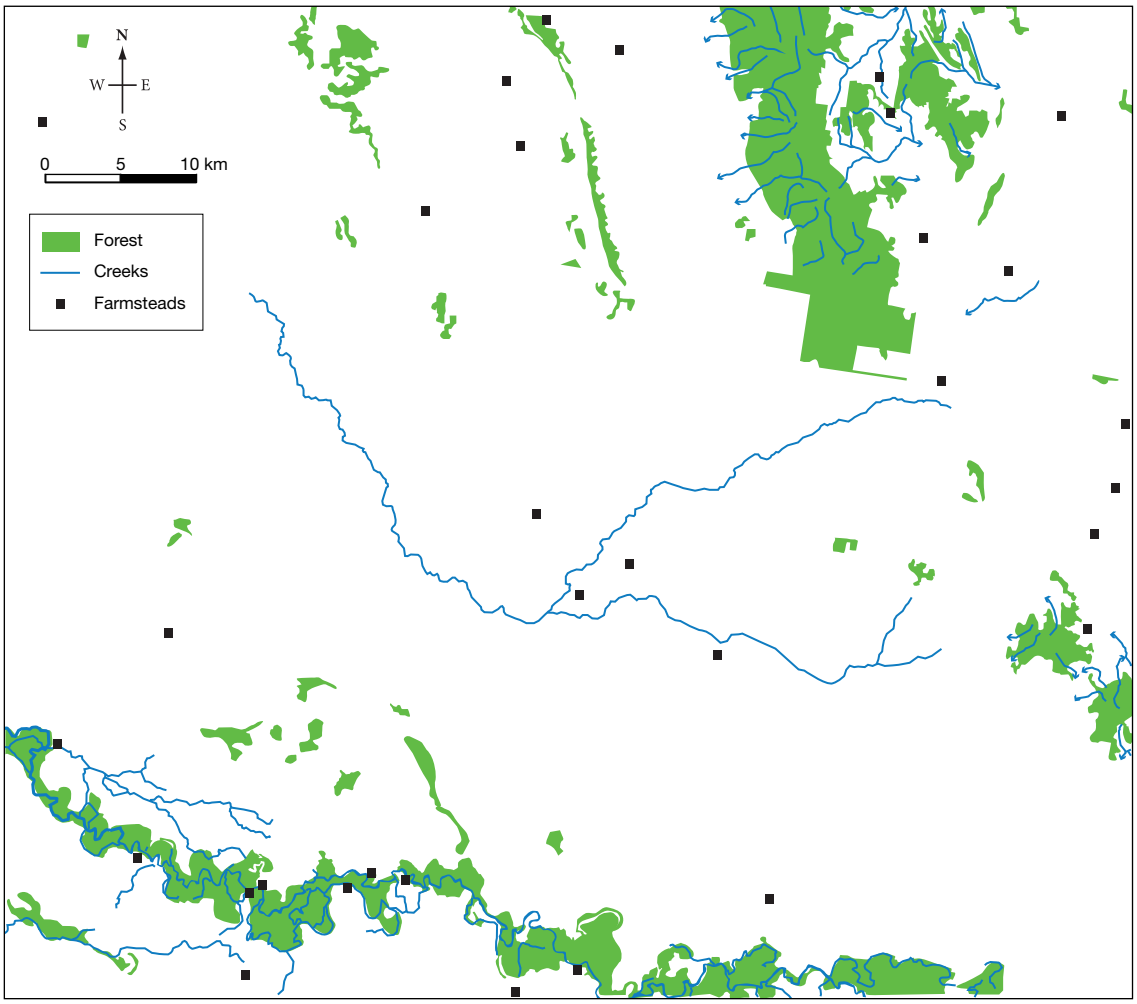
Overlay a third piece of tracing paper on the topographic map and, with an appropriate colour, trace the forests (polygon data; figure 5).

FIGURE 5 The polygon data of forests are traced onto a third piece of tracing paper.

STEP 4

Place the three tracing paper layers in the following order: point features on top, line features underneath, and polygon features at the bottom. Provide BOLTSS for your map (figure 6). In GIS, the finished map would be called a layout.

FIGURE 6 The three layers of tracing paper are now combined, and BOLTSS is added.



Source: Geoscience Australia, Narrandera NSW 1:250 000, 2004.

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Interactivity
GIS — deconstructing a map
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4.6.3 Let me do it

Developing my skills

Use the figure 1 map of Griffith again. Choose one point feature, one line feature and one polygon feature and create three tracing paper overlays. Organise the layers appropriately and add BOLTSS to your map.

Questions

1. What is the name of the district through which the Murrumbidgee River flows?
2. The original biome for this area is likely to have been forest. What has happened to this biome and how would you describe the distribution of forest in the area today?
3. Compare the number of creeks in the map in figure 1 with the number of channels. What is the purpose of the many channels and canals?
4. Figure 1 shows a part of Australia that has undergone change. Using Google Earth and the map, identify the area where there has been the least change and the area where there has been the most change. Explain your choice.
5. This area is an example of intensive farming. What does this mean? Provide at least one piece of evidence from both the map in figure 1 and the satellite image in figure 2 (or Google Earth) to support this statement.
6. Maps and satellite photographs show different ways of recording information. Identify two pieces of information visible in figure 2 (or Google Earth) that are not shown on the figure 1 map.

Checklist

I have:

- traced each set of point, line and polygon data onto three pieces of tracing paper
- used appropriate colours for the features
- layered the features, with points on top, lines underneath and polygons on the bottom
- included BOLTSS.

Skills questions

1. True or false? A GIS stores three sorts of data: vector, raster and tabular data.
2. To view information in a GIS, it is best to place the layers in the following order:
   a. lines above points, with polygons below
   b. polygons above lines, with points below
   c. points above lines, with polygons below
   d. points above polygons, with lines below.
3. Which statement about GIS is false?
   a. Placing the information in layers helps to compare the distribution of features.
   b. Raster images store data in tables.
   c. GIS is a way to view and analyse data that is spatial in nature.
   d. A GPS may be used to collect data for a GIS.
4. What is metadata?

4.9 SkillBuilder: Interpreting a geographical cartoon

4.9.1 Tell me

What are geographical cartoons?

Geographical cartoons are humorous or satirical drawings on topical geographical issues, social trends and events. A cartoon conveys the artist's perspective on a topic, generally simplifying the issue.

Why are cartoons useful?

Cartoons promote an interest in a topic or issue, and encourage discussion and debate. The cartoonist's message about a geographical topic is evident. Our feelings, attitudes and values are expressed in our response to the cartoon. Your response to geographical cartoons encourages discussion and evaluation of alternative responses as you take in other people's viewpoints and perspectives.

Cartoons are useful for:

- showing the key points of a geographical topic
- exaggerating the key points of an issue
- creating a response to an issue, whether in agreement or disagreement with the cartoonist
- presenting information, or an issue, or a viewpoint in an interesting way.

Model

FIGURE 1 Cartoon on overfishing

The cartoon shown in figure 1 is about overfishing our oceans. The cartoonist suggests that by 2048 there will be no more fish left in the oceans. It is not clear why the cartoonist chose this date (2048); perhaps they randomly chose a date well into the future. The cartoon uses exaggeration, as there will be fish, but the quantities may not make it economical to fish using the techniques currently available. The string of hooks in this cartoon is also unrealistic, as this is not the way commercial fishing is undertaken. Our wider perspective on the topic tells us that actual fishing techniques are trawling and purse-seine netting to maximise the catch at any one time. The cartoon plays on the word *bite*. It can mean (a) that a fish bites a hook or (b) that someone reacts or responds to something. Thus, the second fish reacts to the first fish's statement and asks the question *why*, but it might also bite one of the many hooks that surround it. The answer to the *why* question is obvious to the viewer — the fish will be caught because it will be impossible to avoid capture. This cartoon makes us think about the issue of taking fish from the ocean, and it questions the sustainability of the fishing industry: too many people are fishing for a limited resource.

A good interpretation of a cartoon:

- recognises the issue
- analyses the components of the cartoon
- identifies the cartoonist's personal opinion or message
- states your personal response to the geographical topic.

4.9.2 Show me

How to interpret a cartoon

You will need:

- a geographical cartoon.

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Procedure:

STEP 1

Take the time to study the cartoon and carefully look for the overall idea. Next, focus on the artistic work of the cartoonist and any subtleties that have been included. Consider different relative sizes of parts of the drawing, as well as any wording or attitudes expressed in the image. Figure 1 is about overfishing our oceans. In this case, the subtleties are in the words of the fish — what are the fish really saying?

STEP 2

Consider the overarching issue; in this case, overfishing. What is your general knowledge on the topic? In Geography classes, when you are given a cartoon, you know that it relates to the topic you are studying. If you are viewing a cartoon from elsewhere, then you have to think through the issue being portrayed. Things to look for in a cartoon include the following:

- Symbolism — conveying ideas in a concise manner through the use of symbols. In figure 1, the large number of hooks suggests too much fishing.
- Stereotyping — our fixed mental picture of something. In figure 1, the fish are drawn in a stereotypical way. Be wary of stereotyping in a cartoon that involves people.
- Caricatures — overemphasis or distortion of physical features. In figure 1, the fish have large eyes and mouths to draw our attention to their conversation and to give them human qualities.
- Visual metaphors — the artist's means of helping us understand the topic. In figure 1, the large number of hooks and the use of the word *bite* suggest the fish will be caught.
- Exaggeration or distortion — for example, making things appear larger, smaller or greater in number than they really are. The number of fishing hooks is an exaggeration or distortion of commercial fishing techniques.
- Humour — the use of visual or verbal jokes or wit to make the viewer smile or laugh. Irony and satire are commonly used.
- Perspective — the point of view of the cartoonist. In figure 1, it is evident that the cartoonist believes that most fish will be gone by 2048, a date well into the future.
- Captions — text-based content that adds to the visual content. In figure 1, both of the fish have speech bubbles in which they discuss the sustainability of the fishing industry. (A speech bubble usually has a pointed end, like this , but because they are fish and cannot actually talk, the cartoonist has used 'thought bubbles', like this .)

STEP 3

Now systematically approach an analysis of the cartoon. Answer the following three questions.

- What issue does the cartoon convey? In figure 1, the issue is overfishing.
- What geographical concepts are related to the issue in the cartoon? In figure 1, the concepts of environment (the ocean), space (global), change (commercial fishing causing a decline in fish numbers), scale (global), interconnection (fishing techniques and human demand decreasing fish resources) and sustainability (the future) can be mentioned.
- What are the geographical implications of the cartoon? The cartoon in figure 1 implies that the future of the fishing industry could be at risk.

STEP 4

Complete your writing with a concluding statement on how you feel about the topic of the cartoon. The text below figure 1 states that 'This cartoon makes us think about the issue of taking fish from the ocean, and it questions the sustainability of the fishing industry: too many people are fishing for a limited resource'.

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Interactivity
Interpreting a geographical cartoon
Searchlight ID: int-3349

4.9.3 Let me do it

Developing my skills

Using the cartoon in figure 2 in subtopic 4.8 of your textbook, write a paragraph analysing the geographical issue portrayed.

Questions

1. Why is the fishing trawler drawn so small?
2. Has the trawler caught many fish? Explain your answer.
3. Explain the discussion between the two fish.
4. What message do you think is being conveyed in this cartoon?
5. How does this cartoon make you feel?

Checklist

I have:

- recognised the issue
- analysed the components of the cartoon
- identified the cartoonist's personal opinion or message
- stated my personal response on the geographical topic.

Skills questions

1. Cartoons are used to show:
   a. the general public's opinion on an issue
   b. the correct response to an issue
   c. the cartoonist's view on an issue
   d. the humour level of the cartoonist.
2. Cartoons are most often based on:
   a. known facts
   b. questionable data
   c. outdated topics
   d. controversial topics.
3. Why is it important to know the context, or bigger picture, of the issue in the cartoon?
4. Why do cartoonists exaggerate some aspects of their drawings?

4.15 Review

4.15.1 Review

The biophysical world

1. Refer to figure 1 in subtopic 4.2. Rank the Earth's spheres according to which are most affected by the production of food. Which sphere is the most affected? Why?
2. Refer to figure 2 in section 4.2 to answer the following questions.
   a. What continent has the largest area for cropland?
   b. What are the ***environmental*** concerns for agriculture production in Australia?
   c. What is the major ***environmental*** concern for Brazil? What is the name of the ecosystem that is mostly affected?
   d. Suggest why countries in Africa are less affected by agricultural pollution than countries in Europe and Asia.
3. As the world's population has increased, how have people been able to increase food production?

Deforestation

4. Look around the room you are in at present. List all the products you can see that are made of wood. How dependent are we on forests? Explain.
5. Refer to a world vegetation map and a world climatic zone map in your atlas.
   a. Which continents or regions have rainforests?
   b. Rainforests are distributed between which latitudes?
   c. What climate zones are rainforests associated with?
   d. Write a paragraph that describes the ***spatial*** distribution of rainforest biomes.
6. Explain why the production of biofuels has a negative effect on the ***environment*** and food production.
7. There are several organisations, such as the Worldwide Fund for Nature (WWF), which are now involved in rescuing and protecting endangered orangutans in South-East Asia.
   a. Research another organisation that is involved in rescuing and protecting orangutans
   b. Do you think this organisation will be successful in achieving its aims? If so, why? If not, why not? What needs to be done?

Overfishing

8. What does the term 'overfishing' mean?
9. What are the impacts of overfishing practices?
10. What are the advantages and disadvantages of turning to aquaculture for food production?
11. The prestigious Peninsula Hotel in Hong Kong has taken shark fin soup off its menu in protest against shark finning. Is this scale of protest enough? What else could be done?

Land degradation

12. Make a list of the types of human activities that can contribute to land degradation.
13. Why is land degradation a larger concern in rural areas compared to urban areas?
14. Research a ***place*** that is threatened by desertification, such as Mongolia, Patagonia, southern Spain, the Aral Sea or the Sahel in Africa. Write a fact file:
    a. Describe the location.
    b. Outline the factors that have contributed to desertification.
    c. Identify two consequences of desertification in this ***place***.
    d. Describe what is being done to reduce the consequences.

Water

15. What are some of the advantages of irrigated farming over rain-fed farming?
16. How has technology allowed us to access more water for food production? Construct a list and write a brief note on how each invention has ***changed*** water availability.
17. Is the increasing use of groundwater a ***sustainable*** option for future farming? Justify your answer.

Biodiversity

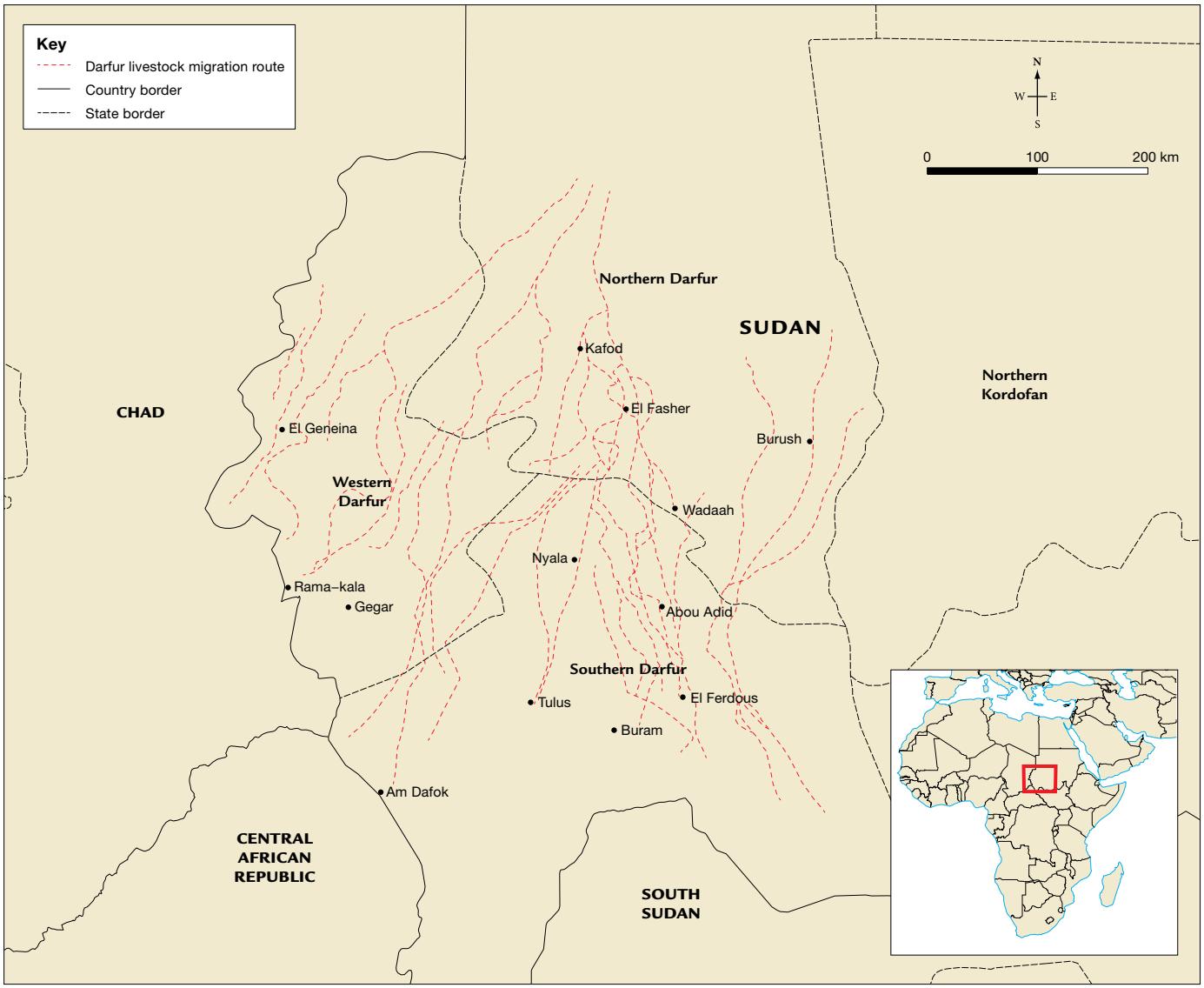
18. How has food production affected biodiversity and the number of threatened species?
19. Use the following data to construct a bar graph showing the worldwide percentages of threatened species.

- Plants 70 per cent
- Invertebrates 51 per cent
- Fish 39 per cent
- Amphibians 31 per cent
- Reptiles 30 per cent
- Mammals 22 per cent
- Birds 12 per cent

4.15.2 Reflect

20. In parts of the Sahel region of Africa, nomads traditionally moved their flocks of goats and camels around in search of water and feed. Over time, their range area has been reduced and political borders tightened up. Governments have installed wells to provide a more reliable water source for grazing animals but these in turn have created land degradation problems. Refer to figures 1, 2 and 3, which show the effects of overgrazing in Sudan, Africa, to answer the questions that follow.

FIGURE 1 Major historical migration routes used by nomadic herders in Sudan, Africa, in the past. Currently, the borders with Chad and the Central African Republic are closed, and even borders between provinces in Sudan are closed, so herders must stay within their own province.



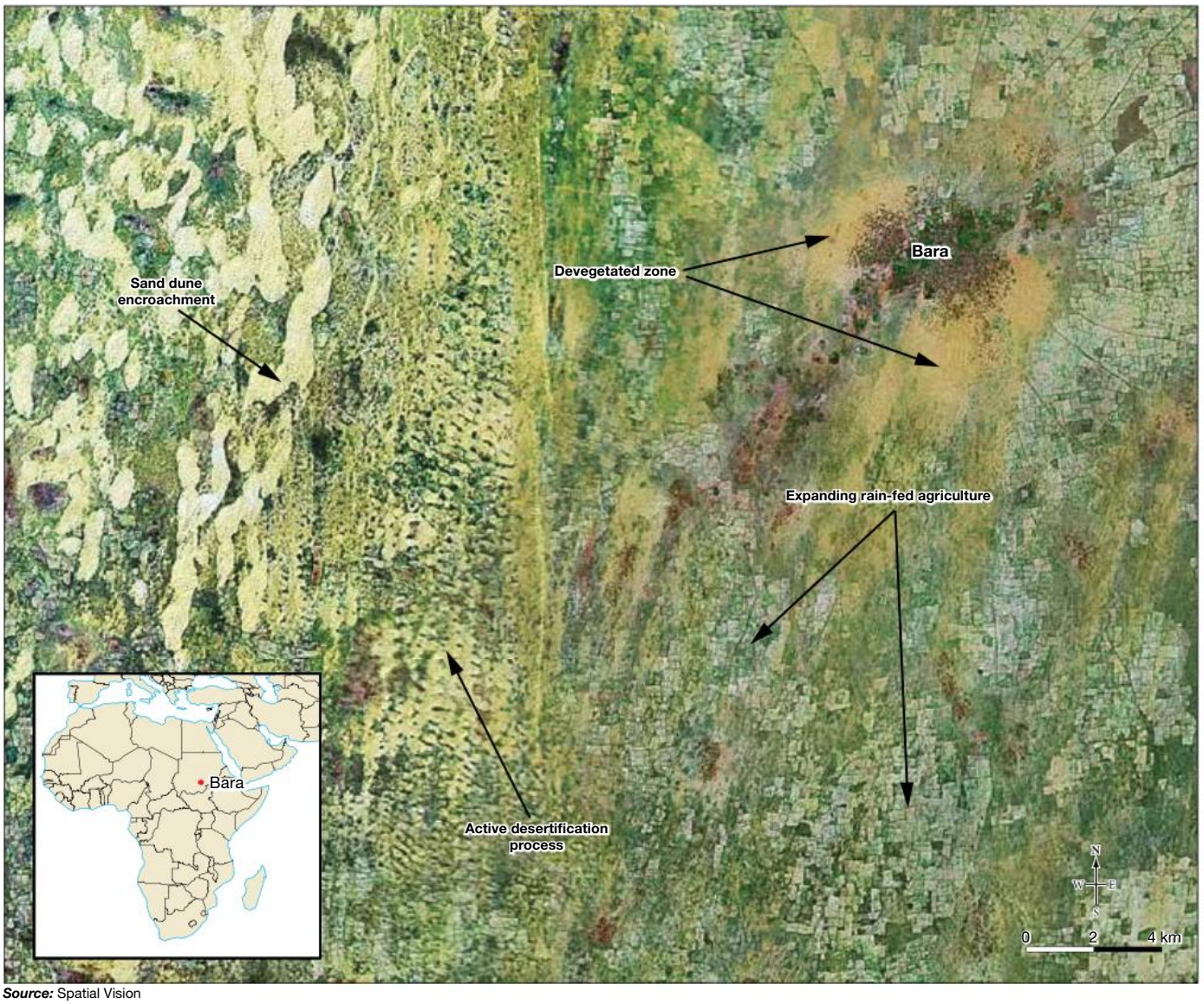
Source: Spatial Vision

Notes:

- Livestock migration from north to south is in February–March and from south to north in May.
- The routes shown on this map are major historical routes that have some degree of official and local recognition. However, routes can change over time and the legitimacy and impacts of many routes are a source of local and regional tension.
- Since the beginning of the Sudanese conflict, all livestock routes have been disrupted.

FIGURE 2 Cattle grazing around a waterhole in Sudan

FIGURE 3 False-colour satellite image showing the effects of agriculture and overgrazing in Sudan, Africa



Source: Spatial Vision

a. Describe the traditional patterns of livestock migration. Use distances, directions and regional borders in your answer.
b. How might conflict between the different regions of Sudan influence nomadic herdspeople?
c. Study figure 2. What ***changes*** do cattle bring to the areas around waterholes?
d. What is the extent of degradation shown occurring around Bara in figure 3? Use the ***scale*** on the satellite image to estimate the size of the area affected by degradation.
e. Predict what might happen if the areas of sand dune encroachment (spreading) and active desertification enlarge.
f. How might this affect available food supplies for Bara?

21. How can you provide assistance to people and their livelihoods and yet prevent ***environmental*** damage?
22. *Desertification is not caused by any one thing, but rather by a combination of factors*. Do you agree or disagree with this statement? Explain your viewpoint.
23. Palau, a small country of 22 000 people and 200 islands, is located 800 kilometres east of the Philippines. It is the first nation in the world to create a shark sanctuary. Estimates have shown that catching 100 reef sharks would be worth a one-off $18 000. Those same reef sharks, as a tourist and diving attraction, currently bring in $18 million annually. It took some effort to convince Palauans to protect sharks, but they are now responsible for managing and enforcing shark-fishing restrictions.
    a. How is the decision of the Palau government an example of sustainability?
    b. Is this the best way to reduce the ***environmental*** threat of overfishing of a species?
24. In Western Australia, there are plans to export shark fins that have a 'green stamp'; that is, they are caught and processed in a ***sustainable*** manner. Demand for ***sustainably*** caught fish would be very high, and they could earn up to $100 per kilogram (presently $10 to $20 per kilogram). Is this type of ***sustainable*** fishing acceptable to you? Give your opinion.

The paper industry

25. Create a table listing all the paper products that you might use in a day. In a second column, for each product suggest ways in which you could reduce your usage or substitute other more environmentally friendly products.
26. Construct a flow diagram to illustrate the different impacts that paper production and use has on the atmosphere, biosphere and lithosphere.

Urban expansion threatens the current and future production of food.

CHAPTER 5

Challenges to food production

5.1 Overview

5.1.1 Introduction

Food needs sunlight, water, land and good soil to be able to grow. Easy, right? The increasing scarcity of water, and demands on land for housing and other fuel, as well as climate change, have all made the production of food both today and in the future increasingly complex.

Starter questions

1. How long has it been since you had anything to eat?
2. How many different food items have you eaten today?
3. How many of these did your family grow?
4. Do you know when and where your next meal is coming from?
5. Do you feel secure in knowing that you have food in your home?
6. Why do you think we have so many people hungry when there is enough food produced in the world?
7. How will the world feed its future population?

Inquiry sequence

	Syllabus outcomes
5.1 Overview	
5.2 How does water security affect food production?	GE5-1, GE5-3
5.3 How does pollution affect food production?	GE5-1, GE5-3
5.4 SkillBuilder: Constructing and describing complex choropleth maps eBook plus ONLINE ONLY	GE5-2, GE5-3
5.5 How does land degradation affect food production? eBook plus ONLINE ONLY	GE5-2, GE5-3
5.6 How does a famine develop?	GE5-2, GE5-3
5.7 How does land use affect food production?	GE5-2, GE5-3
5.8 SkillBuilder: Interpreting satellite images to show change over time eBook plus ONLINE ONLY	GE5-3, GE5-7
5.9 How is Sydney expanding?	GE5-2, GE5-3
5.10 How does climate change affect food production?	GE5-3, GE5-5
5.11 Investigating topographic maps: What can we eat from Yarra Yarra Creek Basin?	GE5-3, GE5-7
5.12 Review eBook plus ONLINE ONLY	
Key terms eBook plus ONLINE ONLY	

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Food for thought
Searchlight ID: eles-1720

5.2 How does water security affect food production?

5.2.1 Are we running dry?

There is no substitute for water. Without water there is no food, and agriculture already consumes 70 per cent of the world's fresh water. Every type of food production — cropping, grazing and processing — requires water. Thus, a lack of water is possibly the most limiting factor for increasing food production in future.

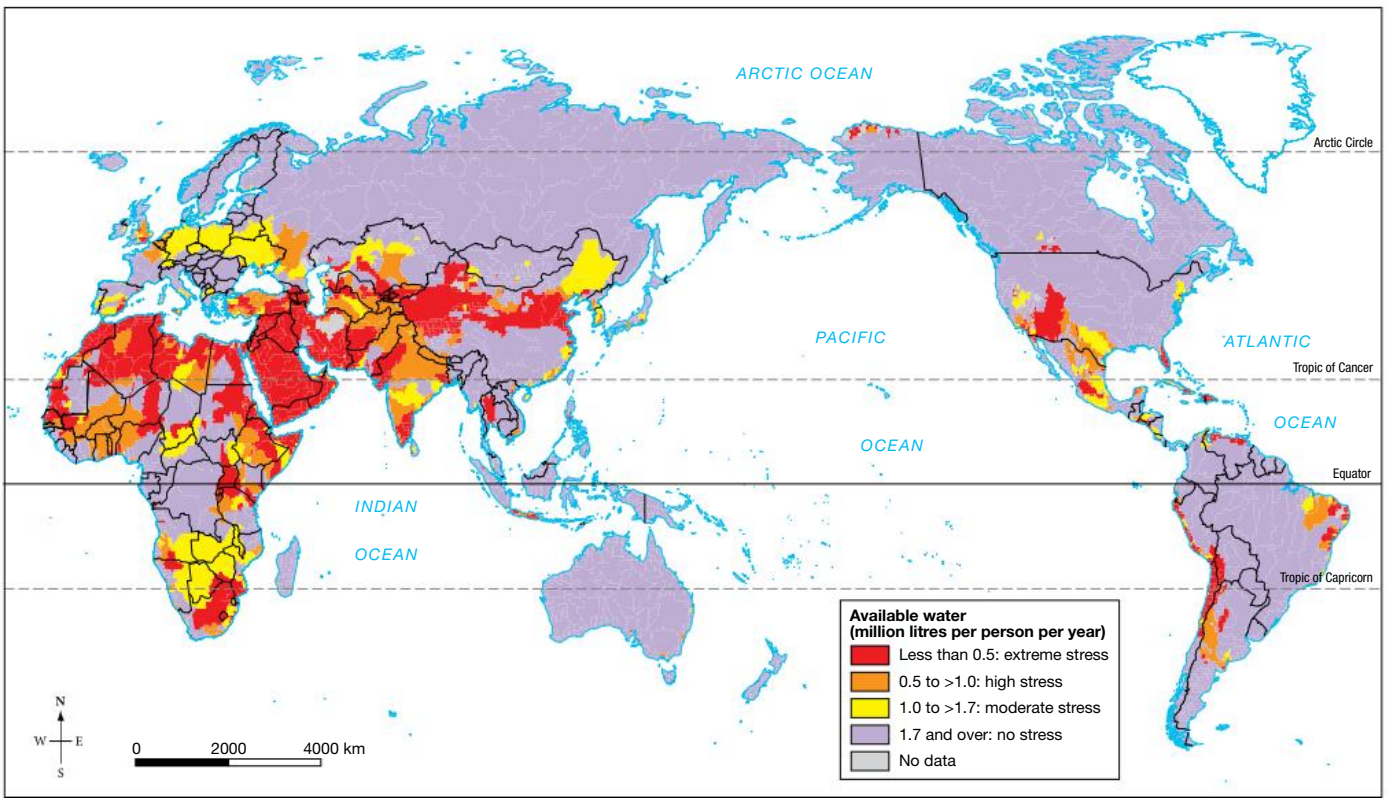
FIGURE 1 Water scarcity is a serious threat to food security.

To feed an additional two billion people by 2050, the world will need to generate more food and use more water. The two main concerns that threaten future water security are water quantity and water quality (see figure 1).

5.2.2 Why are we running low on water?

In theory, the world has enough water; it is just not available where we want it or when we want it, and it is not easy to move from place to place. We already use the most accessible surface water, and now we are looking for it beneath our feet. Underground aquifers hold 100 times more water than surface rivers and lakes. However, groundwater is not always used at a sustainable rate, with extraction exceeding natural recharge, or filling. This occurs in many of the world's major food-producing places, in countries such as the United States, China and India.

FIGURE 2 How water availability may change with temperature, population and industrialisation increase, 2050s



Source: Spatial Vision

Water insecurity is connected with food insecurity. An area is experiencing **water stress** when water supplies drop below 1700 m^3 per person per year. When annual water supplies drop below 1000 m^3 per person the population faces water scarcity, and below 500 m^3 'absolute scarcity'. According to the United Nations, approximately 700 million people currently suffer from water scarcity (2016). It is expected that by 2025, 1.8 billion people will be living in conditions of absolute water scarcity and that 67 per cent of people will be experiencing water stress. By 2030, it is projected that half of the world's population will experience high water stress conditions. Figure 2 shows an interconnection between increased demand for water and predicted climate change, population increase and greater industrialisation in the 2050s.

When water availability drops below 1.5 million litres per person per year, a country needs to start importing food, although that makes the country susceptible to changes in global prices. Developing countries that experience water stress cannot afford to import food. They are also more vulnerable to environmental disasters. Seventy per cent of food emergencies in developing countries are brought on by drought.

- *Food production*. It is estimated that an additional 6000 cubic kilometres of fresh water will be needed for irrigation to meet future food demand. Changes in diet, especially increased meat consumption, require more water to grow the crops and pasture that feed the animals. A typical meat eater's diet requires double the amount of water that a vegetarian diet requires.

water stress situation that occurs when water demand exceeds the amount available or when poor quality restricts its use

FIGURE 3 An increasing number of people around the world will face water stress and water scarcity.

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Interactivity
The last drop
Use this interactivity to further your understanding of the reasons for growing water shortages.
Searchlight ID: int-3328

FOCUS ON FIELDWORK

Fieldwork involves investigation: to determine the importance of water in the production of food you can conduct an investigation of the food found in your kitchen and determine how much water is required in its production. Firstly, you must determine what the raw ingredients are, for example a packet of chips (depending on the type) is made up of potatoes, vegetable oil and salt. Secondly, conduct research online to determine how much water is needed to produce each of the raw materials. Construct a table to show which foods use the most water.

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Weblinks
- Water use
- Water availability

ACTIVITIES

IDENTIFY

1 a Describe the difference between water scarcity and water stress.
b With reference to data, describe the projected changes in the numbers of people affected by water shortages (both scarcity and stress) over the period from now until 2030.

2 If a country has an average of 0.5 to <1.0 million litres of water per person, per year, would they be considered to be water stressed? Why?

EXPLAIN

3 a Refer to figure 2. Describe those ***places*** in the world that are predicted to be in high to extreme water stress in the 2050s.
b Compare your answer with a map of world average rainfall. Are areas that are predicted to be suffering high to extreme stress by 2050 also areas of low rainfall?

INVESTIGATE

4 Use the **Water use** weblink in your eBookPLUS to select a country and find out more about its water usage. Using the data on this website, construct a table to compare water usage for four countries — one from each continent of Europe, Africa, Asia and South America. (Try to select different countries from those chosen by other students.) Write a paragraph to summarise your findings.

PREDICT

5 Use the **Water availability** weblink in your eBookPLUS and scroll to the 2020s map. Compare this with the map for 2050. What are the three most significant ***changes*** you can see?

APPLY

6 What do you think water managers could do to help prevent water scarcity affecting future food security?

5.3 How does pollution affect food production?

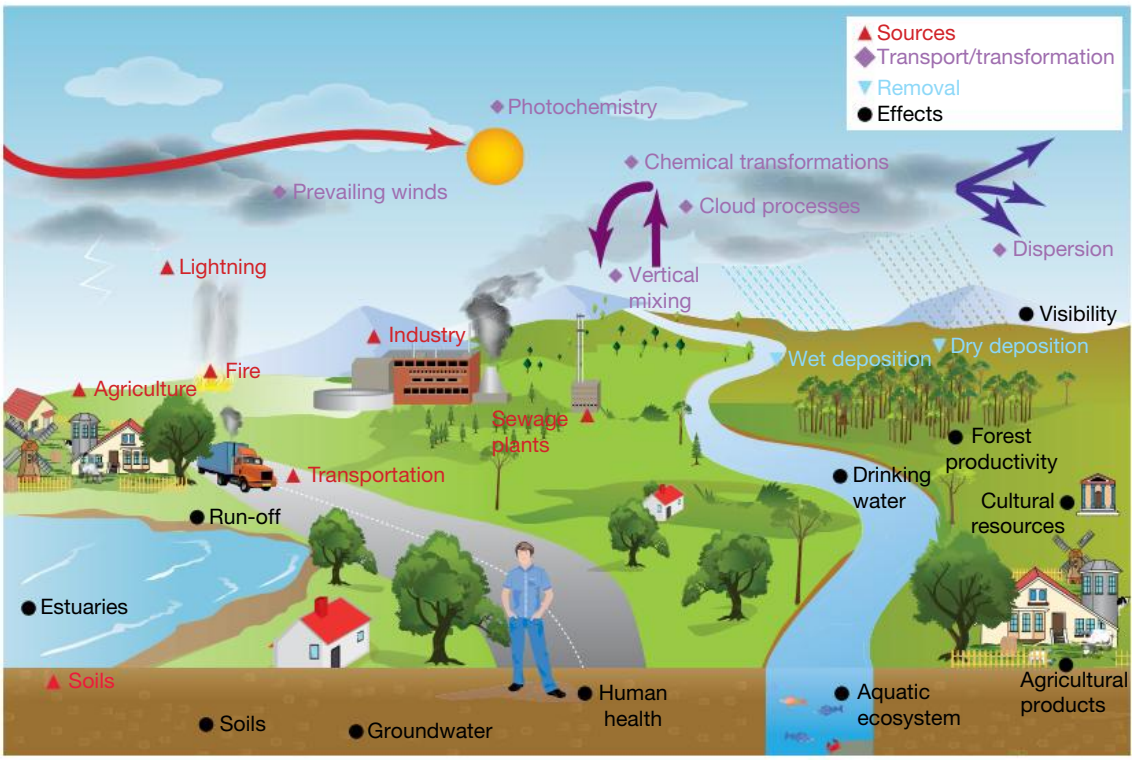
5.3.1 What are the impacts of pollution on food production?

Pollution affects agricultural activity, or food production, almost as much as does water scarcity. In fact, pollution of air and water poses one of the greatest threats to the production of food. The irony is that much of the pollution in the water comes from agricultural processes themselves.

Agriculture is a major contributor to water pollution. Excess nutrients, pesticides, sediment and other pollutants can run off farmland or leach into soils and groundwater. Excessive irrigation can cause waterlogging or soil salinity. This salty water not only poisons the soil but also drains into river systems. Industrial waste, untreated sewage and urban run-off also pollute water that may be used to irrigate farmland. Food that is irrigated with polluted water can actually pass on diseases to people. Pollution is an important contributor to the scarcity of clean, **potable** water.

potable drinkable: safe to drink

FIGURE 1 Global pollutants circuit



5.3.2 Air pollution

Figure 1 demonstrates the variety of ways in which the sources of air pollution can be transported or transformed into harmful effects. These can have a considerable impact on our food production, not only in a direct manner in the form of agricultural products (bottom right) but also indirectly through some of the other effects (shown with black dots in figure 1).

FIGURE 2 An apple a day may not keep the doctor away.

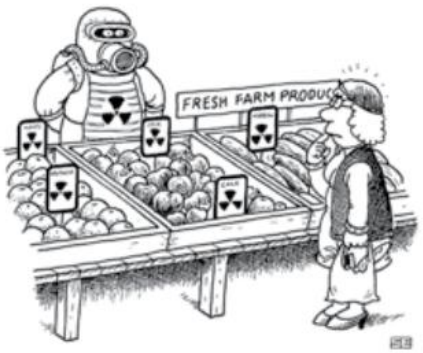
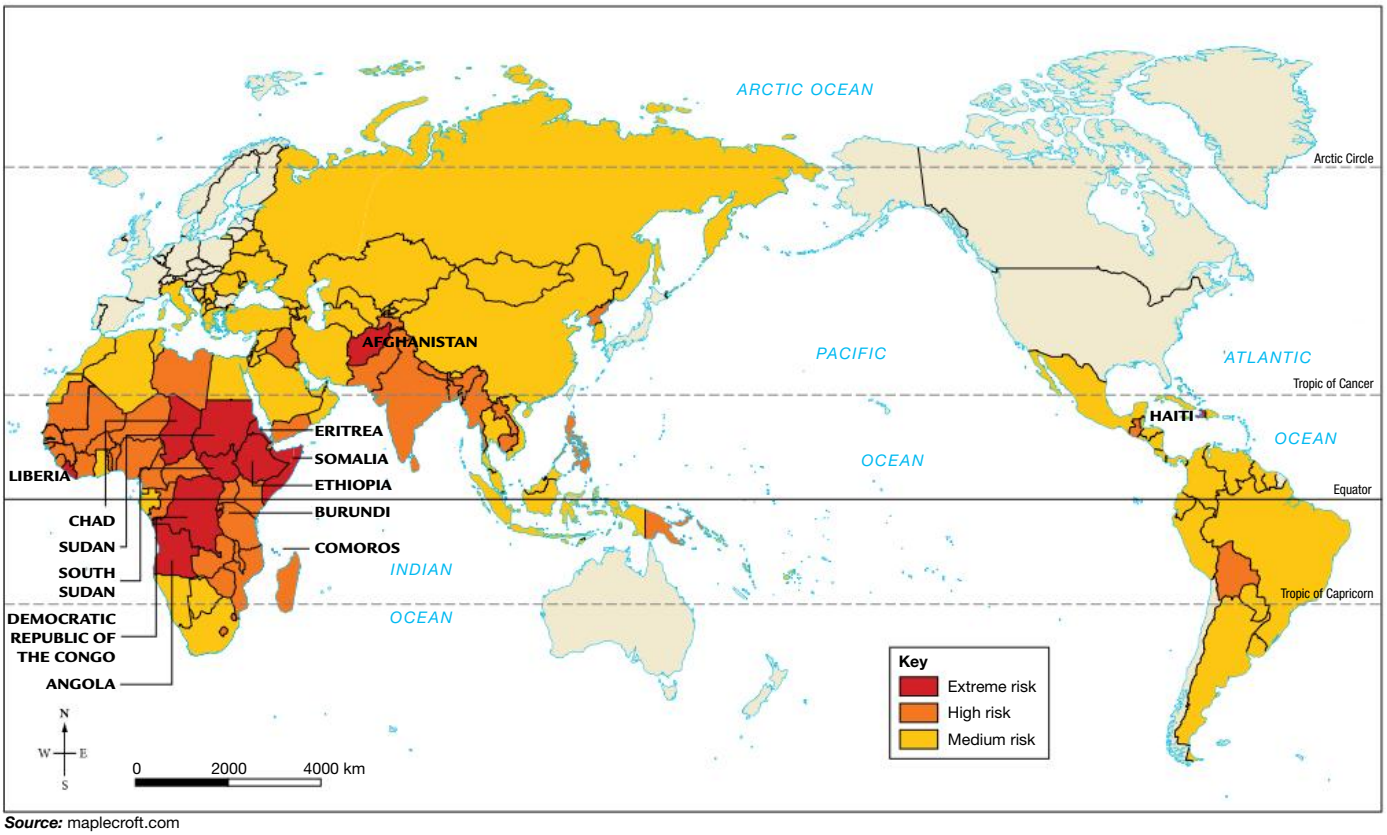


FIGURE 3 Countries with medium to extreme risk of food insecurity



Source: maplecroft.com

TABLE 1 Countries with high or extreme risk of food insecurity

Rank	Country	Category	Rank	Country	Category
1	DR Congo	Extreme	11	Comoros	Extreme
1	Somalia	Extreme	12	Sudan	Extreme
3	Burundi	Extreme	13	Central African Republic	High
4	Eritrea	Extreme	14	Djibouti	High
5	Angola	Extreme	15	Zimbabwe	High
6	Chad	Extreme	16	Yemen	High
7	Ethiopia	Extreme	17	Sierra Leone	High
7	Haiti	Extreme	18	Mozambique	High
9	Afghanistan	Extreme	19	North Korea	High
9	Liberia	Extreme	20	Kenya	High

5.3.3 What happens when people do not have food security?

For the 800 million people who do not have enough to eat, the issue of finding sufficient and nutritious food must be faced daily. At least 75 per cent of the world's people are **undernourished**, with diets that are minimal or below the level of sustenance. People who do not have a regular and healthy diet often have shortened life expectancy and an increased risk of disease. Children are especially vulnerable to poor diet, and their growth, weight, physical and mental development suffer. Almost 50 per cent of India's children are **malnourished**, and it is estimated that there are 146 million children in the world suffering chronic hunger.

This is often referred to as the 'double burden' of disease. This means that individuals who are most at risk of having poor diets are more likely to suffer from the effects of disease. Once a disease has been contracted it has an impact on a person's health and functioning.

undernourished describes someone who is not getting enough calories in their diet; that is, not enough to eat

malnourished describes someone who is not getting the right amount of vitamins, minerals and other nutrients to maintain healthy tissues and organ function

ACTIVITIES

EXPLAIN

1 a Examine figure 1 and make a list of the sources of pollution and factors that remove pollution.

b Compare the two and suggest what happens as a result of the unevenness of the two lists.

2 What are some of the effects that pollution can have on food production?

3 Why is agriculture both a contributor to and victim of water pollution?

INVESTIGATE

4 Select one the countries identified in figure 3 and find out more about its agricultural production. Does agriculture contribute to pollution as well as suffering from it?

APPLY

5 What does figure 2 suggest about the potential for pollutants to affect food production?

6 Draw your own cartoon indicating one of the issues that pollutants cause in agriculture.

7 Looking at figure 3 and table 1, what trends can you identify in the location of countries at risk of food insecurity?

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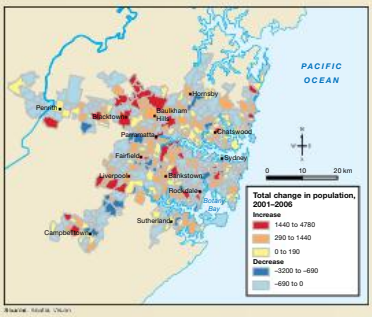
5.4 SkillBuilder: Constructing and describing complex choropleth maps

What is a complex choropleth map?

A complex choropleth map is a map that is shaded or coloured to show the average density or concentration of a particular feature or variable, and it shows an area in detail. The least dense or lowest concentration is usually the lightest shade. Average values are attached to the colour shadings in the key or legend. A complex choropleth map is used to show values in a pictorial way.



eLesson

Watch this video to learn how to construct and describe complex choropleth maps.

Searchlight ID: eles-1732

Interactivity

Try this interactivity to learn how to construct and describe complex choropleth maps.

Searchlight ID: int-3350

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5.5 How does land degradation affect food production?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

5.6 How does a famine develop?

5.6.1 Why did Somalia have a famine?

While many countries across the globe face food insecurity, it is rare for a country or region to be officially declared in **famine**. At the same time that countries in the Horn of Africa were suffering drought, much of southern Australia was similarly affected. Yet we did not suffer from food insecurity, nor was a famine declared. Why is there such a difference?

famine a drastic, widespread food shortage

arable describes land that is suitable for growing crops

Somalia is located in the Horn of Africa. It is an arid place with less than 2 per cent **arable** land. For 20 years, the country suffered almost continual hardship. A *combination* of political, economic and environmental factors combined to create an acute food crisis. The United Nations declared a famine in two parts of southern Somalia in July 2011, and a month later the famine spread to four more regions. Figures 2 and 3 show the progression of the famine across the country. In all, 42 per cent of the population needed emergency life-saving assistance over the six months of the declared famine.

FIGURE 1 Famine in Somalia, May 2011

What contributed to the famine?

- The country experienced the worst drought in 60 years, which led to failed harvests.
- Prices of both local and imported foods soared; cereal prices increased up to 190 per cent.
- Since the 1990s, there have been 14 failed attempts to achieve peace and reconciliation within the country.
- The militant Islamist al-Shabaab group banned most Western aid agencies and expelled the Red Cross from areas it controlled.
- Somalia has not had a functioning central government for more than 20 years.
- Conflict and a shortage of food caused people to flee rural areas, creating large-scale displacement.
- Half of all food aid sent to Somalia is stolen.
- Somalia is dependent on imports for over 60 per cent of its food supply (mostly rice and wheat flour).
- The country lacks good road and rail infrastructure, so food cannot be moved around and delivered easily. Frequent militia-run checkpoints make travel dangerous.
- Shipping has been affected by increased pirate attacks in the Gulf of Aden. This has further increased the shortage and cost of imported foods.
- The main port can only deal with small ships. Larger ships have to offload into smaller ones in Dubai or Oman, which increases the costs of food items.

What were the impacts of famine?

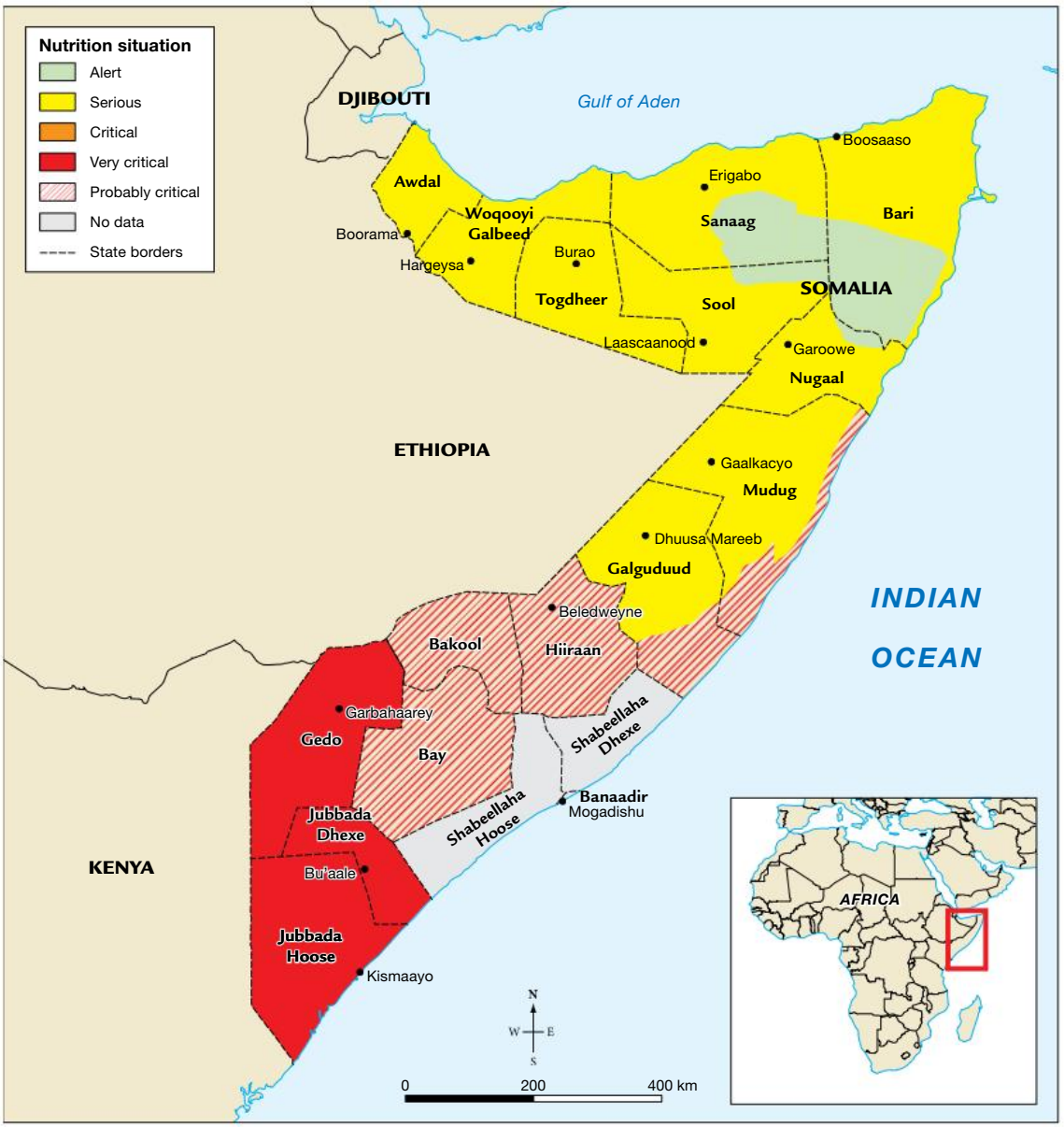
- Approximately 30 000 children died in just four months, from April to July 2011.
- Three million people in southern Somalia became food insecure.
- Along with displaced people, around 25 per cent of urban populations were affected by high food costs and food shortages.
- The United Nations estimated that over 1.4 million people became IDPs (internally displaced persons). Over 900 000 became refugees, fleeing to Ethiopia and Kenya in search of food.
- Livestock were decimated.
- Due to the high costs of purchasing food, diets were reduced to fewer than four food groups per day, mostly grain and oil, and the number of meals per day was reduced.

humanitarian aid assistance provided in response to a human crisis caused by natural or man-made disasters, in order to save lives and alleviate suffering

What is happening now?

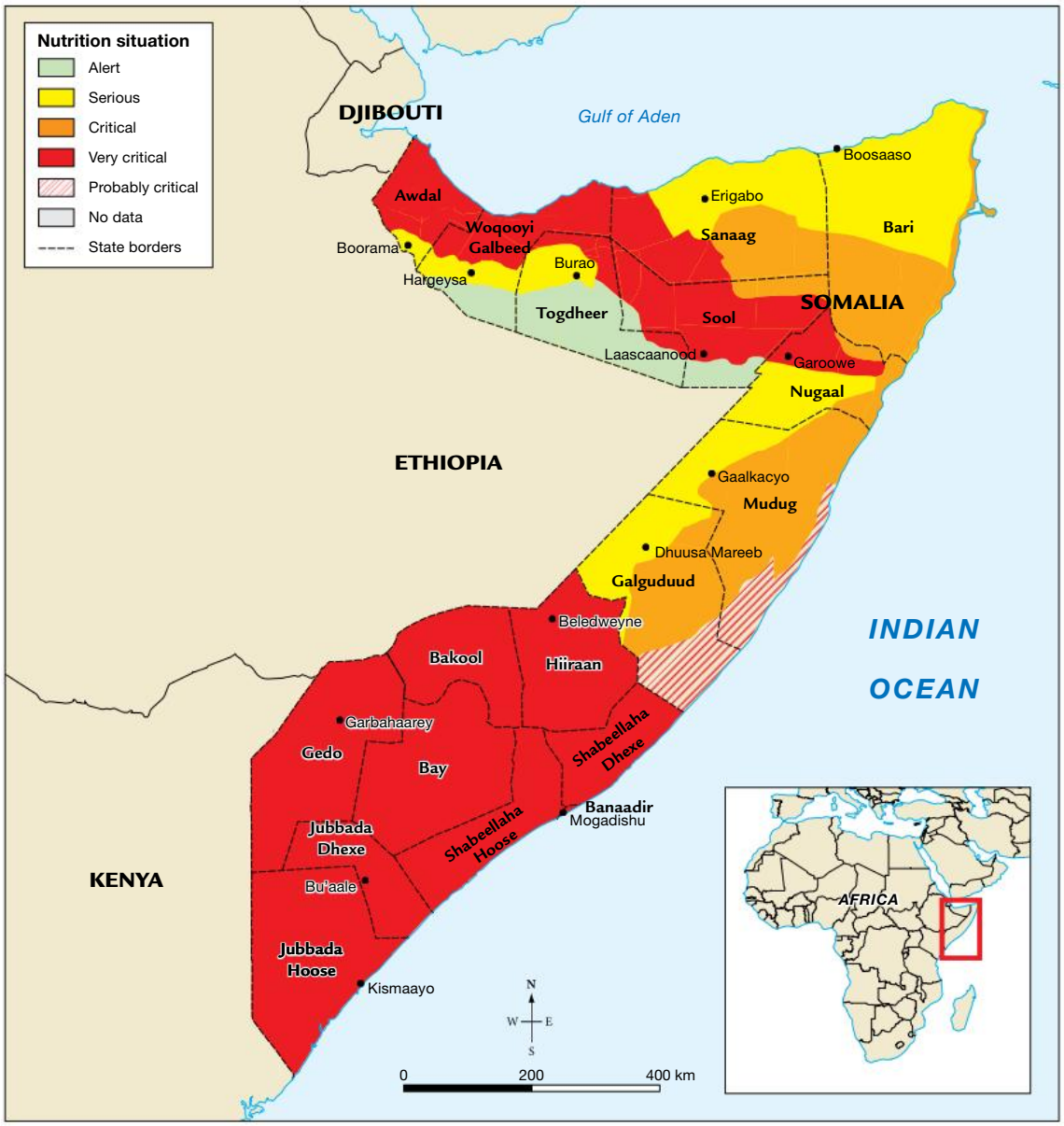
The famine was officially declared over by February 2012. This was due to a combination of good rainfall (allowing crop harvests to double that of the previous 17 years' average) and large-scale **humanitarian aid**. Twelve months later, however, 3.8 million people still needed emergency support in the form of food, clean water, shelter, and help in restocking their land with seeds and grazing animals. Other assistance included drilling more water bores, supplying irrigation pumps, and providing cash-for-work projects to upgrade irrigation channels.

FIGURE 2 Somalia's nutrition situation, January 2011



Source: Data from FAO, Food Security and Nutrition Analysis Unit.

FIGURE 3 Somalia's nutrition situation, August 2011



Source: Data from FAO, Food Security and Nutrition Analysis Unit.

ACTIVITIES

IDENTIFY

1 When does a food crisis become a famine?

INVESTIGATE

2 Refer to figures 2 and 3.
- **a** Construct a table to compare the approximate percentages of the country classified as: on alert, serious, critical, very critical, and likely critical.
- **b** Describe the ***changes*** over time in the spread of the famine.

3 With the help of your atlas, identify the direction and countries that most refugees will flee to.

4 Refer to figure 1 and use the **Fleeing Somalia's drought** weblink in your eBookPLUS to watch a slideshow on the Somalian famine.
- **a** Make a list of all of the belongings of the family in figure 1 in the refugee camp.
- **b** Describe the ***environment*** around the camp and the living conditions there.

5 List the difficulties that aid agencies might have when faced with getting aid to people.

PREDICT

6 **a** What might happen when you get a relatively sudden and large-scale movement of people fleeing from one country and crossing the border into another?
- **a** What happens to the refugees? What can the new host country do?

APPLY

7 Much of Australia was in an extended period of drought for over ten years, yet we did not experience food insecurity. Why?

eBookplus

Weblink
Fleeing Somalia's drought

5.7 How does land use affect food production?

5.7.1 Competition for land

urban expansion the increasing size of urban areas

Urban expansion, industrialisation and energy production is taking over land once used to produce food. This is a major global issue that affects the future production of our food.

There has been a growing global trend to convert valuable cropland to other uses. Urban expansion, industrialisation and energy production all require land. For example, in less than 16 years, China lost more than 14.5 billion hectares of arable land to other uses. This land no longer produces food, which then puts pressure on existing land resources to make up the loss.

5.7.2 Biofuel

biofuel fuel that has been produced from renewable resources, such as plants and vegetable oils, and treated municipal and industrial wastes

jatropha any plant of the genus *Jatropha*, but particularly *Jatropha curcas* which is used as a biofuel

Biofuel refers to fuel that has been produced from renewable resources, such as plants and vegetable oils, and treated municipal and industrial wastes.

Traditionally, the main forms of biofuel have been wood and charcoal. Almost 90 per cent of wood harvested in Africa and 40 per cent harvested in Asia is used for heating and cooking. Today, people are seeking more renewable energy sources and wanting to reduce CO_2 emissions associated with deforestation, so there is greater demand for alternative energy sources. Consequently, the use of agricultural crops to produce biofuels is increasing. Ethanol (mostly used as a substitute for petrol) is extracted from crops such as corn, sugar cane and cassava. Biodiesel is derived from plantation crops such as palm oil, soya beans and **jatropha**.

FIGURE 1 Jatropha

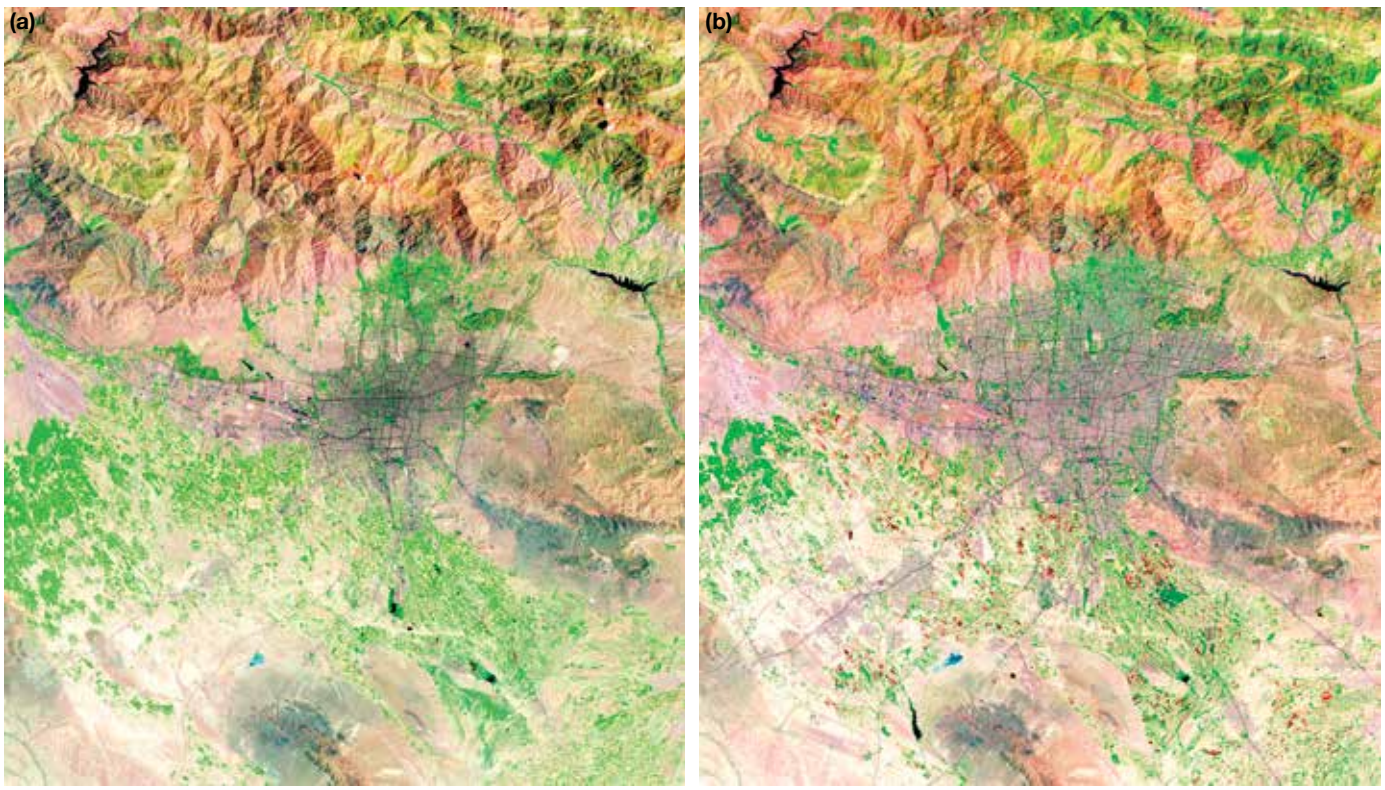
The growth of the biofuel industry has the potential to threaten future food security by:

- changing food crops to fuel crops, so less food is produced and crops have to be grown on marginal land rather than arable land
- increasing prices, which makes staple foods too expensive for people to purchase
- forcing disadvantaged groups, such as women and the landless poor, to compete against the might of the biofuel industry.

5.7.3 Urban expansion

Cities tend to develop in or near places that are agriculturally productive. However, as they expand due to population growth, the city encroaches on valuable farmland. This farmland is then converted into housing and infrastructure to support the population. Additional pressure is placed on farmers to produce more food for the increasing number of people on less arable land.

FIGURE 2 Satellite image of the city of Tehran (a) in 1985; (b) in 2009 — the expansion of the city has taken over valuable arable land.



5.7.4 Land grabs

A growing threat to world food security is the purchase or lease of land in developing nations by resource-poor but wealthy nations or companies. According to Oxfam, more than 60 per cent of crops grown on land bought by foreign investors in developing countries are intended for export, instead of feeding local communities. There are many international groups such as Oxfam campaigning against **land grabs** with some success.

Poor and war-ravaged Liberia, in Western Africa, has sold or leased 57.5 per cent of its land to countries, such as Malaysia, for oil palm plantations. Around 80 million hectares of its land (equivalent to all the farmland in Britain, France, Germany and Italy) is used to grow food or fuel crops for the owner country or corporation. In Mozambique, where one-third of the population suffers food insecurity, less than 10 per cent of land sold for overseas agricultural investment is for food crops. Figure 3 shows the global scale of 'land grabs'.

The dramatic rise in land acquisitions across the globe is in response to the 'triple-F' crisis — food, fuel and finance.

- Food crisis — large increases in world food prices in 2007 and 2008 emphasised the need for food importing countries, such as Saudi Arabia and China, to improve their food security by obtaining land in other countries.
- Fuel crisis — rising and fluctuating oil prices between 2007 and 2009 created an incentive for countries to acquire land for the production of biofuel crops as a substitute for oil (see figure 4).
- Financial crisis — the global financial meltdown in late 2009 saw organisations switch from investing in stocks and shares to investing in land in overseas countries, especially land that could be used for food and fuel crops.

land grabs
large-scale buying or leasing of land by governments or companies

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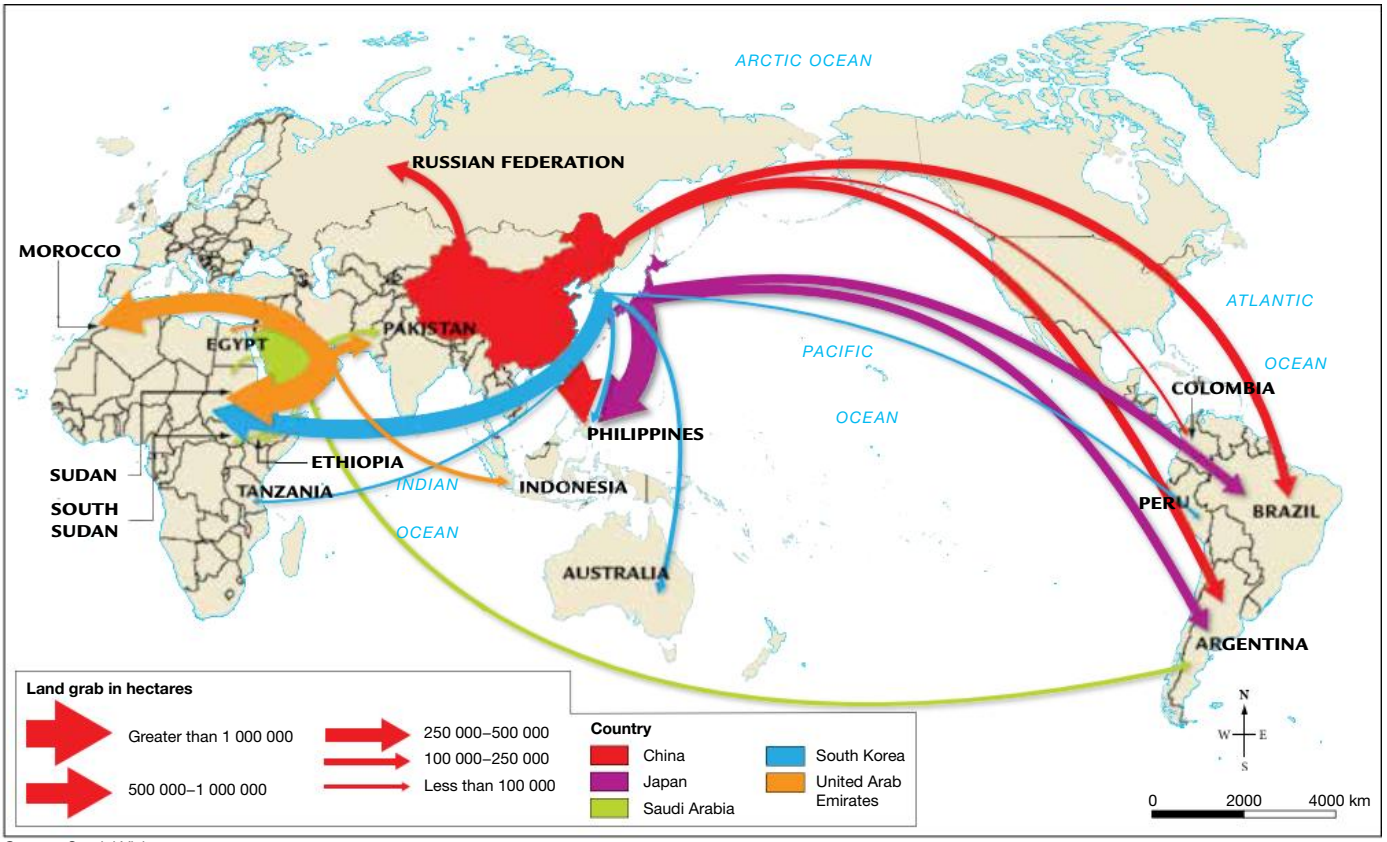
Interactivity
Who is grabbing land?
Use this interactivity to further your understanding of key countries involved in land grabs.
Searchlight ID: int-3327

FIGURE 3 Who is buying land and where



Source: Spatial Vision

FIGURE 4 Countries in Africa where land is being bought by other nations for biofuel crops

Ghana Italian-based Agroils obtains 105 000 hectares, Jatropha Africa (UK) acquires 120 000 hectares, Scanfuel (Norway) cultivates 10 000 hectares and has contracts for 400 000 hectares, Galten (Israel) acquires 100 000 hectares.

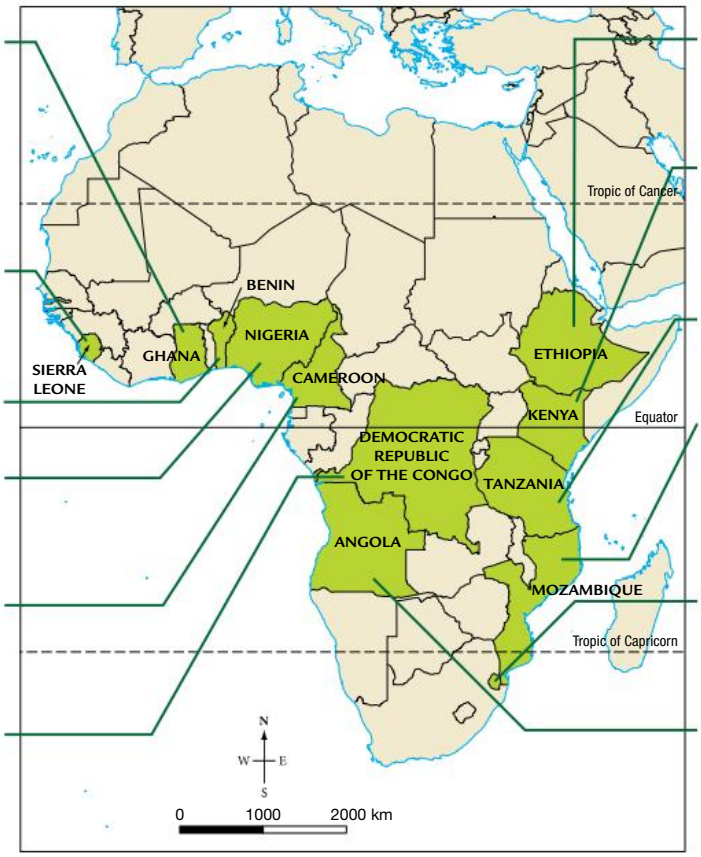
Sierra Leone Swiss-based Addax Bioenergy obtains 26 000 hectares for sugar cane.

Benin Proposed 300 000–400 000 hectares of wetlands to be converted for palm oil.

Nigeria Land acquisitions by the state using foreign capital and expertise. Over 100 000 hectares grabbed.

Cameroon Cameroon/French company expanding palm oil plantations including 60-year lease on 58 000 hectares.

Congo Chinese company requests 1 million hectares. Italian energy corporation ENI plans palm oil plantation of 70 000 hectares.



Source: Friends of the Earth.

Ethiopia 700 000 hectares earmarked for sugar cane. 23 million hectares suitable for jatropha.

Kenya Japanese, Belgian and Canadian companies plan to purchase up to 500 000 hectares.

Tanzania 1000 rice farmers forced off their land to make way for sugar cane.

Mozambique Investors aim for 4.8 million hectares. Over 183 000 hectares currently allocated to jatropha. Companies: UK, Italy, Germany, Portugal, Canada and Ukraine.

Swaziland UK-based D1 Oils suspends expansion of jatropha despite promotion by rockstar Bob Geldof.

Angola 500 000 hectares of land designated for agrofuels. Angolan, Brazilian, Spanish and South African companies.

5.7.5 The risk to food security

Investors in farmland are, understandably, seeking land that has fertile soils and good rainfall or access to irrigation water. With land comes the right to withdraw the water linked to it, and this can deny local people access to water for fishing, farming and watering animals. There may also be negative effects downstream when water is reduced in rivers. The Niger River, West Africa's largest river, flows through three countries and sustains over 100 million people, so any water reductions in it would have enormous effects. Mali is one country through which the Niger flows. There, by the end of 2010, around 500 000 hectares of fertile land had been leased by foreign companies and countries. Despite Mali having limited arable land, and 15 per cent of its children suffering malnutrition, a high percentage of land bought by foreign owners will be used for biofuel crops. Land that is purchased in other countries is usually already occupied and used by small-scale farmers — often women who do not always benefit from any compensation. Prices for land are usually very low, and there is frequently corruption, with much money going to local and government officials. Promised jobs do not always materialise. There are risks associated with monoculture farming and loss of biodiversity in the region.

ACTIVITIES

IDENTIFY

1 Why is the use of corn as a biofuel a threat to food security?
2 What is meant by the term *land grab*?

EXPLAIN

3 Compare the advantages and disadvantages of using biofuels, such as wood and charcoal, instead of oil and gas in developing and developed nations.
4 Refer to figure 3.
   a Which three countries are the largest purchasers of overseas land? Use figures in your answer.
   b Why do you think South Korea has invested in so many countries in such different ***places***?

APPLY

5 What is jatropha? What are the benefits of growing this rather than corn and other biofuels?

PREDICT

6 Do you think Australia will need to purchase farmland overseas? Give reasons for your answer.

INVESTIGATE

7 Are land grabs an effective solution for establishing a country's food security? Discuss your point of view.
8 What is happening in Australia? Investigate which foreign companies own farmland here, what they are using it for and where it is located.

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5.8 SkillBuilder: Interpreting satellite images to show change over time

What is a satellite image?

A satellite image is an image taken from a satellite orbiting the Earth. Satellite images allow us to see very large areas — much larger than those that can be visualised using vertical aerial photography. A satellite image often does not use the natural colours that we expect. This is referred to as using false colours, and these are applied in the computer processing of the images in order to highlight spatial patterns more clearly. You will gain a lot of information from a satellite image that cannot be gained from a topographic map or aerial photograph, so your knowledge of an environment is enhanced.

eLesson

Watch this video to learn how to interpret satellite images to show change over time.

Searchlight ID: eles-1733

Interactivity

Try this interactivity to learn how to interpret satellite images to show change over time.

Searchlight ID: int-3351

5.9 How is Sydney expanding?

5.9.1 Is Sydney expanding?

Sydney's population reached 5 million in 2015 and it is still growing. Due to urban expansion, Sydney's once farmland is being transformed into housing. Food once grown in Sydney is now grown interstate and transported to the markets.

FIGURE 1 The Sydney Royal Botanic Gardens is the oldest botanic garden and scientific institution in Australia. Covering 30 hectares near the CBD, it is protected from urban expansion and sprawl and provides open spaces for people to enjoy.

Sydney is Australia's largest city. By 2055, it is estimated that more than 8 million people will call Sydney home. Challenges come with living in the city such as the cost of living, cost of housing, traffic and commute times and employment opportunities. The State and Federal Governments have to plan sustainably to support the needs of the whole community whilst supporting economic growth and environmental concerns.

The Institute for Sustainable Futures assesses the changes in the Greater Sydney Metropolitan area. Currently, the Sydney Basin produces approximately 500 000 tonnes of food, including eggs, fruit, vegetables, meat and dairy. This supports about 20 per cent of the Sydney population. If current development trends continue, by 2031, Sydney will lose 60 per cent of its total food production. The Sydney basin will produce about 220 000 tonnes of food by 2031. Areas that will experience a decline in food production will see an increase in urbanisation. Housing developments in the Wollondilly, Liverpool, Penrith and Hawkesbury areas are expected to rise to support a growing Sydney population.

The New South Wales Government is planning to improve outdoor spaces, housing affordability and job opportunities throughout the Greater Sydney Metropolitan area. By 2020, the Parramatta CBD would offer over 100 000 jobs that support the health, education, retail and finance sectors. Marsden Park, Campbelltown and Penrith are developing a high-value economic zone especially for business and industrial activities.

5.9.2 How is the landscape changing?

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Weblink
Urban sprawl eats into Sydney's farmland

Urban sprawl eats into Sydney's farmland

Despite his family growing peaches and lemons on the fringes of Sydney for nearly 50 years, Warren Rowles says the farming tradition will end with him. 'It's never been so tough,' said Mr Rowles, 59, from his Glenorie farm near the Hawkesbury River on the outskirts of the Hills district. 'I'm waiting for a developer to give me an offer. My two daughters have city jobs and they aren't interested.' Mr Rowles is part of Sydney's shrinking pool of farmers sending fresh fruits and vegetables to the Sydney Markets at Flemington, which now draws two-thirds of produce from interstate.

Victorian growers sent 28 per cent and Queensland 21 per cent of the 860 000 tonnes of fruit and vegetables sold at the markets in 2010, a study by the University of Western Sydney found.

More than 97 per cent of fruit and vegetables were grown beyond a 150-kilometre radius of the market, which serves greengrocers, supermarkets and restaurants weekdays and the public on weekends.

Supplies of local produce had become 'disappointingly insignificant', said Professor Phillip O'Neill, who worked on the study. 'Sydney farms are disappearing but now we know it's fallen below any levels of significance,' he said. The study found that more than 93 per cent of leafy and stem vegetables such as spinach and celery — the category dominated by producers in the Sydney basin — came from Victoria.

Sydney's urban sprawl had wiped out market gardens on peripheral land since first settlement, said Professor O'Neill. 'The problem now is Sydney's expansion has reached the last phase, where in 20 to 50 years the sprawl will eradicate unprotected farms,' he said. NSW growers had excelled in producing mushrooms, with most less than 50 kilometres from the market. They also contributed three-quarters of citrus fruit and melons sold at the market. The study found 75 per cent of produce travelled between 500 and 2000 kilometres, while tomatoes from Perth came 3041 kilometres.

The chief executive of Sydney Markets, Brad Latham, said produce travelled vast distances because it was cultivated in the most ideal regions. 'Victoria is great for leafy greens. It's feeding NSW and Australia,' he said. 'Northern Queensland's climate is fantastic for bananas and mangoes. The diversity is great.'

Colin Gray, chief executive of NSW Chamber of Fruit and Vegetable Industries, said wholesale and retail prices were determined by supply and demand. 'A good tomato from 20 kilometres away can be more expensive than poor quality ones 3000 kilometres away,' he said. 'The transport cost is absorbed by the grower in most cases.'

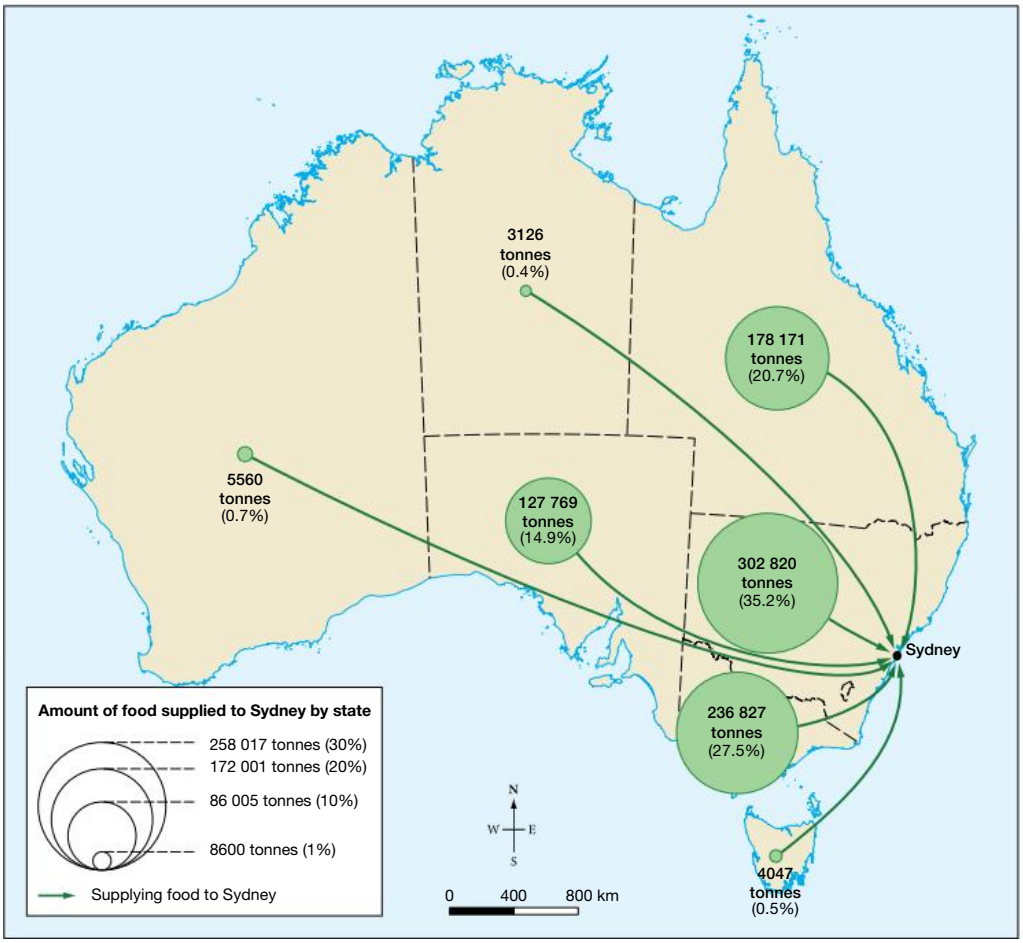
The level of specialisation in agricultural regions, such as stone fruits in northern Victoria and leafy vegetables in the south, surprised Professor O'Neill. 'We felt the impact of this during the Black Saturday bushfires in Victoria. The leaves absorbed the smoke and couldn't be eaten. The industry was severely hit and prices rocketed.'

Julian Lee, founder of Sydney Food Connect, said flaws of the central market system were exposed during natural disasters and revealed the need for various food supply chains such as farmers markets.

At his farm, Mr Rowles reflected on the impact of the urban sprawl on his family. His parents grew peaches and plums in Carlingford in the 1960s but were pushed out by housing constructions. They moved to Glenorie, where he lives today. 'Getting fruits from interstate is part of the progression of things, fuelled by reliability of weather and affordability of farming land. I get it,' he said.

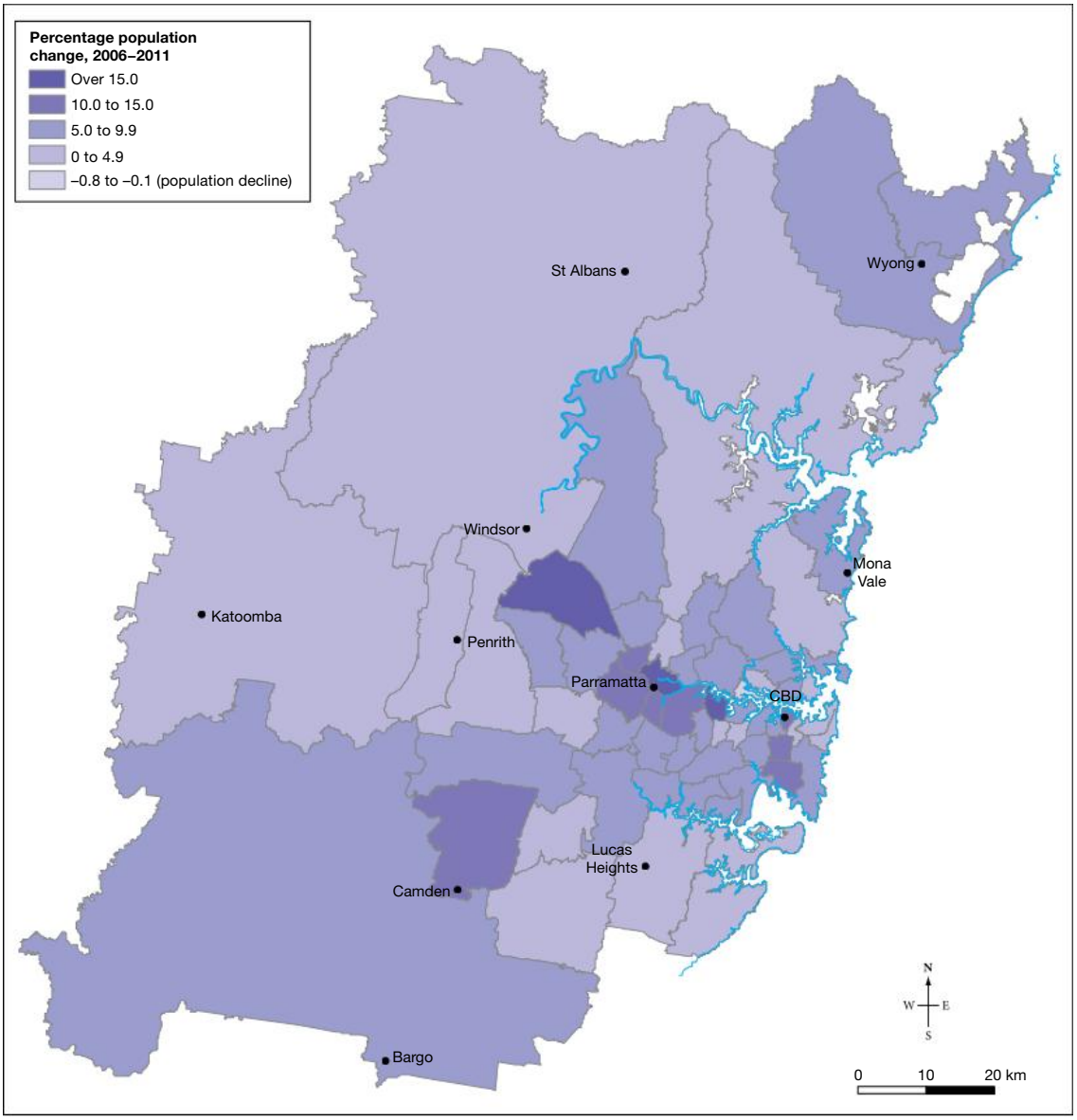
Source: Esther Han, *Sydney Morning Herald*, 28 July 2013

FIGURE 2 Sydney's Food Footprint; where our fresh fruit and vegetables come from.



Source: Urban Research Centre, University of Western Sydney.

FIGURE 3 Urban growth in Sydney



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 a How much food is transported interstate to Flemington markets?

b Where does the food come from?

2 State reasons food has to be transported to Flemington markets.

3 Which fruits and vegetables have to travel the furthest to reach Flemington markets?

4 Why was agricultural land replaced?

EXPLAIN

5 Refer to figure 3. Study the map.

a Explain the history of urban expansion in Sydney.

b Describe some problems associated with urban expansion.

c State some benefits of fruit coming from interstate.

APPLY

6 Why is there a declining number of farmers sending fruit to Flemington?

PREDICT

7 With such limited agricultural land, there is a lot of pressure placed on farmers to feed people. As the Australian population continues to grow in urban areas, less agricultural land is available. Suggest some solutions to meet the food requirements. Consider what individuals, groups and the government could do to assist.

5.10 How does climate change affect food production?

5.10.1 How will food security be affected by climate change?

The impacts of climate change on future world food security are a case of give and take. Some regions of the world will benefit from increases in temperature and rainfall, while others will face the threat of greater climatic uncertainty, lower rainfall and more frequent drought. In either case, food production will be affected.

Agriculture is important for food security, because it provides people with food to survive. It is also the main source of employment and income for 36 per cent of the world's workforce. In heavily populated countries in Asia, between 40 and 50 per cent of the workforce is engaged in food production, and this figure increases to over 63 per cent in sub-Saharan Africa.

FIGURE 1 The majority of the workforce in sub-Saharan Africa are employed in the agriculture industry.

It is difficult to predict the likely impacts of climate change, because there are many environmental and human factors involved (see figure 2), as well as different predictions from scientists (see figure 3). Use the **How to feed the world in 2050** weblink in your eBookPLUS to find out more about this topic.

eBookplus

Weblink
How to feed the world in 2050

FIGURE 2 Possible impacts of climate change on food production

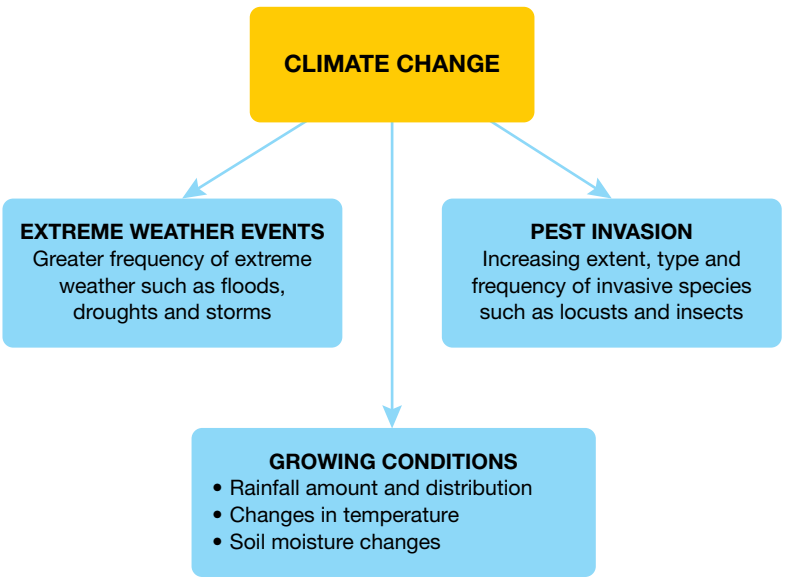
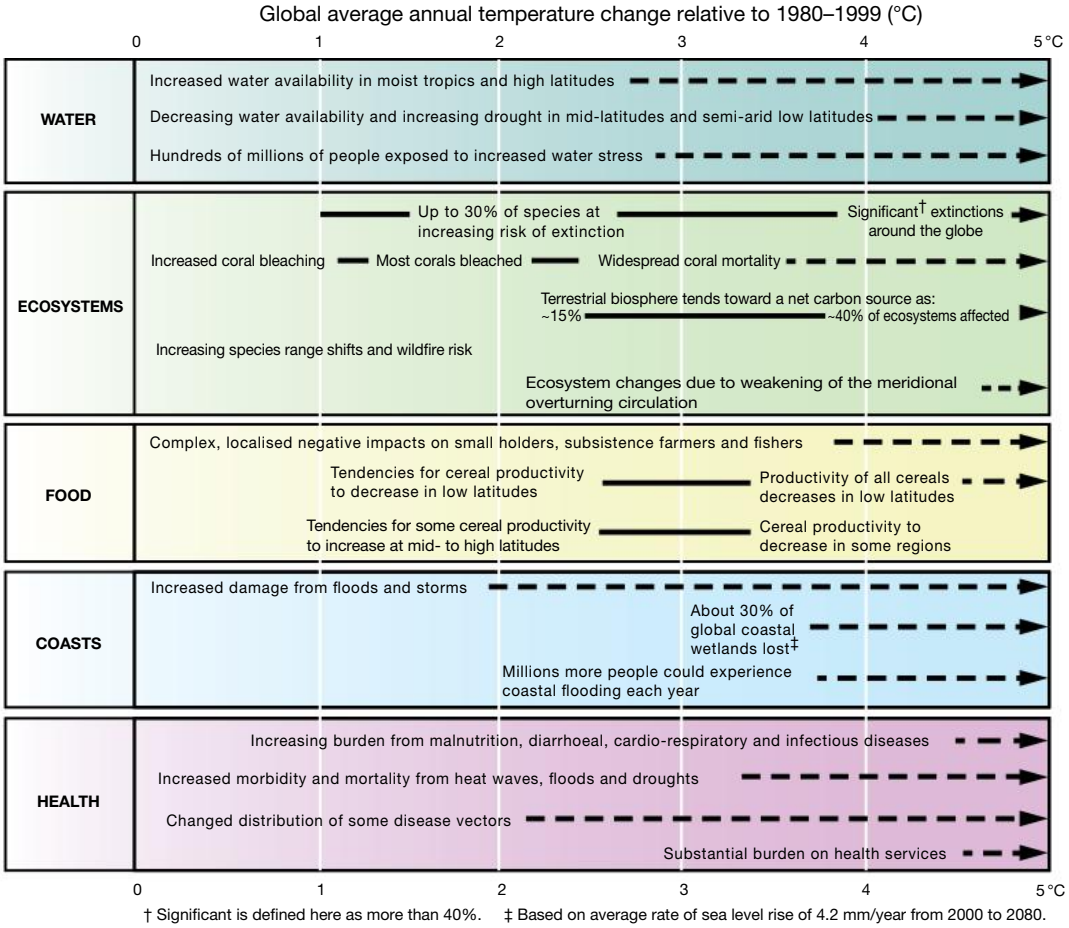
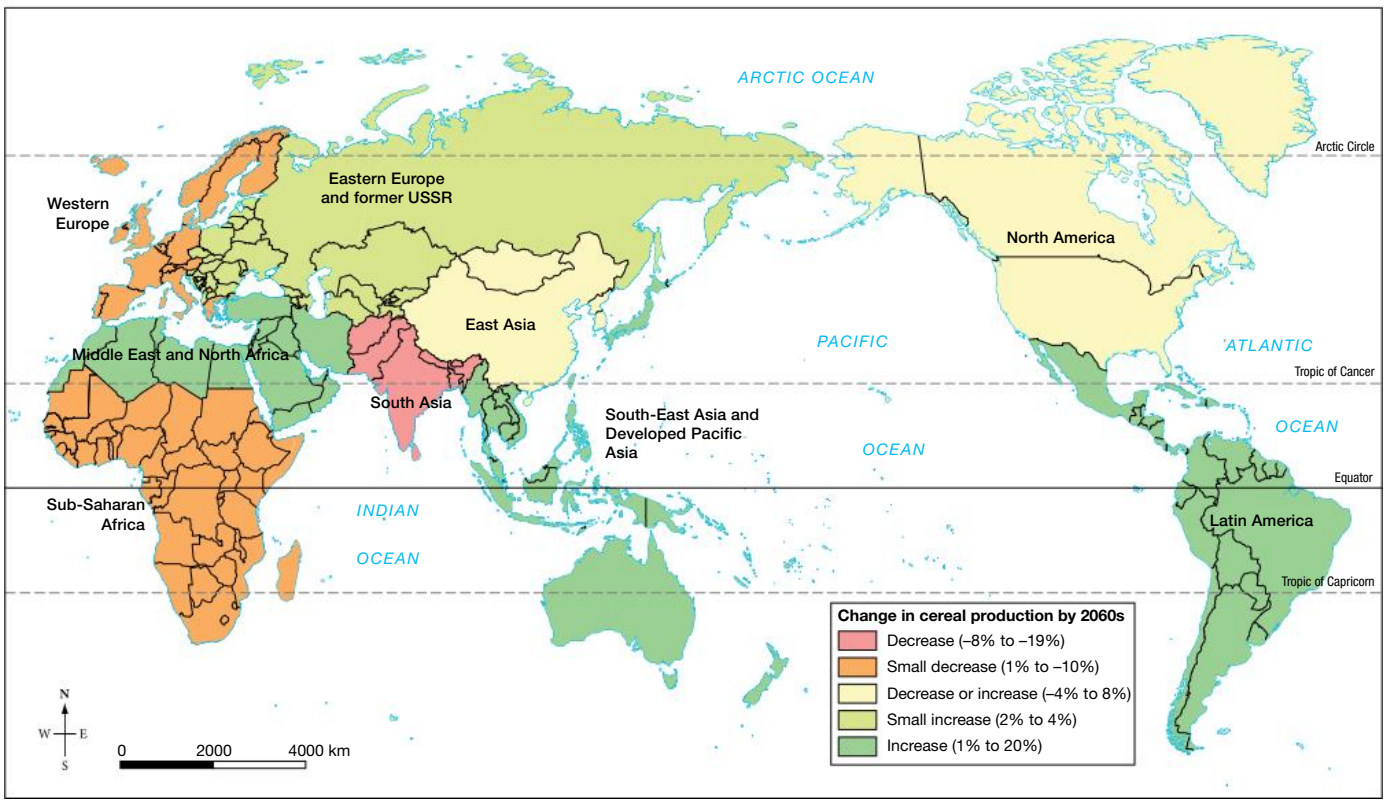


FIGURE 3 Projected consequences of climate change



† Significant is defined here as more than 40%. ‡ Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

FIGURE 4 Predicted regional effects of climate change on cereal production, 2050s–2080s



Source: Spatial Vision

There is a wide range of possible impacts of climate change. Sea-level rises may cause flooding and the loss of productive land in low-lying coastal areas, such as the Bangladesh and Nile River deltas. Changes in temperatures and rainfall may cause an increase in pests and plant diseases. However, agriculture is adaptable. Crops can be planted and harvested at different times, and new types of seeds and plants, or more tolerant species, can be used. Low-lying land may be lost, but higher elevations, such as mountain slopes, may become more suitable. The loss in productivity in some places may be balanced by increased production in other places. Figure 4 demonstrates the effects of climate change on cereal crops, while figure 5 shows the range of potential impacts across the European Union.

Essentially, hundreds of millions of people are at risk of increased food insecurity if they have to become more dependent on imported food. This will be evident in the poorer countries of Asia and Sub-Saharan Africa, where agriculture dominates their economy. There is also a risk of greater numbers of **environmental refugees** or people fleeing places of food insecurity.

FIGURE 5 Examples of potential consequences of climate change in the European Union

Source: Spatial Vision

environmental refugees people who are forced to flee their home region due to environmental changes (such as drought, desertification, sea-level rise or monsoons) that affect their wellbeing or livelihood

ACTIVITIES

IDENTIFY

1 Refer to figure 3 and decide whether the following statements are true or false.
- **a** If temperatures increase by 3 °C, you would expect to see crop yields rising around the equator.
- **b** ***Changes*** in extreme weather events are unlikely unless temperatures increase by at least 1 °C.
- **c** Food insecurity will be felt greatly in developing regions if temperatures rise by more than 4 °C.
- **d** ***Places*** that are likely to experience decreasing crop yields will be found in the higher latitudes.

EXPLAIN

2 **a** Refer to figure 4. Which ***places*** have the potential to be grain exporters and which ***places*** are likely to become dependent on grain imports? Use data in your answer.
- **b** What are the economic and social implications of this for countries in these regions?

3 **a** Refer to figure 5. Which countries of Europe will benefit from climate ***change*** in terms of food production and which countries are likely to suffer negative outcomes?
- **b** Would increased irrigation be a ***sustainable*** solution to growing food in Spain? Explain your answer.

4 Describe the ***interconnection*** between ***environmental*** refugees and climate ***change***.

INVESTIGATE

5 Research potential impacts of climate ***change*** on Australia. Create an annotated map to illustrate your findings.

PREDICT

6 How might a country such as Australia best prepare its food production systems to cope with potential ***changes*** in climate?

APPLY

7 How might food be shared more equitably around the world? Discuss with a group and report your suggestions back to the class.

5.11 What can we eat from Yarra Yarra Creek Basin?

improved pasture pasture that has been specially selected and sown, which is usually more productive than the local native pasture

fodder food such as hay or straw for cattle and other livestock

5.11.1 Yarra Yarra Creek Basin (near Holbrook), NSW

The Yarra Yarra Creek Basin is renowned for producing high-quality beef and sheep meat. The Yarra Yarra Basin is located east of Holbrook, a small agricultural town with a population of approximately 1300. Holbrook is located 492 kilometres south-west of Sydney along the Hume Highway between Melbourne and Sydney.

The Yarra Yarra Basin is in a high-rainfall region at the foothills of the Great Dividing Range. Many small creeks feed water into the Yarra Yarra Creek (AR 3951). The high levels of beef and lamb production in the Basin are due to good water resources and the use of **improved pasture**. Crops such as oats, triticale and canola are grown mostly for livestock grazing and sometimes harvested for hay and grain for **fodder**. Farms in the basin are relatively large, in the range of 800–1200 hectares.

FIGURE 1 Silos, tall cylindrical structures that store grain, are used in the Yarra Yarra Creek Basin to store fodder.

ACTIVITIES

IDENTIFY

1 What is the contour interval of the map?
- **A** 1 : 100 000
- **B** 1 : 20
- **C** 20 metres
- **D** 1 kilometre

2 What is the area reference for the spot height of 538 metres on Morgans Ridge?
- **A** AR3547
- **B** AR4542
- **C** AR3443
- **D** AR4343

3 What is the aspect of the slope of the spot height 538m (from question 2)?
- **A** South east
- **B** South west
- **C** North east
- **D** North west

4 Which of the following is the NOT the correct scale of the map?
- **A** 1/100 000
- **B** 1 : 100 000
- **C** 1 cm represents 1000 metres
- **D** 1 cm equals 1000 metres

5 In which general direction would you need to drive to get from Holbrook to Yarra Yarra Junction?
- **A** West
- **B** East
- **C** North
- **D** South

6 What is the major vegetation type on top of Morgans Ridge?
- **A** Swamp
- **B** Mangrove
- **C** Orchard
- **D** Dense

EXPLAIN

7 Which area is more likely to produce food — AR3054 or AR3547? Justify your answer.

APPLY

8 **a** How might climate change affect water security of the Yarra Yarra Creek Basin in the future?
b Discuss how this could influence food production.
c What steps could be taken to ensure food production levels are maintained?

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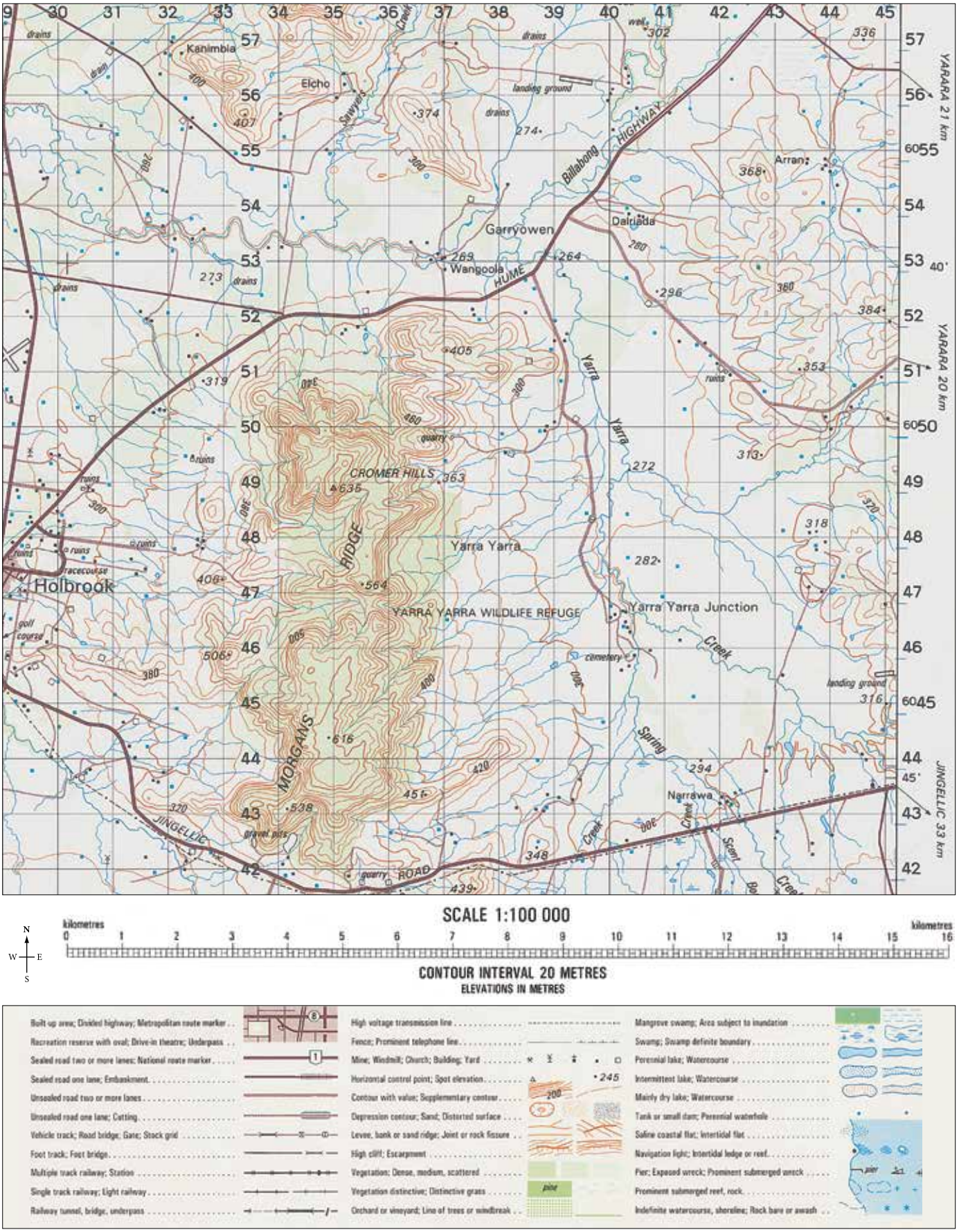
5.12 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

FIGURE 2 Topographic map of the Yarra Yarra Creek Basin



Source: Spatial Vision

5.4 SkillBuilder: Constructing and describing complex choropleth maps

5.4.1 Tell me

What is a complex choropleth map?

A complex choropleth map is a map that is shaded or coloured to show the average density or concentration of a particular feature or variable, and it shows an area in detail. The collector areas of data are smaller, so they show the mapped information more precisely. The key or legend shows the value of each shading or colouring. The densest or highest concentration is usually the darkest shade. The least dense or lowest concentration is usually the lightest shade. Average values are attached to the colour shadings in the key or legend. In constructing your own choropleth map, you need to determine the values that relate to each shade within a colour range.

Why are complex choropleth maps useful?

A complex choropleth map is used to show values in a pictorial way. It allows the viewer to quickly identify where the values are highest (darkest) and lowest (lightest) and to 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.

Complex choropleth maps are useful for showing:

- the distribution of a feature across a city or country
- the extent of a feature across a region
- patterns, which are indicated by the changing colours of the map
- conglomerations of data in specific locations.

Model

The change in Sydney's population between 2001 and 2006 has been very uneven. The areas of greatest increase (1440 to 4780) are scattered across the city, with most of this found on the urban fringes.

Most areas that have experienced the greatest increase are clustered together — for example, around Baulkham Hills, Blacktown and Parramatta in the west and north-west, and Liverpool and Campbelltown in the south-west. There are relatively few census areas that show minimal increase (0 to 290 people).

The areas of greatest decrease (–3200 to –690) are also scattered across the city. Most of these decreases are found on the urban fringes, especially in the west and south-west of Sydney, between Liverpool and Campbelltown.

The areas with the smallest change (0 to 290 increase) tend to be found in areas about 5 to 15 kilometres from the city. Clusters are found on the north shore around Chatswood, north-east and south-east of Parramatta, and around Penrith.

The most common kind of change is moderate decline (–690 to 0). Clusters of this change are found around Penrith and Botany Bay, north and south-east of Hornsby, and north of Campbelltown.

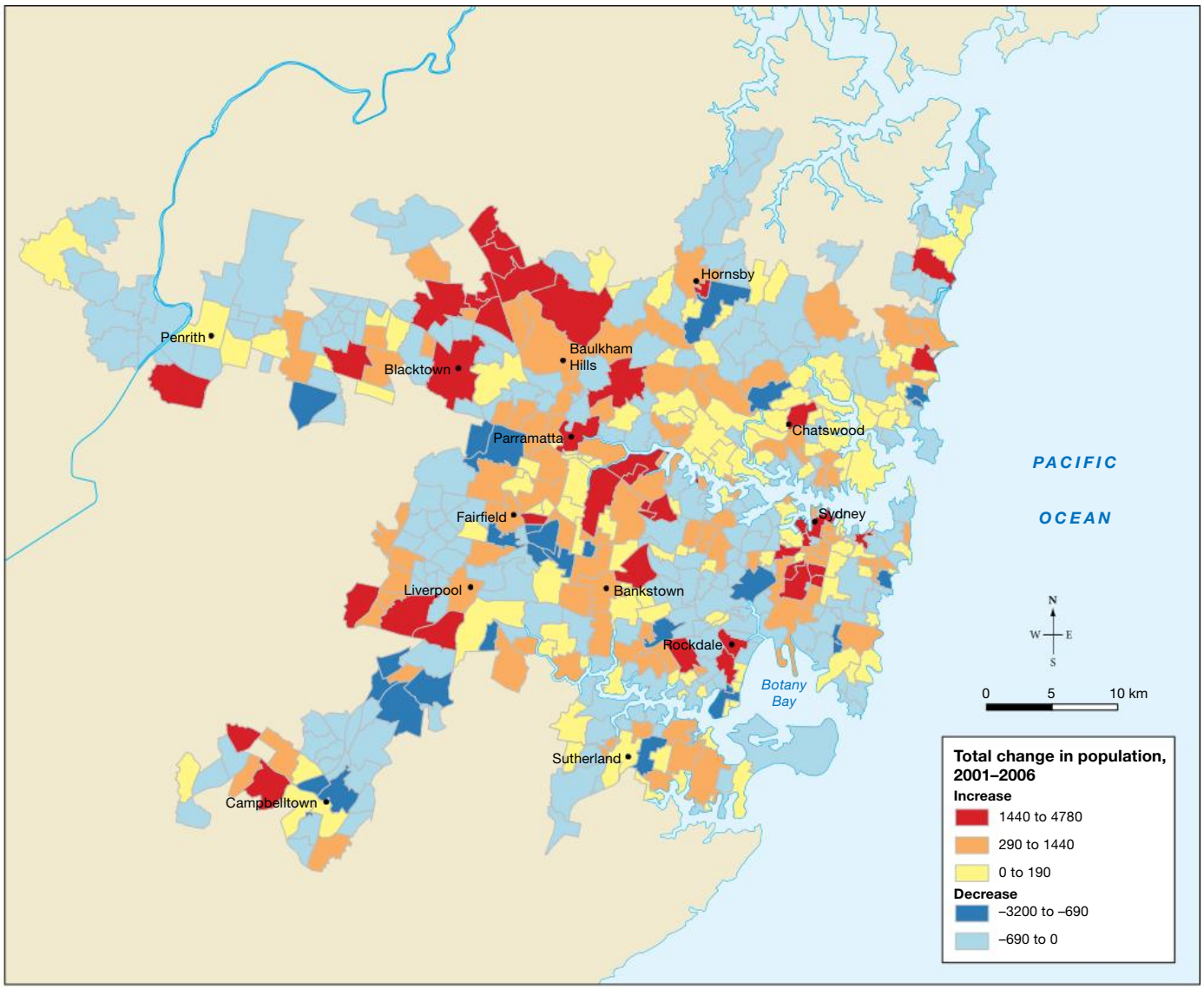
A good complex choropleth map:

- uses a base map
- has clearly determined values for each colour
- uses shades within a colour spectrum
- is neatly coloured
- includes a clear title.

A good description of a complex choropleth map:

- looks for a pattern and subtleties within a broad pattern
- notes any anomalies
- uses quantities
- refers to the title and legend.

FIGURE 1 Population change in Sydney, 2001–06



Source: Spatial Vision

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eLesson
Constructing and describing complex choropleth maps
Searchlight ID: eles-1732

5.4.2 Show me

How to construct and describe a complex choropleth map

You will need:

- a set of data specific to a range of places
- a base map to match the places
- coloured pencils with a range of shades
- a ruler.

Procedure:

Constructing a choropleth map

STEP 1

Select a set of data to map, and ensure that you have a base map to match the area. In figure 1, the ABS data is based on small regions across Sydney, and the base map shows the boundaries of those regions. The ABS website will provide you with the names of these areas.

STEP 2

Look at the range of data you have to plot. In figure 1, there were positive and negative numbers to consider, but this is not always the case. You should try to divide the data into approximately

five categories — too many categories will spread the data too thinly, while too few categories will show few variations in the data. For each category, select a colour shade where the darkest colour represents the greatest value and the lightest colour represents the lowest value. Create a key on the base map.

STEP 3

Now very carefully colour all areas on the base map with the highest value. It is a good idea to go through the list of data and colour code each place before you begin.

STEP 4

Check that the geographical conventions are complete: border, orientation, legend, title, scale and source.

Describing a choropleth map

STEP 5

To interpret the colours, you need to comment on where the deepest or most intense colours occur. Can you discuss the map by areas? For example, in figure 1 the areas of greatest change (1440 to 4780 people), represented by a deeper colour, are scattered across the city but are most likely to be found on the urban fringes, indicating the growth of the city's boundaries.

STEP 6

To further interpret the colours, you need to comment on where the lightest or least intense colours occur. Can you discuss the map by areas? For example, in figure 1 most of the areas that have shown only moderate increase (0 to 290) are found 5 to 15 kilometres from the city.

STEP 7

To identify a subtle change, you need to look for a change of colour within an area that is predominantly one colour. In figure 1, in the middle of the northern area of 1440 to 4780 increase there are two census areas that show 290 to 1440 increase.

STEP 8

Are there any coloured areas that stand out from the rest as being unusual? That is, is there a colour among a mass of other colour that isn't expected? This is called an anomaly, and needs to be discussed. Identify the place that is different from the surrounding places. For example, there are no areas of 1440 to 4780 increase in the Sutherland Shire, south of the river that flows into Botany Bay.

5.4.3 Let me do it

Developing my skills

Use the data from table 1 (showing official development assistance to agriculture in sub-Saharan Africa in 2010) and a base map of Africa (use doc-12012 in the Resources tab) to construct a choropleth map.

Describe what is shown on your map.

Questions

1. Which regions of sub-Saharan Africa receive the most agricultural assistance?
2. Which regions of sub-Saharan Africa receive the least agricultural assistance?
3. Which countries within southern Africa (south of 10°S) received quite different agricultural aid from that of their neighbours?

TABLE 1 Official development assistance to agriculture in sub-Saharan Africa, 2010

Country	($US million)
Angola	27
Benin	21
Botswana	1
Burkina Faso	71
Burundi	96
Cameroon	62
Cape Verde	3
Central African Republic	3
Chad	9
Comoros	2
Congo	1
Cote d'Ivoire	93
Democratic Republic of Congo	100
Eritrea	13
Ethiopia	222
Ethiopia (People's Democratic Republic)	28
Gabon	15
Gambia	126
Ghana	8
Guinea	10
Guinea-Bissau	323
Kenya	0
Lesotho	36
Liberia	19
Madagascar	79
Malawi	223
Mali	11
Mauritania	0
Mauritius	72
Mozambique	14
Namibia	43
Niger	69
Nigeria	68
Rwanda	3
Sao Tome and Principe	256
Senegal	1
Seychelles	75
Sierra Leone	1
Somalia	20
South Africa	145
Sudan	6
Swaziland	36
Togo	198
Uganda	132
United Republic of Tanzania	36
Zambia	81
Zimbabwe	3

Source: Food and Agriculture Organization of the United Nations, 2012, FAO, *The State of Food and Agriculture 2012*, http://www.fao.org/docrep/017/i3028e/i3028e.pdf

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Interactivity
Constructing and describing complex choropleth maps
Searchlight ID: int-3350

4. Are there any parts of the region that you think should receive more aid? Can you think of a reason why aid might not be going to these countries? Look at the food security risk map, figure 3 in section 5.3.2, to support your ideas.
5. Will aid make a difference to the figures produced in 10 years' time? Explain your answer.

Checklist

In drawing a complex choropleth map, I have:

- used a base map
- included clearly determined values for each colour
- used shades within a colour spectrum
- coloured neatly
- included a clear title.

In describing a complex choropleth map, I have:

- looked for patterns and subtleties within a broad pattern
- noted the anomalies
- used quantities
- referred to the title and legend.

Skills questions

1. Complex choropleth maps are used to show:
   a. the height of the land across a region
   b. a range of colours
   c. the distribution of one factor
   d. the detailed distribution of one factor.
2. A complex choropleth map includes information about:
   a. numbers
   b. colours
   c. species
   d. ground cover.
3. Why should you use a carefully selected colour spectrum?
4. Why does your map need to be neat?

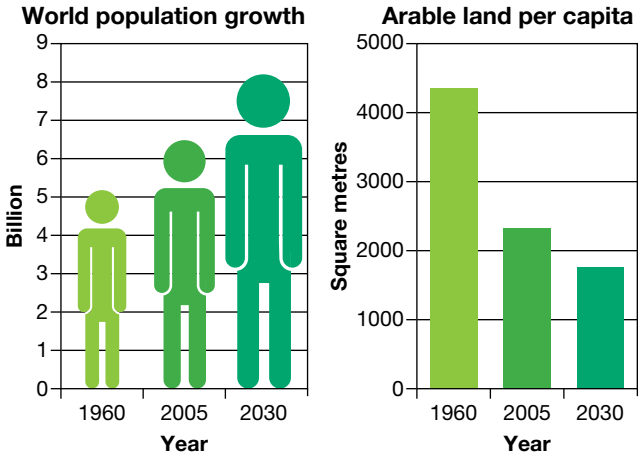
5.5 How does land degradation affect food production?

5.5.1 How is land lost?

Land is absolutely essential for food production, and the world has more than enough arable land to meet future demands for food. Nevertheless, we need to find a balance between competing demands for this finite resource.

The loss of productive land has two main causes. First, there is the degradation of land quality through such things as erosion, **desertification** and **salinity**. Second, there is the competition for land from non-food crops, such as **biofuels**, and from expanding urban areas. As figure 1 shows, the growth in world population is inversely proportional to the amount of arable land available. This does not even take into consideration the land that is degraded and no longer suitable for growing food.

FIGURE 1 Comparison of world population growth and arable land per capita



desertification the transformation of arable land into desert, which can result from climate change or from human practices such as deforestation and overgrazing

salinity the presence of salt on the surface of the land, in soil or rocks, or dissolved in rivers and groundwater

biofuels refers to fuel which has been produced from renewable resources, such as plants and vegetable oils, and treated municipal and industrial wastes

Land degradation

Although there have been significant improvements in crop yields, seeds, fertilisers and irrigation, they have come at a cost. Environmental degradation of water and land resources places future food production at risk.

The main forms of land degradation are:

- erosion by wind and water
- salinity
- pest invasion
- loss of biodiversity
- desertification.

Land degradation occurs in all food-producing biomes across the globe. Some degradation occurs naturally; for example, a heavy rainstorm can easily wash away topsoil. However, the most extensive degradation is caused by overcultivation, overgrazing, overwatering, overloading with chemicals and overclearing (see figure 2). Currently, 25 per cent of the world's land is highly degraded, while only 10 per cent is improving in quality. In South-East Asia, 50 per cent of cultivated land has severe soil quality problems, which prevent increases in food production. The Ministry for Agriculture in China estimates that 3.3 million hectares of arable land is polluted with chemicals and heavy metals, mostly in regions that grow grains.

FIGURE 2 Land degradation caused by deforestation in Madagascar

Competition for land

There has been a growing global trend to convert valuable cropland to other uses. Urban growth, industrialisation and energy production all require land. For example, in less than 16 years, China lost more than 14.5 million hectares of arable land to other land uses. This land no longer produces food, which then puts pressure on existing land resources to make up the loss.

ACTIVITIES

IDENTIFY

1 What are the two main ways that productive farmland can be lost?

EXPLAIN

2 Refer to figure 1.

a Describe the ***changes*** in population growth and the arable land per person between 1960 and 2030, making use of figures.

b What do these graphs suggest about food security?

3 What are the three main causes of the most extensive land degradation that occurs in the world?

INVESTIGATE

4 Using the internet, investigate how deforestation can lead to land degradation, such as has occurred in Madagascar.

5.8 SkillBuilder: Interpreting satellite images to show change over time

5.8.1 Tell me

What is a satellite image?

A satellite image is an image taken from a satellite orbiting the Earth. Satellite images allow us to see very large areas — much larger than those that can be visualised using vertical aerial photography. A satellite image often does not use the natural colours that we expect. This is referred to as using false colours, and these are applied in the computer processing of the images in order to highlight spatial patterns more clearly.

Why is a satellite image useful?

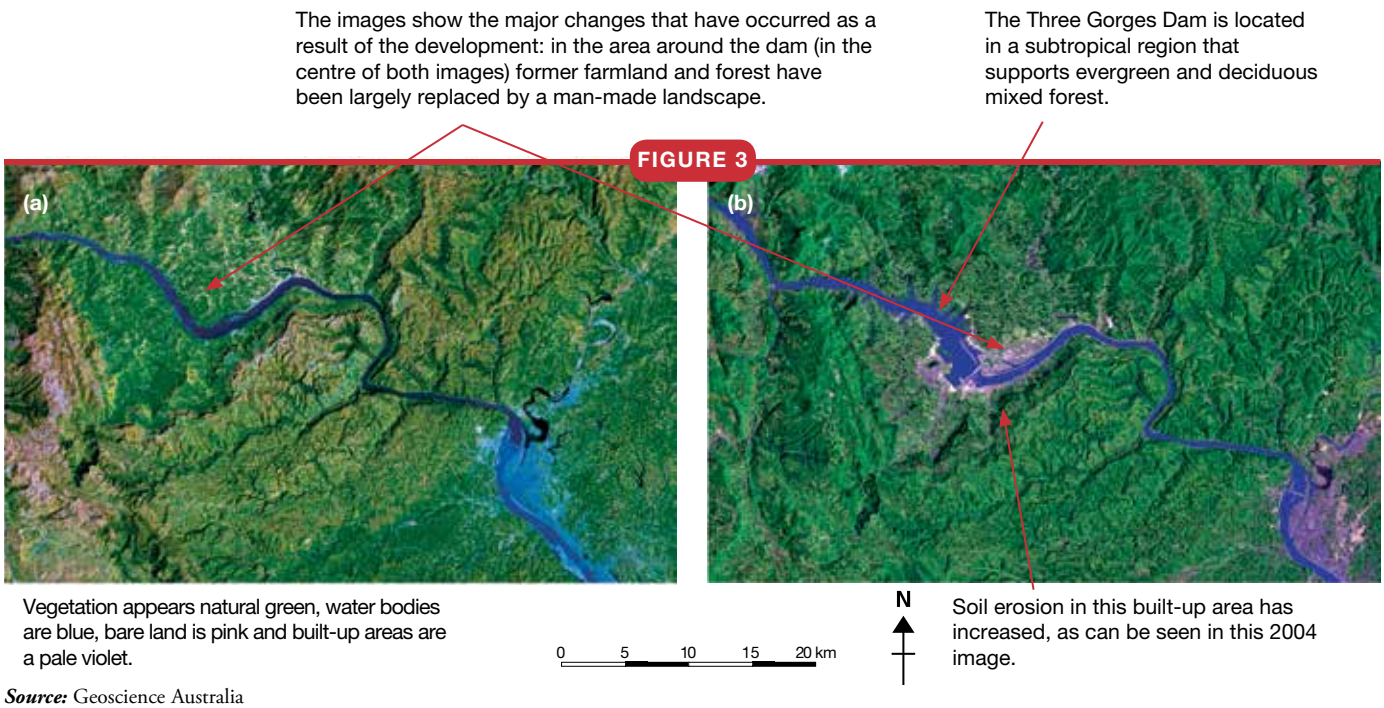
A satellite image is useful because its size allows us to see trends and patterns, interconnections and relationships. Cartographers are able to increase the intensity of colours and use false colours to distinguish one feature from another. Satellite images are enhanced photography. Comparing satellite images can provide information about change over time. You will gain a lot of information from a satellite image that cannot be gained from a topographic map or aerial photograph, so your knowledge of an environment is enhanced.

Satellite images are useful for:

- identifying changes in heat patterns from different surfaces
- assessing vegetation modifications
- identifying urban sprawl
- tracking data across international boundaries.

Model

FIGURE 1 Change over time around the Yangtze River, China: (a) in 1987 and (b) in 2004, after the building of the Three Gorges Dam



Source: Geoscience Australia

The Yangtze River in 1987 was a natural river running through a deep gorge. In the satellite image from 1987, the area is surrounded by high, barren hills and areas of dense subtropical forest (natural green). By 2004, the Three Gorges Dam wall (pale violet) had been built across the river. The water (blue) filled behind the two-kilometre dam wall and spread across the gorge floor, flooding back up the river about eight kilometres. New urban areas (pale violet) developed east and west of the dam wall on both sides of the river. In the 17 years since the first satellite image was taken, a town has developed on the low-lying land in the south-east covering an area of about 36 square kilometres.

A good interpretation of a satellite image:

- translates the false colours
- identifies patterns
- makes logical inferences
- uses distance and direction to locate places.

5.8.2 Show me

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eLesson
Interpreting satellite images to show change over time
Searchlight ID: eles-1733

How to interpret satellite images to show change over time

You will need:

- two satellite images of the same place, taken at different times
- an atlas.

Procedure:

STEP 1

Determine the dates for the satellite images. Consider how many years it is between the images. In figure 1, the time span is 17 years. Check that the satellite images are at the same scale. Note that in figure 1, the 1987 and 2004 images show slightly different areas, but at the same scale. The central area of interest is covered by both images.

STEP 2

Study the satellite images carefully, identifying the key features of the place. In satellite imagery, true colours are not always used. It is helpful to learn the colours commonly used in false-colour imagery.

TABLE 1 Colours commonly used in false-colour satellite imagery

Colour	Ground feature
Green	Vegetation
Dark blue	Water — the deeper the water, the darker the colour
Bright blue to mauve/grey	Housing and industrial areas
White to cream	Beaches and sands
Yellow	Barren areas, heavily grazed or fallow land
Pink to red	Recent plant growth, suburban parklands
Red	Flourishing vegetation, including forests (mangroves appearing brown)

In the description in figure 1, the colours have been included to help you see the patterns evident in the satellite images.

STEP 3

To interpret the colours, you need to comment on where the various colours appear. Use compass directions, scale or features identifiable on the satellite image, such as roads and rivers, to help reference the place that you are discussing. For example, the text following figure 1 says 'The water (blue) filled behind the two-kilometre dam wall'.

STEP 4

Use the same feature in each of the satellite images as a reference point for identifying change. It may be the road system, a railway line passing across the region, a river flowing through the area or a town established in the earliest dated image. For example, in figure 1 the Yangtze River is a key feature that allows you to identify points by the bends in the river.

STEP 5

It may be possible to make inferences from the satellite image. You may be able to see changes in topography, and these may relate to changes in land use. For example, in 1987 the area of the present-day dam was surrounded by high, barren hills and areas of dense subtropical forest; by 2004 a human-constructed landscape surrounded the dam.

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Interactivity
Interpreting satellite images to show change over time
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5.8.3 Let me do it

Developing my skills

Refer to the satellite images for Tehran in 1985 and 2009 shown in figures 2a and 2b in section 5.7.3. Write a description of the change over time that has occurred to the boundaries of Tehran.

Questions

1. Is Tehran a growing or declining city? Explain your answer.
2. The colouring indicates large areas of barren land. Why is this the case on the outskirts of Tehran? (*Hint:* where is Tehran?)
3. How has the vegetation cover of the area changed?
4. How has the road pattern changed by 2009?
5. Why do you think Tehran has not expanded into the south-east corner of the satellite image?
6. How has the growth of Tehran affected food security in the area?

Checklist

I have:

- translated the false colours
- identified patterns
- made logical inferences
- used distance and direction to locate places.

Skills questions

1. Satellite images are used to show:
   a. the height of the land at a place
   b. details of a small area
   c. rainfall intensity
   d. information for a vast area.
2. Interpreting satellite images includes being able to understand:
   a. a legend
   b. false colours
   c. natural colours
   d. contours.
3. Why are false colours often used on satellite images?
4. When looking for change over time, why might it be important to look at a satellite image carefully before making an interpretation?

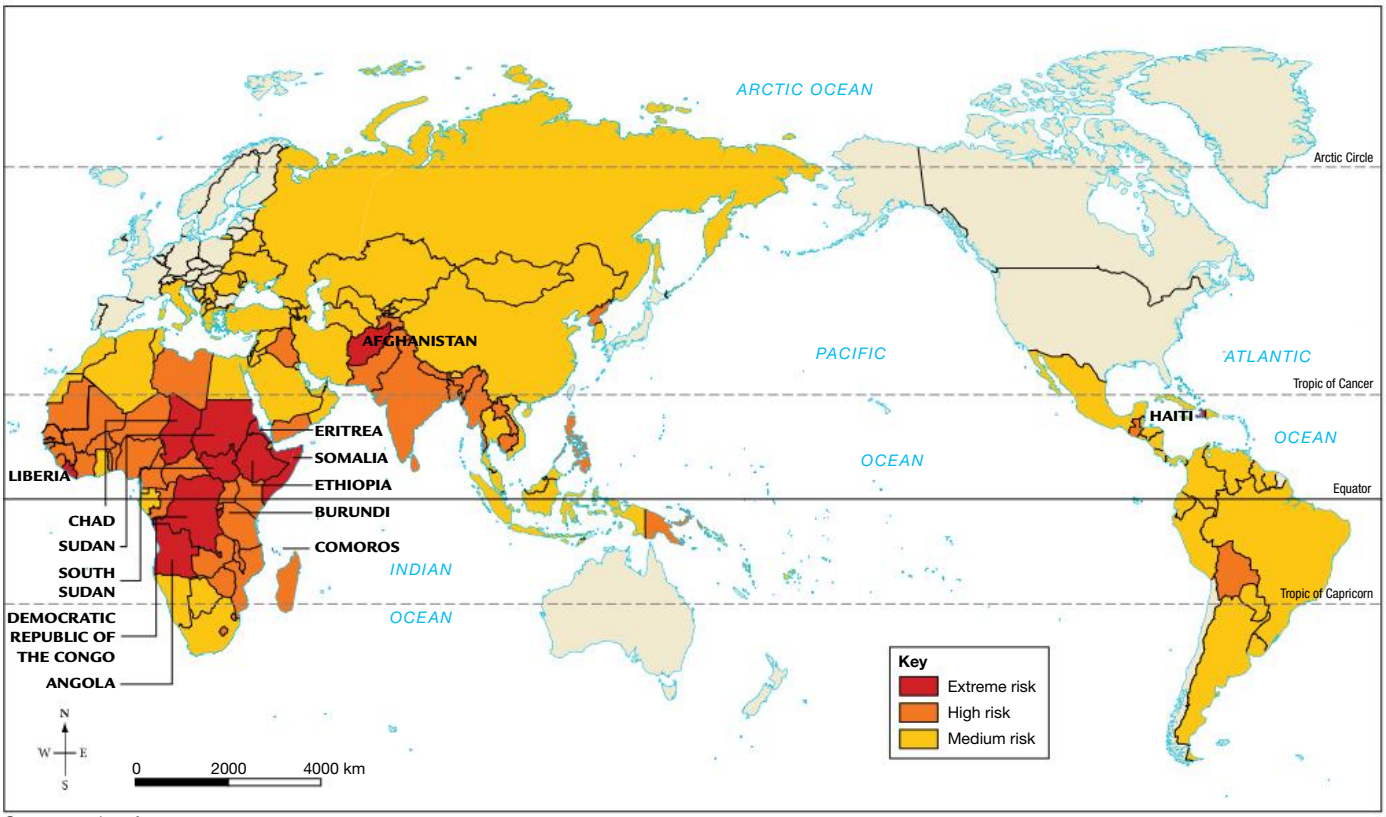
5.12 Review

5.12.1 Review

Food security

1. Refer to figure 1 below and in subtopic 5.3 (figure 3).

FIGURE 1 Countries with medium to extreme risk of food insecurity



Source: maplecroft.com

a. Construct a three-colour bar graph to list the number of countries in each world region (Europe, North America, South America, Central America, Asia, sub-Saharan Africa, North Africa, Middle East and Oceania) that have a low, medium or high to extreme risk of food insecurity.
b. Which regions of the world are most represented in the low risk category?
c. Which regions of the world are most represented in the high to extreme risk category?
d. Compare those ***places*** at extreme risk shown in figure 1 above and in subtopic 5.3 with an atlas map of world GDP and an atlas map of infant mortality or life expectancy. Write a detailed summary of your observations, using country names and data in your answer.

2. Each member of the class should select a country in Africa that is shown to be at high or extreme risk in table 1 in subtopic 5.3. Conduct research to find out the leading causes of their food shortages. Collate the results, and then, using a series of symbols, create a map of Africa to show the main factors contributing to food shortages in these countries. Summarise your map with a written description.

Famine in Somalia

3. a. Refer to the case study on the famine in Somalia in subtopic 5.6. Create a mind map diagram to show the ***interconnections*** between the different factors contributing to the famine.
   b. Of the range of factors contributing to the famine, which do you consider to be the three most influential? Rank the top three and justify your ranking.
4. Use the **Fleeing Somalia's drought** weblink in the Resources tab to watch a slide show about Somalia's famine. Select three images and write annotations for these based on what you have learned from the case study on Somalia.

eBookplus
Weblink
Fleeing Somalia's drought

Land

5. What is the ***interconnection*** between urbanisation and food security?
6. Read the article extract below, and then answer the questions that follow.
   a. What land uses have taken over from farmland since 1984?
   b. What types of crops need to be grown close to cities?
   c. Why do you think Australia's agricultural land is a scarce and finite resource?

Paving devours farmland faster than foreign buyers

by Natasha Bita

Australians have lost five times more farmland to urban sprawl than to foreign buyers, with 89 million hectares vanishing in a generation.

Housing subdivisions, national parks, forestry plantations and mining leases have chewed up 18 per cent of Australia's agricultural land since 1984.

The Planning Institute of Australia has warned a federal government taskforce drafting the nation's first 'food plan' that the conflict over rural land is 'one of the most significant issues facing food production'.

'Urban development is paving over farmland on the edge of our metropolitan cities,' the institute says in its submission.

'Australia's agricultural land is a scarce and finite resource. There is a need to ensure that the land that grows the food is preserved for that purpose.'

Foreigners have almost doubled their stake in Australian farms, with full or part-ownership of 11.3 per cent of farmland in 2010 compared with 5.9 per cent … in 1984.

'Two thirds of the perishable vegetables grown in Australia are grown on the metropolitan fringe of the capital cities and the coastal areas of Queensland. That's where the best soil is, and we're running out of land to grow food.'

The Australian, 21 January 2012

7. Foreign investment in Australian farmland has increased from 5.9 per cent in 1984 to 11.3 per cent in 2011. How might foreign owners benefit from owning farmland in Australia? How might Australia benefit?
8. Refer to figure 2 below.

FIGURE 2 Land degradation caused by deforestation in Madagascar

The original land use for this location was tropical rainforest.

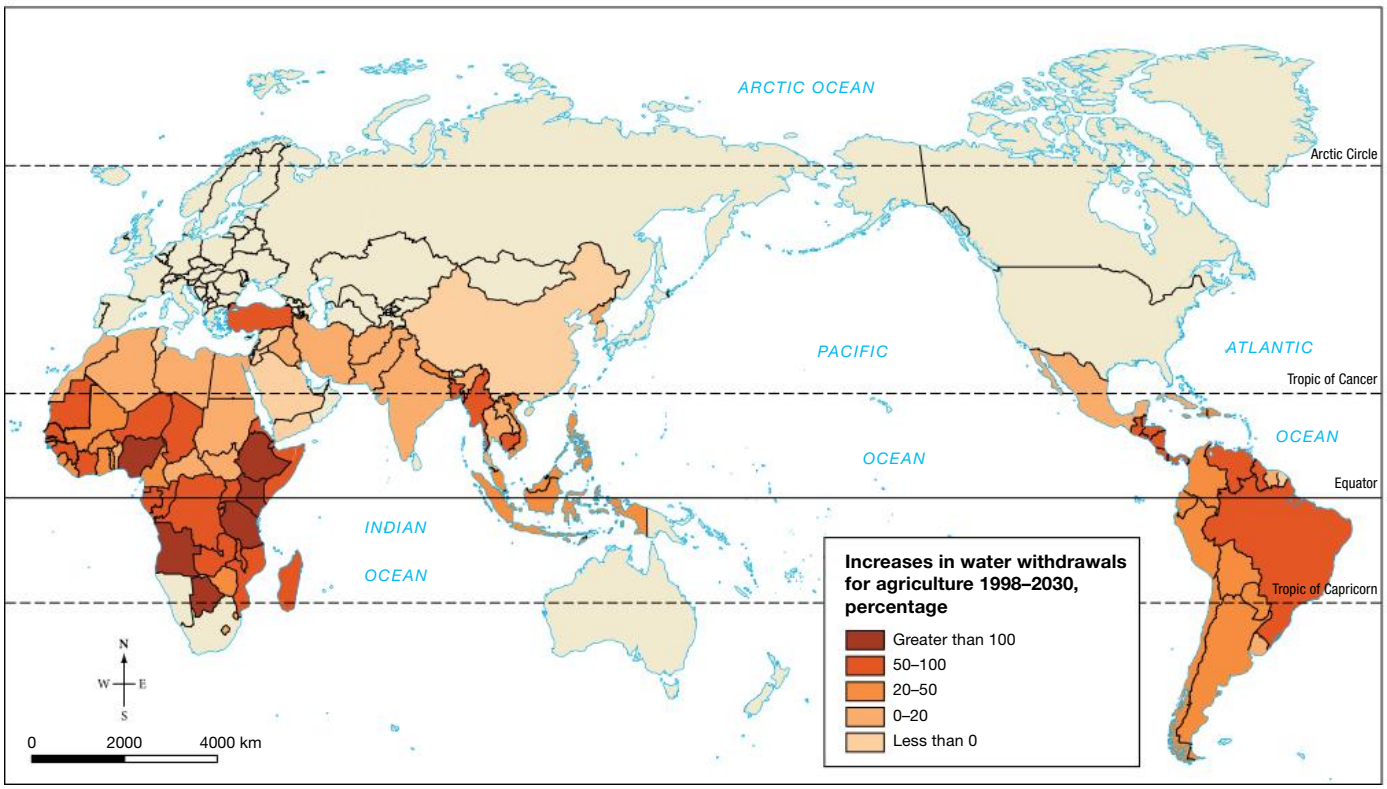
a. Why might this area have been cleared?

b. Is this a suitable landscape for such extensive clearing? Explain your answer.

Water

9. Approximately 20 per cent of the protein that humans eat comes from animal-based products. Scientists suggest that if people reduce their meat consumption to 5 per cent of their daily diet, this will allow more water to be available for plant-based food production. Keep a record of your daily food intake over several days and calculate (using an online kilojoule counter) what percentage of your diet is made up of meat. How does this compare with others in your classroom? Now plan a three-day menu in which only five per cent of your diet is made up of meat-based products.
10. Study the information in figure 3.
    a. Describe the distribution pattern of countries that are predicted to withdraw over 100 per cent more water in the years to 2030.
    b. Suggest a reason why Australia, the United States and countries in Europe are not in this category.

FIGURE 3 Predicted increases in water use for agriculture 1998–2030. There will be increases greater than 100 per cent in six countries, and increases less than 20 per cent in 41 countries.

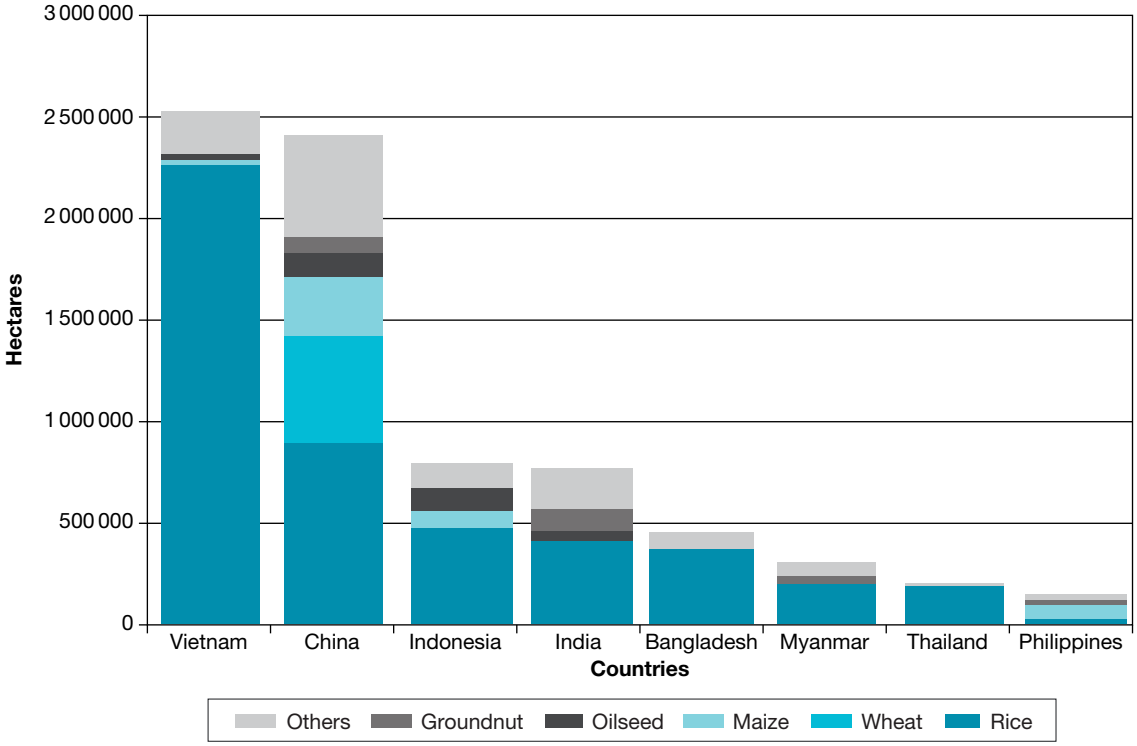


Source: Spatial Vision

Climate change

11. Refer to figure 4 to answer the following questions.

FIGURE 4 Countries in Asia and the Pacific that will lose over 100 000 hectares of cultivated cropland if there is a one-metre rise in sea level



Source: © A. Srinivasan. *Presentation on Climate Change and Food Security in Southeast Asia: Issues and Policy Options*, slide 8. Adopted from ADB 2009, *Building Climate Resilience in the Agriculture Sector of Asia and the Pacific*, Manila. p. 99.

a. Which type of cropland is predicted to be the most ***changed*** by a one-metre rise in sea level in Asia?
b. Using data in your answer, list the three countries that will be most at risk of losing cropland.
c. What might be some of the repercussions for food production in those countries?

5.12.2 Reflect

12. What is the cartoon in figure 5 trying to tell us?
13. What would you suggest a host country does to ensure its own food security?

FIGURE 5

Source: © Glenn Lumsden

CHAPTER 6

2050 — food shortage or surplus?

6.1 Overview

6.1.1 Introduction

Currently we produce enough food to adequately feed everyone in the world. However, it is estimated that the world's population will grow by another two billion people in the next 30 years. A greater proportion of people will live in urban areas, and it is estimated that almost one in seven people will go hungry. If we want to stop the number of hungry people from increasing, we will need improvements in food production, new sources of food, better aid programs, and different attitudes to food consumption and waste.

Starter questions

1. Look at the photo and annotations on these pages. Make some predictions about the type of food you might eat in the year 2050 and how it might be produced.
2. Ask your parents or grandparents what type of food they ate when they were young. Did they grow any of their own food?
3. Does your family produce any of its own food? Why or why not?
4. Do you think we have food shortages in Australia? Why or why not?
5. Which countries in the world face food shortages today?

Inquiry sequence

		Syllabus outcomes
6.1 Overview		
6.2 Can we feed the future world population?		GE 5-3, GE 5-5
6.3 Can we improve food production?		GE 5-5
6.4 What food aid occurs at a global scale?		GE 5-5
6.5 Investigating topographic maps: How is Lake Victoria a food source?		GE 5-3, GE 5-5, GE 5-7
6.6 SkillBuilder: Constructing a box scattergram	eBook plus ONLINE ONLY	GE5-7
6.7 Do Australians need food aid?		GE 5-5
6.8 Is trade fair?		GE 5-5
6.9 SkillBuilder: Constructing and describing proportional circles on maps	eBook plus ONLINE ONLY	GE5-7
6.10 How do dietary changes affect food supply?		GE 5-5
6.11 Can urban farms feed people?		GE 5-5
6.12 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Watch this video
Future food
Searchlight ID: eles-1721

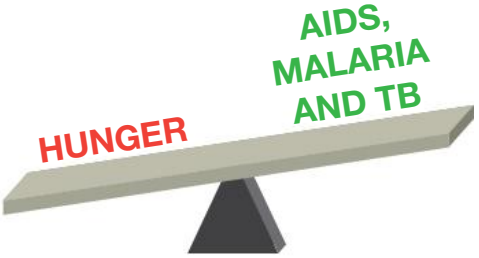
6.2 Can we feed the future world population?

6.2.1 What are the causes of hunger?

How can we best manage the challenge of ensuring that everyone in the world has access to a healthy and adequate diet?

By 2050, one in seven people in the world will not have enough food to lead an active and healthy life, yet there are rising global rates of obesity.

FIGURE 1 Hunger is the world's number 1 health risk, killing more people each year than AIDS, malaria and tuberculosis combined.



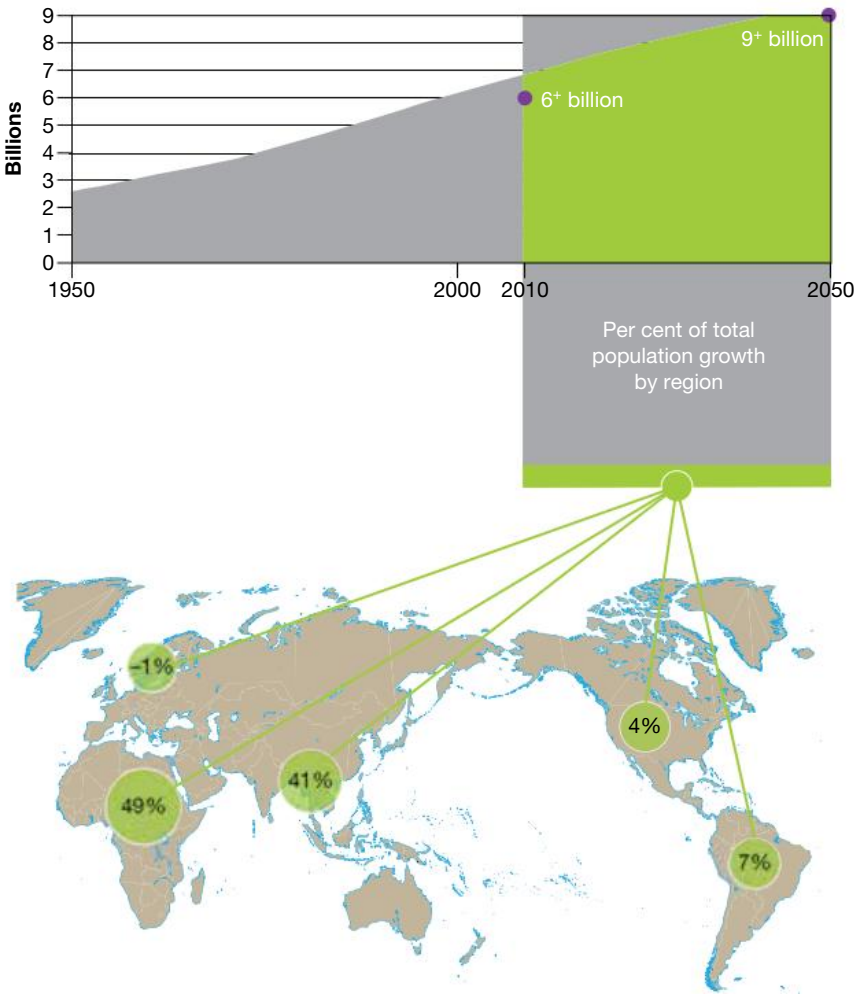
hunger the sensation felt when a person does not have enough to eat to meet their body's energy needs

malnourishment a condition that results from not getting the right amount of vitamins, minerals and other nutrients needed to maintain healthy tissues and organ function

The impact of hunger on people cannot be overstated. **Hunger** kills more people each year than disease (see figure 1). It is estimated that we will need to produce between 60 to 70 per cent more food in order to feed future populations. New ideas, knowledge and techniques will be needed if we do not want millions more people to suffer **malnourishment**, starvation and vulnerability to disease. The challenge, though, is to do this in a way that is also sustainable. However, population growth and limited supplies of arable land will affect how much food can be produced.

One solution to feeding people who will live in crowded spaces, such as Asia, or in environmentally challenging spaces, such as sub-Saharan Africa, is to increase the amount of trade in food products. This will involve moving food from places with crop surpluses (North America, Australia and Europe) to regions that are crowded or less productive. This means there will be an increase in the interconnection between some countries.

FIGURE 2 Population growth by world and region, 1950–2050



As Figure 2 shows, the world's population growth is increasing over time. In the forty-five years between 1960 and 2005 the world's population grew from 3 billion to 6.5 billion. It is predicted by 2050 that the world will support approximately 9.6 billion. Between 1950 and 2050, as the population has been growing the average amount of land available for crops (**arable** land) has been declining and is predicted to decline further.

arable describes land that is suitable for growing crops

6.2.2 Plumpy'nut — a short-term solution to malnutrition

In 2005 a revolutionary approach to treating malnutrition was released. This is a ready-to-use therapeutic food (RUTF) called Plumpy'nut.

It is a sweet, edible paste made of peanut butter, vegetable oils, powdered milk, sugar, vitamins and minerals. Its advantages are that it:

- is easy to prepare
- is cheap (a sachet costs about $1.40)
- needs no cooking, refrigeration or added water
- has a shelf life of two years.

Children suffering from malnutrition can be fed at home without having to go to hospital. It is specially formulated to help malnourished children regain body weight quickly, because malnutrition leads to stunting of growth, brain impairment, frailty and attention deficit disorder in children under two years of age.

Plumpy'nut is not a miracle cure for hunger or for malnutrition; it only treats extreme food deprivation, mainly associated with famines and conflicts. It is not designed to reduce chronic hunger resulting from long-term poor diets or malnutrition. Since its introduction, Plumpy'nut has lowered mortality rates during famines in Malawi, Niger and Somalia. Most of the world's peanuts are grown in developing countries, where allergies to them are relatively uncommon. Manufacturing plants have been established in several developing countries, including Mali, Niger and Ethiopia. These factories provide employment and ensure ease of access when needed.

FIGURE 3 Plumpy'nut is a therapeutic food that helps treat malnourished children.

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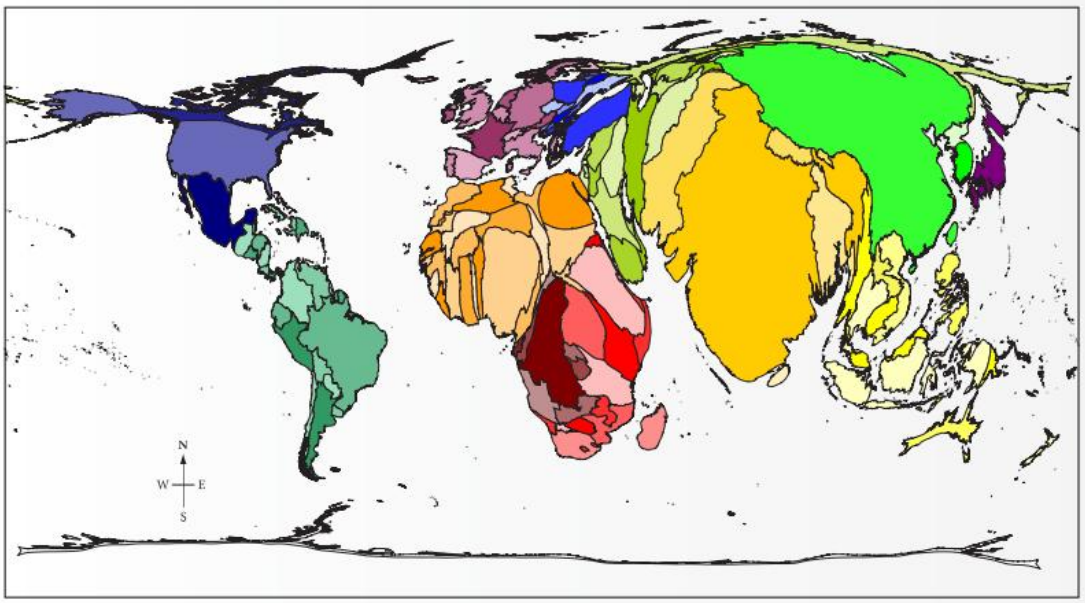
Weblink
Cartogram

GEOskills TOOLBOX

A cartogram is a type of map used to visually display data. The size of a country on the map of the world, reflects the measurement. The cartogram below showing projected global population for 2050 can be found at the **Cartogram** weblink in your eBookPLUS. The most populated countries are the largest in size.

FIGURE 4



Source: http://www.sasi.group.shef.ac.uk/worldmapper/display.php?selected=11

ACTIVITIES

IDENTIFY

1 What is the estimated increase in food production required to feed future populations?
2 Examine figure 2. Discuss the effect world population growth between 1950 and 2050 is likely to have on the amount of arable land available. Support your answer with statistics.
3 Examine figure 2.
  a What ***change*** do you predict will occur by 2050 to the proportion of the world's population that is urban?
  b What region is expected to experience the greatest population growth between 2010–2050?
4 What are the ingredients in Plumpy'nut?

EXPLAIN

5 Explain why you think hunger may threaten people's health and be responsible for so many deaths.
6 How might ensuring that people have enough to eat ***change*** overall living conditions in a country?
7 Outline the advantages and disadvantages of using Plumpy'nut or other RUTFs to treat childhood malnutrition in developing countries.
8 What may need to happen to ensure there is enough food in the future for people who live in ***places*** with growing populations and limited arable land?

INVESTIGATE

9 As well as affecting people's health, a shortage of food can have social and political effects. Undertake research into the series of food riots that occurred in a number of countries around the world in 2008.
  a Where did these riots occur?
  b What were the causes of these riots?
  c Why might governments be keen to prevent this situation from occurring again?

PREDICT

10 a Refer to table 1. Enter these figures into a spreadsheet and create a graph (or series of graphs) to demonstrate the predicted ***changes*** to rural and urban populations.
  b Lack of food has been a factor in pushing people to leave their homes and move to cities in search of employment and food. Predict the places of the world where this is most likely to happen.

TABLE 1 Rural–urban population 1960–2050

Population	1960	2005	2050
% Urban	34%	49%	66%
% Rural	66%	51%	34%

APPLY

11 Draw a poster or advertisement that informs Australians about Plumpy'nut and seeks donations for its use.

6.3 Can we improve food production?

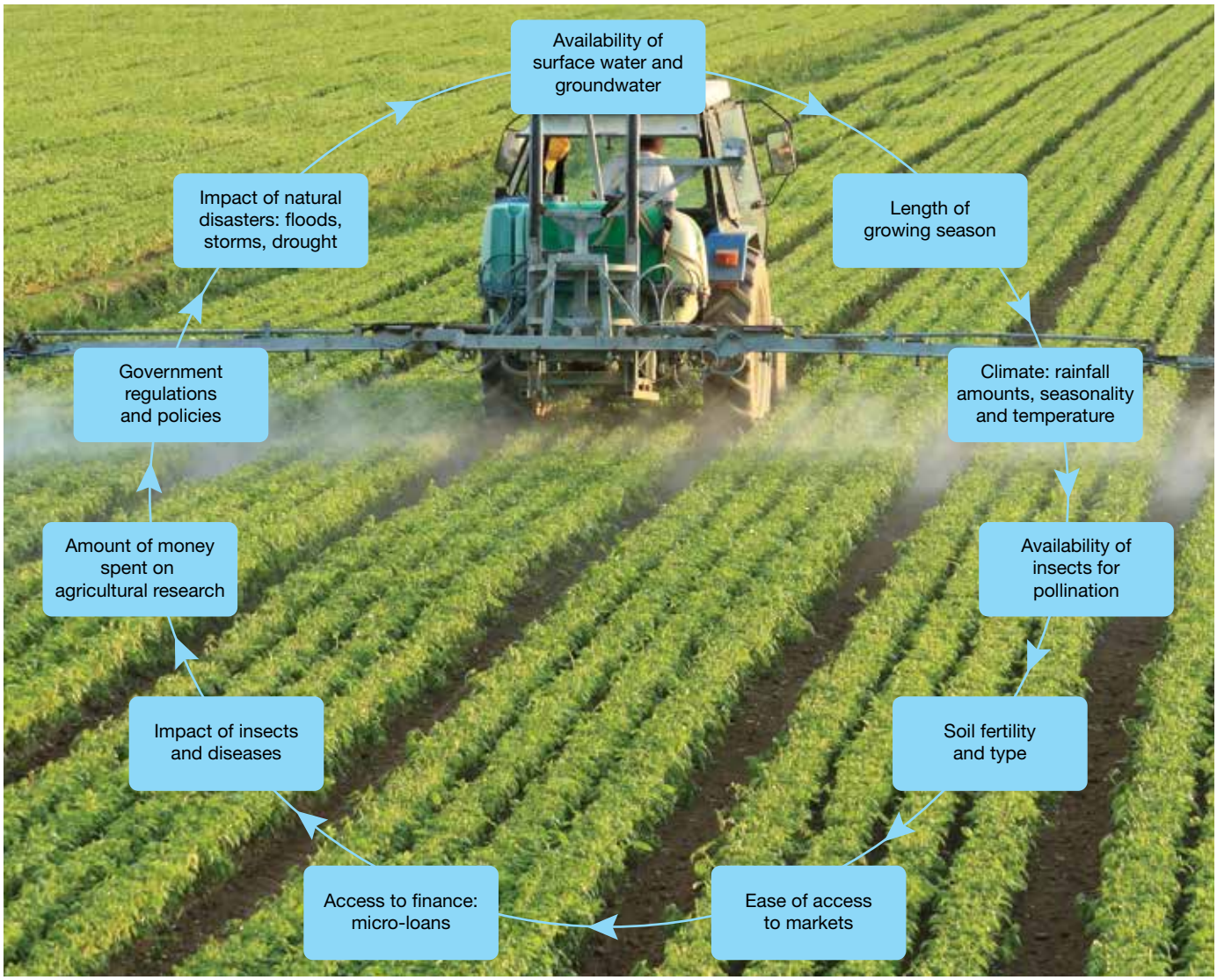
6.3.1 How can we improve food production?

Over 70 per cent of the world's poor live in rural areas, and improving their lives would create greater food security. If poor farmers can produce more food, they can feed themselves and provide for local markets. Improved infrastructure, such as roads in rural regions, would enable them to transport their produce to market and increase their incomes. Preventing hunger at a global scale is important, but action is also needed at a local scale.

Future changes to food production

Farming is a complex activity, and farmers around the world face many challenges in producing enough food to feed themselves and to create surpluses they can sell to increase their incomes (figure 1). As already identified in the previous chapter, there is limited arable land in the world. According to the United Nations Food and Agriculture Organization (FAO), the world has an extra 2.8 billion hectares of unused potential farmland. This is almost twice as much as is currently farmed. However, only a fraction of this extra land is realistically available for agricultural expansion, owing to inaccessibility and the need to preserve forest cover and land for infrastructure.

FIGURE 1 Factors affecting farming yields



In Australia there are hopes to expand the agricultural output from the Ord River irrigation scheme in the Kimberley region of Western Australia.

The growing populations of the future will be found in places where expansion of agricultural land is already limited (see figure 3). Consequently, increased food production will need to come from better use of current agricultural areas, better use of technology, and new ways of thinking about food production and approaches to farming. Figure 2 outlines some strategies that may be used to improve food production.

FIGURE 2 Strategies for improving sustainable food production

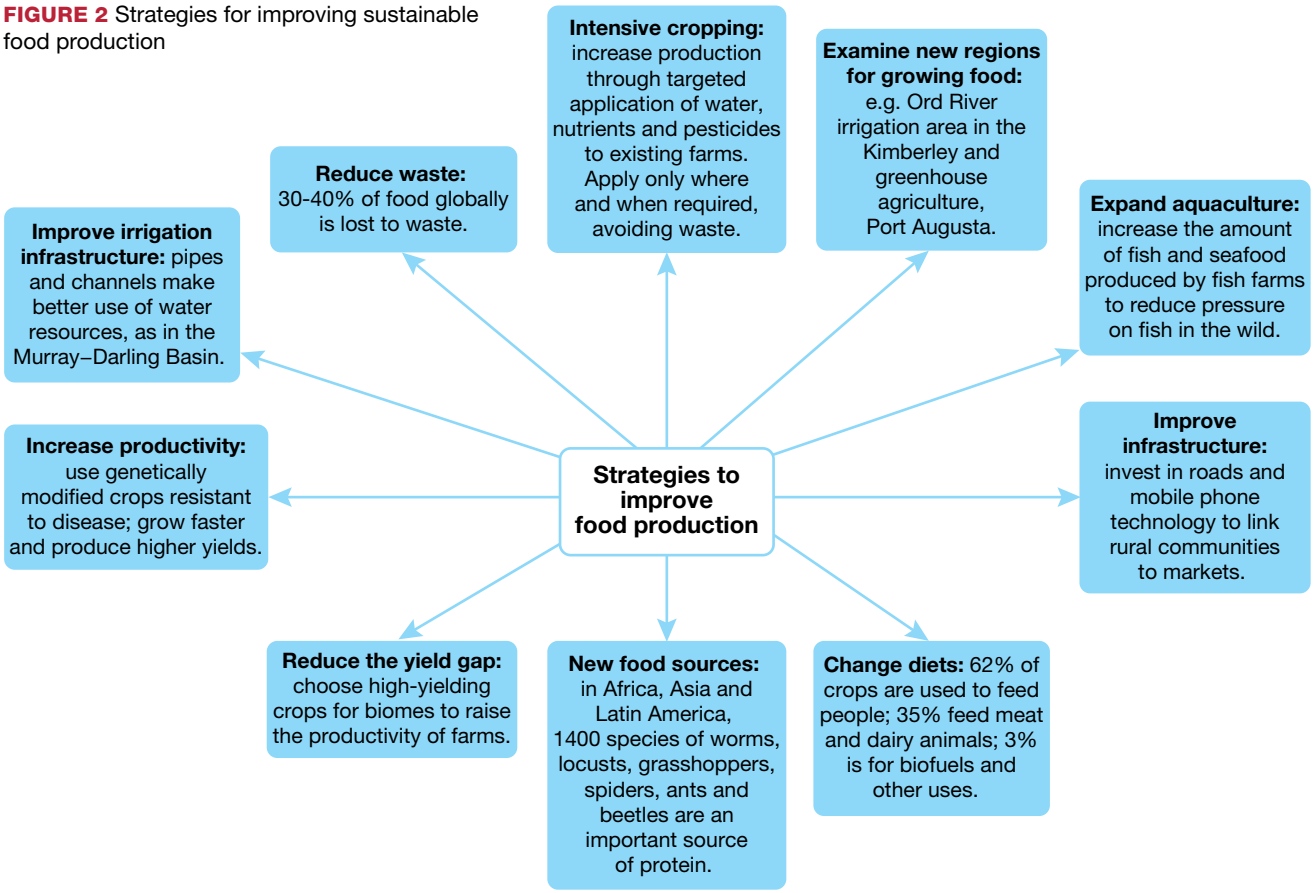
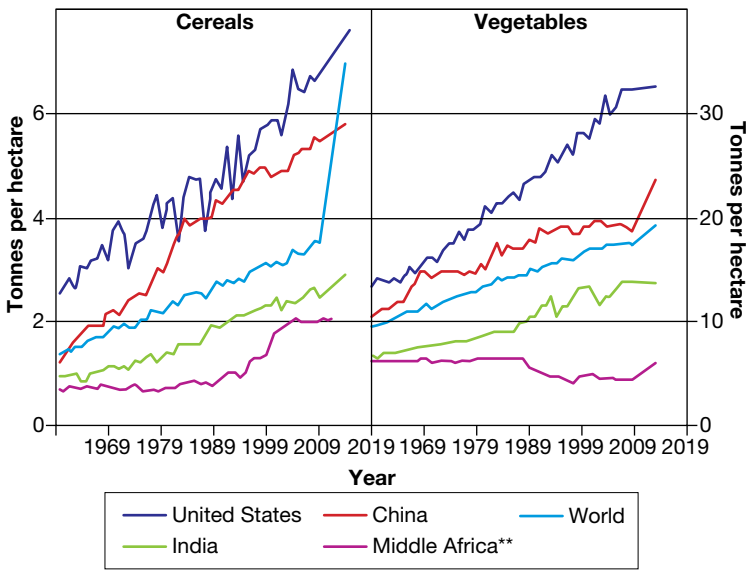


FIGURE 3 The yield gap of cereals and vegetables in selected regions, 1969–2019



**Angola, Cameroon, Central African Republic, Chad, Congo (Brazzaville) Democratic Republic of the Congo, Equatorial Guinea, Gabon, Sao Tome and Principe

Source: FAO

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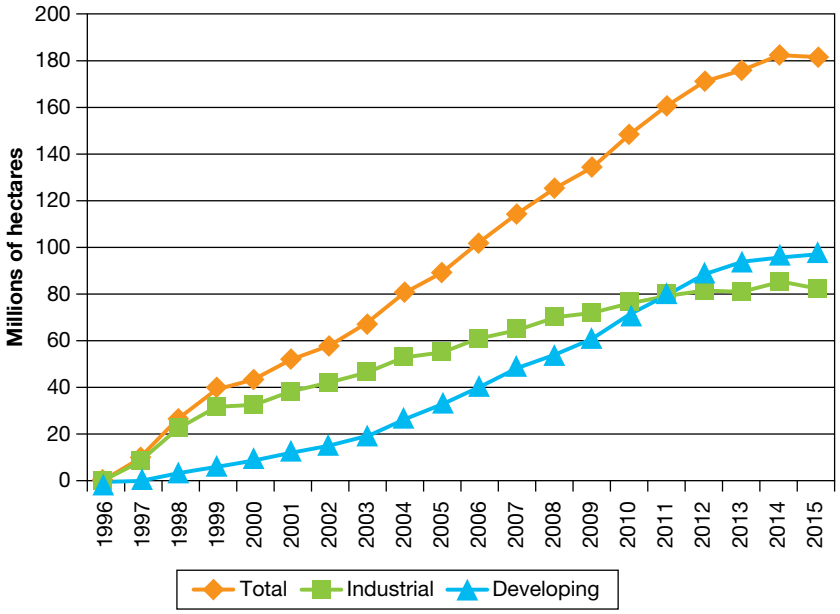
Interactivity
More, or less, food
Use this interactivity to further your understanding of factors that influence crop yields.
Searchlight ID: int-3329

Strategies for improving food production

The strategy that is likely to be the most important in increasing future crop production is called closing the **yield gap**. This means that farmers who are currently less productive will need to increase their yields so that their outputs are closer to those of the more productive farmers. There is a serious yield gap in more than 157 countries. If this were achieved, larger amounts of food would be available without needing more land. There are wide geographic variations in crop and livestock productivity. (See figure 4.) Brazil, Indonesia, China and India have all made great progress in increasing their agricultural output. Much of the increase has been achieved through more efficient use of water and fertiliser.

FIGURE 4 Growth of genetically modified crops, 1996–2015



Source: Clive James, 2015

The use of **genetically modified** (GM) foods has increased, and this has increased crop yields. However, there is some opposition to GM crops because of concerns about:

- their safety
- loss of seed varieties
- potential risks to the environment and people's health
- the fact that large companies hold the copyright to the seeds of GM plants that are food sources.

yield gap the gap between a certain crop's average yield and its maximum potential yield

genetically modified describes seeds, crops or foods whose DNA has been altered by genetic engineering techniques

6.3.2 Solving problems and coming up with solutions

Because agriculture uses 60 to 80 per cent of the planet's increasingly scarce fresh water resources, any method that can produce food without needing fresh water at all is a great advance.

Port Augusta is located in a hot, arid region of South Australia, and is not normally associated with agriculture. However, one company, Sundrop Farms, is using this region's abundant renewable resources of sunlight and sea water to produce high-quality, pesticide-free vegetables, including tomatoes, capsicums and cucumbers, and it does so all year round.

Large mirrors concentrate the sun's energy and the collected heat creates steam to drive electricity production, heat or cool the greenhouse and desalinate sea water, producing up to 1 million litres of fresh water a day to irrigate the crops.

Experimental greenhouse in Port Augusta

The current experimental greenhouse, covering 2000 square metres, is operating on a small scale (figure 5). A new $150 million greenhouse will be completed in 2016. This new project aims to produce approximately 15 000 tonnes of truss tomatoes per year, which equates to about 10 per cent of Australia's demand. The new greenhouse uses renewable energy to be not just carbon and water neutral, but positive. It is hoped that this greenhouse system can be used in more places, here and around the world, which have hot, arid climates, are close to sea water and are currently unsuited to agriculture. Their produce may be able to supply millions of people with healthy food, in a sustainable manner, using limited amounts of fossil fuels.

Australian farmers see technology as a means of decreasing production costs and increasing crop production. Additional technologies in Australian agriculture include the following.

FIGURE 5 The world's first Sundrop Farm is situated in Port Augusta, South Australia.

- Robots are being tested to determine whether they can be used in complex jobs such as watering or harvesting. This would be of advantage in the horticultural sector, which is the third largest sector in agriculture, with an export trade worth $2.1 billion in 2014–2015.
- Technology such as satellite positioning is being used to determine the optimal amounts of fertiliser to use on crop farms, which could increase profitability by as much as 14 per cent.
- Robots and an unmanned air vehicle (drones) have passed field tests at an almond farm in Mildura, Victoria. They are fitted with sensors, vision, laser, radar and conductivity sensors—including GPS and thermal sensors.

FOCUS ON FIELDWORK

Researching the source of your food

On a visit to your local food store or when you have a piece of fruit in your lunch box, carefully remove the small, brightly-coloured sticker that details the source of this piece of food. Where has the food come from? What is the name of the company that has produced this food?

Research the farm and identify the environment in which this food is produced. Does the website of this producer refer to sustainable farming methods? Your class could record the source of their recess snacks over a one-week period and map the location of each in the world.

ACTIVITIES

IDENTIFY

1 List three different strategies, other than closing the yield gap, for improving food production.
2 What is meant by the term *yield gap* and why is it important that this gap be narrowed to increase future crop yields? See figure 3.
3 What is meant by the term *genetically modified* (GM)?
4 Examine figure 4. What ***changes*** have there been in the production of genetically modified foods in:
   a developed countries
   b developing countries?
   Use the data from the graph to support your answer.
5 a Referring to figure 3, identify the ***changes*** in both cereal and vegetable yields between 1969 and 2015 in various parts of the world.
   b Which ***places*** have produced the largest and smallest increases in yields over this period?

EXPLAIN

6 Explain the advantages and disadvantages of locating the large greenhouse near Port Augusta. You may need to consult your atlas.
7 Select one of the strategies outlined in figure 2 that can be used to improve food production. Explain this strategy in your own words and outline some of the strengths and weaknesses of this strategy.
8 Use the **Sustainable farming** weblink in your eBookPLUS to watch a video clip on this topic. What is being suggested about ***environmentally sustainable*** farming in the future? Draw a diagram to show what a future vertical farm might look like. How might a vertical farm help in feeding future populations?

PREDICT

9 Many Australian cities have large housing estates on their outskirts. This land was often used for market gardens or farmland. What impact might the loss of this productive land have on the price of food?
10 Predict what the impact might be on people and ***places*** if the greenhouse method of farming shown in figure 5 were to become more readily available. What might be the effects on ***places*** where the yield gap is large compared to ***places*** that are currently more productive?

APPLY

11 Examine figure 5.
   a Identify at least three geographic features of the Port Augusta landscape.
   b Sundrop distributes its **hydroponic** produce across Australia. What locational advantages does the Port Augusta site have?
   c Why would the Middle East be interested in Sundrop technology?
12 Some areas of Australia that are currently national parks or marine parks may be sought after as agricultural land in future. Outline your views on this.

hydroponic describes a method of growing plants using mineral nutrients, in water, without soil

eBookplus

Weblink
Sustainable farming

6.4 What food aid occurs at a global scale?

6.4.1 Who needs food aid and how is it delivered?

The World Food Programme (WFP) is a voluntary arm of the United Nations. It reaches more than 80 million people, in more than 82 countries, with food assistance after disasters and conflicts. Food aid is food, money, goods and services given by wealthier, more developed nations to less developed nations for the specific purpose of helping the poor.

Food aid is delivered in several ways, depending on the type of need that exists. The three main forms of food aid include:

- Program food: organised between national governments
- Emergency food: short-term relief free to victims of disaster and conflict
- Project food: longer-term support towards poverty reduction and future disaster prevention.

People who need food aid may be fleeing violence, persecution or civil conflict, homeless due to the effects of a natural disaster, unable to farm or provide for their family due to illness or trapped in a cycle of hunger and poverty, unable to afford food.

In 2015, the Syria conflict triggered the world's largest humanitarian crisis since the Second World War. More than 13.5 million people required ongoing food aid, water, sanitation, health and shelter as they were displaced or moved into neighbouring countries and across Europe to seek refuge. The provision of food became a major challenge for all humanitarian agencies. More than 4 million refugees awaited processing six months after the crisis (see figure 1). Emergency food assistance included food vouchers and rations of **staple** food items such as rice, wheat, canned foods and cooking oil. When funding is available, food **vouchers** are distributed to displaced people.

staple an important food product or item that people eat or use regularly

voucher a card or ticket that allows you to purchase goods and services to a set value

FIGURE 1 Syrian refugee families living in emergency accommodation in Turkey

6.4.2 How do we end hunger?

A plan to end hunger is being driven by the United Nations through its Zero Hunger campaign. It encourages the global community to work together on solving the issues of poverty, inequality and climate change. Seventeen Sustainable Development Goals (SDGs) were formally adopted in 2015 by 193 members of the United Nations. Zero Hunger by 2030 is Goal 2 and is based on five elements outlined in figure 2.

FIGURE 2 Elements of Sustainable Development Goal 2: Zero Hunger

- Zero stunted children less than two years old
- 100 per cent access to adequate food all year round
- All food systems are sustainable
- 100 per cent increase in smallholder productivity and income
- Zero loss or waste of food

These goals hope to address the causes of poverty and hunger and to build resilience levels of those nations most at risk.

6.4.3 Who gives food aid?

The major donor countries to the WFP in between 2011 to 2015 are shown in table 1.

TABLE 1 Top contributing countries and their total food aid contributions between 2011 and 2015

Country	Cumulative contributions 2011–2015 (US$)
United States	8 431 740 849
United Kingdom	1 664 389 184
Canada	1 617 113 095
European Commission	1 593 185 660
Germany	1 206 241 406
Japan	1 064 719 351
Australia	542 353 459

Source: World Food Programme.

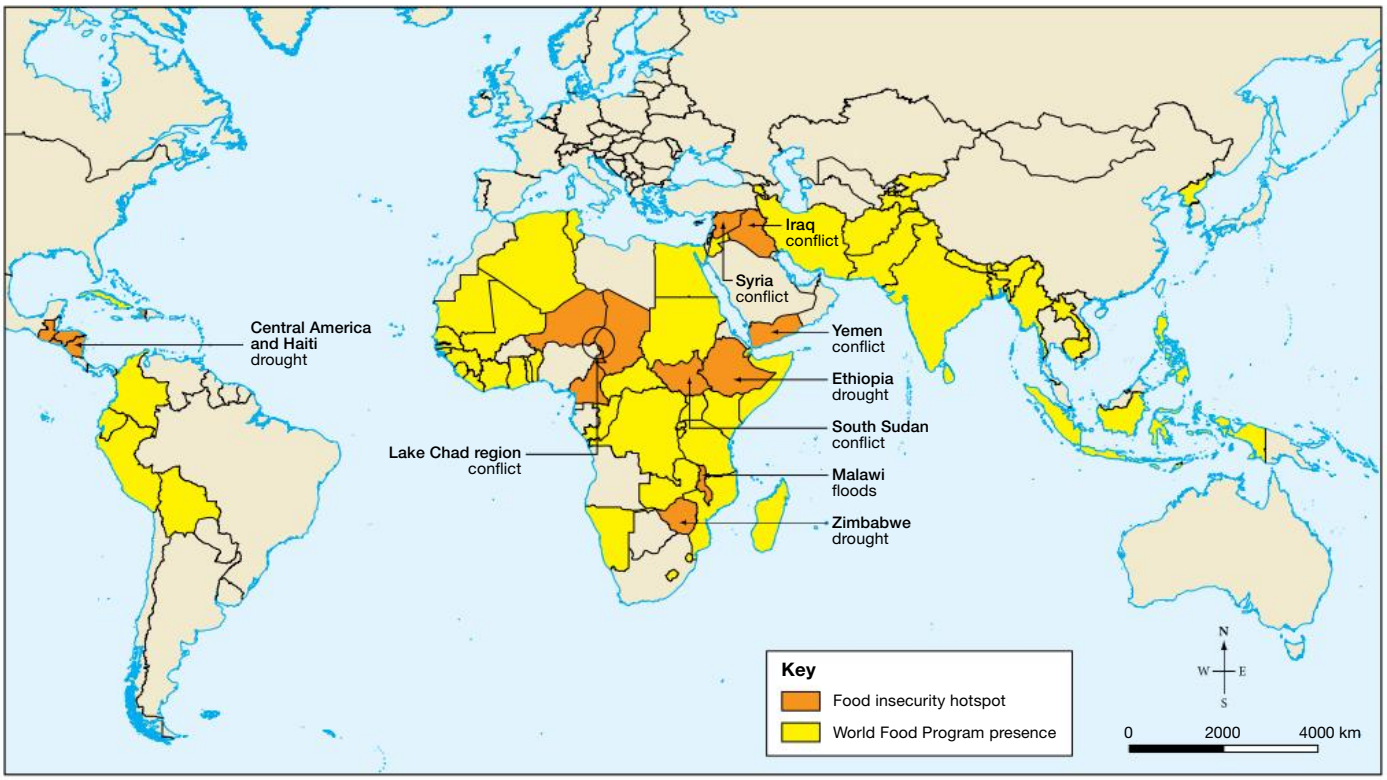
eBookplus

Interactivity
Food aid
Use this interactivity to further your understanding of different types of food aid.
Searchlight ID: int-3330

6.4.4 Who receives food aid?

At the start of 2016, the WFP faced many food insecurity hotspots (see figure 3) as a result of drought, floods, disease and conflict. Weather patterns continued to impact growing seasons and harvests long after the El Niño event reached its peak intensity. The WFP addresses ongoing food security issues through food projects and food programs. It also responds to humanitarian crises by providing emergency food aid.

FIGURE 3 Food insecurity hotspots in 2016



Source: World Food Programme

CASE STUDY

School feeding programs

The United Nations WFP is supporting an initiative that enhances local food production capacities, creates employment, stimulates the local economy and invests in the future of Syria. Date bars made from local ingredients and enriched with vitamins and nutrients, are being manufactured in Syria and distributed to schoolchildren as part of a school feeding program.

In 2015, Australia funded school feeding programs in Gambia. This program is having a strong positive impact on both the children and the wider community. School rates of enrolment increased and engagement in learning and regular attendance improved. Households also benefited through a reduced need to purchase food. Australia contributed more than US $69 million of funding through the World Food Program in 2015. This included food assistance for Syrian refugees in Jordan, Lebanon, Iraq, Turkey and Egypt and emergency assistance to Nepal (earthquake), Vanuatu (cyclone) and Iraq (conflict).

FIGURE 4 Children in school receiving nutritious food bars made in Syria.

ACTIVITIES

IDENTIFY

1 What are the three different types of food aid?
2 Refer to table 1. How much food aid did Japan give to the WFP in 2011–2015?
3 How does the WFP fund its donations of food aid?

EXPLAIN

4 Explain why the WFP is so active in school feeding and emergency aid programs.
5 Use the **WFP** weblink in your eBookPLUS to help you explain the benefits of food aid shown here.

APPLY

6 Select a major donor of food aid from table 1. What are the main population characteristics of this country, such as life expectancy, literacy levels and death rates? Discuss your findings in class.
7 Use the **WFP** weblink in your eBookPLUS to help you explain the WFP's involvement in Syria and surrounding ***places*** in 2015. What action is the WFP taking there and why?
8 How might food aid ***change*** when a donor country experiences a major economic downturn?
9 Predict the likely consequences for children who suffer from malnutrition. Present your information in an appropriate diagram.

INVESTIGATE

10 Write a letter to your federal member of parliament, outlining your views on increasing Australia's food aid contribution.

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Weblink
WFP

6.5 How is Lake Victoria a food source?

6.5.1 Lake Victoria

Lake Victoria, with a surface area of 68 800 km², is Africa's largest freshwater lake and a source of water for the Nile River. The lake supports a population of over 30 million people in east Africa through fishing, agriculture, local industry, forestry, hydro-electric power, transport and tourism. Lake Victoria is shared by Uganda, Kenya and Tanzania, and its catchment area includes Rwanda and Burundi.

High levels of hunger exist within the densely populated communities (see figure 1) that live around Lake Victoria. Crops grown within the river catchment include: beans, coffee, cotton, maize, sisal, sugarcane and tobacco. The lake also supports a productive fishing industry (figure 2); however, fish stocks in recent years have declined due to overfishing and increased environmental pressures. Invasive weeds, such as the water hyacinth, have contributed to this decline in fish stock, increased the incidence of water borne diseases, reduced drinking water and reduced navigability of the lake.

FIGURE 1 Densely populated areas along the shores of Lake Victoria.

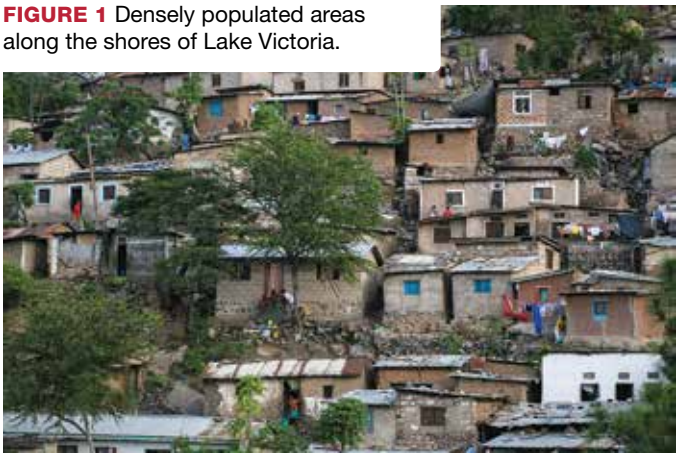

FIGURE 2 Fishermen carrying their catch from Lake Victoria onshore.

ACTIVITIES

IDENTIFY

Refer to figure 3 to answer the following questions.

1. List the names of each of the countries that share the edge of Lake Victoria.
2. Which country is to the east of Lake Victoria?
3. If a fishing boat was located at 2° 00' S 32° 00' E, what country would it be in?
4. What is the distance across the widest part of Lake Victoria?
5. How many airports and landing grounds can you see in the region shown in this map?
6. How many kilometres would a plane travel on a trip from Entebbe airport to Mwanza airport, then to Kisumu airport, before a return trip to Entebbe?

PREDICT

7. Examine figures 1 and 2.
   - a Suggest impacts that humans might have on the water quality of Lake Victoria.
   - b How might these factors affect the ability of the lake to support a fishing industry?

INVESTIGATE

8. The Lake Victoria area faces increasing pressure from large numbers of people moving into densely populated settlements around the lake. High rates of hunger are being recorded, as food sources are being exploited. The 'Friends of Lake Victoria' group plan to hold a session to discuss the issue of food scarcity in the district.
   - a Investigate the sources of food available to people living around Lake Victoria.
   - b What issues are faced by workers in the Lake Victoria fishing industry?
   - c As a class, suggest sustainable solutions to the problems faced by these workers.
   - d Discuss which solution would ensure the greatest level of food security for the region.

FIGURE 3 Topographic map of Lake Victoria

Source: Vector Map (VMap) Level 0, World Database of Protected Areas, Spatial Vision.

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6.6 SkillBuilder: Constructing a box scattergram

What is a box scattergram?

A box scattergram is a table with columns and rows, which displays the relationship between two sets of data that have been mapped. Box scattergrams are a useful way of summarising data from maps.

Hunger level (% undernourished)	Aid received per person ($US)			
	No data	Less than 20	20–99	Over 100
35 +				• Congo • Mozambique
25–34			• Chad • Angola	
15–24				
5–14		• Nigeria	• Niger	
Less than 5		• South Africa • Algeria • Libya		
No data				• Mauritania

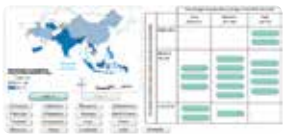
eLesson

Watch this video to learn how to construct a box scattergram.

Searchlight ID: eles-1734

Interactivity

Try this interactivity to learn how to construct a box scattergram.



Searchlight ID: int-3352

6.7 Do Australians need food aid?

6.7.1 Who needs food aid in Australia?

In 2015, it was estimated that one in seven Australians lived in poverty. The prices of essentials — food, health, education, housing, utilities and transport — have climbed so much in recent years that people who are already struggling are unable to cope. They may need food aid. The economic climate saw people turning to charity who would never have dreamed of seeking such support in the past. It is not just traditionally vulnerable groups, such as the homeless, who are seeking food relief; it is also the aged, single parents and the 'working poor'.

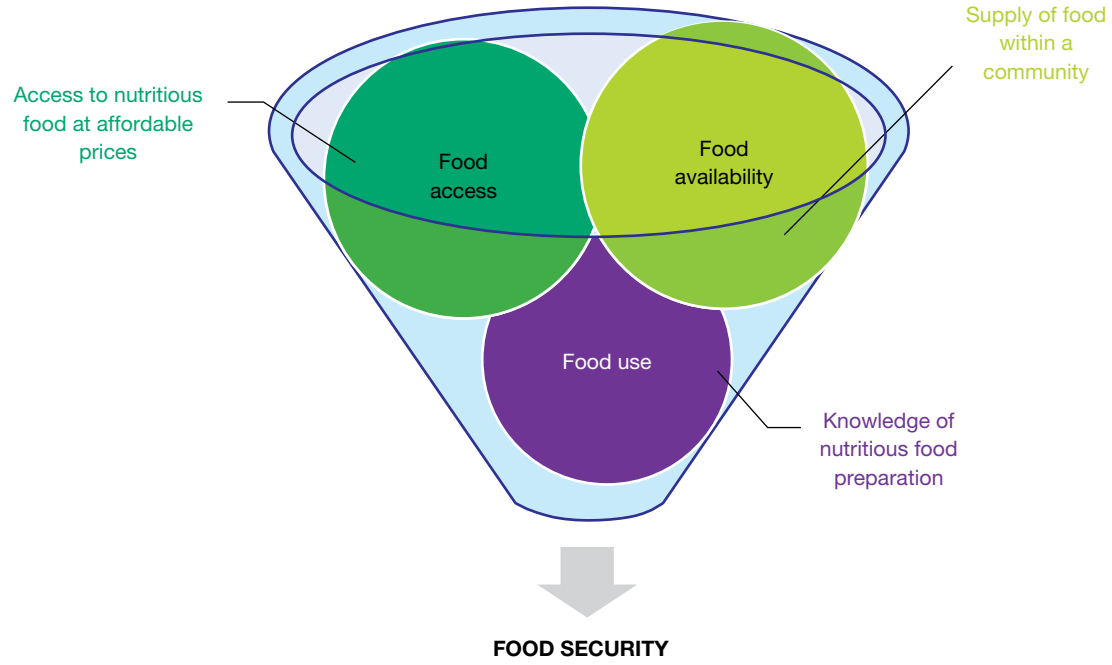
Food security is broadly defined as 'access by all people at all times, to enough food for an active, healthy life' and the World Health Organization (WHO) identifies three factors that determine food security (see figure 1). These challenges force many Australians to regularly skip meals.

In 2015, it was reported that in Australia:

- 2.5 million live in poverty
- 256 000 are currently homeless
- 17.7 percent of all children live below the poverty line
- one in seven children are arriving at school hungry
- one in ten people receiving unemployment benefits are unable to get a substantial meal each day.

Food banks and charitable organisations work to collect and redistribute food to those in need. Other strategies include school breakfast programs and cooking classes, food waste education and community garden initiatives. Studies have revealed that Australians discard up to 20 per cent of the food that they purchase. To address this issue in France, legislation has been introduced to force large grocery stores to donate unsold food to charitable organisations. In Australia, pressure to reduce food waste has led to the promotion and sale of odd-shaped fruit and vegetables.

FIGURE 1 Factors that may determine food security levels (WHO)



CASE STUDY 1

SecondBite

SecondBite rescues and redistributes food to agencies that service people in need. Food is donated from farm gate, wholesalers, markets, supermarkets and caterers.

SecondBite has rescued over 20 million kilograms of food nationally and redistributed this food free of charge to more than 1200 community food program partners. Figure 2 shows a truck used to collect and deliver donated food to the SecondBite warehouse.

FIGURE 2 SecondBite delivery

CASE STUDY 2

Outback Australia

Access to adequate food and the opportunity to feed oneself now and in the future, is a fundamental human right. Foodbank is Australia's largest hunger relief organisation, distributing 35 per cent of its volume to rural and regional areas. These areas face uncertain growing conditions, farm yields and transport costs from year to year. Donations of grain allow Foodbank to manufacture pasta and breakfast cereals and distribute it to those in need.

In Australia, rates of food insecurity are highest in remote Aboriginal communities, where the food supply is often limited and very expensive to purchase. Fewer shops and a limited range of healthy foods such as fruit and fresh vegetables can lead to poor nutrition in remote communities. Traditionally, the diet of Aboriginal communities had a high nutritional value and used local and sustainable food sources. One not-for-profit farming initiative called Arid Edge Environmental Services, is working to develop small scale farming opportunities in remote Aboriginal communities. Food gardens have been set up in the Utopia homelands, 250 kilometres north-east of Alice Springs in consultation with community members, using **permaculture** techniques and hardy plant species.

permaculture
a view that farming should work with nature, not against it

CASE STUDY 3

Meals on Wheels

Meals on Wheels began in the United Kingdom during World War II. In Australia, it began in Melbourne in 1952, and it plays an important role in helping aged and disabled people to remain in their homes. Some people may not be able to get out and about, so 78 700 volunteers help to deliver meals to them. By providing nutritious, relatively cheap meals, costing between $4.50 and $9.00, Meals on Wheels helps to make it possible for people to maintain their independence. Some 14.8 million meals are served annually to 53 000 people across the nation. The social interaction and regular visits are an important part of this service.

The services of groups like Meals on Wheels may be in greater demand as Australia's population ages (figure 4). In 2015, 15 per cent of Australia's population was aged over 65 years. By 2056, it is predicted that there will be 23–25 per cent aged over 65 years (figure 5).

FIGURE 3 Volunteers for Meals on Wheels

FIGURE 4 Australia's population structure 2015 and 2050

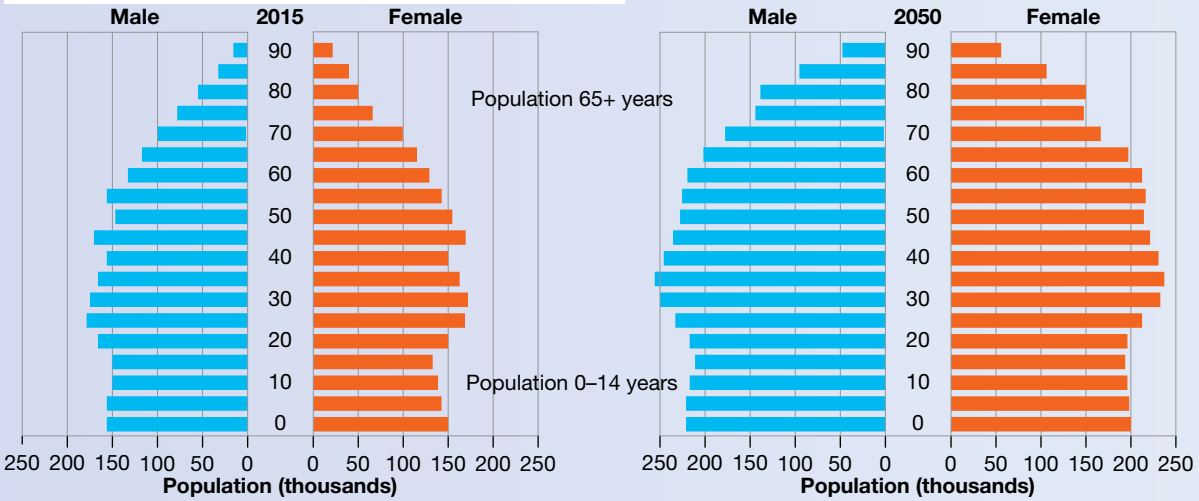
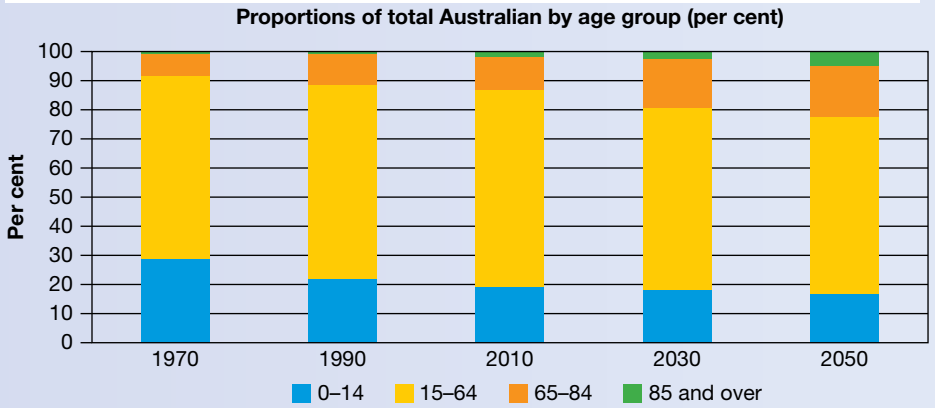


FIGURE 5 The number of Australians in older age groups is expected to grow strongly.



FOCUS ON FIELDWORK

Investigating indigenous uses of plants

How has the natural environment near your home been modified over time? What plants exist in your community that have Aboriginal significance? Invite a local expert to chat to your class about the local environment and share their knowledge of the change that has occurred over time. What local plants are used by the Aboriginal people? Prepare a plant identification chart (see figure 6) to record the main points from the talk for use by others, and take photographs of the plants referred to. To identify the plants, save a photograph of the plant on your computer. Go to Google Images, click the camera icon and follow the prompts to search for similar images; this information should help you find the name of your plant. What other information can you add to your chart?

FIGURE 6 Vegetation identification chart

What plant is that?

Our environment: Our school is situated on part of the Hornsby Plateau. There are many sandstone rocks around our area. The sandstone is easily seen along the M1 motorway heading north to Newcastle.

Plants observed around our school today:

Name: Mountain Devil	Grey Spider Flower	Scribbly Gum
Date:	Date:	Date:

ACTIVITIES

IDENTIFY

1 Examine figure 1.
- **a** Describe food security.
- **b** For each of the following groups of people, identify the type of food insecurity that may be experienced.
  - Homeless teenager
  - Child caring for a parent
  - Farmer on remote property
  - Widower lacking cooking skills
  - Overseas student unable to earn money
  - Single parent faced with high medical costs
  - Family in small town with one general store
  - Single elderly person with limited mobility
  - New immigrant unfamiliar with local products
  - Person with no access to car or public transport
  - Person in remote community with no access to refrigeration

2 State how many Australians in 2015 were living in poverty.

3 State the percentage of food purchased by Australians that is wasted.

4 State how many meals are served each year by SecondBite.

5 Describe the ***change*** that occurs in the shape of the population pyramids for Australia between 2015 and 2050.

EXPLAIN

6 Explain why there might be difficulties with access to food in 2050 if 25 per cent of the population is over 65 years old.

7 Explain the importance of volunteers in food redistribution.

8 Explain how Australia's size could lead to food shortage in some ***places***?

APPLY

9 Consider why food waste is a problem for the world. Using an infographic web tool (see GeoSkills feature), prepare a suitable 'Reduce food waste' information campaign and presentation for your school.

10 Using the internet, investigate the traditional Aboriginal foods native to your local ***environment***. When are these food sources available for use? Consider factors such as flowering plants and native bees. Prepare a table like the one below, with columns for each month of the year. For at least two food sources, indicate the time of the year when this source of food is available.

Food source	J	F	M	A	M	J	J	A	S	O	N	D
Lillipilli	✓	✓										✓
Food source 1												
Food source 2												

INVESTIGATE

11 Conduct your own research into one local and one national organisation that provides food aid.
- **a** Compare the aim of each organisation.
- **b** Compare the ***scale*** of each organisation.
- **c** Describe how effective you think ONE organisation is at delivering food aid. Give reasons for your answer.

12 Use the **Australian poverty** weblink in your eBookPLUS to discover other aspects of poverty in Australia. What volunteer opportunities are available for you within your local community? In your opinion, how does this organisation address food security issues?

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Weblink
Australian poverty

GEOskills TOOLBOX

Infographics

When summarising large amounts of information, it is fun to create a brightly-coloured graph or to use an important statistic. Using the **Infographics** weblink in your eBookPLUS you can use a template to create exciting presentations that allow you to use videos, maps, graphs, photographs and icons to communicate your research. Useful hints:

- Organise your information into brief points and statistics.
- Choose a template that matches the content of your topic.
- Make sure your information flows from the top to the bottom of the page.
- Use colours that provide contrast (e.g. white on red — see figure 7).
- Keep your message simple.

FIGURE 7 An example of an infographic

eBookplus

Weblink
Infographics

6.8 Is trade fair?

6.8.1 Why is trade not fair for everyone?

As people become more concerned about the level of poverty and hunger in the world, they sometimes seek ways to improve the situation. Trade is the way countries sell what they have produced and buy what they need. On a global scale, this does not mean that trade is mutually beneficial. Trade usually favours countries that are the strongest economically, and it disadvantages those countries that are poor.

active consumerism a movement that is opposed to the endless purchase of material possessions and the pursuit of economic goals at the expense of society or the environment

FIGURE 1 Advertising for Fairtrade certification

Trade is not a level playing field. It favours the strongest countries, often to the disadvantage of the poor and weak. Strong or developed countries are able to:

- stockpile or dump crops so that they sell for a maximum price
- negotiate some political advantage
- refuse to sell crops if they have a shortage, so some nations go hungry
- dump crops of low quality onto poorer nations.

In contrast, fair trade is a consumer-driven movement to promote fair prices and reasonable conditions for producers in developing regions. It tries to ensure, for example, that a group of farmers is able to sell its crop for a guaranteed price. Fair trade is seen by some as **active consumerism**. In addition to the general movement known as fair trade, there is an organisation called Fairtrade International. This is a group of 25 organisations trying to ensure a better deal for producers (see figure 1).

6.8.2 Why do small farmers turn to Fairtrade certification?

In Ghana, cocoa farmers with 2- to 3-hectare plots of land face a number of problems.

- They may grow one main cash crop for low prices that do not even cover the costs of production; they may also grow some vegetables for family use and extra income.
- They face expensive production inputs (tools, fertilisers and pesticides) and family costs (education, medicine, food and clothes).
- Poor education makes it difficult for them to try different crops, which could earn more money.
- The use of child and slave labour is common in cocoa-producing West African countries.
- Technical, financial and scientific advice is limited.
- Credit is a key issue for farmers with **seasonal crops** like cocoa. Farmers need money for food and immediate needs, as well as pre-financing for planting and cultivation of their crop. Most borrow money from family, and a small percentage take a loan.
- There are taxes or tariffs on products.

As a consequence, many farmers are turning to Fairtrade as a means of improving their livelihoods.

seasonal crops crops that are harvested in a certain season of the year, rather than all year round

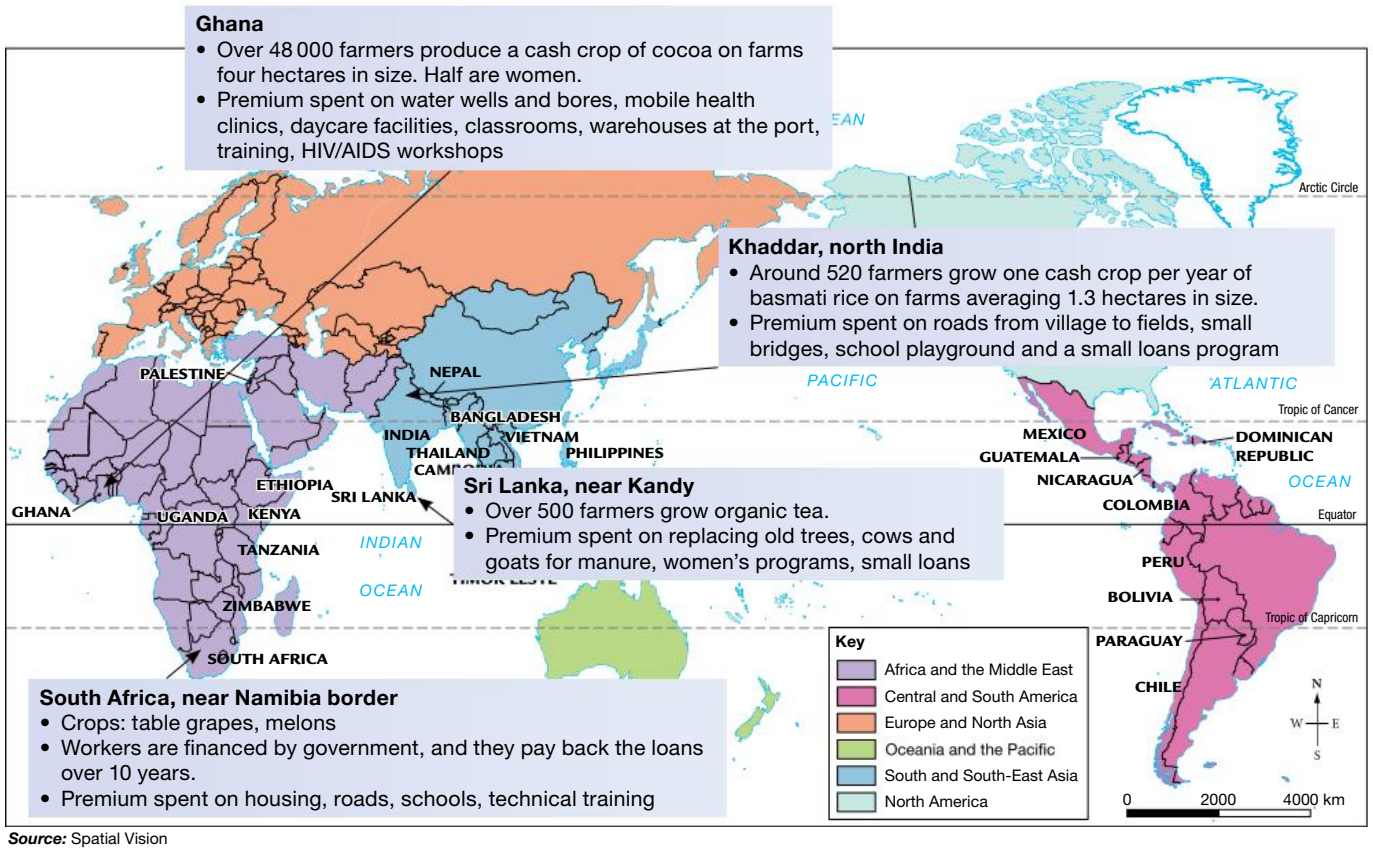
Where are Fairtrade farmers found?

Countries with Fairtrade organisations are in the poorer nations. They are frequently found in Asia, Africa and South America (see figure 2). These farmers produce crops such as grapes, cocoa, coffee, tea, dried fruits, bananas, sugar, rice, nuts and handicrafts. The consumers who are likely to buy crops produced by Fairtrade farmers are located in the wealthy nations, because they have the ability to pay a little more to buy their goods.

Do farmers benefit from Fairtrade?

Fairtrade farmers enjoy the certainty of having a fixed price and a guaranteed market for their product. This gives them the ability to undertake farming improvements. The Fairtrade Premium

FIGURE 2 Map showing Fairtrade producer countries. The annotations describe how selected producers use their Fairtrade premium — a sum of money paid in addition to the Fairtrade price, to be invested in social, environmental or economic development projects, decided by farmers or plantation workers.



Source: Spatial Vision

provides money for infrastructure, training, education and medical services. It also allows women farmers access to international trade. In Ghana, training of farmers improved the yield by as much as 50 per cent, and it improved school attendance for children by 26 per cent. Fairtrade also benefits the environment, as many of the farming groups produce organic crops.

ACTIVITIES

IDENTIFY

1 Refer to figure 2.
- **a** Which countries have Fairtrade farmers?
- **b** On which continents are most Fairtrade consumers found?

EXPLAIN

2 In Ghana, improving farmer education led to an increase in crop yield of 30 to 50 per cent, as well as improved school attendance. Explain this ***connection***.

3 Read the annotations on figure 2. What similarities are there between fair trade farmers in different ***places***?

4 What does being an 'active consumer' mean? Why are some willing to pay more for Fairtrade chocolate?

APPLY

5 Investigate your favourite chocolate brand. Who owns the brand, and what are their attitudes to Fairtrade chocolate? Write a letter to them expressing your views about Fairtrade cocoa.

6 Research an example of a Fairtrade crop. What are the advantages and disadvantages of Fairtrade?

PREDICT

7 Predict the future of Fairtrade. What factors might affect your prediction?

INVESTIGATE

8 Undertake a class debate on the topic: 'Fairtrade farmers will improve the future food supply'.

9 Analyse figure 1. What makes it an effective poster? Alternatively, design a poster about one of the Fairtrade crops. Include ***change*** or ***place*** or ***sustainability*** in your poster.

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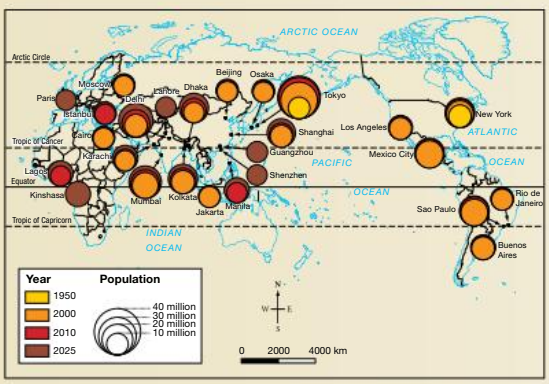
6.9 SkillBuilder: Constructing and describing proportional circles on maps

What are proportional circle maps?

Proportional circle maps are maps that incorporate circles, drawn to scale, to represent data for particular places. Different-sized circles on a map reflect different values or amounts of something. Proportional circles provide an easy way to interpret patterns, give an instant impression and allow us to compare data for different places.



Source: Spatial Vision

eLesson

Watch this video to learn how to construct and describe proportional circles on maps.

Searchlight ID: eles-1735

Interactivity

Try this interactivity to learn how to construct and describe proportional circles on maps.

Searchlight ID: int-3353

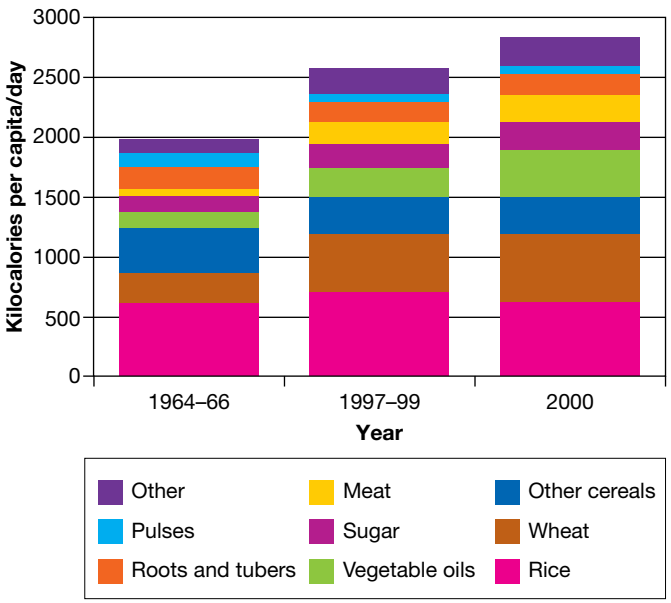
6.10 How do dietary changes affect food supply?

6.10.1 How are diets changing?

According to the Red Cross, 1.5 billion people in the world are dangerously overweight, while 925 million people are underfed. People in both of these categories have health problems. Diets have changed over time and continue to change. This is especially the case in China and India, where the standard of living is rising and people can afford access to a wider variety of foods.

Modern diets have been changing and are expected to change in future (see figure 1). One-third of the world's grain crop is fed to animals to produce meat. Some people consider this wasteful, as it takes about eleven times as much grain to feed a person if it passes through a cow first. It requires 1500 litres of water to produce one kilogram of cereal, but 15 000 litres to produce one kilogram of meat.

FIGURE 1 Changes in the composition of human diet over time



Changing diets in Asia

Rice is a valuable source of protein, but as people's incomes grow, per capita rice consumption is expected to decline. Rice is being substituted by food containing more protein and vitamins and by more processed foods. Japan, Taiwan and the Republic of Korea have already made this dietary change, and the rest of the Asian countries are expected to follow as their economies change and people's incomes increase (see figure 2).

For centuries, the typical Chinese diet was rice and vegetables, occasionally supplemented by small amounts of meat or fish. In 1962, the average Chinese person ate four kilograms of meat a year. By 2005, this figure was 60 kilograms and rising (see figure 3). Americans currently consume the most meat of any country, eating an average of 312 grams per person, per day. This is significantly more than the global average of 113 grams per person.

FIGURE 2 Impacts of dietary changes

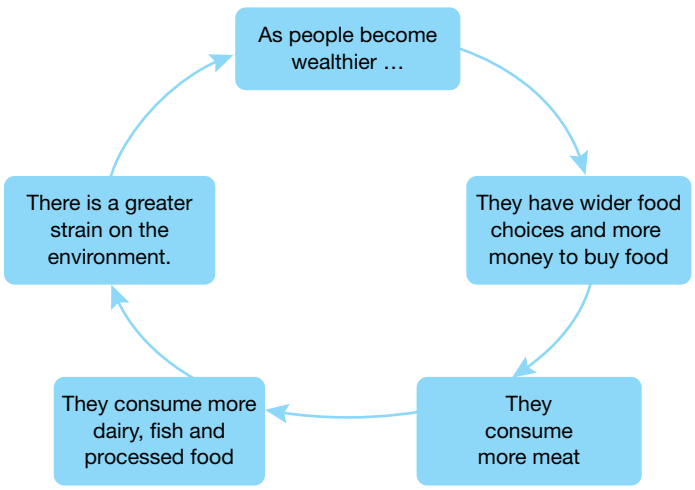
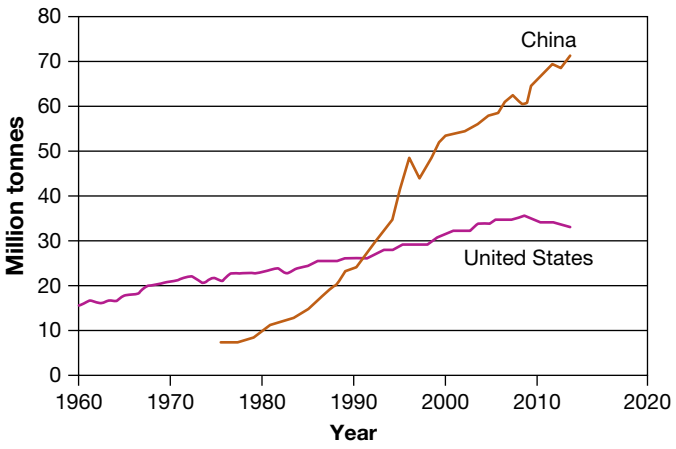


FIGURE 3 Changes in meat consumption in the United States and China, 1960–2013



How can dietary change enable sustainable food production?

Meeting the needs of future populations is not just the responsibility of farmers and producers. We as consumers can also contribute. Attitudes may need to change towards what and how we eat.

Western-style diet eating pattern common in developed countries, with high amounts of red meat, sugar, high-fat foods, refined grains, dairy products, high-sugar drinks and processed foods

- If we are to feed nine billion people sustainably in 2050, it is unlikely to be on a **Western-style diet**, which is rich in meat.
- The world produces enough food to feed 10 billion people. However, a significant portion of our crops is used to feed animals or is used as biofuel to produce energy.
- A switch to a diet containing more plant material would allow land currently used to produce animal feed to instead grow crops to feed humans. Although such a huge change is unlikely, even a small shift can have an impact.
- The Meatless Monday campaign encourages people to go without meat for one day per week. This small change would benefit human health and the health of the planet. Meat production requires a large amount of land, water and energy. Cattle are the largest source of methane gas, which is one of the main contributors to greenhouse gases.
- It is estimated that there are 23 000 edible plants that we do not eat yet. Old foods such as quinoa (pronounced *keen-wah*) could be included in our diets. A crop from South America, quinoa was used over 4000 years ago by the Incas. It has high nutritional value, and grows in a wide variety of climatic conditions. Another advantage of the crop is that all parts of it can be eaten. Peru and Bolivia supply 99 per cent of the world's rapidly expanding quinoa demand. Many countries are investigating its suitability for their locations. 2013 was the International Year of Quinoa, as designated by the FAO. 2016 is the International Year of **Pulses**.

pulses plants that have nitrogen-fixing properties contributing to soil fertility

6.10.2 Can Australia be a food bowl for Asia?

By 2020, it is predicted that half of the world's population will be on Australia's northern borders. Four billion people across Asia will experience economic growth of around 10 per cent per year, representing unparalleled opportunities for Australian farmers and the Australian economy. As Asian societies become more affluent, the people are requiring higher standards of living and this includes more and varied foods and a greater quality of fibre. Australian farmers are reported to have clean and green agricultural systems and this, coupled with our location, should provide an economic advantage for our farmed goods.

There has been increased Asian interest in Australia's good quality produce and reputation for sustainable practice. The challenge for Australian farmers will be in meeting this booming global need for food and fibre by increasing production—at a time when we have less arable land, less water and fewer people working in agriculture.

eBookplus

Interactivity
What are we eating?
Use this interactivity to compare how our diets have changed since the 1960s.
Searchlight ID: int-3331

ACTIVITIES

IDENTIFY

1 Refer to figure 1. What crops are people eating more of? What crops are they eating less of?
2 Refer to figure 2. What is the ***connection*** between diet and economic development?
3 Refer to figure 3. Describe the ***changes*** in meat consumption by Americans and Chinese over time.

EXPLAIN

4 Why have people's diets ***changed*** over time?
5 Explain the ***interconnection*** between food and your family traditions and celebrations.

APPLY

6 How has your family's diet ***changed*** over time? Ask your parents and family to describe foods and cooking methods from when they were young.

PREDICT

7 Predict what the consumption of meat in China and the United States might be in 2020. Upon what did you base your prediction?
8 Predict where your foods might come from in 2050. Research how aquaponics or vertical farming could be a source of your future food.

INVESTIGATE

9 A United Nations report stated that 'As changing the eating habits of the world's population will be difficult and slow to achieve, a long campaign must be envisioned, along with incentives to meat producers and consumers to ***change*** their production and dietary patterns. Healthy eating is not just important for the individual but for the planet as a whole'. Design a television commercial to promote a Meatless Monday campaign.
10 What might be some of the issues confronting Australia as it attempts to become the 'food bowl of Asia'? What advantages does Australia have in this attempt? How might a farmer react to this suggestion?

6.11 Can urban farms feed people?

6.11.1 What are the advantages of urban farming?

In many industrialised countries, it takes over four times more energy to move food from the farm to the plate than is used in the farming practice itself. Properly managed, urban agriculture can turn urban waste (from humans and animals) and urban wastewater into resources, rather than sources of serious pollution. By 2050, it is predicted that 66 per cent of the world's populations will live in urban areas. Currently, more than 800 million people worldwide practice urban farming.

Farming is usually associated with rural areas, but a growing trend in food production is urban farming. This involves the growing of plants and raising of animals within and around cities, often on unused spaces — even the rooftops of buildings.

Benefits of urban farming include:

- increasing the amount, variety and freshness of vegetables and meat available to people in cities through sustainable production methods
- improving community spirit through community participation, often including disadvantaged people
- incorporating exercise and a better diet into people's lives, leading to improved physical and mental health
- using urban waste water as a resource for irrigation, rather than making it a source of serious pollution
- spending a smaller percentage of people's income on food.

Urban farming could become more important with rapid urbanisation. By 2020 the developing countries in Africa, Asia and Latin America will be home to 75 per cent of all urban dwellers. They will face the problems of providing enough food and disposing of urban waste.

CASE STUDY 1

Container fish farm

On a smaller scale, a German company has developed a sustainable form of aquaculture that can be used in small spaces in cities. It is called **aquaponics**. Fish swim in large tanks in a recycled shipping container (see figure 1). These structures can be located on rooftops and in car parks. The fish waste fertilises tomatoes, salad leaves and herbs growing in a greenhouse mounted above the tank, and the plants purify the water, which is returned to the tanks.

These sustainably produced fresh vegetables and fish can be delivered to nearby city markets and shops, reducing the distance that the products have to travel. The aquaculture containers can be set up almost anywhere, and farmers only need to feed the fish and to keep the fish-tank water topped up. Electric pumps move the ammonia-rich water into the hydroponic vegetable garden in the greenhouse.

FIGURE 1 Urban farming — fish and agriculture

aquaponics a sustainable food production system in which waste produced by fish or other aquatic animals supplies the nutrients for plants, which in turn purify the water

Ramsar site a wetland of international importance, as defined by the Ramsar Convention — an intergovernmental treaty on the protection and sustainable use of wetlands

CASE STUDY 2

Kolkata sewage ponds

The East Kolkata wetlands cover 12 500 hectares and contain sewage farms, vegetable fields, pig farms, rice paddies and over 300 fishponds. With a population of almost 15 million, the Indian city of Kolkata produces huge volumes of sewage daily. The wetlands system treats this sewage, and the nutrients contained in the waste water then sustain the fish ponds and agriculture. About one-third of the city's daily fish supplies come from the wetlands, which are the world's largest system for converting waste into consumable products. The wetlands are also a protected **Ramsar site** for migratory birds. However, the area is now under pressure from urban growth and from the subsequent increase in waste that it needs to treat.

FIGURE 2 The Kolkata wetland system

ACTIVITIES

IDENTIFY

1 What are the main features of urban farming?
2 What functions do the East Kolkata wetlands perform?
3 How do communities benefit from urban farms?

EXPLAIN

4 Suggest what the advantages and disadvantages might be of producing food on the rooftop ***spaces*** of city buildings. What factors might influence the types of food that could be produced on rooftops?
5 Use the **Aquaponics** weblink in your eBookPLUS, and outline the advantages of aquaponics presented in the video.

APPLY

6 Use the **Vertical farming** weblink in your eBookPLUS to help you understand vertical farming.
  a Draw an annotated diagram to illustrate vertical farming.
  b Research an urban farming project in a city. Present it as a PowerPoint presentation.

PREDICT

7 a Predict the ***places*** in the world likely to have vertical farms.
  b Explain why you selected these ***places***.
8 a Could urban farms encourage agricultural tourism?
  b In future, would you consider visiting an urban farm while on holiday?
  c Examples of urban farms as agritourism already exist. Can you name any such ***places***?

INVESTIGATE

9 Write a letter to the minister for planning, suggesting that urban farming ***spaces*** should be included in every new urban development.
10 Design a new housing estate with a community garden. What would be needed in order to set up a community garden?
11 When investigating urban farms and people's gardening activities in Denver, USA, researchers found that:
- people's community pride improved
- graffiti and vandalism decreased
- gardeners felt a greater connection with their local ***place***.

Are these worthwhile results from urban farming? Explain.

eBookplus
Weblinks
- Aquaponics
- Vertical farming

eBookplus ONLINE ONLY

6.12 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

6.6 SkillBuilder: Constructing a box scattergram

6.6.1 Tell me

What is a box scattergram?

A box scattergram is a table with columns and rows which displays the relationship between two sets of data that have been mapped. The distribution becomes clear, although in a generalised way, as there are usually only four to five categories of data.

Why is a box scattergram useful?

Box scattergrams are a useful way of summarising data from maps. You are able to put the data into categories in a table (a series of boxes) and then, when analysing the information, you can discuss the different categories. Using box scattergrams is a technique that allows you to think carefully about features and see the relationships between data. You will find these useful when drawing together data that may initially seem quite complex.

Box scattergrams are useful for:

- summarising data shown on maps
- presenting data during an oral presentation
- planners conveying complex ideas and social differentiation between countries
- economists showing the interconnection between features.

Model

TABLE 1 A box scattergram showing the relationship between undernourishment and aid received per person

Hunger level (% undernourished)	Aid received per person ($US)			
	No data	Less than 20	20–99	Over 100
35 +				• Congo • Mozambique
25–34			• Chad • Angola	
15–24				
5–14		• Nigeria	• Niger	
Less than 5		• South Africa • Algeria • Libya		
No data				• Mauritania

A good box scattergram:

- is drawn as a table
- has appropriately labelled axes
- accurately displays two sets of mapped data
- includes a clear title.

6.6.2 Show me

How to construct a box scattergram

You will need:

- two maps
- a ruler
- an atlas.

Procedure:

You will need the two maps of data shown in figures 1 and 2.

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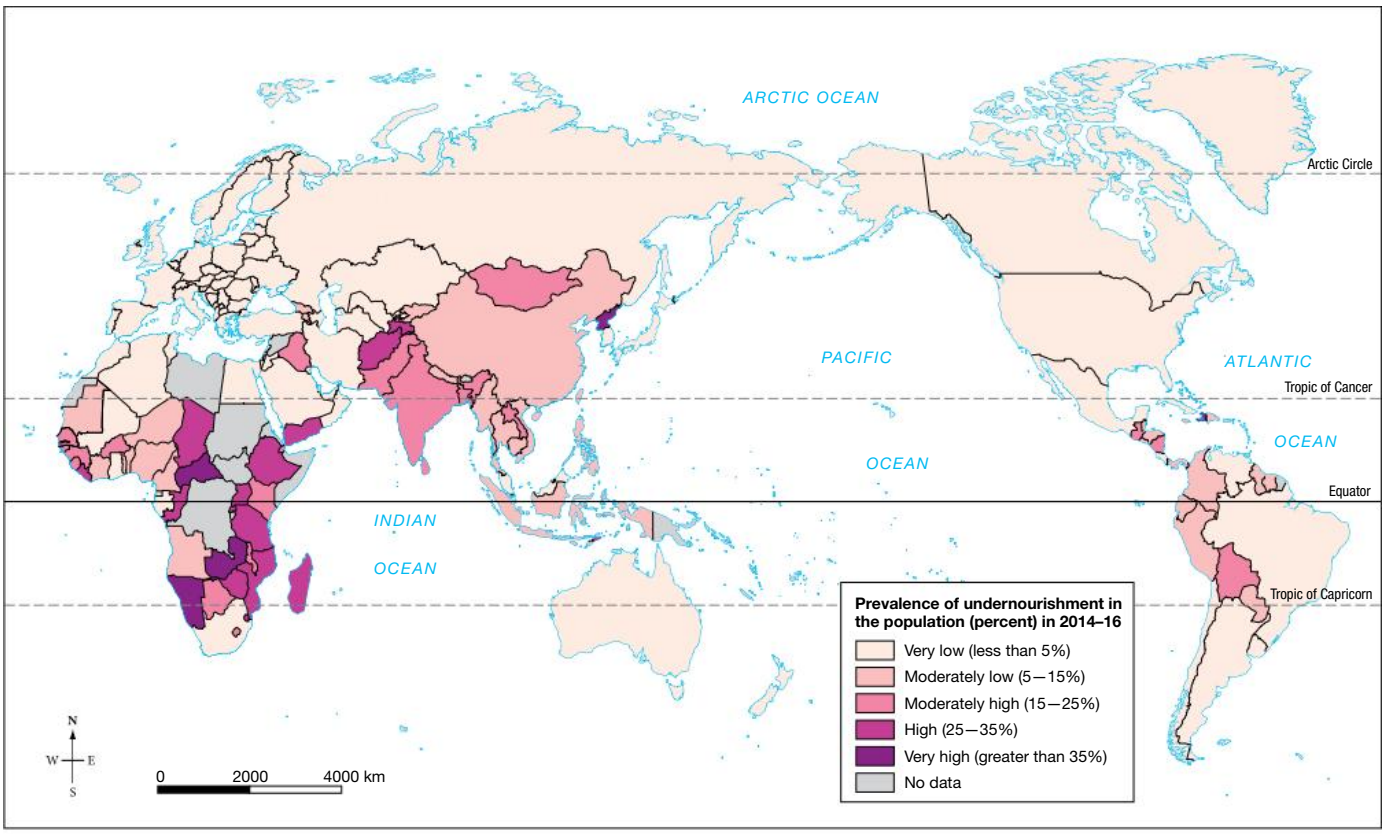
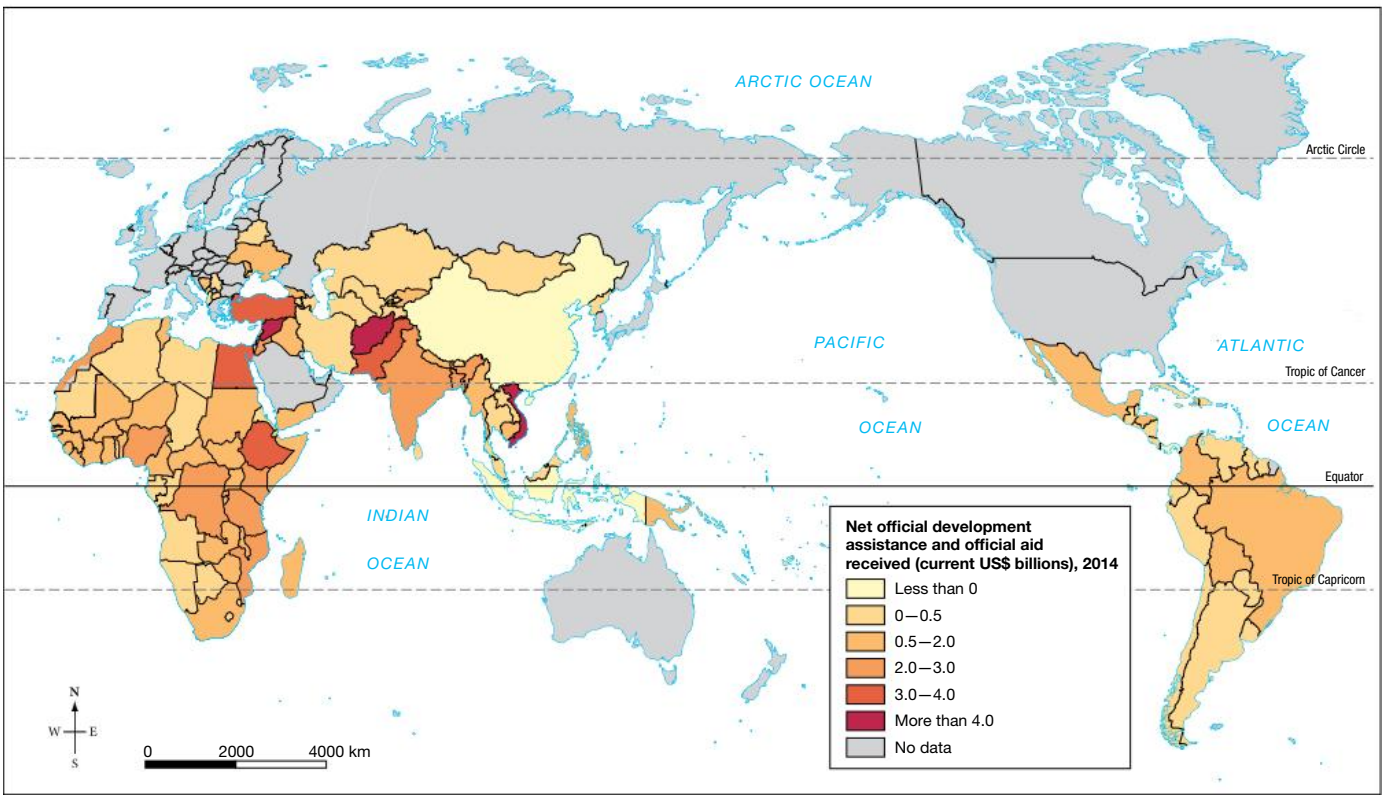
eLesson
Constructing a box scattergram
Searchlight ID: eles-1734

FIGURE 1 World hunger map, 2015



Source: World Food Programme, 'Hunger Map 2015'.

FIGURE 2 Net official development assistance and official aid received (current $US)



Source: World Bank.

STEP 1

Construct a table or series of boxes with enough spaces for all the titles, columns and rows and all the categories of the data shown in the legends of both maps. Figure 1 has six categories and figure 2 has seven categories.

STEP 2

In the left-hand column, enter the title and units of measurement from figure 1. Table 2 shows this step. Place the lowest numbered category at the base of the column.

TABLE 2 A box scattergram layout

Hunger level (% undernourished)	Aid received (US$ billions)						
	No data	Less than 0	0–0.5	0.5–2.0	2.0–3.0	3.0–4.0	More than 4.0
35 +							
25–34							
15–24							
5–14							
Less than 5							
No data							

STEP 3

In the heading row, enter the title and units of measurement from figure 2. Place the lowest numbered category on the left-hand side. This step is shown in table 2.

STEP 4

To plot the data, find the two categories for a place on the map and put the country name in the appropriate square of the table. Continue this with as many countries as necessary. The box scattergram in table 3 shows ten African countries.

TABLE 3 Ten selected African countries, showing the relationship between undernourishment and international aid received per person

Hunger level (% undernourished)	Aid received (US$ billions)						
	No data	Less than 0	0–0.5	0.5–2.0	2.0–3.0	3.0–4.0	More than 4.0
35 +			Namibia	Zambia			
25–34			Chad		Tanzania	Ethiopia	
15–24			Botswana				
5–14							
Less than 5			Algeria	South Africa		Egypt	
No data					The Democratic Republic of Congo		

STEP 5

Complete the box scattergram with a suitable title. The title for table 1 would be: Relationship between undernourishment and aid received per person.

6.6.3 Let me do it

Developing my skills

Using the data in figures 1 and 2, complete a box scattergram showing the distribution of hunger in Asia and the amount of American aid sent to Asia.

eBook*plus*

Interactivity
Constructing a box scattergram
Searchlight ID: int-3352

Questions

1. Which Asian countries have a hunger level of over 15 per cent but receive less than US$100 million in American aid?
2. Which countries receive less than US$10 million in American aid and suffer from hunger within their borders?
3. Why might some countries receive high levels of American aid even though hunger is not a key problem there? Identify the countries that fit this category.
4. Some Asian countries have no difficulty in feeding their population and receive no American aid. Name these countries and suggest why no aid is provided.
5. Describe the pattern of hunger across Asia. Does the American aid pattern correlate with this pattern?

Checklist

I have:

- drawn a table
- labelled each axis appropriately
- shown two sets of mapped data accurately.

Skills questions

1. Box scattergrams are used to show:
   a. detailed information about a place
   b. unique information about a place
   c. generalised information about a place
   d. anomalies about a place.
2. A box scattergram always includes mapped information about:
   a. two features
   b. three features
   c. four features
   d. five features.
3. Why do you have to take great care when entering data in a box scattergram?
4. What is the value of a box scattergram to your learning?

6.9 SkillBuilder: Constructing and describing proportional circles on maps

6.9.1 Tell me

What are proportional circle maps?

Proportional circle maps are maps that incorporate circles, drawn to scale, to represent data for particular places.

Why are proportional circles useful?

Proportional circles are useful as an immediate visual pattern, especially when the figures being handled are large. Different-sized circles on a map reflect different values or amounts of something. Proportional circles provide an easy way to interpret patterns, give an instant impression and allow us to compare data for different places. In class, you might use these to show population size, agricultural production of a specific crop, or endangered species.

Proportional circles are useful for:

- geography students wanting to gain a quick impression of varying amounts over space
- geography students showing relationships on a map
- economists showing the level of production across a region
- tourism authorities showing the numbers of tourists
- emergency management organisations showing the quantities of water moving through a catchment.

Model

The growth of megacities has been most noticeable across Asia, with 11 of the 18 megacities identified in 2000 located in that region. The only megacities in 1950 were Tokyo and New York, and by 2025 Tokyo is predicted to be the largest megacity. By 2025 Asia will have 14 megacities, with Lahore, Guangzhou and Shenzhen reaching megacity status between 2010 and 2025. In 2010, North America and South America each had three megacities, Africa had two and western Europe one. By 2025, Africa will have three megacities. Australia/Oceania had no cities of this size in 2000, and is not predicted to have any by 2025.

A good proportional circle map:

- is drawn in pencil with a mathematical compass
- has circles that are accurately drawn according to the scale provided in the legend
- includes a key/legend to show the proportions of the circles
- has a title.

A description of a proportional circle map:

- effectively communicates differences in values over space
- identifies places
- uses directions.

6.9.2 Show me

How to draw and describe proportional circles

You will need:

- a base map
- a set of data
- a calculator
- a light-grey pencil
- a mathematical compass for drawing circles
- an atlas
- coloured pencils.

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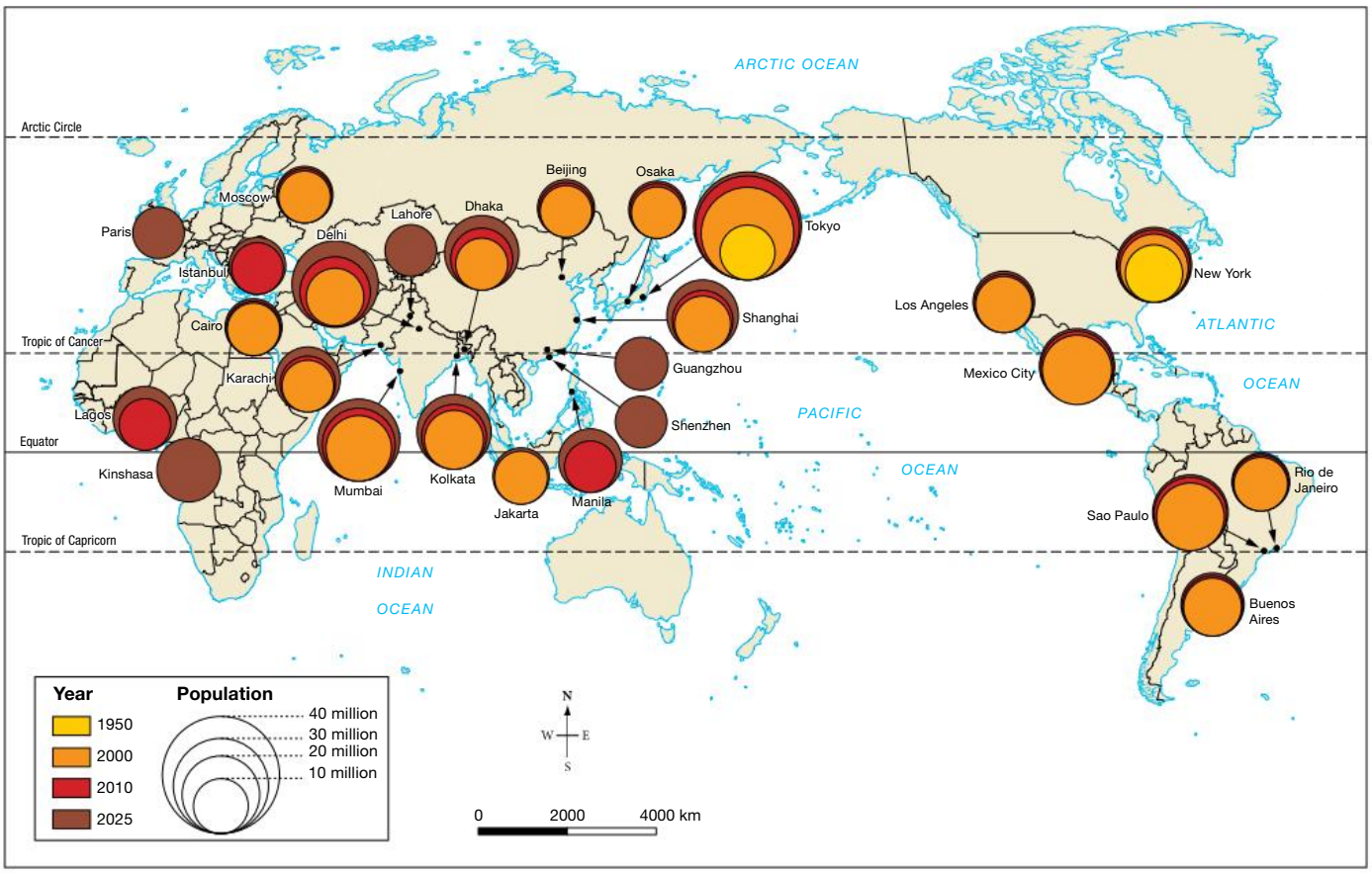
eLesson
Constructing and describing proportional circles on maps
Searchlight ID: eles-1735

FIGURE 1 Growth of megacities over time, 1950–2025 (projected)



Source: Spatial Vision

Procedure:

To complete a proportional circle map, you need a set of data and a base map onto which to draw the circles.

Constructing a proportional circle map

STEP 1

Study the data and decide how many categories or circle sizes you need in order to include the highest and the lowest values to be represented by the circles. You should have no more than five categories. The key in figure 1 has only four categories: 10, 20, 30 and 40 million. Notice, however, that there are more sizes shown on the map itself. We have to estimate what number, or value, those other sizes represent. For example, Tokyo's population in 2015 is about 35 million. Step 3 shows how sizes are calculated.

STEP 2

Determine the size of the circles that you wish to use. Don't make these too ridiculous for the map base you are given. They should not be too large and not too small.

STEP 3

Take a table of data and rank the values from highest to lowest. For example, in 2000 the largest megacity, Tokyo, had 26.4 million people. Manila had the lowest population with 10.9 million people. Work out the square root (√) of each value, leaving off the millions. For Tokyo the square root of 26.4 is 5.1 and for Manila the square root of 10.9 is 3.3. These numbers then give you the measurement of the radius of your proportional circles.

STEP 4

Construct a scaled group of circles as seen in the legend for figure 1. To do this, allow one millimetre to represent one unit. If you were drawing Tokyo's population for figure 1, you would draw your largest circle with a radius of six millimetres to ensure that the largest megacity, Tokyo, could be plotted with a radius of 5.1 (see step 3). Use the mathematical compass and the ruler, and set the compass to six millimetres. On your map base, draw a circle with a six-millimetre radius. Your smallest circle would need a radius of three millimetres to include Manila (see step 3). All other data in the table will fit somewhere between these two sizes.

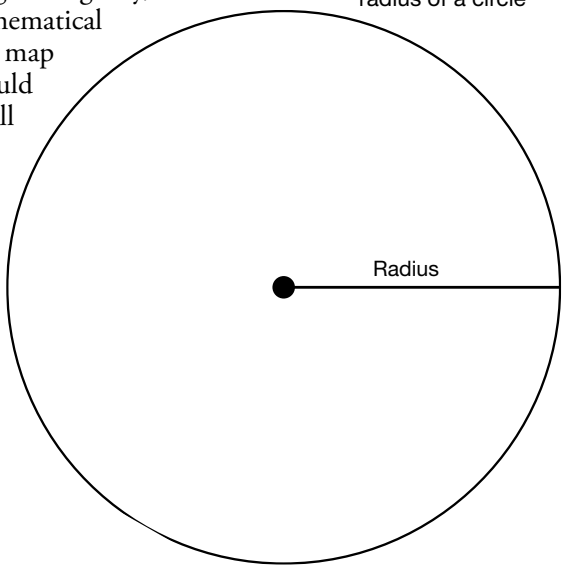


FIGURE 2 The radius of a circle

STEP 5

Map all the megacities on the base map according to these scaled proportional circles. Take care with the use of the mathematical compass to ensure that your circles are accurate and neat. Using an atlas, place circles as close as possible to the location they represent. You may use an arrow if there are too many circles near each other.

STEP 6

You will need to adjust the measurements for the circles according to the data set for each type of map you plot.

STEP 7

Complete the map with the geographical conventions of BOLTSS.

Describing a proportional circle map

STEP 8

To interpret your mapped data, you need to look for patterns. Where are the largest circles? Where are the smallest circles? Are there any groupings of circles? Are there any patterns that can be identified, such as radial, linear, clustered or sporadic?

6.9.3 Let me do it

Developing my skills

Using the data on Fairtrade purchases in table 1, complete a proportional circles map to show the level of Fairtrade purchases across the world in 2010. Describe the distribution pattern revealed by your map.

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Interactivity
Constructing and describing proportional circles on maps
Searchlight ID: int-3353

Questions

1. Which continent has the greatest number of Fairtrade workers?
2. Which continent/s do not have Fairtrade workers?
3. Describe the pattern of Fairtrade worker numbers across the world.
4. Explain why Fairtrade workers are only found in developing countries.
5. Are there any countries in this list that surprise you with the number of Fairtrade workers? Explain your answer.

Checklist

In drawing a map of proportional circles I have:

- drawn in pencil using a mathematical compass
- drawn circles that are accurate according to the scale provided in the legend
- included a key/legend to show the proportions of the circles
- included a title.

In describing a map of proportional circles, I have:

- effectively communicated differences in values or amounts of something over space
- identified places
- used directions.

TABLE 1 Top ten countries for Fairtrade farmers and workers, 2015

Country	2015 (€)
Kenya	295 400
Tanzania	164 100
India	139 400
Ethiopia	138 000
Ghana	104 400
Peru	61 300
Colombia	49 100
Uganda	47 600
Mexico	40 300
Cote d'Ivoire	34 300

Source: http://fairtrade.se/wp-content/uploads/2012/09/150211-Fairtrade-By-The-Numbers-2015-final.pdf

Skills questions

1. Proportional circles are used to show:
   a. a value
   b. the location of a place
   c. the scaled amounts of a value
   d. places and times.
2. A proportional circle map always includes:
   a. actual total values
   b. standards of living
   c. patterns represented through scaled visuals
   d. a global base map.
3. What is the purpose of calculating the square root of the numbers when planning the size of your proportional circles?
4. Why might it be important to have good skills with a mathematical compass?

6.12 Review

6.12.1 Review

1. Use the **World Hunger Map 2015** weblink in the Resources tab to answer the following questions.
   a. How much does it cost to provide enough nutrition to feed a child each day?
   b. It has been estimated that the cost of hunger to developing nations is US$450 million a year. List some of the effects of hunger on people.
   c. Into which category of hunger do these countries fit: Australia, Indonesia, Cambodia, Ethiopia, Brazil and France?
2. Name four problems that the world faces when it comes to producing enough food to feed everyone sustainably by 2050.
3. Construct a graphic showing eight cartoon-style people from around the world. Each person will have a speech bubble. In the speech bubbles, place a positive statement to show that it will be possible to feed the world in 2050.

eBookplus

Weblink
World Hunger Map 2015

CASE STUDY

Potato yield

Potatoes are the world's most important non-grain food crop, and they are essential to global food security. China and India are currently the world's largest and third largest producers of potatoes respectively. Together, they account for almost a third of the world's total production. However, crop yield in China and India is relatively low compared to the United States and Europe. In 2008, potato crop yields in the United States were 44 tonnes per hectare — almost three times higher than in China, which had 15 tonnes per hectare. The lower crop yields in China and India are owing to the low quality of their seed potatoes. Less than 20 per cent of China's potato acreage is covered by virus-free seed potatoes. As a result, there is enormous potential for increasing potato crop yields in Asia through genetic improvement.

4. a. Describe the yield gap between developed and developing countries.
   b. What would act as incentives for China and India to ***change*** their crop yield?
5. Use the **Story of agriculture and the green economy** weblink in the Resources tab to answer the following questions.
   a. List five things that you learned from this clip and share them in groups.
   b. Identify three suggested ways in which farmers can ***change*** their farming.
6. Consider requesting ***changes*** in your school canteen, such as buying Fairtrade chocolate, coffee or tea. Outline reasons you would give to support your request.
7. Use the **WFP** weblink in the Resources tab to answer the following questions.
   a. Prepare a case study on one of the ***places*** in which the World Food Program (WFP) is currently working. Check the *Hotspots* section on the website.
   b. Outline the actions that the WFP is taking at this ***place***.
   c. Outline why these actions are necessary.
8. Research the population characteristics of one ***place*** where Australia has school feeding programs. Consider life expectancy, literacy levels and death rates, or some other indicators you think are important.
9. Write a letter to your local member of parliament, outlining your views on Australia's aid programs.

eBookplus

Weblinks
- Story of agriculture and the green economy
- WFP

CASE STUDY

Sacred Heart Mission

The Sacred Heart Mission is located in St Kilda, Melbourne. It is an example of a local-scale organisation seeking to decrease homelessness and the food shortage associated with it. Sacred Heart Mission aims to ensure that homeless and disadvantaged people have access to life's necessities, including housing, food and health care, and that they can connect with their community. As part of the Mission's service to the homeless, it provides breakfast and lunch free of charge, 365 days a year. A professional kitchen staff of seven and a team of 15 volunteers prepare food each day. The program relies on food donations that come from a wide range of businesses across Melbourne.

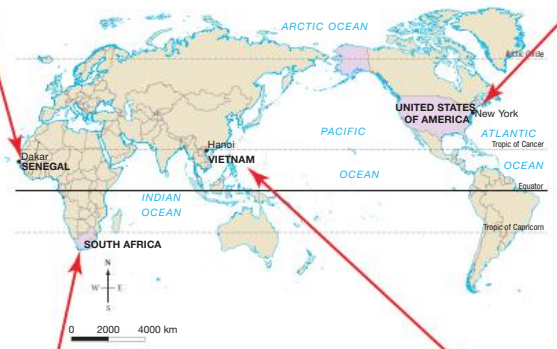
10. a. What might happen to some of the 53 000 people living independently in Australia if Meals on Wheels could not deliver meals to them?
    b. What types of consequences might this have?
    c. The hungry are not all located in the world's poorer countries. In your area, undertake an investigation into a charitable organisation, like the Sacred Heart Mission, which helps people to meet their food needs.

The future of food

11. Section 6.3 discusses one possible way of improving ***sustainable*** food supplies: building a greenhouse that uses salt water.
    a. What resources are needed to establish this type of agriculture?
    b. Undertake research and describe the following characteristics of Port Augusta: location, climate, population and economic activities.
    c. Why would this be an important ***change*** in a ***place*** such as Port Augusta?
    d. Predict what the impact might be on people and ***places*** if the greenhouse method of farming were to become more readily available.
    e. Which water-stressed ***places*** of Australia might be able to ***sustainably*** use this type of production?
12. Explain how an individual's choice of diet can influence their own health and the health of the planet.
13. Some countries, such as China, Saudi Arabia and South Korea, which cannot produce enough food for their needs, are buying agricultural land in other countries. Investigate examples of this and outline the advantages and disadvantages of this scheme for the countries involved.
14. Study figure 1 and then answer the questions that follow.

FIGURE 1 The importance of urban farming

Dakar produces more than 60 per cent of the nation's poultry, milk and vegetables.



New York's urban gardens provide space, community areas and food.

South Africa's urban gardens are educational and cultural places.

Source: © Photo by www.abalimi.org.za

Hanoi's gardens produce over 80 per cent of the city's vegetables and 50 per cent of its pork and poultry.

a. What are examples of urban farming in your locality?
b. Which city has established tourism based on urban farming?
c. How can urban gardens be places of education?
d. Explain why more ***space*** in cities may need to be set aside — either vertically or horizontally — for urban farming in future.
e. Research and create an annotated map of urban farming in different ***places***.

15. Design and annotate your own vertical urban farm concept for 2050.
16. Construct a concept map, using an appropriate computer program, and include the main ideas from this chapter. Include any research and fieldwork data as well.

FIGURE 2 A possible structure for a vertical urban farm

6.12.2 Reflect

17. There are many controversial issues involved with food supply. What are your opinions on the following issues of ***interconnection***?
    a. Live animal exports to overseas countries
    b. Australia selling farmland to overseas countries
18. Investigate a place in Australia that depends on irrigation to produce food, such as the Murray–Darling Basin or the Ord River region of Western Australia.
    a. What crops are produced there using the irrigation water?
    b. List the positive and negative consequences of this use of irrigation.
    c. Is this type of farming environmentally sustainable in Australia?
19. Discuss the issues that may arise as the consequences of a country deciding to slash its overseas food aid program by half.
20. *A Western diet is going to be unsustainable in the future.*
    Provide an argument supporting this statement and a counter argument for the statement.

CHAPTER 7

Geographical inquiry: Sustainable biomes

7.1 Overview

7.1.1 Scenario and task

Task: Create a website that informs people of the importance of one particular biome as a producer of food, and the current threats to food production.

Everyone in the world depends completely on the Earth's biomes for the services they provide — from our food and water supply to the regulation of our climate. Over the past fifty years, people have had a more rapid and more extensive impact on these biomes than during any other time in human history. Our demand for food, water, fibres, timber and fuel has driven these changes. The results have contributed to improvements in human wellbeing and economic development, but there has also been detrimental change to many of our major food-producing biomes.

Your task

Your team has been selected to create a website that not only grabs people's attention but also informs them of the importance of one particular biome as a producer of food, and the current threats to food production. Looking into the future, you will also suggest more sustainable ways of managing this biome.

7.2 Inquiry process

7.2.1 Process

Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button and set up your project group. You can complete this project individually or invite members of your class to form a group. Save your settings and the project will be launched.

- **Planning:** Navigate to your Research Forum. You will need to research the characteristics of a biome and address the four key inquiry questions supplied in the Research Forum. Each group should decide how to divide the workload so that each of the four inquiry questions is studied.

7.2.2 Collecting and recording data

Once you have chosen your biome and divided the key questions among the team, it is time to start researching information. For your own key question, break it down into several minor questions that can become subheadings to form the structure of your research. As a group, check each person's research structure to ensure that it follows the inquiry sequence.

When researching, look for maps, graphs and images that supports your key question or that of another team member. You should also look for data or statistics that you can show visually in the form of maps, diagrams or graphics.

7.2.3 Processing and analysing your information and data

Once you have researched and collected relevant information, you need to review it, ensure that you understand the material

and then use it to answer your key questions. From maps and graphs, describe any patterns or trends that you identify. If using photographs, write clear annotations for each one, highlighting particular features.

Visit your Media Centre and download the website model and website-planning template to help you build your website. Your Media Centre also includes images and audio files to help bring your site to life.

Use the website-planning template to create design specifications for your site. You should have a home page and at least three link pages per topic. You might want to insert features such as 'Amazing facts' and 'Did you know?' into your interactive website. Remember the three-click rule in web design — you should be able to get anywhere in a website (including back to the homepage) with a maximum of three clicks.

7.2.4 Communicating your findings

Use website-building software to build your website. Remember that less is more with website design. Your mission is to engage and inform people about a topic they may never have thought about. You want people to take the time to read your entire website.

7.3 Review

7.3.1 Reflecting on your work

Think back over how well you worked with your partner or group on the various tasks for this inquiry. Reflect on your contribution to the team by completing the Reflection template in your Media Centre. Determine strengths and weaknesses and recommend changes you would make if you were to repeat the exercise. Identify one area where you were pleased with your performance, and an area where you would like to improve. Write two sentences outlining how you might be able to do this.

Print out your Research Report from ProjectsPLUS and hand it in with your website and reflection notes.

Your ProjectsPLUS application is available in this chapter's Resources tab in your eBookPLUS. Visit **www.jacplus.com.au** to locate your digital resources.

Suggested software

- ProjectsPLUS
- Microsoft Word or any other word processing tool
- FrontPage, Dreamweaver, iWeb or other website-building software

Media Centre

Your Media Centre contains:

- a website model
- a website-planning template
- weblinks to sites to assist in your research and to see website-building software
- an assessment rubric.

The world is fast becoming urbanised.

TOPIC 2

CHANGING PLACES

For the first time in history, more people around the world live in urban areas than in rural areas. At the same time the world is experiencing high levels of internal and international migrations as people flee crises or look for better opportunities in other places. So what has caused urbanisation and the large-scale movement of people? What are the consequences of these changes and how can we best manage them to enhance sustainability?

KEY INQUIRY QUESTIONS

- Why has the world become more urbanised?
- How does migration affect the concentration of people in urban places?
- How does urbanisation change environments and places?
- What strategies are used to manage environmental change in urban places to enhance sustainability?

Tokyo at night

CHAPTER 8

Urbanisation

8.1 Overview

8.1.1 Introduction

There are many advantages to living in large cities — for example, the economic benefit brought about by sharing the costs of providing fresh water, electricity or other energy sources and public transport between many people. There may be social benefits, because the cities provide a wider choice of sporting, recreational and cultural events. However, there are also disadvantages of living in a large city environment.

Starter questions

1. What are some examples of recreational, social or cultural activities that are found only in larger cities?
2. Apart from congestion of people and traffic issues, what are some disadvantages of living in a large city rather than a smaller town?
3. As a class, brainstorm some of the advantages and disadvantages of large cities, such as New York, Tokyo, São Paolo and Shanghai.
4. Would you rather live in a large city or a small country town? Explain your answer.
5. Why do you think people move to urban areas?

Inquiry sequence

		Syllabus outcomes
8.1 Overview		
8.2 Where do most Australians live?		GE5-2, GE5-3, GE5-7, GE5-8
8.3 Where have Australians lived in the past?		GE5-2, GE5-3, GE5-7, GE5-8
8.4 What is urbanisation?		GE5-2, GE5-3, GE5-7, GE5-8
8.5 Is Australia an urbanised country?		GE5-2, GE5-3, GE5-7, GE5-8
8.6 SkillBuilder: Creating and reading pictographs	eBook plus ONLINE ONLY	GE5-7, GE5-8
8.7 SkillBuilder: Comparing population profiles	eBook plus ONLINE ONLY	GE5-7, GE5-8
8.8 How Urban are the United States and Australia?		GE5-2, GE5-3, GE5-7, GE5-8
8.9 How has international migration affected Australia?	eBook plus ONLINE ONLY	GE5-2, GE5-3, GE5-7, GE5-8
8.10 What are the causes and effects of Indonesia's urban explosion?		GE5-2, GE5-3, GE5-7, GE5-8
8.11 Why are people on the move in Australia		GE5-2, GE5-3, GE5-7, GE5-8
8.12 Why are people on the move in China?		GE5-2, GE5-3, GE5-7, GE5-8
8.13 Investigating topographic maps: Urbanisation in Albury–Wodonga		GE5-7
8.14 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Watch this video
Our urban world
Searchlight ID: eles-1628

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 have high population densities and remote places such as deserts usually have low population densities

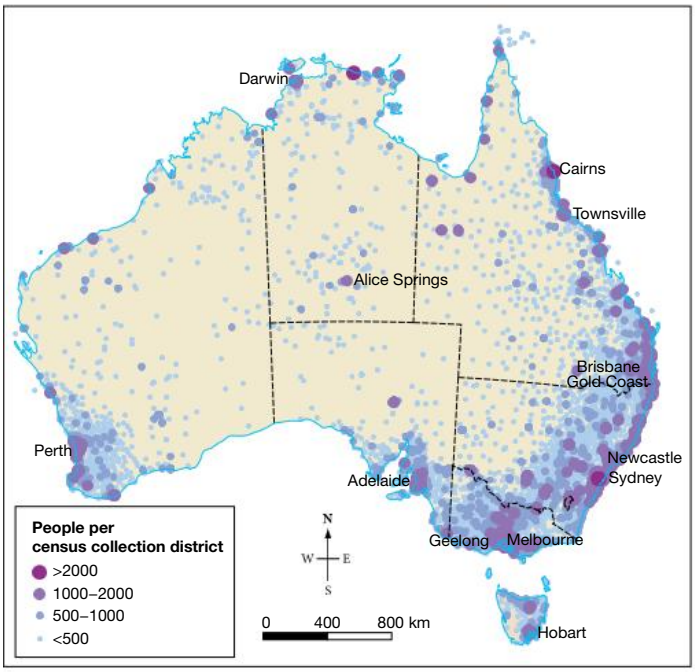
8.2 Where do most Australians live?

8.2.1 Why do Australians live where they do?

Australians live on the smallest continent and in the sixth largest country on Earth. With a population of 24 million and an area of 7 690 000 square kilometres, our **population density** is 3.1 people per square kilometre. We may think of ourselves as an outback-loving, farming nation, but we mostly live near the coast.

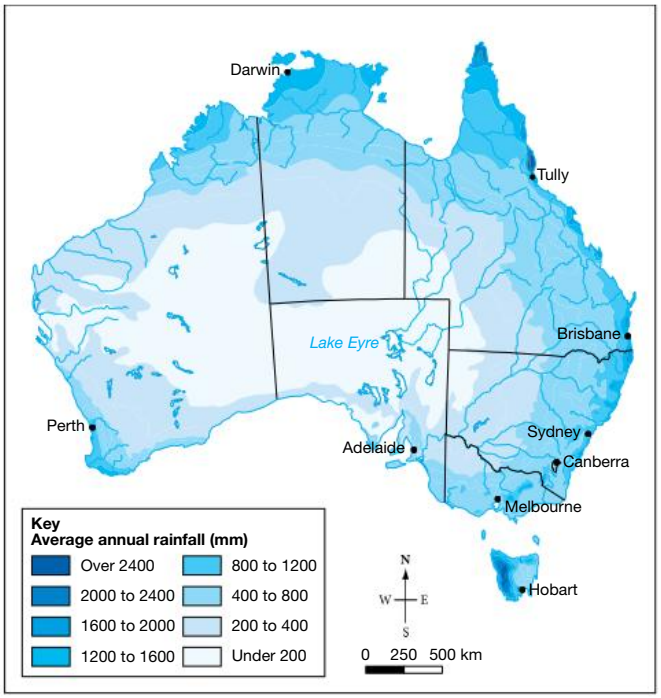
Most Australians currently live within a narrow coastal strip which extends from Brisbane in the north to Adelaide in the south. Over 80 per cent of Australians live in towns that have more than 1000 residents and are located within 50 kilometres of the coast (see figure 1). Australians love the beach, but is it just a coastal location that can explain this uneven **population distribution** pattern?

FIGURE 1 Australia's population distribution and density



Source: Spatial Vision

FIGURE 2 The distribution of annual rainfall in Australia



Source: Spatial Vision

Figure 2 shows the distribution of rainfall within Australia. Comparing figures 1 and 2, it is apparent that there is a strong interconnection between the availability of more than 800 mm of rainfall per year and population densities of more than 10 and more than 100 people per square kilometre in the east, south-east and south-west of Australia. It would be easy to say that Australians live in places where rainfall is higher, but if you look at these maps carefully there are major exceptions to this spatial pattern. What is the relationship between population density and total rainfall in the north of Australia? Is the population density high in the regions of high rainfall in Queensland and the Northern Territory?

FIGURE 3 A remote town in northern Australia, which has a very low population density

Coastal locations and rainfall are not the only reasons Australians live where they do. The availability of mineral resources, irrigation schemes to enhance farm production, and remote and stunning tourist destinations are **geographical factors** that draw people to live in a particular place.

geographical factors reasons for spatial patterns, including patterns noticeable in the landscape, topography, climate and population

8.2.2 How do population densities in Australia compare with those in other places?

Figure 1 shows both the population distribution and density for Australia in the present day. To better understand this data, we need to compare Australia's population density with that of other places in the world. This map shows that small areas around the major state capital cities have population densities of over 100 people per square kilometre of land. Look at table 1 and you can see that the average population density for Australia is well below the global average, and is easily the lowest of any of the permanently inhabited continents.

The population density of Australia is similar to that of Canada (3 people per square kilometre), but much lower than that of New Zealand (15 people per square kilometre), the United States (29 people per square kilometre) or China (134 people per square kilometre). Consider the geographical factors that Australia might share with Canada but not New Zealand, the United States or China that could explain the significant difference between their population densities.

TABLE 1 The average population density for each continent

Continent	Average population density (people per km^2)
Asia	86.7
Europe	69.7
Africa	29.3
North America	21.0
South America	20.8
Australia	3.1
Antarctica	0.00007
World	51.0

ACTIVITIES

IDENTIFY

1 Which regions of Australia have the highest population density?
2 What is the difference between population density and population distribution?

EXPLAIN

3 What geographical factors other than rainfall may lead to the uneven distribution of population in Australia?
4 Use the statistics in table 1 to produce a world map that illustrates the contrasts between the average population densities for each continent. *Hint:* A pictograph may best highlight the differences.
5 Refer to figures 1 and 2 to produce an overlay map that identifies the ***interconnection*** between the distribution of population and the distribution of rainfall within Australia.
   a Describe areas where there are strong similarities between these two features, i.e. high population distribution and high rainfall, or low population distribution and low rainfall.
   b Describe ***places*** that have a high population distribution but low rainfall or vice versa.
6 Use information from figure 2 to explain why, in the future, there may be significant movement of people from the southern states of Australia to ***places*** in the tropical north. Your answer must refer to specific information from the map.

APPLY

7 Use your atlas to identify and list:
   a geographical land forms or climatic features that are common to Australia and Canada. *Hint:* Look for large regions that have an extreme climate. Explain why.
   b reasons New Zealand, the United States or China may have a higher population density than Australia. Explain.
8 Use various theme maps of Australia in your atlas to identify at least four possible explanations, other than rainfall distribution, for the pattern of distribution and density of Australia's population. Discuss your findings with the class.

PREDICT

9 Write a paragraph to explain the possible ***change*** in the distribution of Australia's population over the next 50 years if one of the following situations occurs.
   a The current regions of high population density continue to expand unchecked
   b A 20-year-long drought occurs in south-eastern Australia

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8.3 Where have Australians lived in the past?

8.3.1 Before European settlement

Before European settlement, Aboriginal people inhabited the whole of Australia and Torres Strait Islanders lived in the islands between Australia and Papua New Guinea. There were over 500 different nations within the continent, all with distinctive cultures, beliefs and languages. The arrival of British Colonists created vast changes to Aboriginal culture and society and today, **Indigenous** people make up three per cent of the total Australian population.

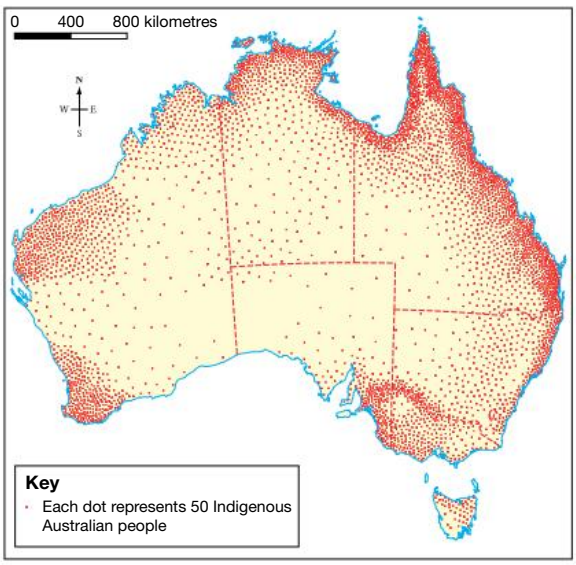
indigenous native to or belonging to a particular region or country; Australia's Indigenous peoples are made up of Aboriginal people (who live all around Australia) and Torres Strait Islanders (who settled the many small islands to the north of Cape York Peninsula in Queensland)

In 1788, Aboriginal people inhabited all parts of Australia (see figure 1). The most densely populated areas, with 1–10 square kilometres of land per person, were the south-east, south-west and far north coastal zones, the north of Tasmania and along the major rivers of the Riverina region (south-western New South Wales).

The population density of Aboriginal and Torres Strait Islander people was highest in places close to coastal and river environments. These places had the best availability of food and other resources. In a location such as Port Jackson, New South Wales, food was abundant, meaning that the inhabitants needed to spend only about four hours each day hunting or gathering enough for their survival. In places where rainfall was unreliable, such as central Australia, the local inhabitants found it harder to survive. They often needed more than half a day to hunt and gather enough to satisfy their basic needs. When food resources ran low or with changing seasons, tribes moved on to another part of their **country**. Being nomadic, they could manage their environment by not over-using the resources available at any one site.

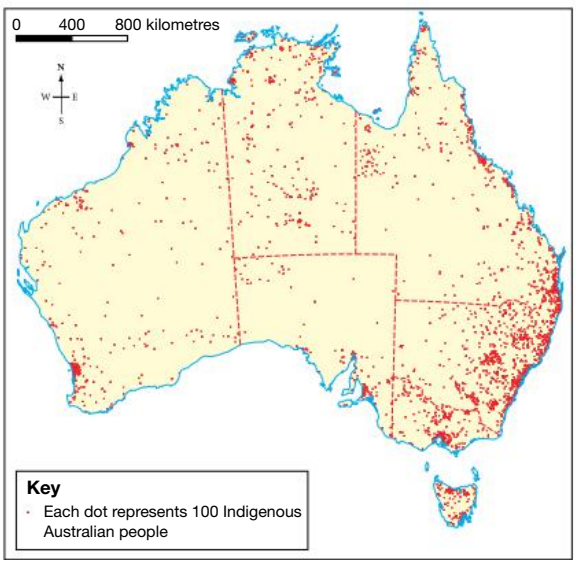
country the area of land, river and sea that is the traditional land of each Aboriginal language group or community; the place where they live

FIGURE 1 The population distribution of Aboriginal and Torres Strait Islander peoples in 1788



Source: MAPgraphics Pty Ltd, Brisbane

FIGURE 2 The distribution of Aboriginal and Torres Strait Islander peoples today



Source: MAPgraphics Pty Ltd, Brisbane

8.3.2 Where do Aboriginal and Torres Strait Islander people live today?

It is believed that in 1788 there were between 350 000 and 700 000 Indigenous Australians, although within 50 years this population had been greatly reduced by disease and competition for resources with the British colonists. There are currently more than 520 000 Indigenous Australians, making up about 2.5 per cent of Australia's population.

The Australian environment has changed significantly since 1788. Much land has been cleared, shaped and blasted for cities, farms and mines. Other than the management of vegetation by fire, prior to European settlement the landscape of Australia had not been greatly altered by its human inhabitants.

By the twenty-first century, little of Australia's environment has not been changed significantly by human occupation.

The patterns shown in figures 1 and 2, showing the distribution of Australia's indigenous population in 1788 and 2006, are generally very similar. Since before 1788, most of Australia's inhabitants have tended to live in the same relatively small region of our country.

FIGURE 3 Many Indigenous Australian families enjoy living in remote parts of the country.

FIGURE 4 Regional distribution of the Indigenous and non-Indigenous population of Australia

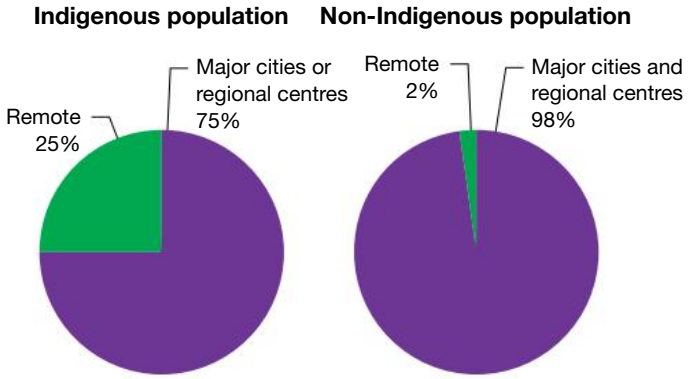
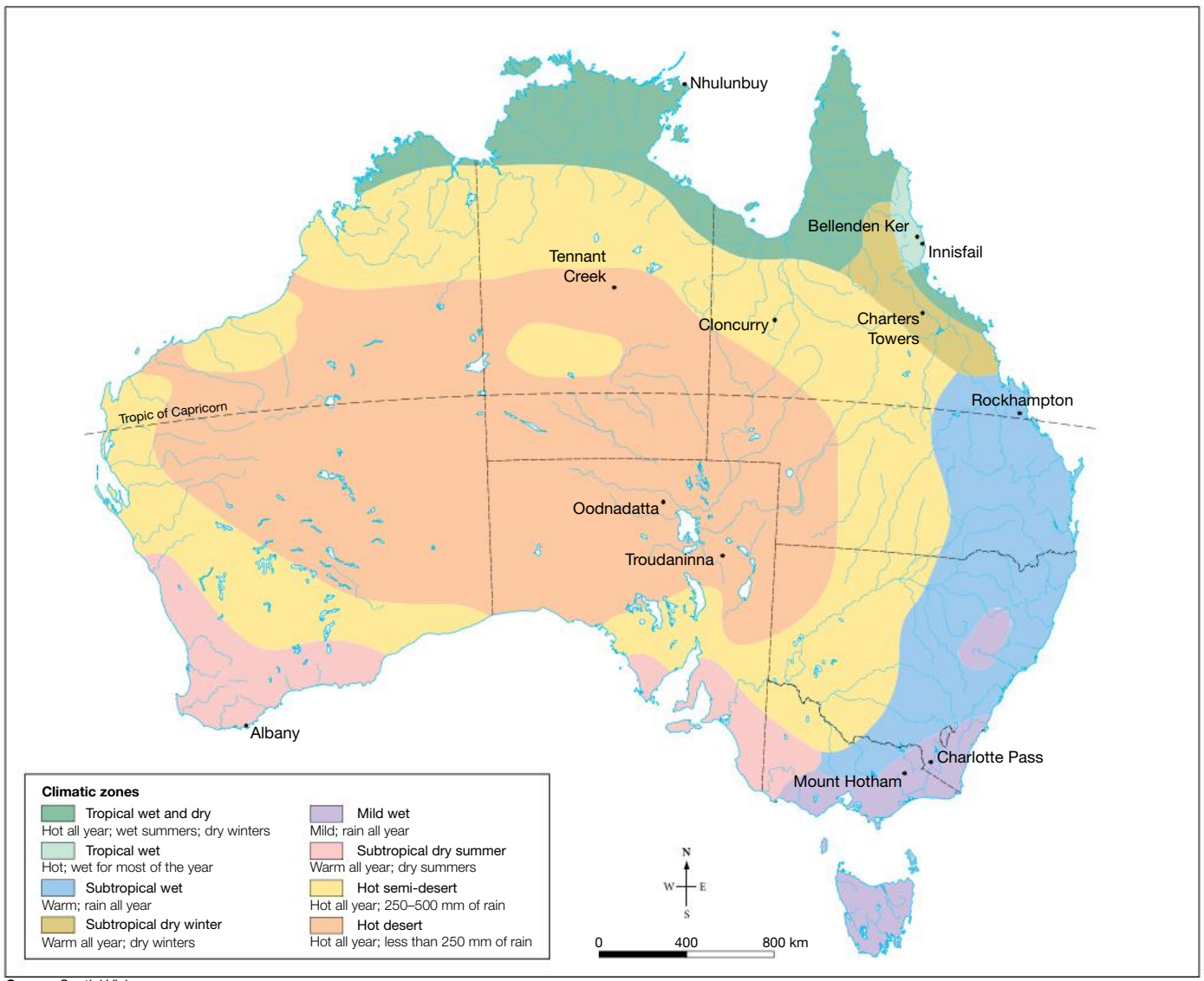


FIGURE 5 The eight main climatic zones of Australia



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 How many Indigenous Australians:
   a lived in Australia in 1788
   b live in Australia today?

EXPLAIN

2 a Identify the climatic zones in figure 5 that best match the four population density levels in figure 1.
   b For each of the population density areas shown in figure 1, write a sentence to describe the climate for the region. For example, 'This region has a mostly mild to subtropical climate with rainfall all year round.'

INVESTIGATE

3 Refer to figure 4. Living so far away from major cities means that 25 per cent of Aboriginal communities have limited access to many of the services and opportunities that cities offer their residents. In a small group, brainstorm the lifestyle and service difficulties that may be associated with living so remotely.
4 Collect some statistics that identify the health, wealth and educational inequalities which exist between Indigenous and non-Indigenous Australians. For example, Aboriginal males have a life expectancy 17 years less than that of non-Indigenous males born in the same year. Use the **ABS** weblink in your eBookPLUS to start your research. Write a paragraph or produce a series of graphs to comment on the inequalities you have discovered.

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Weblink
ABS

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8.4 What is urbanisation?

8.4.1 Urbanisation

As the world's population increases, **urban** areas continue to grow. In some regions, people are moving from rural to urban areas at very high rates.

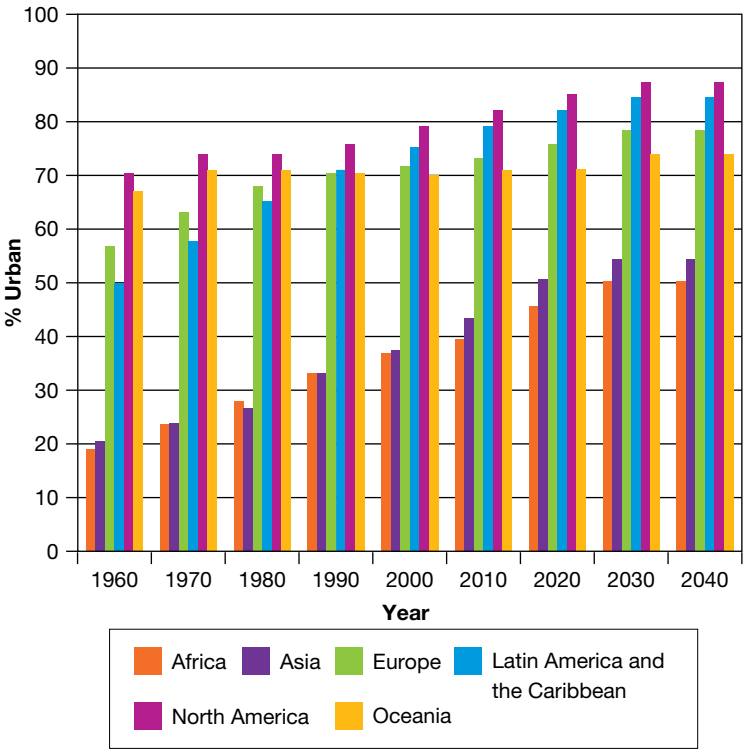
urban relating to a city or town. The definition of an urban area varies from one country to another depending on population size and density

urbanisation the social and economic processes whereby an increasing proportion of the population of a country or region live in urban areas

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.

However, as cities grew and trade developed, urban areas became centres for merchants, traders, government officials and craftspeople. By 2008 the number of people living in urban areas had increased to 50.1 per cent, and in 2010 the figure had risen again to 50.5 per cent (see figure 2). The rate of growth has varied in different regions (see figure 1).

FIGURE 1 The growth in urban populations over time

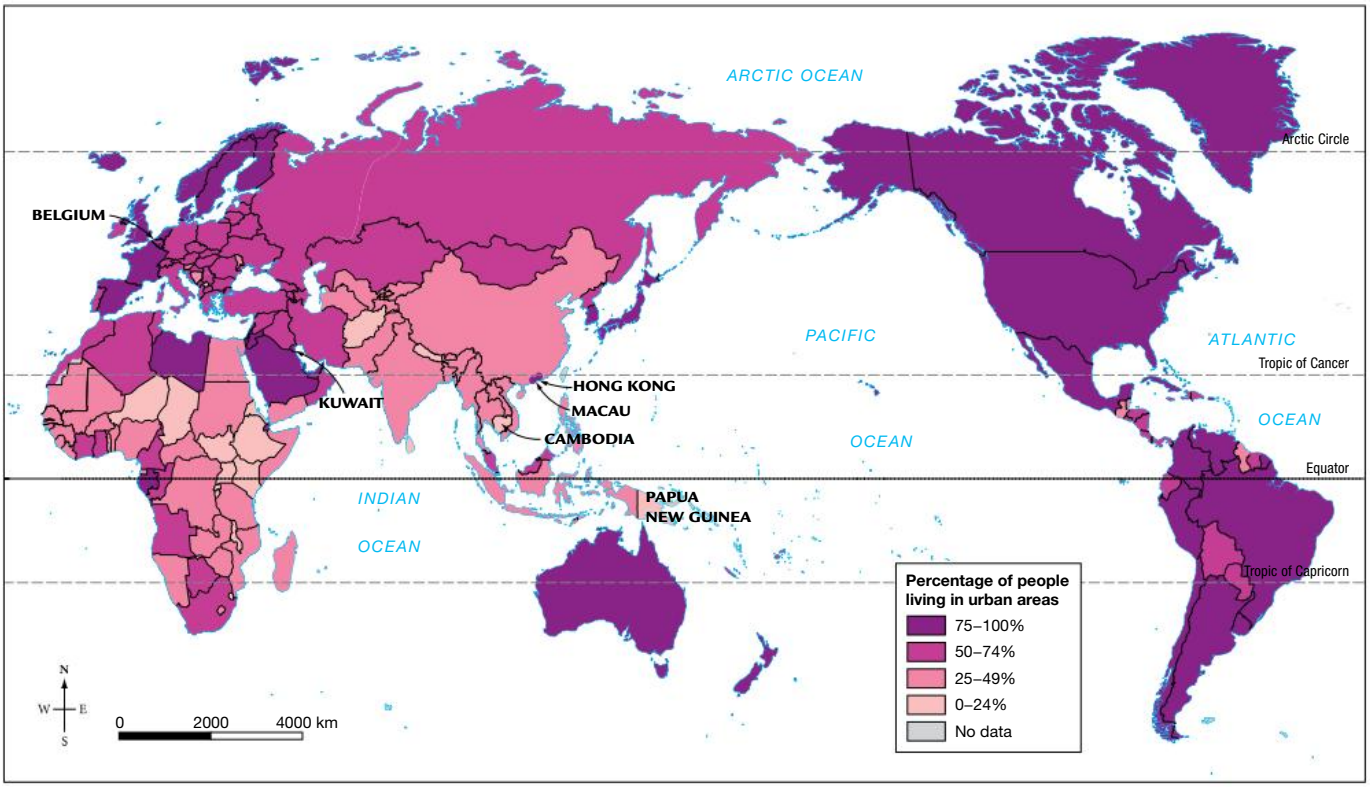


Uneven urbanisation

Urbanisation has not occurred evenly across the world. Some countries are predominantly

rural, such as Cambodia and Papua New Guinea (populations 85 per cent and 87 per cent rural respectively), whereas others are almost completely urban, such as Belgium and Kuwait (97 per cent and 98 per cent urban respectively) (see figure 3). 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 Percentage of population living in urban centres, 2010



Source: Spatial Vision

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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 (see figure 4). This means about 3.2 billion people live 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.

FIGURE 3 Urban housing in Kuwait

FIGURE 4 Cape Town in South Africa is a city located on the coast.

ACTIVITIES

IDENTIFY

1 Define *urbanisation* in your own words.

EXPLAIN

2 Use the **An urban world** weblink in your eBookPLUS to watch an animation of how urbanisation has ***changed***.
   - a How has urbanisation ***changed*** from 1950 to present?
   - b How is this different around the world?
   - c What is expected to happen in the future?

3 Use the **Urbanisation Gapminder** weblink in your eBookPLUS to watch an animation on urbanisation.
   - a What does the graph show?
   - b What do the colours represent?
   - c In 1963, name two countries that were at the bottom of the graph and two at the top.
   - d Why does Singapore appear where it does on the graph? What is an 'urban nation'?
   - e Why do the 'bubbles' increase in size over time?
   - f Which regions were highly urbanised in 2004?
   - g What do the positions of the bubbles show about urbanisation in Africa, South Asia and China?

4 Look at figure 1—which two regions have the greatest rural population?

APPLY

5 Refer to a world population density map in your atlas or online. Compare this map with the two regions that have the highest rural population. What pattern do you see?

6 Look at figure 2, which shows the population in urban areas. Identify and name the three countries with the highest and the three with the lowest percentage of people living in urban areas. Write a description of the general pattern shown in the map. Include patterns within different continents in your description.

PREDICT

7 Draw a sketch of the photograph of Cape Town in figure 4. Annotate the sketch, identifying the possible advantages and disadvantages to the natural environment when cities and towns are located on the coast.

8 Look at a physical map in an atlas to locate the countries with more than 80 per cent of their population located on the coast. Study the location of each country and create a table to record possible reasons for this pattern.

9 Rural areas are where most food is produced. What are two possible outcomes for food production if urbanisation continues?

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Interactivity
Urban Indonesia
Use this interactivity to find out more about how Indonesia is becoming urbanised.
Searchlight ID: int-3115

Weblinks
- An urban world
- Urbanisation Gapminder

8.5 Is Australia an urbanised country?

8.5.1 Australians in urban areas

With a population of 24 million people and a very large landmass, Australia has an average population density of only 2.9 people per square kilometre. Yet 84 per cent of people live within 50 kilometres of the coast, and most of these people — in 2010, 89 per cent of Australians — live in urban areas.

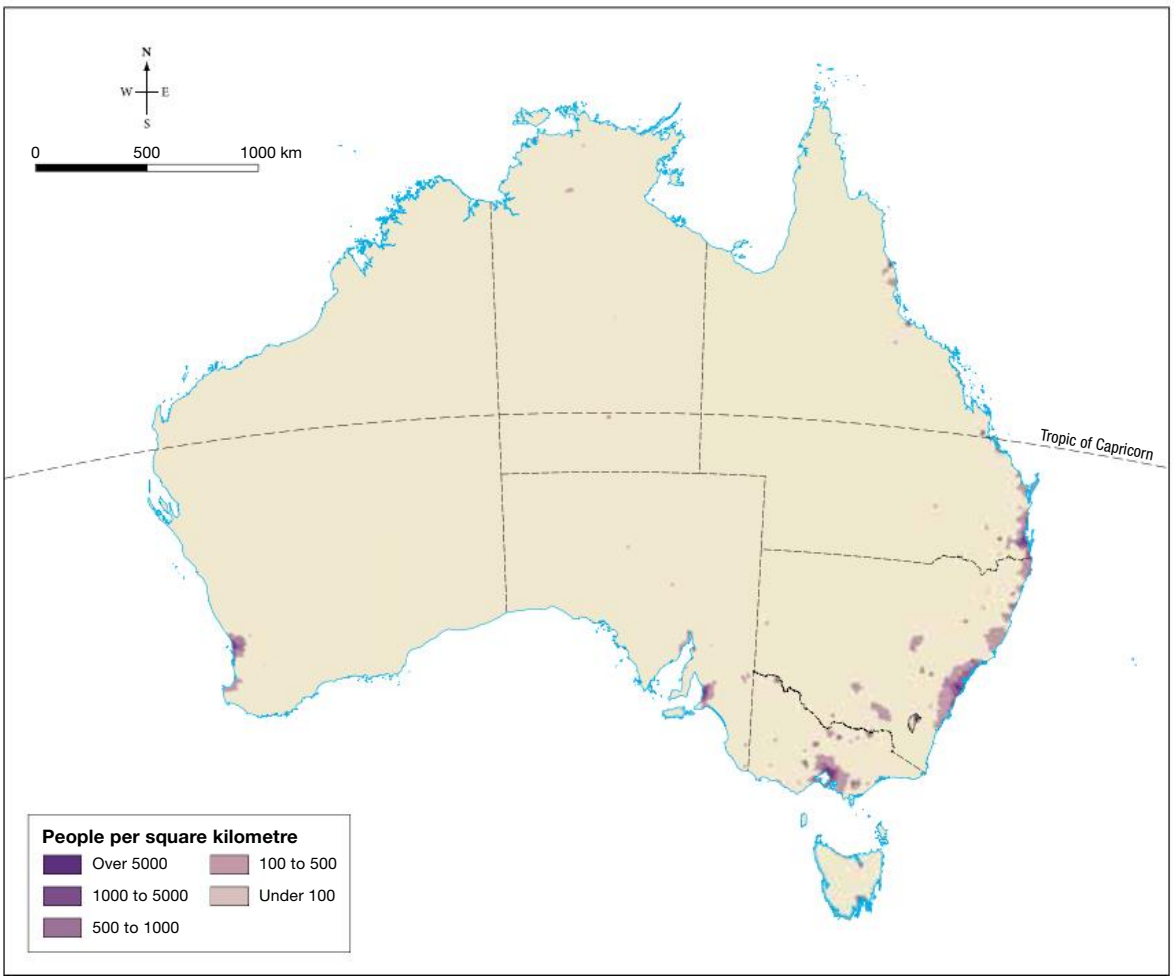
Australia is one of the most urbanised and coast-dwelling populations in the world and the level of urbanisation is increasing (see figure 1). From Federation (1901) until 1976, the number of Australians living in capital cities increased gradually from a little over one-third (36 per cent) to almost two-thirds (65 per cent). From 1977 to the present, the population in capital cities has remained at 64 per cent of the total.

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 populations, 2010 and 2056 (projected)

Capital city	2010 population	2014 population	2056 population (projected)
Sydney	4 575 532	4 840 600	6 976 800
Melbourne	4 077 036	4 440 300	6 789 200
Brisbane	2 043 185	2 274 600	3 979 300
Perth	1 696 065	2 021 200	3 358 400
Adelaide	1 203 186	1 304 600	1 651 800
Canberra	358 600	386 000	509 300
Hobart	214 705	219 200	279 700
Darwin	127 532	140 400	243 000
Total	14 295 841	15 627 000	23 787 500

FIGURE 1 A map of Australia's population distribution shows that it is highly urbanised and coastal.



Source: Spatial Vision

8.5.2 What are the consequences of a highly urbanised Australia?

urban sprawl the spreading of urban areas into surrounding rural areas to accommodate an expanding population

More land is needed when cities expand and this results in the greatest change — from agricultural to urban land. This has been called **urban sprawl**. Sydney's Greater Metropolitan Region now extends from Port Stephens in the north to Kiama in the south. Some townships in the Blue Mountains are now also considered part of Sydney despite being located 50–120 kilometres west of Sydney's CBD (see figure 2). Melbourne, Perth and Brisbane have also spread into distant, previously agricultural areas.

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, as 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 have been called 'car cities' due to the reliance on cars and road networks for transport. These have an impact on commuting times to and from workplaces (see figure 3).

FIGURE 2 Urban sprawl (shown in purple) in Sydney

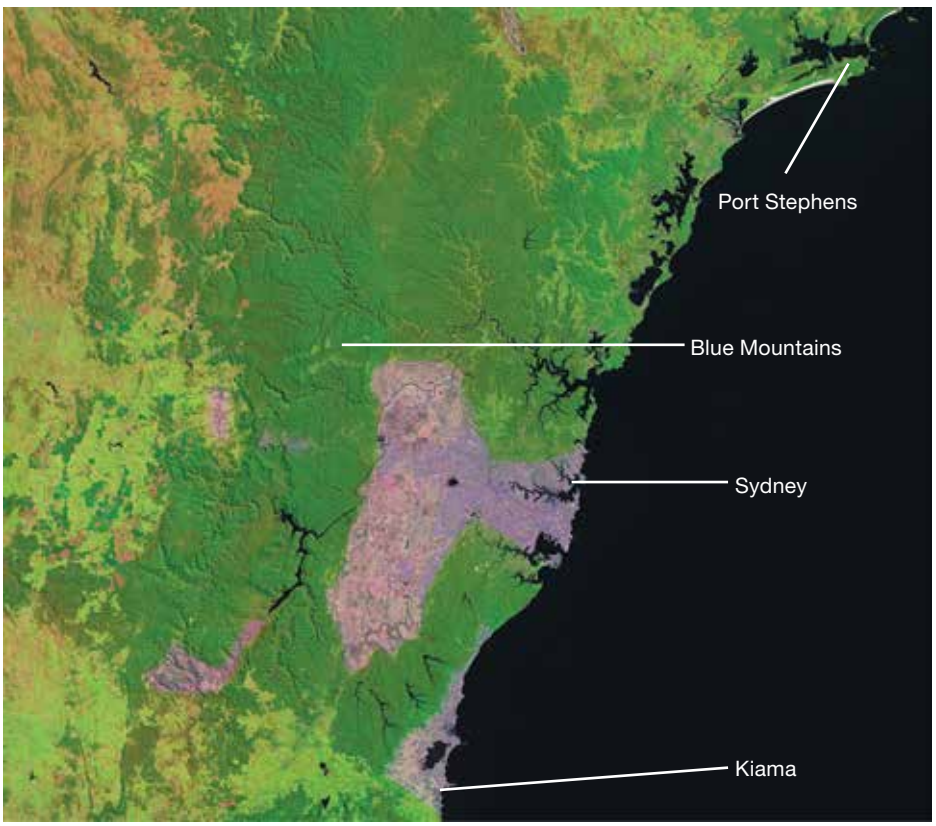
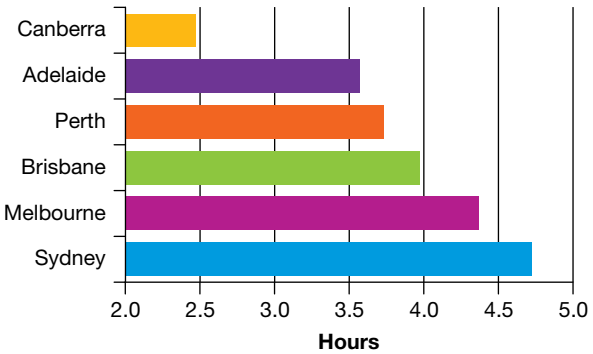


FIGURE 3 Average weekly commuting times in selected Australian cities



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

8.5.3 Ecological footprint

The amount of productive land needed on average by each person (in the world or in a country, city or suburb, for example) for food, water, transport, housing and waste management is known as an **ecological footprint**. It is measured in hectares per person per year. The average global ecological footprint is 2.7; Australia has an average ecological footprint of 6.84 (see table 2). The country with the highest ecological footprint is the UAE with 10.68.

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

FOCUS ON FIELDWORK

Investigating urban growth and decline in Australia through shopping precincts — pre-fieldwork activities

The power of the shopping centre

Through the process of urbanisation, some areas will grow and others will decline. This is very easily seen in the availability of services. Shopping centres grow with an increase in population, while shopping centres gradually close or struggle to stay open in areas where population is declining. Through fieldwork, a pattern of growth or decline in a community is able to be identified.

It is essential, however, that pre-fieldwork activities are completed to gain some insight into the area that is going to be studied to accurately identify if it is experiencing urban growth or urban decline. Use the following as pre-fieldwork activities to determine which investigation needs to be done in your area.

Step 1: Finding the facts

Using the Australian Bureau of Statistics to identify population movements and trends in your focus area will provide some background into the issue. Use this information to draw population profiles and annotate them to identify trends.

Step 2: Locating shopping precincts

Use Google Maps or Scribble Maps to find the location of nearby shopping precincts. Annotate this satellite image to create the boundaries of the investigation.

Step 3: Designing data collection methods

Design surveys and data collection methods that will help to demonstrate the impact of urban growth or decline.

GEOskills TOOLBOX

Surveys

Surveys are a useful data collection method to find out opinions on various issues. Surveys should have a mixture of open-ended and closed-ended questions.

Open-ended questions will allow people to provide more information about the issue, while closed-ended questions could be a yes or no answer, a number or a tick box.

Examples of an open-ended and a closed-ended question are given below.

- *Open-ended question:* Why do you think that the shops find it difficult to attract business in this area?
- *Closed-ended question:* Do you regularly shop here? Yes/No

Consider administering a survey at your local shopping centre.

1 Consider the number of people who will be in the shopping centre at different times of the day or week. Determine the best time to carry out the survey.
2 Write two open-ended questions that you would ask at the shopping centre. Ensure that the questions relate to the topic of urban growth or decline.
3 Write two closed-ended questions that you would ask at the shopping centre. Perhaps provide the respondent with multiple-choice answers to choose from.

FOCUS ON FIELDWORK

1 Urban growth investigation

Sample focus questions

Below are two sample focus questions.

- How is urban growth reflected in the availability of services?
- How do the services change to help urban growth occur?

Undertaking fieldwork

Visit the local shopping precinct and collect data through the following methods:

- Create a map showing the various services the shopping precinct provides, for example retail, entertainment, parking or dining.
- Photograph examples of the amenities in the shopping precinct to consider how they improve the shopping experience.
- Speak to the centre management of the shopping precinct to find out how they keep up to date with changes in the local community.
- Survey the residents in the shopping precinct to find out how often they visit and for what purpose, for example shopping, entertainment or dining

2 Urban decline investigation

Sample focus questions

Below are two sample focus questions.

- How is urban decline reflected in the availability of services?
- What difficulties is the community facing in keeping these services available?

Undertaking fieldwork

Visit the local shopping precinct and collect data through the following methods.

- Count the number of shops that are vacant compared to the number of total shops.
- Survey business owners to find out any difficulties that exist in attracting business to the area.
- Survey residents in the shopping precinct to find out if they regularly shop in the area, and if they have noticed a decline in services.
- Speak to the local council to find out what is being done to help improve the situation.

ACTIVITIES

IDENTIFY

1 What percentage of Australians live in urban areas? Of these, what percentage live in urban areas close to the coast?

2 List the disadvantages of urban sprawl.

EXPLAIN

3 Refer to figure 1 and describe the population distribution of Australia.

4 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?

5 Describe the spread of Sydney shown in figure 2. Use an atlas to explain why growth has not occurred as much to the north and south as it has to the west.

6 Describe the average commuting times shown in figure 3. What reasons can you give for the differences between cities?

7 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.

PREDICT

8 Conduct research to find which country in the world has the highest average population density. Find one country with a lower average population density than Australia.

INVESTIGATE

9 a What is an ecological footprint?

b Refer to table 2. How does the ecological footprint data compare for Australian cities?

c How do these figures compare with the average global ecological footprint?

d Use the **UAE ecological footprint** weblink in your eBookPLUS to watch a video. How does the ecological footprint in the UAE compare to that of Australian cities? What would happen if all cities had such a high footprint?

e Create your own advertisement or animation using a video editing program to encourage people in your capital city to reduce their ecological footprint.

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Weblink
UAE ecological footprint

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8.6 SkillBuilder: Creating and reading pictographs

What is a pictograph?

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

Country	Population
1. China	1 324 700 000
2. India	1 149 300 000
3. USA	304 500 000
4. Indonesia	239 900 000
5. Brazil	195 100 000

100 000 000 people

eLesson
Watch this video to learn how to create and read pictographs.

Searchlight ID: eles-1659

Interactivity
Try this interactivity to learn how to create and read pictographs.

Searchlight ID: int-3155

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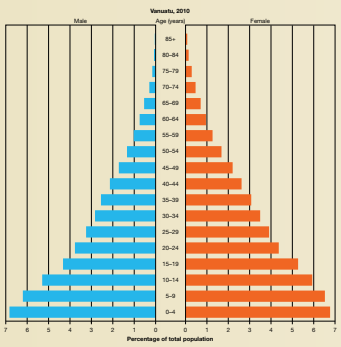
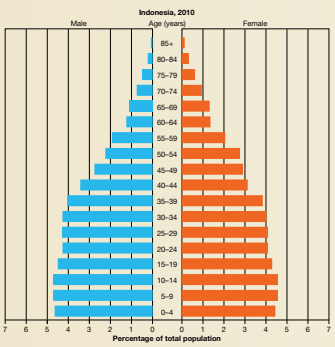
8.7 SkillBuilder: Comparing population profiles

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 shape of the population profile tells us about a particular population. Comparing population pyramids of different places helps us try to understand how and why they may be similar or different.

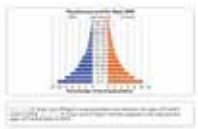




eLesson
Watch this video to learn how to compare population profiles.

Searchlight ID: eles-1704

Interactivity
Try this interactivity to learn how to compare population profiles.



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8.8 How urban are the United States and Australia?

8.8.1 Urbanisation in the USA and Australia

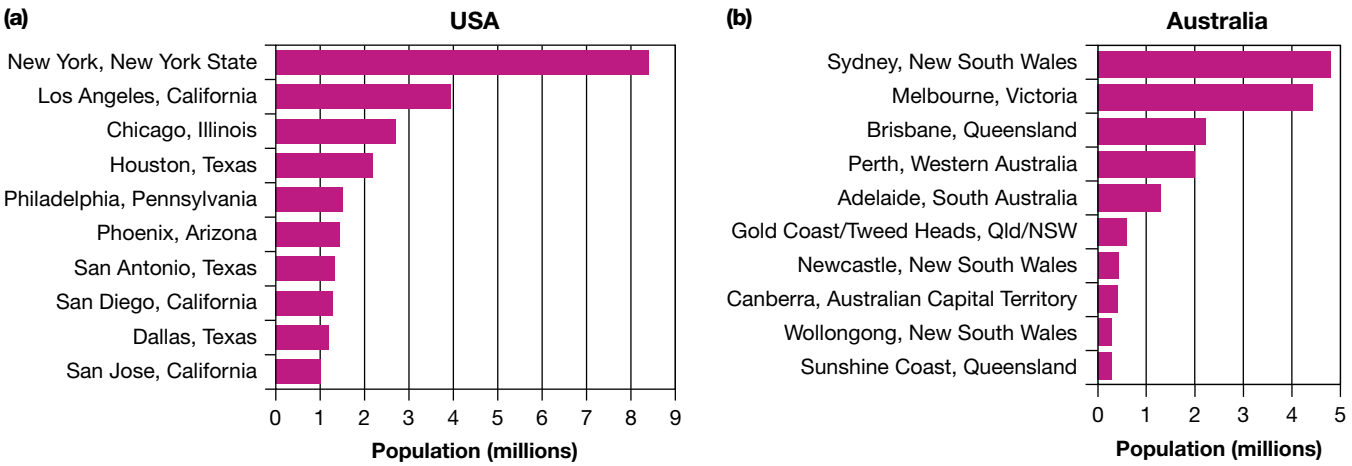
Both the United States and Australia are very large countries that are highly urbanised. In fact, both are among the world's most urbanised nations.

The United States and Australia have some similarities and some differences in terms of how urbanised they are, as revealed in table 1 and figure 1.

TABLE 1 A comparison of urbanisation in the USA and Australia

	United States	Australia
Population	308 700 000 (2010 census)	21 507 719 (2011 census)
Population distribution	Over 80% live in urban areas, less than 20% in rural areas.	Over 89% live in urban, less than 11% in rural areas.
People living in large cities	The United States has 9 cities that have a population of more than 1 million people.	Australia has 5 cities that have a population of more than 1 million people.
	Approximately 1 of every 10 people in the United States live in either the New York or Los Angeles metropolitan areas.	Approximately 4 of every 10 people in Australia live in either Melbourne or Sydney.

FIGURE 1 Population of the top 10 urban settlements in (a) the United States and (b) Australia



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Interactivity
City folk
Use this interactivity to learn more about how urbanised Australia and the USA are.
Searchlight ID: int-3117

8.8.2 Causes of urbanisation

The causes of urbanisation are similar for both Australia and the United States. In each case, since the country was founded:

- fewer people were needed to work in rural areas as technology reduced the demand for labour on farms
- more jobs and opportunities were available in factories, which were located in urban areas
- the development of railways allowed goods produced in one city to be transported to rural and urban areas
- cities could grow and develop thanks to new technologies (steel-framed skyscrapers) and utilities (for example, electricity and water supply).

8.8.3 Consequences of urbanisation

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.

United States

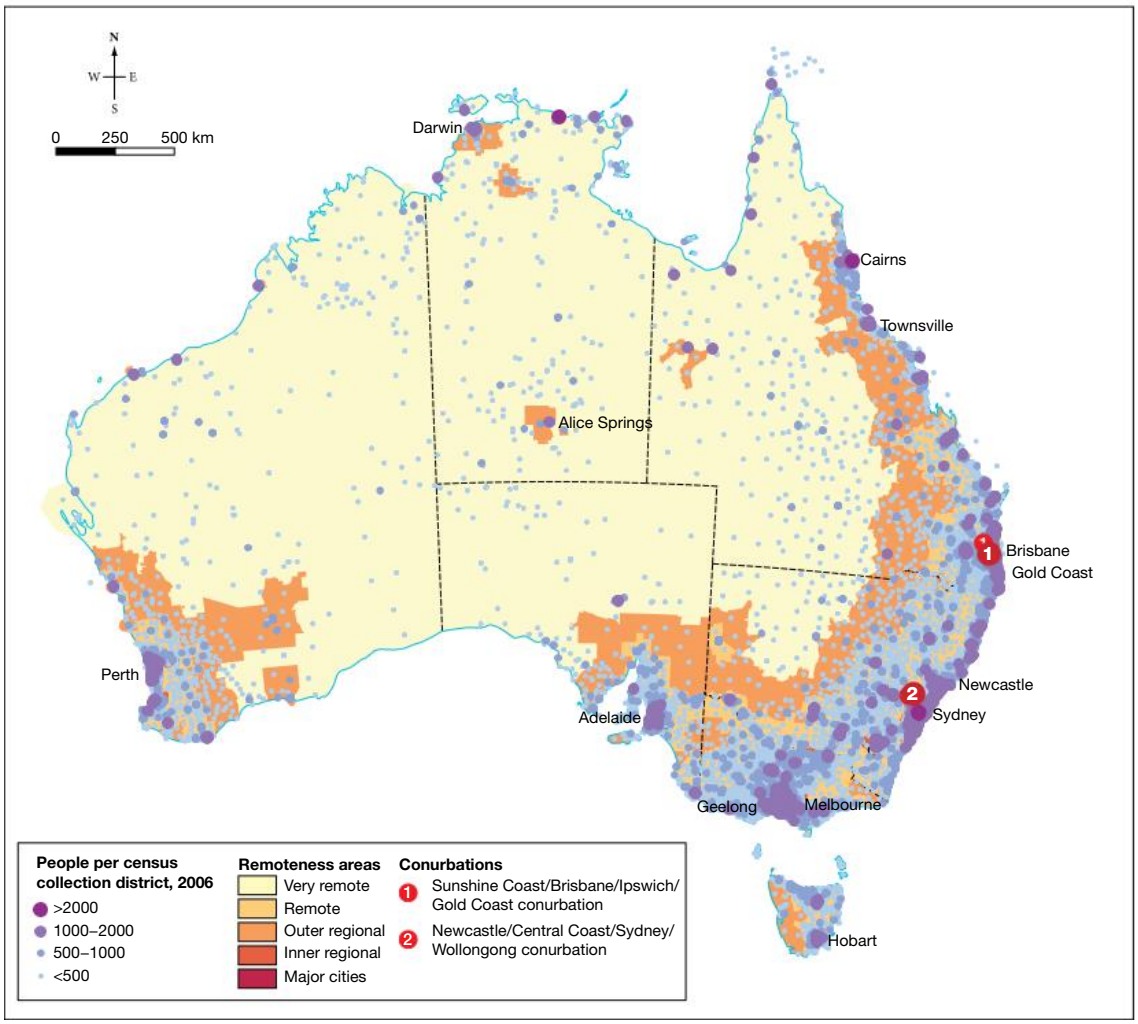
Eleven conurbations have been identified in the United States (see figure 2). The major conurbation is in the north-east region. It is often called BosNYWash because it covers the area from Boston in the north, through New York, to Washington in the south. This region is home to over 50 million people and accounts for 20 per cent of the gross domestic product (GDP) of the United States.

FIGURE 2 Conurbations in the United States

Australia

Australia, on the other hand, has only two main conurbations (see figure 3). One is in south-east Queensland; the other, the Newcastle–Wollongong conurbation, stretches for over 250 kilometres and is home to almost 6 million people.

FIGURE 3 Australia's population centres and conurbations



Source: Australian Bureau of Statistics

Homelessness

It has been estimated that there are more than 650 000 homeless people (living on the streets or in temporary shelters) in the United States and around 105 000 homeless people in Australia. One reason for this is that urban housing projects do not provide affordable housing for the poor.

In the United States, it has been estimated that 71 per cent of homeless people reside in cities, 21 per cent are in suburbs and only 9 per cent are in rural areas.

Health issues

High population densities in urban areas make it easier for diseases to be transmitted, especially in poor neighborhoods. The urban poor suffer health issues caused by reduced access to sanitation and hygiene facilities and health care.

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.

ACTIVITIES

IDENTIFY

1 How does the population of the United States compare to that of Australia? How many times larger (approximately) is one than the other?
2 Refer to figures 2 and 3. Describe the distribution of the population in the United States and in Australia.
3 What is a conurbation?

EXPLAIN

4 Refer to table 1.
  a Compare the ***scale*** of urbanisation in the United States and in Australia.
  b Compare the numbers of people living in large cities in the United States and in Australia.
5 Refer to figure 1.
  a Compare the size of the 10 largest cities in the United States and in Australia.
  b What might explain the differences you noticed?
6 Explain, in your own words, the causes of urbanisation in the United States and Australia.
7 Why do you think both Australia and the United States have conurbations?
8 Why might there be more conurbations in the United States than in Australia?

INVESTIGATE

9 Conduct research to find out about other consequences of urbanisation in the United States and Australia, such as those affecting traffic, provision of adequate public transport, water supply and energy, waste management issues, urban sprawl, and loss of farmland.

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8.9 How has international migration affected Australia?

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8.10 What are the causes and effects of Indonesia's urban explosion?

8.10.1 Indonesia

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 current population of more than 249 million people 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 (see figure 2).

FIGURE 1 Map of Indonesia

Source: MAPgraphics Pty Ltd, Brisbane.

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 2010, this had increased to almost 50 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 four cities by 1980, eight by 1990 and ten by 2000. In fact, more than one-fifth of the Indonesian urban population now lives in the Jakarta metropolitan area (JMA).

8.10.2 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. Although the growth rate has fallen dramatically (from 2.3 per cent in 1970 to about 1.04 per cent today), about 3.5 million babies are born in Indonesia each year.

The Indonesian government placed few restrictions 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.

FIGURE 2 Distribution of population in Indonesia and surrounding nations, 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 Jakarta has a population density of 14 464 people per square kilometre — the ninth largest urban population density in the world.

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.

8.10.3 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 JMA is now one of the world's largest urban centres. 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. Today, Jakarta's population is over 10 million and the city controls around 70 per cent of Indonesia's economy.

FIGURE 4 Jakarta's urban growth

1976 (population 6 million) | 1989 (population 9 million) | 2004 (population 13 million)

Source: © NASA Earth Observatory

Loss of land

Prime agricultural areas have been lost and become residential and industrial areas. Urban land is worth more than agricultural 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 today.

FIGURE 5 Smog over Jakarta

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 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.

FIGURE 6 Traffic congestion in Jakarta

Subsidence

Land has been subsiding because more groundwater is being extracted, and also because of the additional load that the ground has to bear because of 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. However, heavy flows of commuter traffic have led to increased levels of traffic congestion between the scattered new towns and the cities.

ACTIVITIES

IDENTIFY

1 a What is Indonesia's current population? If the area of Indonesia is 1 904 569 square kilometres, what is its approximate population density?

b How does this compare to Australia's population density of 2.9 people per square kilometre?

2 Describe, using statistics, how Indonesia has become very urbanised in a relatively short time.

EXPLAIN

3 Explain, in your own words, why Indonesia has become very urbanised.

4 Explain how and why Jakarta has become a major city within Indonesia and also on a world ***scale***.

5 Why do you think people have moved from rural areas to urban areas within Indonesia?

6 What is the ***interconnection*** between the increasing population in Indonesia and the subsidence of land?

PREDICT

7 What do you believe are the three main reasons that Indonesia has undergone such rapid urbanisation? Give reasons for your choices.

8 Which of the consequences of urbanisation do you think may continue to have the biggest effects on the ***environment*** in the future? Why?

9 How is the urbanisation of Indonesia similar to and different from the urbanisation of another country you have studied, such as Australia, China or the United States?

10 As a group, brainstorm the issues and possible solutions to rapid urbanisation in Jakarta.

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. **› Urbanisation in Indonesia**

8.11 Why are people on the move in Australia?

8.11.1 What makes Australians move?

In the United States, it is common for young people to leave home and travel to a university in another state or on the opposite side of the country. This is less common in 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.

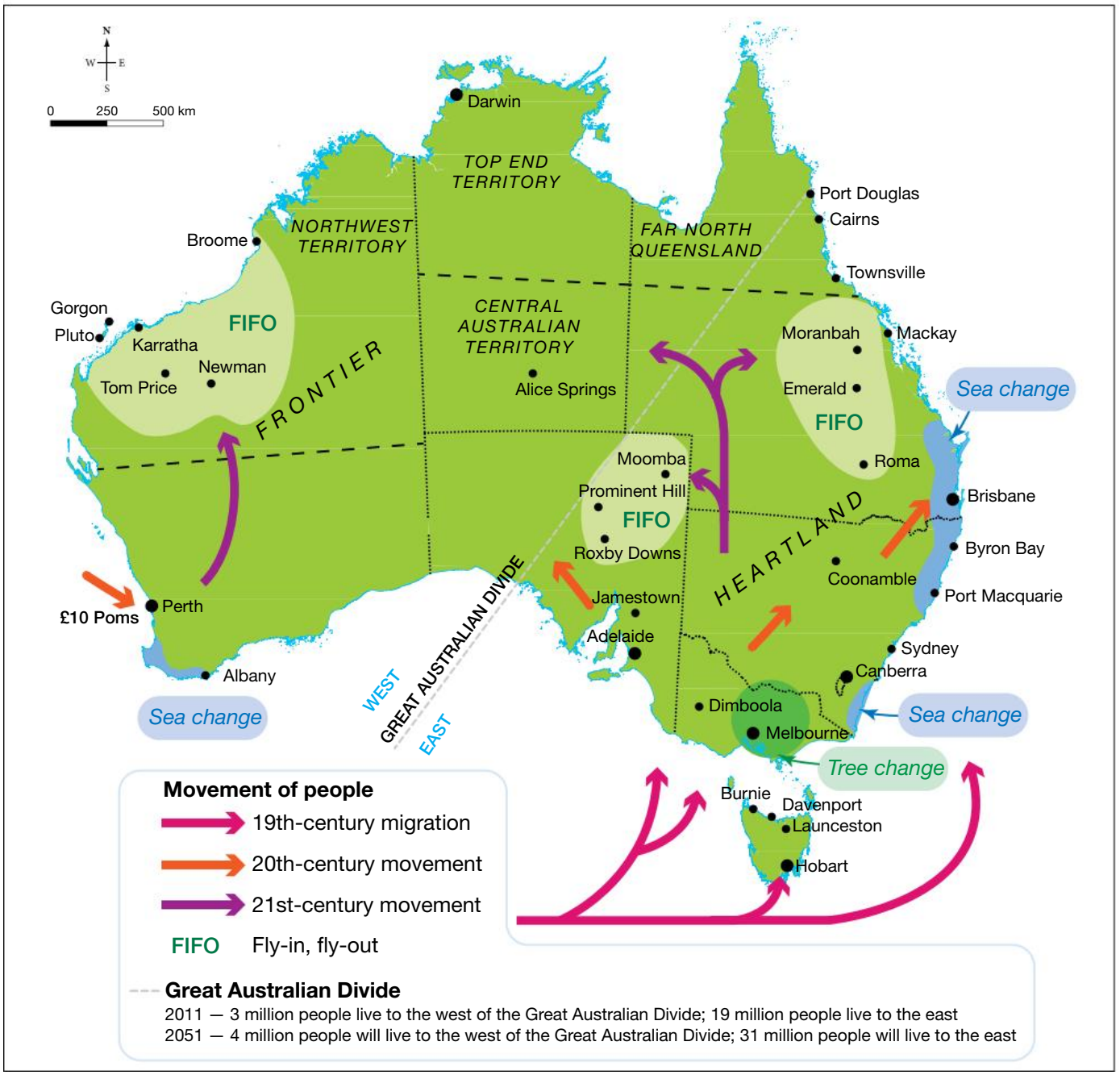
Forty per cent of Australians have changed the place where they live in the past five years (see table 1). Some have moved only within their suburb, but 6 per cent, or 1.2 million people, have moved from a different country.

The major movements of Australians since 1788 are shown in figure 1. The Great Australian Divide separates Australia into two regions, known as the

TABLE 1 The usual place of residence for Australians in 2006 versus 2011

Location	Number of people
Same address	11 million
Same suburb, different address	1.4 million
Different suburb or state	5.2 million
Overseas	1.2 million
Not stated	1.2 million
Total	20 million

FIGURE 1 Australia's moving population



Source: Bernard Salt, KPMG Demographics, 2001.

Heartland and the Frontier. The Heartland is home to about 19 million people who live in a modern, urbanised, industrial state. The Frontier is a sparsely populated region of only about 3 million people who live in a place that is remote but rich in resources.

FOCUS ON FIELDWORK

Comparing movements in the classroom

Survey the students in your class to find out if they live in the same place of residence in 2011 as they did in 2006. Compare these findings to table 1 and graph the information in a comparative column graph.

Sea change or tree change

sea change/tree change movement of people from major cities to live near the coast or forests, to achieve a change of lifestyle

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, Wollongong, Cairns and the Gold Coast are all popular places for sea changers to settle.

Not every sea changer loves their new life, and many return to the city. The perceived dangers of bushfire, storms or sharks and a lack of family, old friends and cultural activities can pull people back to their previous city residences.

Fly-in, fly-out workers

fly-in, fly-out (FIFO) 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

Employment opportunities have grown within the mining industry in places such as the Pilbara. 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; many places do not have mobile phone reception, and even internet access can be costly and slow. One way to attract workers to these regions is to have a **fly-in, fly-out (FIFO)** workforce. FIFO workers are not actually 'settlers', as 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—for example, the picking and pruning of grapes and fruit trees 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 plus 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 more than 20 nationalities as either residents or seasonal workers.

ACTIVITIES

IDENTIFY

1 What does FIFO mean?
2 What is the difference between a *tree changer* and a *sea changer*?

EXPLAIN

3 Refer to figure 1. Explain the difference between Australia's Heartland and its Frontier.
4 Look carefully at figure 1 and explain how the gap between Australia's east and west is predicted to alter over the next 40 years.

APPLY

5 List the positive and negative factors of making a tree ***change*** or sea ***change*** as a:
a family with young children
b retired couple.

6 Convert table 1 into a pie graph, either using Excel software or by hand using a protractor. Describe the patterns that you can identify in your graph.

PREDICT

7 Do you think that the patterns you described in question 6 will still be evident in five years' time? Explain your answer.

INVESTIGATE

8 'A sea change may be the calm before the storm.' Use your answer to question 5 to write at least half a page discussing this statement.

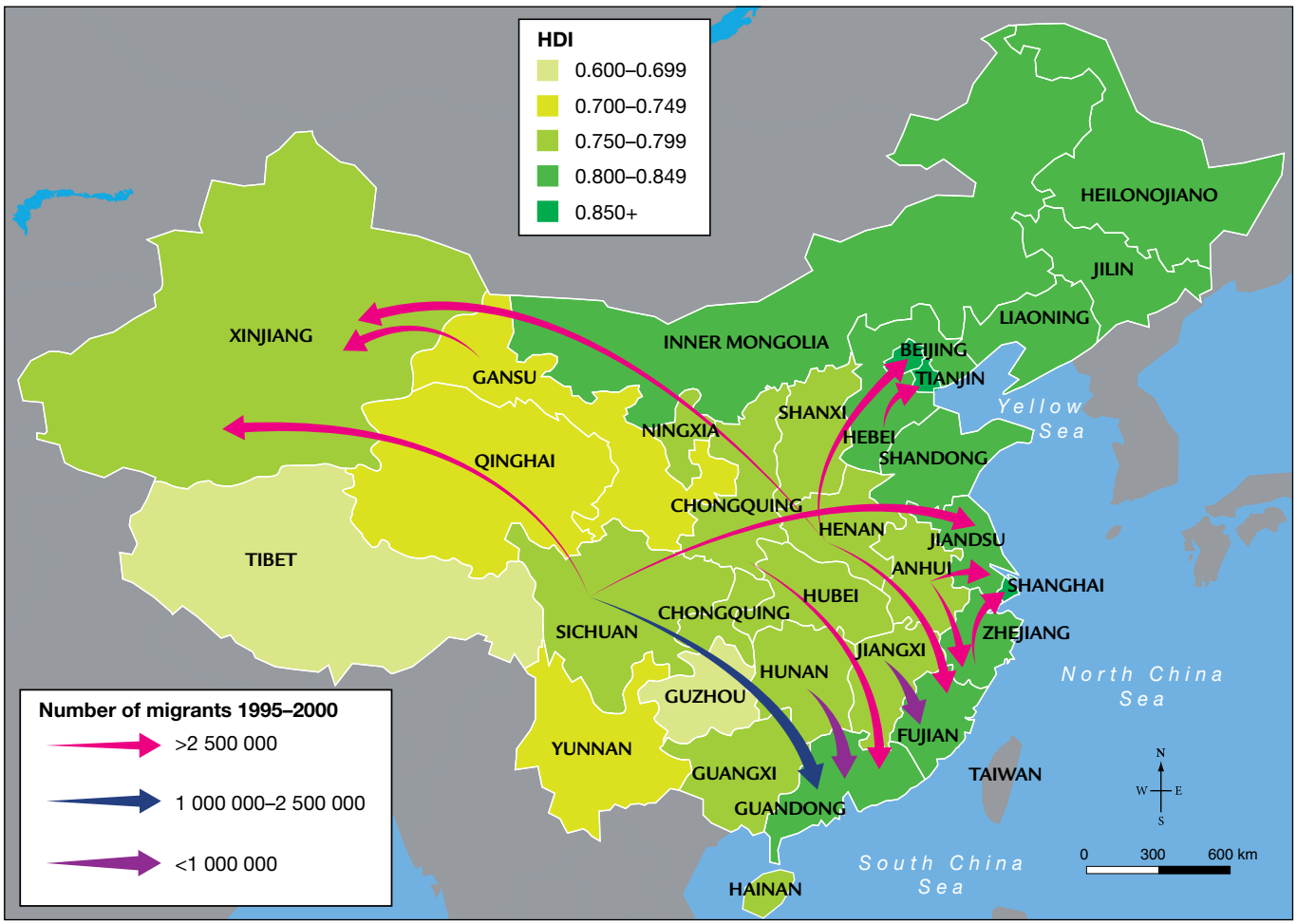
8.12 Why are people on the move in China?

8.12.1 Reasons for rural–urban migration

China has been experiencing a changing population distribution. The country's urban population became larger than that of rural areas for the first time in its history in 2012, as rural people moved to towns and cities to seek better living standards. China has become the world's largest urban nation.

Chinese labourers from the provinces have been moving to coastal cities in search of job opportunities, following reforms in 1978 which 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 1).

FIGURE 1 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: Spatial Vision

Pull factors

Migrants from rural areas are attracted to urban regions largely for economic reasons—a higher income is achievable in a city (see figure 3). 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

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 (see figure 2).

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 2 A dramatic rural–urban migration shift has been occurring in China. In 2010, over half of China's population lived in rural areas, but by 2011 it was less than half.

Consequences of rural–urban migration

- China's urban population rose from around 170 million people in 1978 to 540 million in 2004, and then to more than 690 million in 2012.
- In 1949, 89 per cent of people lived in rural areas; by 1979 this figure had dropped to 81 per cent.
- It is expected that, within 20 years, only 25 per cent of China's population will be living in rural areas, while the number of city-dwellers will rise to well over 1 billion people.
- Some people predict that, by 2025, China will have 15 super-cities with an average population of 25 million people each.
- It is thought that the number of people living in China's countryside could shrink from 500 million to 400 million people.

- 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.

FIGURE 3 Although Shanghai's birth rate is the lowest in the world (0.7 per cent), its population increased from 16.41 million to 22.21 million in 2010 — an increase of 35 per cent. Nearly all of this population gain was due to migrants moving from rural areas.

ACTIVITIES

IDENTIFY

1 How has the percentage of people living in China's rural areas ***changed*** since 1949? What is this number expected to be in the future?
2 Describe the main ***changes*** that have occurred within China's urban population since 1978.

EXPLAIN

3 Explain in your own words the main reasons for the dramatic ***change*** in China's population distribution.
4 Classify each of the various consequences of this ***change*** as positive or negative.
5 Creatively (in graphic or diagrammatic form) present some of the dramatic statistics in this section to inform others of the ***scale*** of the ***changes*** happening to the distribution of China's population.

INVESTIGATE

6 Use the **China's urban growth** weblink in your eBookPLUS to respond to the following.
a Describe population ***changes*** in the various cities in China.
b 'The largest population growth has occurred in cities on China's coastline.' How true is this statement? Explain your answer using figures from the website.

eBook*plus*

Interactivity
Urban/rural China
Use this interactivity to learn more about China's rapid urbanisation.
Searchlight ID: int-3116

Weblink
China's urban growth

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. **› China**

8.13 Urbanisation in Albury–Wodonga

8.13.1 Decentralisation

Most of Australia's urbanisation has occurred in our large coastal capital cities. However there are also some large inland regional centres which have experienced urban growth.

Albury–Wodonga is located on the New South Wales—Victoria border and the two locations share a 'twin city' relationship. Albury, 580 kilometres from Sydney, is located on the northern bank of the Murray River and Wodonga, 300 kilometres from Melbourne, is located on the southern bank of the Murray River.

To try to halt the spread of Australia's large coastal cities the federal government developed a policy in the early 1970s to encourage people to move from large cities, such as Sydney and Melbourne, to regional centres such as Albury–Wodonga. This process is called decentralisation. Industries and government departments were encouraged to locate in Albury–Wodonga, which attracted people to live there.

anabranch section of a river or stream that diverts from the main channel

FIGURE 1 An **anabranch** of the Murray River which separates Albury and Wodonga.

ACTIVITIES

IDENTIFY

1. Identify the freeway that passes through both Albury and Wodonga.
2. What is located at the following points?
   - a GR905060
   - b GR927072
   - c GR940080
   - d GR913072
   - e GR924046
   - f GR927060
3. What is the approximate distance from the Albury Visitor Information Centre to Albury Botanic Gardens?
4. What do you notice about the number of parks on the eastern side of Albury compared to the number of parks on the western side?
5. In which direction does Albury seem to be expanding?
6. Is the state boundary between New South Wales and Victoria in the middle, on the Victorian side or on the New South Wales side of the Murray River?
7. What evidence is there on the map in figure 2 that Albury and Wodonga will physically remain two separate cities in the future and not merge into one city?

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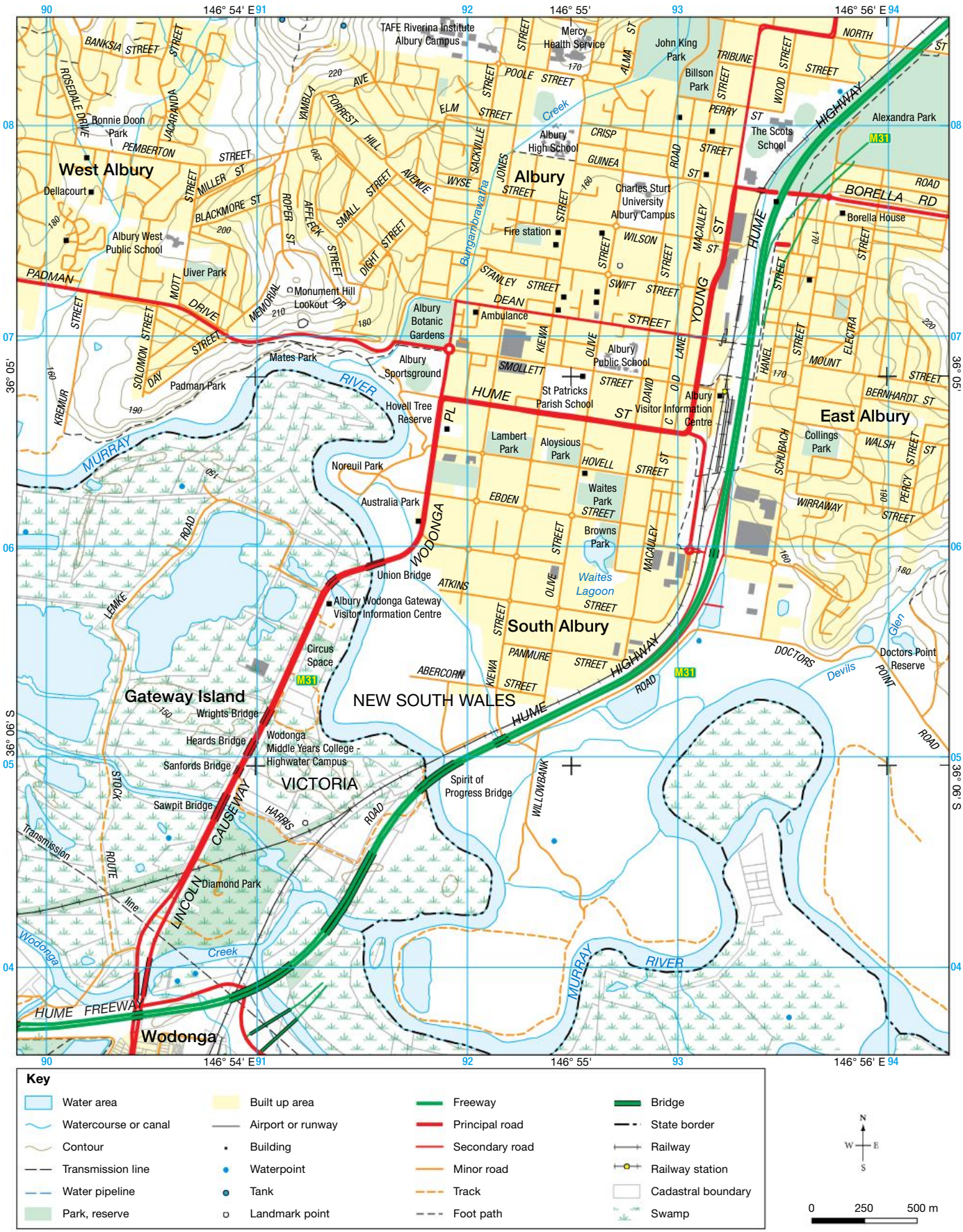
8.14 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

FIGURE 2 Topographic map of Albury–Wodonga



Source: Copyright © The State of Victoria, Department of Environment, Land, Water & Planning 2016.

8.6 SkillBuilder: Creating and reading pictographs

8.6.1 Tell me

What is a pictograph?

A pictograph is a graph drawn using pictures to represent numbers, instead of bars or dots which 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.

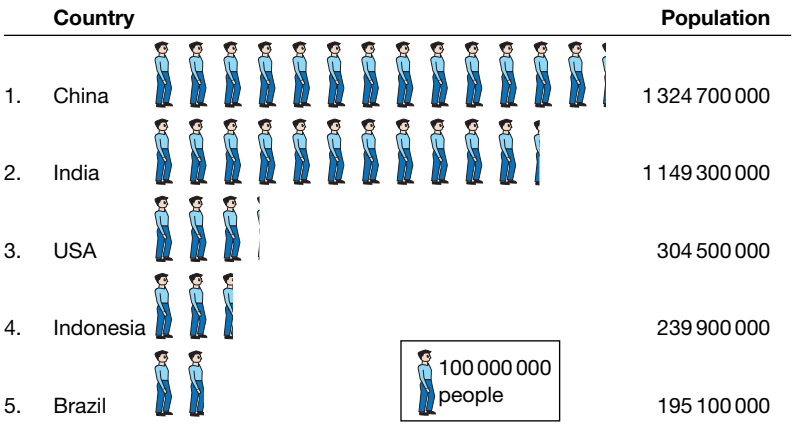
Pictographs are useful for:

- simplifying data
- showing differences between data
- presenting data.

Model

The pictograph in figure 1 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/legend 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



A good pictograph has:

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

8.6.2 Show me

How to create and read a pictograph

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.

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eLesson
Creating and reading pictographs
Searchlight ID: eles-1659

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 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/legend is in place and that the pictograph has a clear title.

STEP 6

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

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Interactivity
Creating and reading pictographs
Searchlight ID: int-3155

8.6.3 Let me do it

Developing my skills

Use the data below to draw a pictograph of the 10 cities with the largest populations.

Rank	City	Country	Population (rounded figures, 2011)
1	Tokyo	Japan	35.7 million
2	Mexico City	Mexico	19 million
2	Mumbai	India	19 million
2	New York City	United States	19 million
5	São Paulo	Brazil	18.8 million
6	Delhi	India	15.9 million
7	Shanghai	China	15 million
8	Kolkata	India	14.8 million
9	Dhaka	Bangladesh	13.2 million
10	Jakarta	Indonesia	13.2 million

Questions

1. What did you immediately notice when you first looked at your completed pictograph?
2. Which cities did you not expect to see on this list? Why?
3. Which country did you think would contain one of the 10 cities with the highest populations, but does not?
4. How much larger is Tokyo than Mexico City?
5. Sydney is Australia's largest city (4.61 million). Draw a pictograph to show the population of Sydney. Use the same representation as you did for the first pictograph. What do you notice?

Checklist

I have:

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

Skills questions

1. Pictographs show:
   a. a series of numbers
   b. numbers as pictures
   c. pictures of a range of ideas
   d. your drawing skills.
2. A pictograph does not:
   a. show differences between data
   b. present data
   c. simplify data
   d. complicate data and its interpretation.
3. Why should you take time to decide on the quantity that each picture will represent?
4. Why might it be important to carefully choose the picture to be used?

8.7 SkillBuilder: Comparing population profiles

8.7.1 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 (a prediction of Germany's population in 2050), tells us that there is negative growth — that is, the population is decreasing.

FIGURE 1 Population profile of Niger, 2009

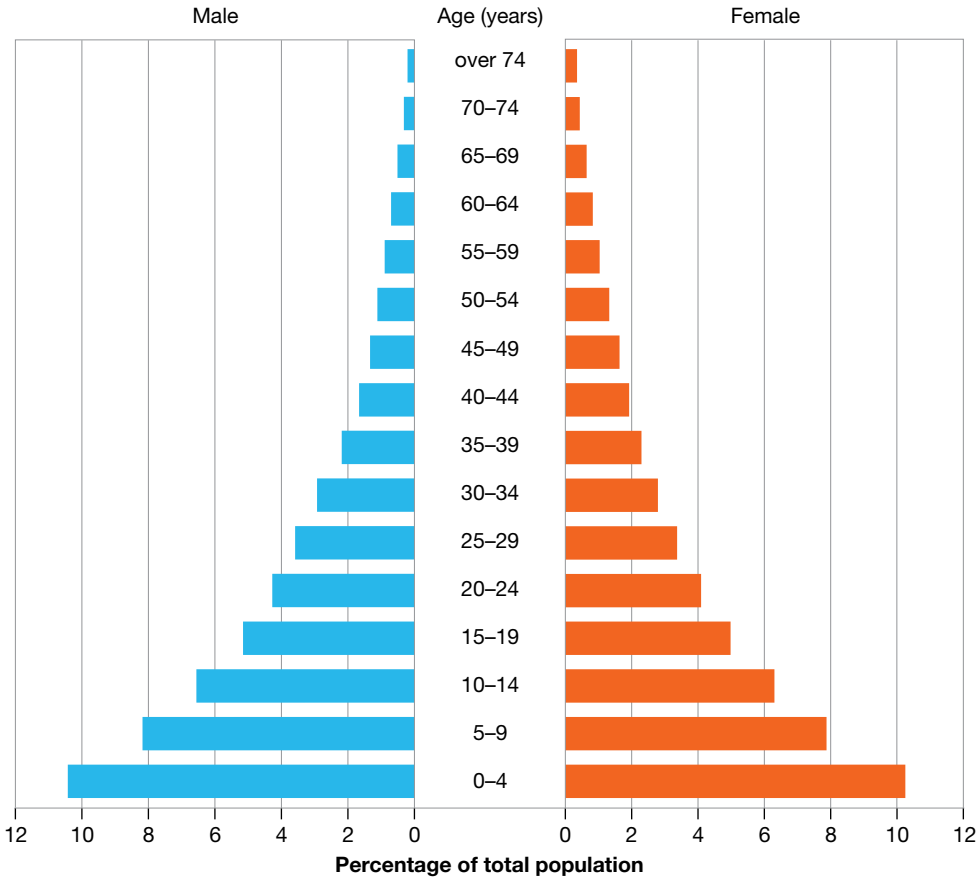


FIGURE 2 Population profile of Germany, 2009

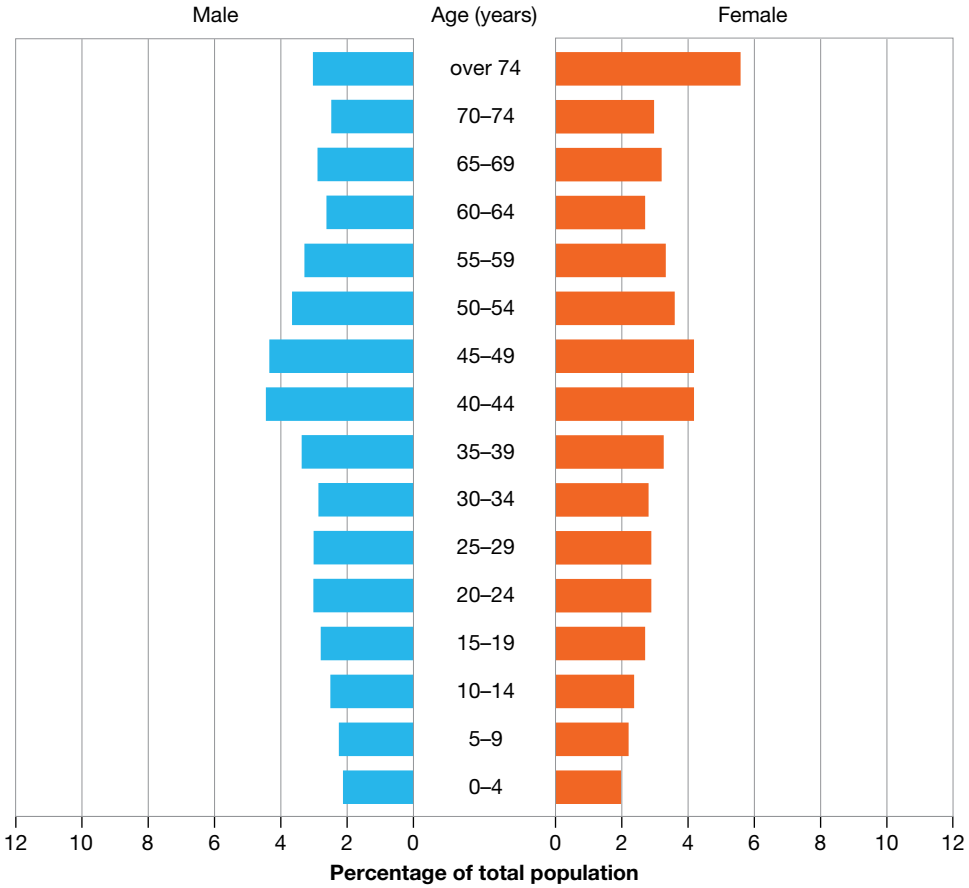
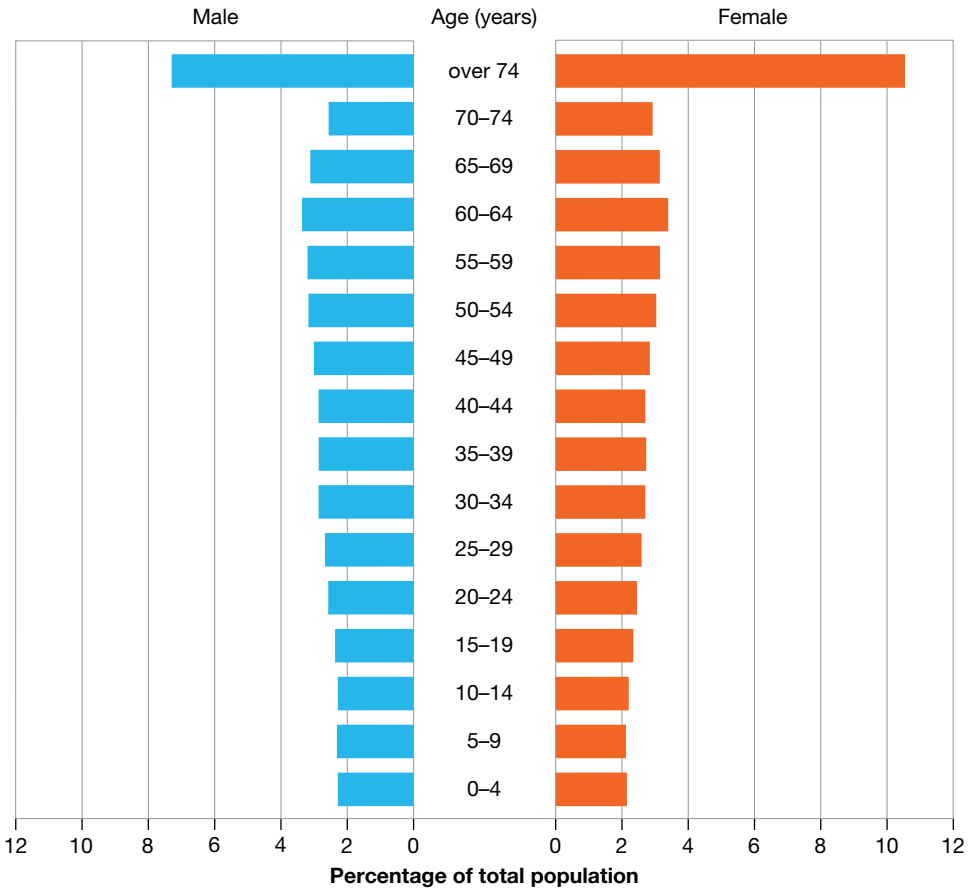


FIGURE 3 Population profile of Germany, 2050



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

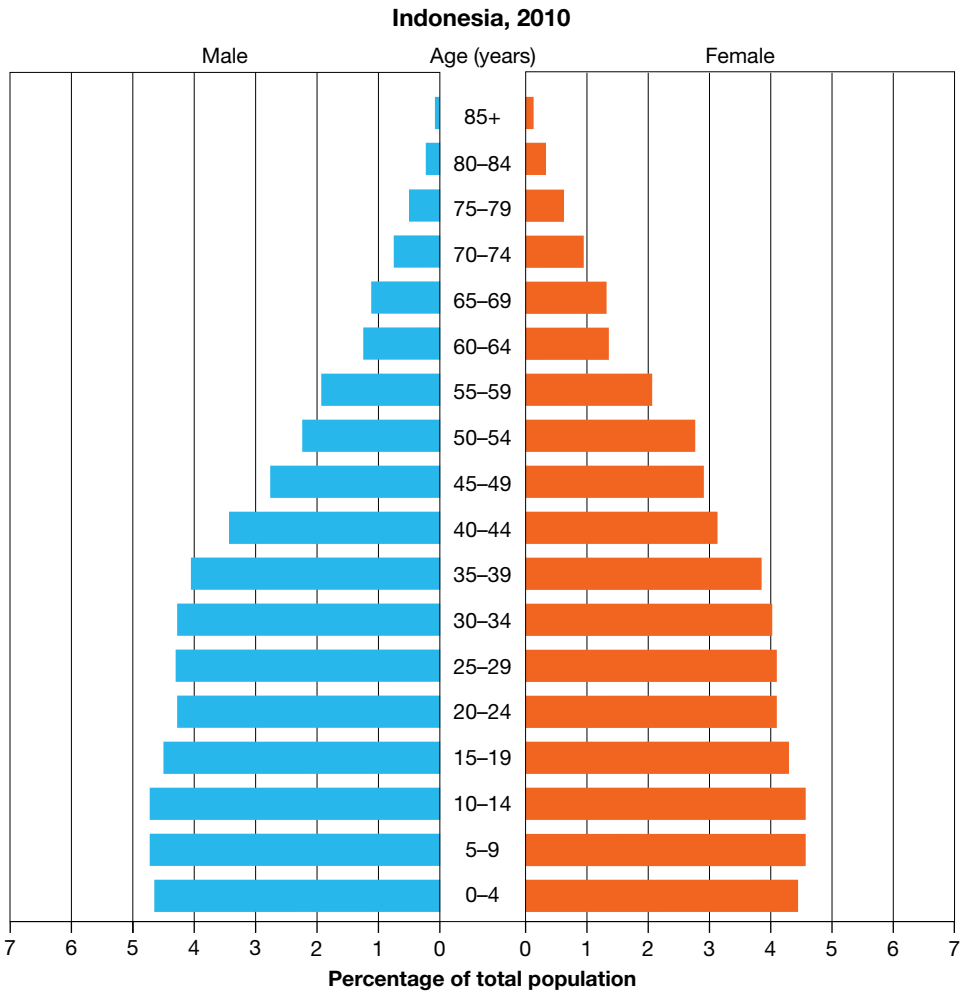
- If the lower bars of the profile are wide, then the population is young (that is, there is a larger proportion of young people than older people in the population).
- If the upper bars of the profile are wide, then the population is ageing.
- Comparisons can be made of the numbers of males and females 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 groups means more schools will be needed, while a widening in the bars showing the 60+ years age groups means aged care facilities will be required
- planning by governments for services for the future.

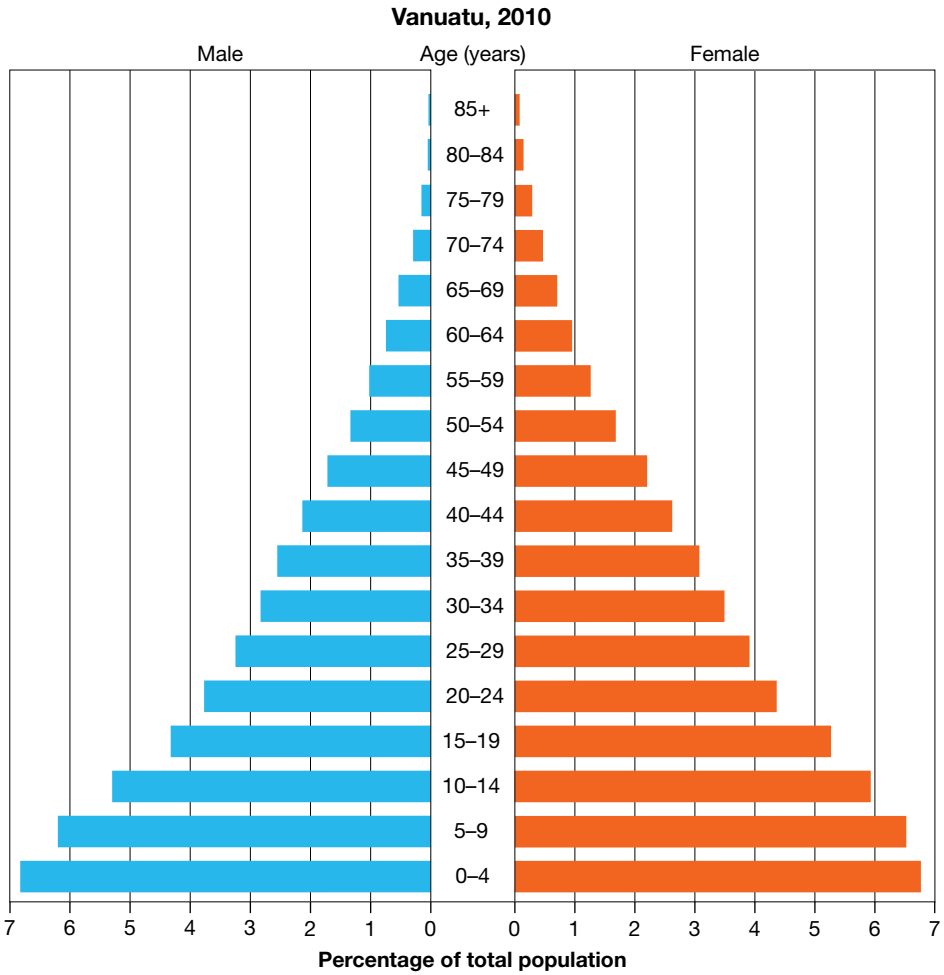
Model

FIGURE 4 Population profiles of Indonesia and Vanuatu, 2010



(*continued*)

FIGURE 4 Population profiles of Indonesia and Vanuatu, 2010 (*continued*)



In figure 4, 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 could 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 groups).

A clear comparison of population profiles has:

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

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eLesson
Comparing population profiles
Searchlight ID eles-1704

8.7.2 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 (as in figure 4).

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 figure 4.

STEP 2

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

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

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 tab and selecting the country and year that you want to research. Alternatively, use the **US Census Bureau** weblink in the Resources tab and select the report type 'Population by five year age groups', then choose the country and year that you want to research. You will find that population figures (as a percentage or the actual number of people) are produced for each age group. 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?

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Weblinks
- Population pyramid
- US Census Bureau

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 as a higher proportion of men may be killed. After a war, however, more births are likely to occur. Government policies such as the one-child policy of China (since 1979, and 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 groupings 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 programmes 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 may 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 background of a country to gain information that will allow you to make an accurate interpretation of its population figures.

8.7.3 Let me do it

Developing my skills

Using the **Population pyramid** weblink in the Resources tab, find the population profile for South Africa in 2010 and compare it with the population profile for Thailand in 2010 by writing a paragraph about population structure (using the steps above to help you).

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Interactivity
Comparing population profiles
Searchlight ID int-3284

Spend some additional time on the website looking at the changes in population pyramids over time and for other countries. It is amazing what you will discover!

Questions

1. What percentage of people in Thailand are aged less than 10 years? Compare this with the figure for South Africa — what percentage of people in that country are aged less than 10 years?
2. In which country, South Africa or Thailand, is a female most likely to live longest?
3. Which population profile is narrowest in the 0–4 years age group?
4. At what point does the population structure for South Africa take on a pyramid shape?
5. Which country, South Africa or Thailand, is likely to have more people in the workforce in 2025? Give reasons for your answer.

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.

Skills questions

1. Population profiles are used to show:
   a. the number of people at a place
   b. the number of men in a population
   c. the number of women in a population
   d. the structure of a population.
2. A population profile includes information about:
   a. age
   b. housing
   c. health
   d. history.
3. Suggest why population profiles use five-year age groupings.
4. Why is it easier to deal with population profiles using percentage figures rather than total population numbers?

8.9 How has international migration affected Australia?

8.9.1 Why have people migrated to Australia?

Australia is a land of **migrants**. In a way we are all migrants — at some stage in the past, our ancestors came to this country to live. Today, half of our population of just over 23 million people either was born overseas or has at least one parent who was born overseas.

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 1).

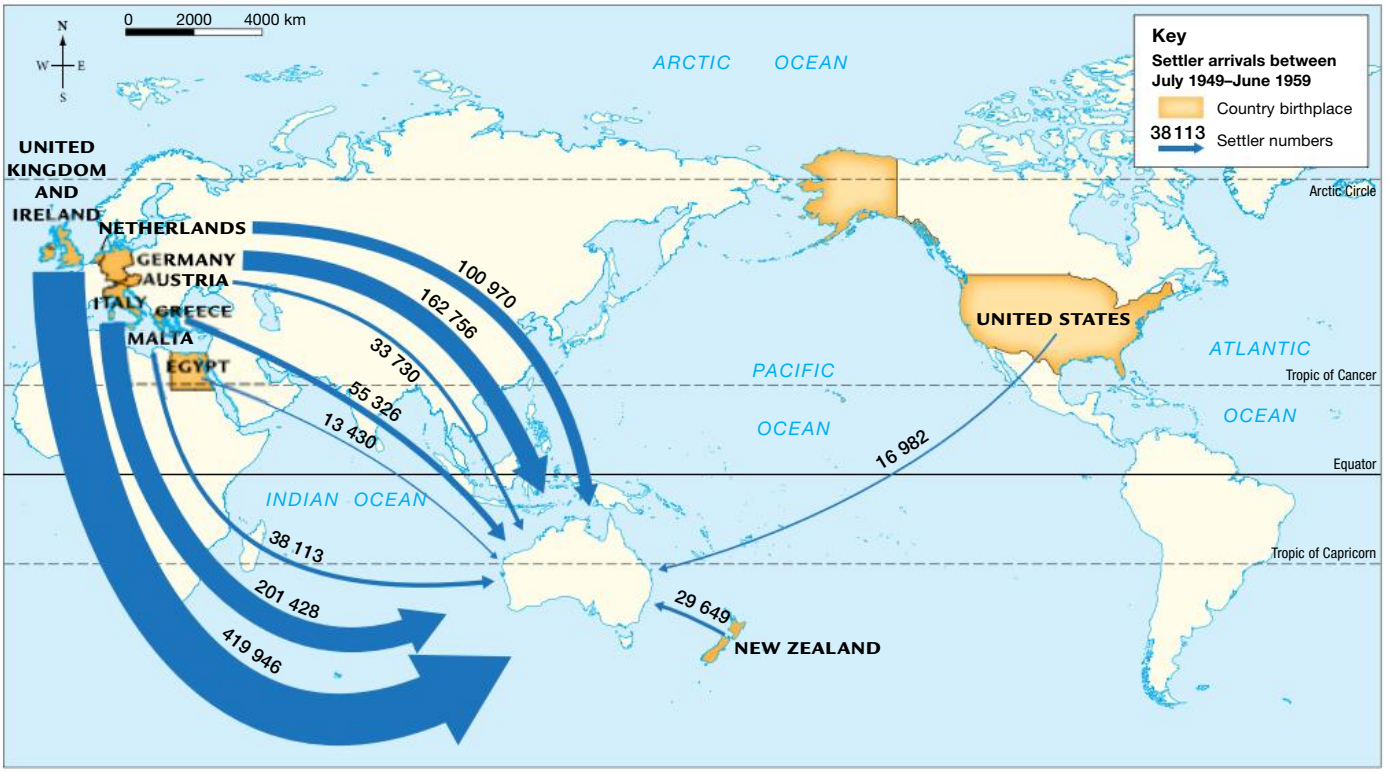
migrant a person who leaves their own country to go and live in another

FIGURE 1 Reasons for immigration to Australia

8.9.2 Where have our migrants come from?

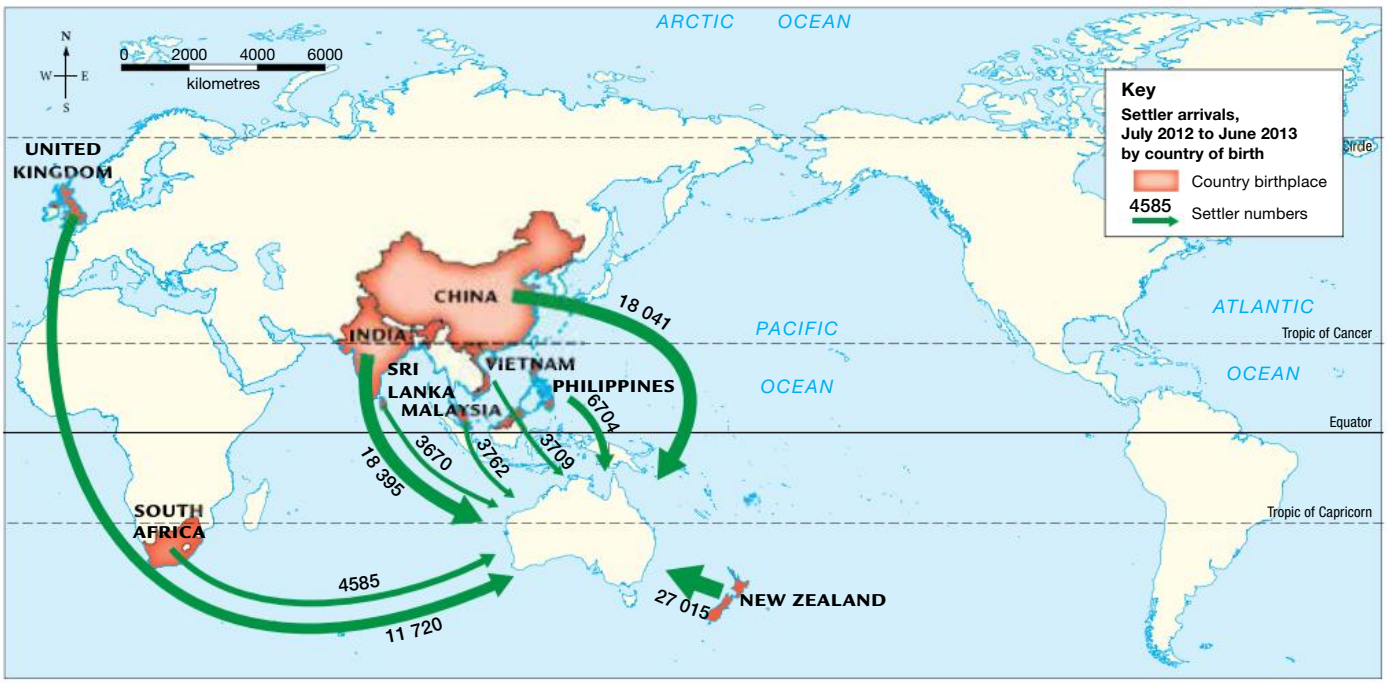
At first, migrants to Australia came exclusively from Europe (see figure 2); however, since 1975, the country has attracted more immigrants from Asia (see figure 3 and table 2). Despite this, the most common ancestries today are still English, Australian, Irish, Scottish and Italian (see table 1).

FIGURE 2 Origin of Australia's migrants, 1949–1959



Source: Spatial Vision

FIGURE 3 Settler arrivals July 2012 to June 2013 by country of birth



Source: Department of Immigration and Border Protection

TABLE 1 Ancestry of Australians, 2011

Ancestry (top responses)	Number of Australians	Percentage
English	7 238 533	25.9
Australian	7 098 486	25.4
Irish	2 087 758	7.5
Scottish	1 792 622	6.4
Italian	916 121	3.3

Source: © Australian Bureau of Statistics, licensed under a Creative Commons Attribution 2.5 Australia licence

Where have our migrants settled?

When they arrive, migrants tend to live in capital cities because of the greater availability of jobs and to be near family members, friends and people from the same country (see table 2). In 2011, 82 per cent of the overseas-born population in Australia lived in capital cities, compared with 66 per cent of all people in the country. About one-third of the population in our large cities was born overseas.

Overseas-born migrants who arrived in the past 20 years are more likely to live in a capital city than those who arrived before 1992 (85 per cent compared to 79 per cent).

TABLE 2 Top 10 birthplaces of Australians, 2011

Country of birth	Number of people	Percentage of state population	Percentage of state population living in capital city
United Kingdom	1 098 638	5.1	5.6
New Zealand	483 376	2.2	2.3
China	318 965	1.5	2.1
India	295 355	1.4	1.9
Italy	185 402	0.9	1.1
Vietnam	185 032	0.9	1.3
Philippines	171 223	0.8	1.0
South Africa	145 670	0.7	0.8
Malaysia	115 790	0.5	0.8
Germany	108 001	0.5	0.5

Source: Based on Australian Bureau of Statistics data (Census of Population and Housing 2011) © Commonwealth of Australia, licensed under a Creative Commons Attribution 2.5 Australia licence

Migrants from certain countries tend to be attracted to certain Australian states or territories more than others (see table 3). For example:

- more than half of all overseas-born people in Western Australia, South Australia and Tasmania were born in the United Kingdom and Ireland. Western Australia is the state with the highest proportion of its population having been born overseas, and is home to around one in five of all British-born migrants in Australia.
- Queensland has the greatest proportion of migrants born in Papua New Guinea and New Zealand
- nearly half of all Australian migrants born in Greece live in Victoria. People from Sri Lanka, Turkey and Greece also tend to live in Victoria. Victoria is home to the second-largest number of overseas-born people.
- New South Wales, Victoria and Western Australia account for about 80 per cent of Asian migrants.
- combined, Victoria and New South Wales are home to almost 80 per cent of migrants from Vietnam.

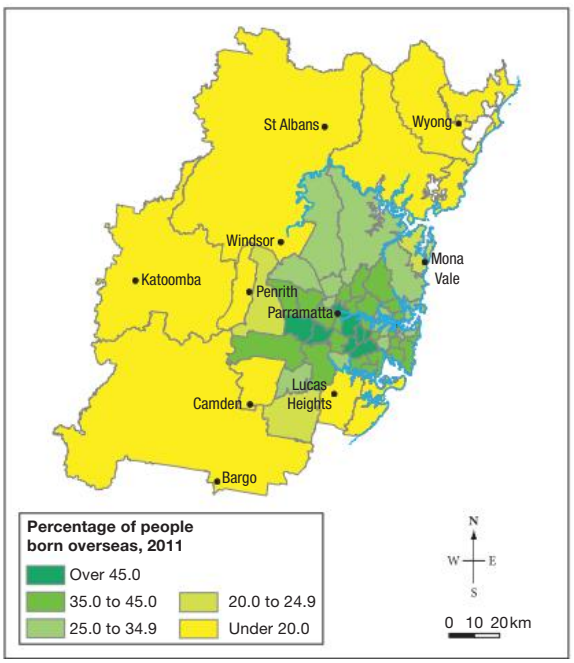
TABLE 3 Top five countries of birth by state or territory, 2006 and 2011

ACT	NSW	NT	QLD	SA	TAS	VIC	WA
United Kingdom	United Kingdom	United Kingdom	United Kingdom	United Kingdom	United Kingdom	United Kingdom	United Kingdom
China	China	New Zealand	New Zealand	Italy	New Zealand	India	New Zealand
India	New Zealand	Philippines	South Africa	India	China	China	South Africa
New Zealand	India	India	India	China	Germany	New Zealand	India
Vietnam	Vietnam	Greece/USA	China	New Zealand	South Africa/ India	Italy	Malaysia

Source: © Australian Bureau of Statistics

Not only have immigrants tended to settle in larger cities, they have settled in particular suburbs and regions within the capital cities. Many migrants have settled in inner Sydney, for example, and especially in western Sydney suburbs (see figure 4).

FIGURE 4 Percentage of Sydney residents born overseas, 2011



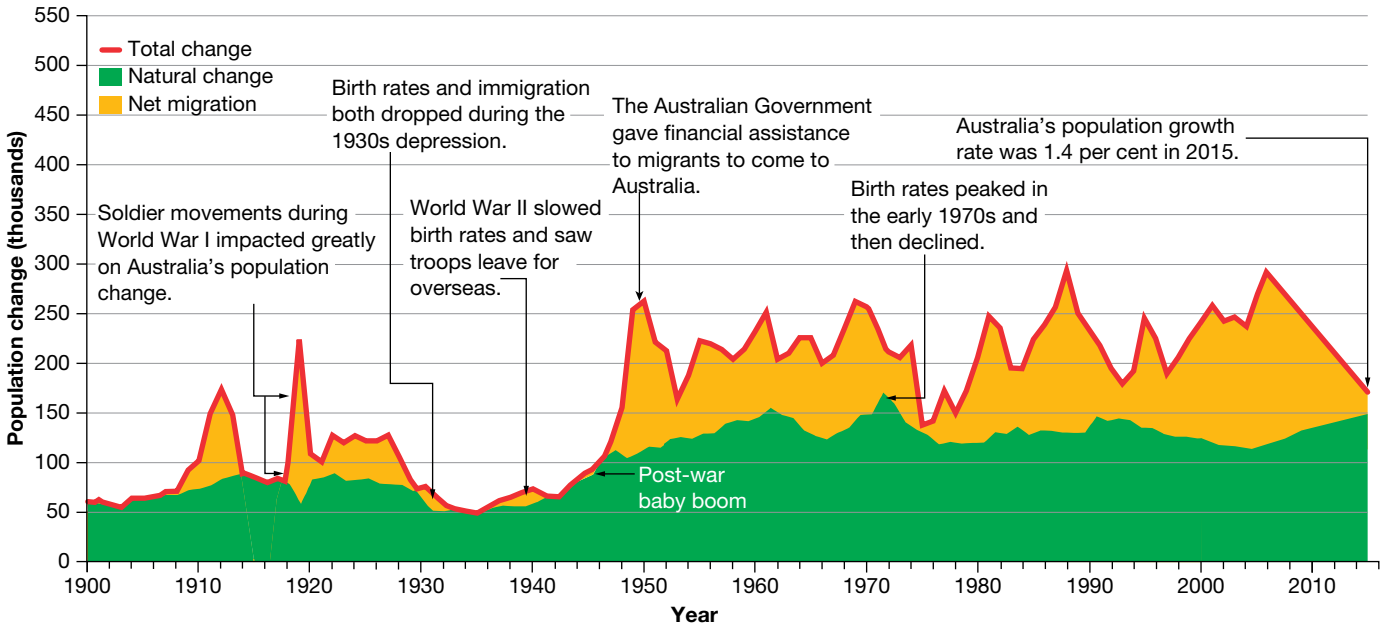
Source: Spatial Vision

8.9.3 Effects of international migration

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 5).

FIGURE 5 Australia's population growth, 1900–2014



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 which needs to respect and support each other's 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 allows businesses to expand. Apart from labour and capital (money), migrants also bring many skills to Australia (see figure 6).

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.

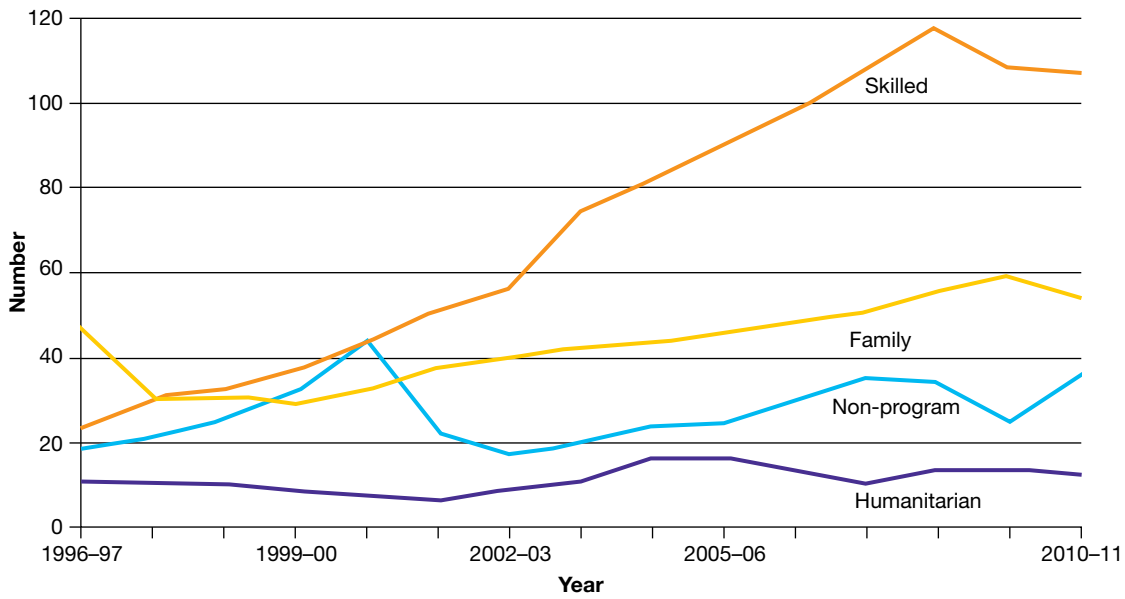


FIGURE 6 Types of migrants to Australia, 1996–2011

Source: © G. Hugo, *Australia's changing population and the future*, presentation to the Migration Institute of Australia Migration 2010 conference, Sydney, 8 October 2010, and advice provided by the author to the Parliamentary Library, March 2012. Data sources: ABS 2007, *Australian Social Trends*, DIAC 2009 and 2011

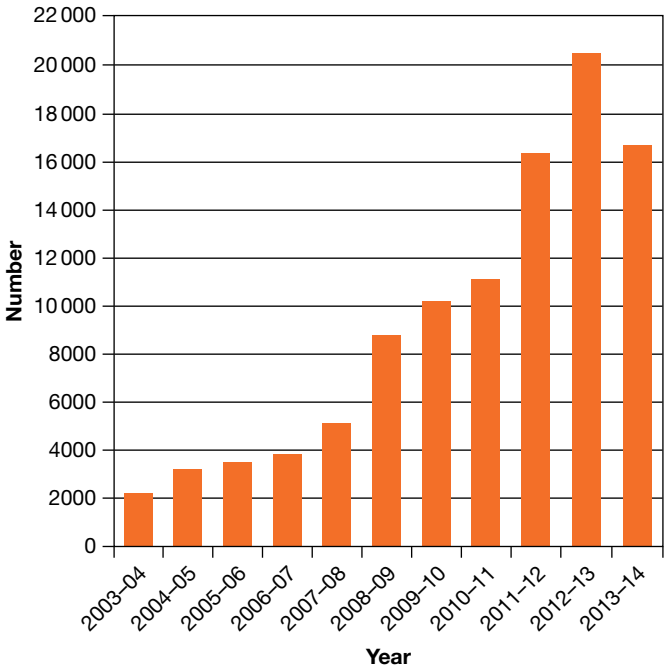
Environmental effects

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. Today, however, many people believe that Australia's environmental problems are not caused by migration and population increase, but by inadequate planning and management.

8.9.4 The future

Since 1995, the Australian government has been working to encourage new migrants to settle in regional and rural Australia. The Regional Sponsored Migration Scheme (RSMS) allows employers in areas of Australia that are regional, remote or have low population growth to sponsor employees to work with them in those regions (see figure 7). This takes the pressure off large cities and also provides regional employers with skilled workers. As we have seen, it has always been the case that most immigrants settle first in our cities, especially the state capitals. However, more migrants are now choosing to settle initially in regional areas. Around one in six new permanent arrivals are settling in regional Australia. There are many regional locations that want to attract migrants.

FIGURE 7 Migrants arriving under the Regional Sponsored Migration Scheme, 2003–14



Source: © Department of Immigration and Border Protection, 2014–15 Migration Programme Report

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ACTIVITIES

IDENTIFY

1. Using statistics, describe how Australia is truly a land of migrants.
2. Refer to figures 2 and 3. Describe how the origins of our migrants have ***changed*** since 1949.
3. Refer to figure 7. Describe how the number of migrants coming into Australia under the Regional Sponsored Migration Scheme has ***changed*** between 2003–04 and 2013–14.
4. Refer to table 3 and figure 4. Describe how the distribution of the areas of settlement by migrants varies within Australia.

EXPLAIN

5. Refer to figure 5. Describe how important migration has been in terms of Australia's population growth.
6. What do you consider to be the main reasons for why people would migrate to Australia?
7. What do you believe are the two main benefits of migration to Australia? Give reasons for your answer.

8.14 Review

8.14.1 Review

1. Describe the locations of the ***places*** in Australia that have the greatest population densities.
2. Describe the locations of the ***places*** in Australia that have the lowest population densities.
3. What is the ***interconnection*** between the location of regions with high population density and the distribution of rainfall within Australia?
4. How might a ***change*** in the patterns of rainfall distribution affect the location and density of population within Australia?
5. Use figure 2 in subtopic 8.2 and figure 2 in subtopic 8.3 to compare the population distribution of Aboriginal and Torres Strait Islander peoples with the distribution of rainfall in Australia.
   a. Describe the ***interconnection*** between these two maps.
   b. The Aboriginal and Torres Strait Islander peoples prior to the British invasion in 1788 had a significant population distribution in the wet tropical north of Australia. How does this compare to Australia's current population density in figure 1 in subtopic 8.2?
   c. Try to explain your answer to question 2 by referring both to figure 2 in subtopic 8.2 and to what you know about the Aboriginal and Torres Strait Islander peoples' rotational occupation of land.
   d. Prior to the British invasion in 1788, the Aboriginal and Torres Strait Islander peoples inhabited regions that are now inhabited by other people as well. Figure 2 in subtopic 8.3 shows that the distribution of Aboriginal and Torres Strait Islander peoples was in some ways quite different from that of other people (see figure 1 in subtopic 8.2). Describe and try to explain these differences in population distribution and density.
6. What does the term *urbanisation* mean?
7. What ***change*** over time has there been in the percentage of people living in urban areas?
8. Has growth in urban areas been even across the world?
9. What is the global pattern of urban growth along coastlines?
10. Is Australia an urbanised country? Describe where most of the population lives (refer to figure 1 in subtopic 8.5).
11. How has China been 'reshaped' by internal population movements? Comment on changing distribution patterns of where people live in your answer, and refer to specific ***places*** and provinces that have been affected.
12. Classify the reasons for rural–urban movements within China into economic, social and political factors. Which factor do you consider the most important? Explain why.
13. Refer to table 1.

TABLE 1 Population figures for cities in China (census figures), 1990–2010

City	1990 (1 July)	2000 (1 November)	2010 (1 November)
Shanghai	8 205 598	15 758 892	22 315 426
Beijing	7 362 426	8 503 385	11 716 000
Tianjin	5 804 023	8 146 128	11 090 314
Guangzhou	3 918 010	8 524 826	11 070 654
Shenzhen	875 176	7 008 831	10 357 938
Wuhan	3 832 536	8 312 700	9 785 392
Dongguan	—	6 445 777	8 220 237
Chengdu	3 483 834	5 267 817	7 677 122
Chongqing	3 122 704	6 158 790	7 457 600
Foshan	429 410	5 337 340	7 194 311

Source: National Bureau of Statistics, China

a. Construct a line graph using the data in table 1 to show how the population of the 10 largest cities in China has changed between 1990 and 2010.
b. Which city has had the quickest growth?
c. Which city had the smallest population increase in that period?
d. Refer to table 2. What do you notice about the ***scale*** of the population increase in China compared to that in Australia for the same period?

TABLE 2 Population figures for Australian capital cities in 1990 and 2010

City	Population 1990	Population 2010
Sydney	3 643 660	4 567 578
Melbourne	3 125 919	4 070 514
Brisbane	1 330 879	2 039 379
Adelaide	1 044 602	1 202 357
Perth	1 175 362	1 696 043
Hobart	189 039	214 551
Darwin	76 542	127 397
Canberra	281 099	358 494

14. How are settlement patterns between Australia and the United States:
    a. similar
    b. different?

8.14.2 Reflect

15. Study figure 1. Brainstorm and make a list of all the effects that urban growth might have on this coast.

FIGURE 1 Urban growth on the coast of Tel Aviv, Israel

16. Create a bar graph to show the data in table 3.

TABLE 3 Population change: components of total population growth rate 2008

	NSW	Victoria	Qld	SA	WA	Tasmania	NT	ACT	Australia
Natural increase (%)	0.66	0.68	0.84	0.48	0.89	0.52	1.31	0.91	0.72
Net overseas migration (%)	1.07	1.29	1.17	1.01	1.9	0.33	0.33	0.77	1.19
Net interstate migration (%)	–0.33	–0.02	0.5	–0.33	0.29	0.15	0.32	—	—
Total population growth (%)	**1.40**	**1.95**	**2.52**	**1.16**	**3.09**	**0.99**	**1.95**	**1.69**	**1.91**

   a. Which state or territory had most people who came from overseas (net overseas migration)?
   b. Which state or territory had most people who came from other states or territories in Australia (net interstate migration)?
   c. Which state or territory had the highest population increase due to natural births?
   d. Which state or territory had the highest population growth?

17. What might explain the similarities and differences between settlement patterns in Australia and the United States?
18. What do you think will be the main consequences of continued urbanisation in China in the future, if it continues at a similar rate as for the past 40 years:
   a. for China itself
   b. for countries that trade with China?
19. What are your predictions for the development of conurbations in the United States and Australia in the future? Explain your answer.

Smog over the city of Shanghai

CHAPTER 9

The rise and rise of urban settlements

9.1 Overview

9.1.1 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 — and along with opportunities come many problems. It is a challenge to create sustainable urban environments that meet the needs of the people living in these places.

Starter questions

1. Would you prefer to live in an urban rather than a rural area? Why or why not?
2. Ask other students or members of your family which they would prefer and why. Are their reasons similar or different?
3. List two positive and two negative things about living in a large city.
4. Study the photograph of the city of Shanghai on these pages.
   - **a** What do you think it would be like to live in this ***place***?
   - **b** How might this ***place*** be connected to other ***places***?
   - **c** How do you think this ***place*** has ***changed*** from the past? How might it ***change*** in the future?

Inquiry sequence

		Syllabus outcomes
9.1 Overview		
9.2 Where are the world's cities?		GE5-2, GE5-3
9.3 **SkillBuilder:** Describing photographs	eBook plus ONLINE ONLY	GE5-7
9.4 **SkillBuilder:** Creating and reading compound bar graphs	eBook plus ONLINE ONLY	GE5-7
9.5 Why do people move to urban areas?		GE5-2, GE5-3
9.6 How do urban areas affect people's ways of life?		GE5-3
9.7 **SkillBuilder:** Constructing a basic sketch map	eBook plus ONLINE ONLY	GE5-8
9.8 Where are the world's megacities located?		GE5-3
9.9 What are the characteristics of cities in South America?		GE5-3
9.10 **Investigating topographic maps:** What is the city of São Paulo like?		GE5-7
9.11 What are the characteristics of cities in the United States?		GE5-3
9.12 What are the characteristics of cities in Europe?		GE5-3
9.13 How do people shape places in Australia?		GE5-5
9.14 How can cities become sustainable?	eBook plus ONLINE ONLY	GE5-5
9.15 **Review**	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Watch this video
Megacities and megaregions
Searchlight ID: eles-1629

9.2 Where are the world's cities?

9.2.1 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.

FIGURE 2 Medellin, the second-largest city in Colombia, South America

This image of the Earth at night (figure 1) 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 term urban is defined differently around the world. In Australia, 'a settlement with 1000 or more inhabitants' is defined by the United Nations as urban. In contrast, Peru uses a definition of 'populated centres with 100 or more dwellings'.

FIGURE 1 Satellite image of the Earth at night

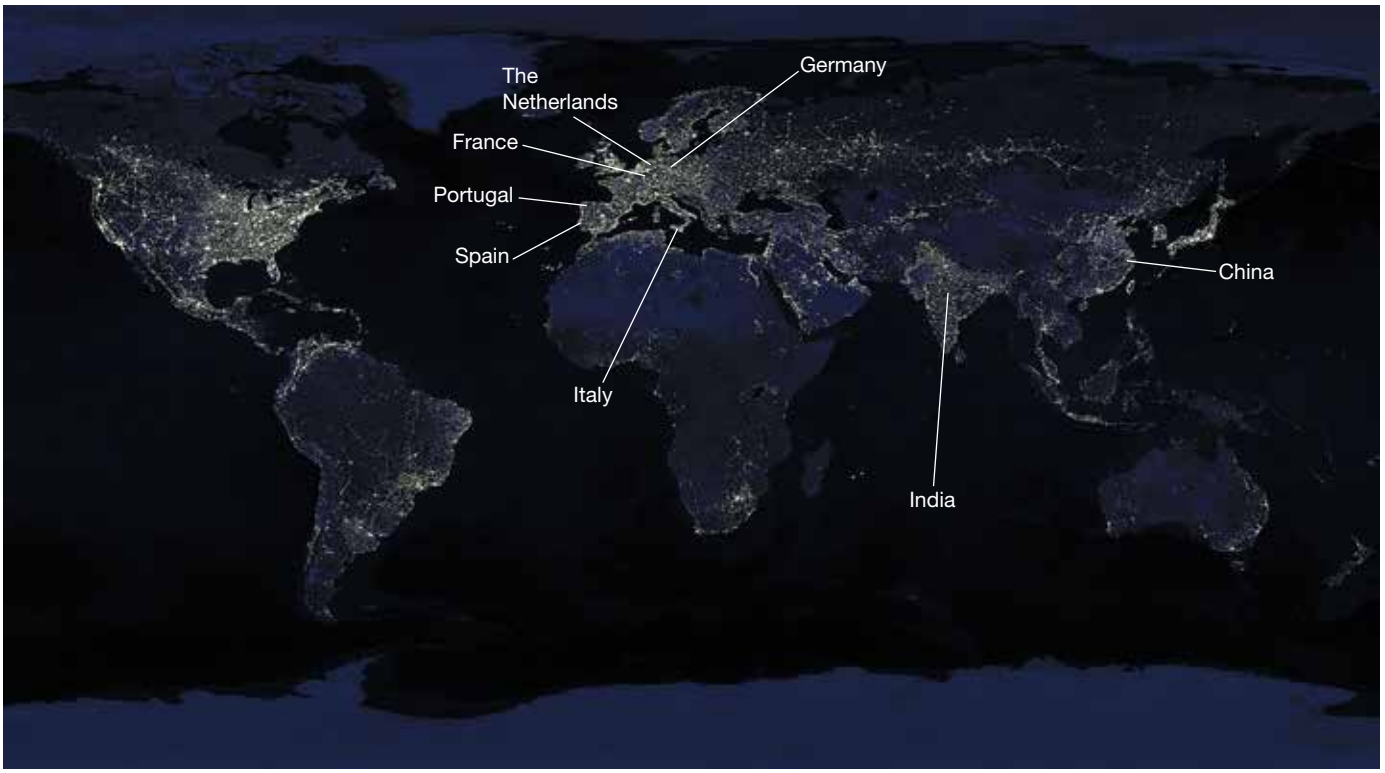
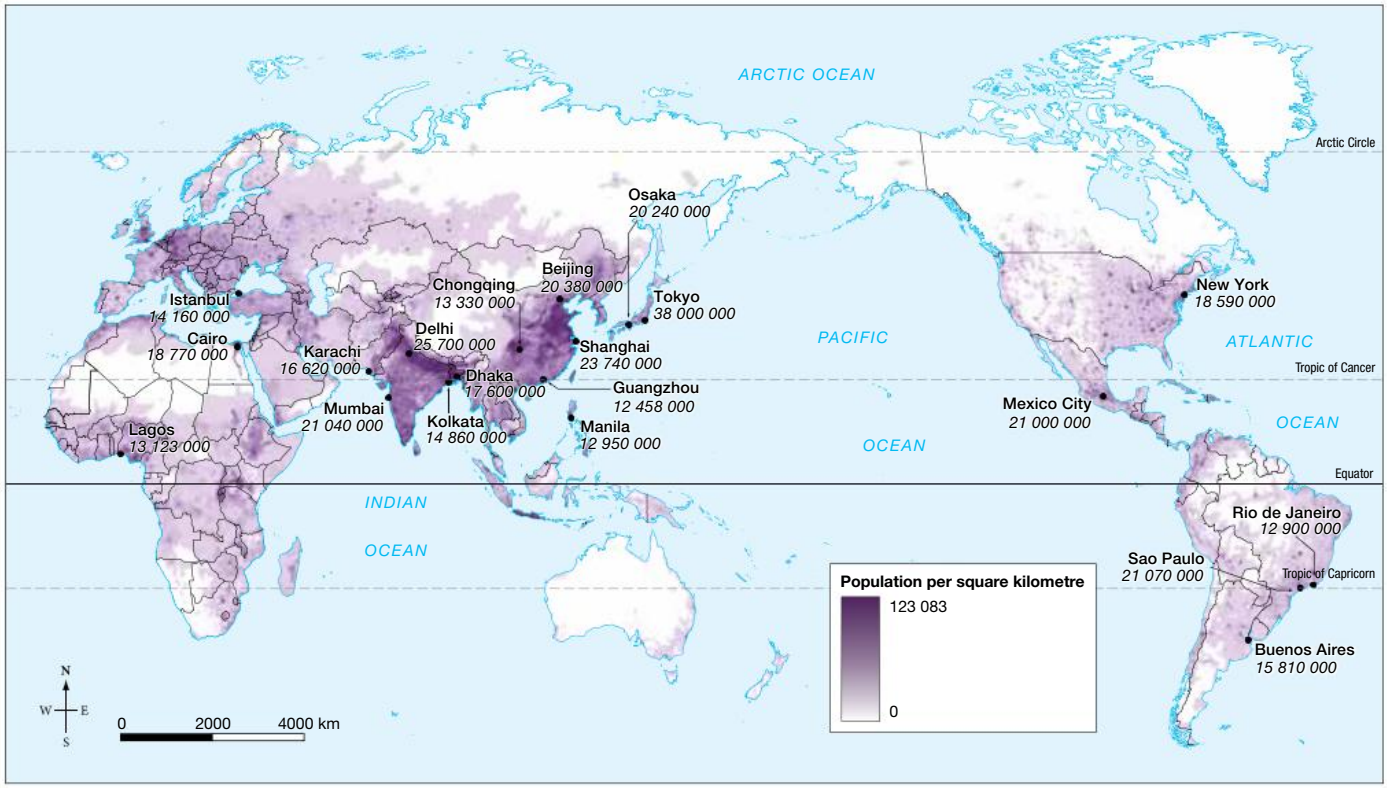


FIGURE 3 Distribution of urban centres, 2015, with selected city populations



Source: United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, CD-ROM Edition.

ACTIVITIES

IDENTIFY

1 How is a city different from a town or a village?
2 What do the bright lights in figure 1 show?

EXPLAIN

3 Study figures 1 and 3 and refer to a political map in your atlas. Which of the following statements are true and which are false? Rewrite the false statements to make them true.
- **a** Japan is a highly populated country with many cities.
- **b** The west coast of the United States is more densely populated than the east coast.
- **c** The Amazon rainforest does not have any settlements.
- **d** The eastern region of China has more cities than the western region.
- **e** The main city settlements in Australia are along the east coast.
- **f** The distribution of cities across Europe is uneven.

4 After completing the 'Describing photographs' SkillBuilder in your eBookPLUS, complete the following questions about figure 2.
- **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 chapter 13 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 'greenfield sites'? Where are they and why are they there? Do you think they should be protected from development? Justify your answer.

APPLY

5 Use a political map in your atlas and figure 1 to identify the following.
- **a** The Nile River
- **b** The Trans-Siberian railway from Moscow to Vladivostok
- **c** Highways linking cities in the western and eastern United States
- **d** The Himalayan mountain range

INVESTIGATE

6 Refer to the **Urban definition** weblink in your eBookPLUS. Select three countries from the list, to describe the different definitions of urban. Why are the definitions of these countries so different?

eBookplus

Weblink
Urban definition

eBook*plus* ONLINE ONLY

9.3 SkillBuilder: Describing photographs

What is meant by 'describing a photograph'?

Describing a photograph involves giving 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.

eLesson

Watch this video to learn how to describe a photograph.

Searchlight ID: eles-1660

Interactivity

Try this interactivity to learn how to describe a photograph.

Searchlight ID: int-3156

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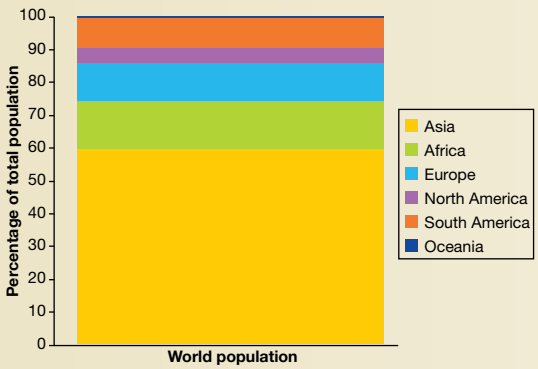
9.4 SkillBuilder: Creating and reading compound bar graphs

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. Compound bar graphs allow us to see at a glance the various components that make up the total.



eLesson

Watch this video to learn how to create and read compound bar graphs.

Searchlight ID: eles-1705

Interactivity

Try this interactivity to learn how to create and read compound bar graphs.

Searchlight ID: int-3285

9.5 Why do people move to urban areas?

9.5.1 Push factors

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.

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.

migration the movement of people (or animals) from one location to another

push factor unfavourable quality or attribute of a person's current location that drives them to move elsewhere

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.

9.5.2 Pull factors

pull factor favourable quality or attribute that attracts people to a particular location

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.

FIGURE 2 Examples of pull factors include religious tolerance, improved healthcare, job opportunities, family links, better housing and infrastructure, political freedom and better educational opportunities.

CASE STUDY 1

Rural–urban migration in India

More than 250 million Indian people migrate within their country at some time in their life. Although most movements are only short distances from the family home, more than 40 million Indians move to another state. The largest number of people (around 40 per cent) are attracted to the largest cities — Delhi and Mumbai. These cities are located in the richer states (those with a higher Gross State Domestic Product, or GSDP), therefore attracting more workers. The population density of Mumbai is 20 694 people per square kilometre, while that of Delhi is 25 535.

FIGURE 3 Urban and rural migration in India

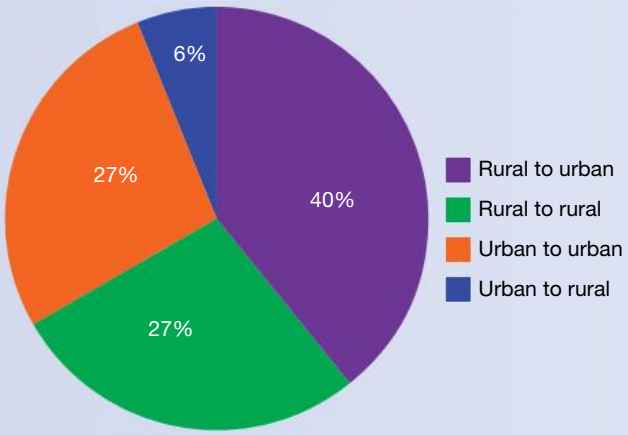
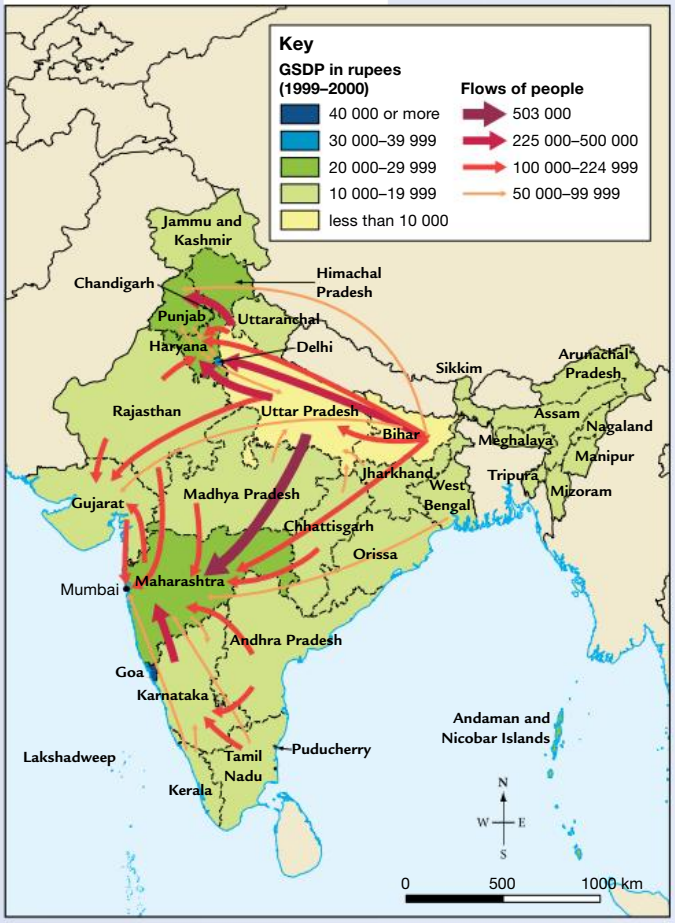


FIGURE 4 Migration flows in India



Source: Spatial Vision

FIGURE 5 India's largest city.

FIGURE 6 These migrants are working in a fish-cleaning station in Dubai, United Arab Emirates

9.5.3 Which cities attract workers?

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 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, many working in building construction. These labourers — mostly from India, Pakistan and Bangladesh — live in migrant camps that can be up to two hours away from the work site. They are often poorly paid.

TABLE 1 The 25 gateway cities with the largest foreign-born population

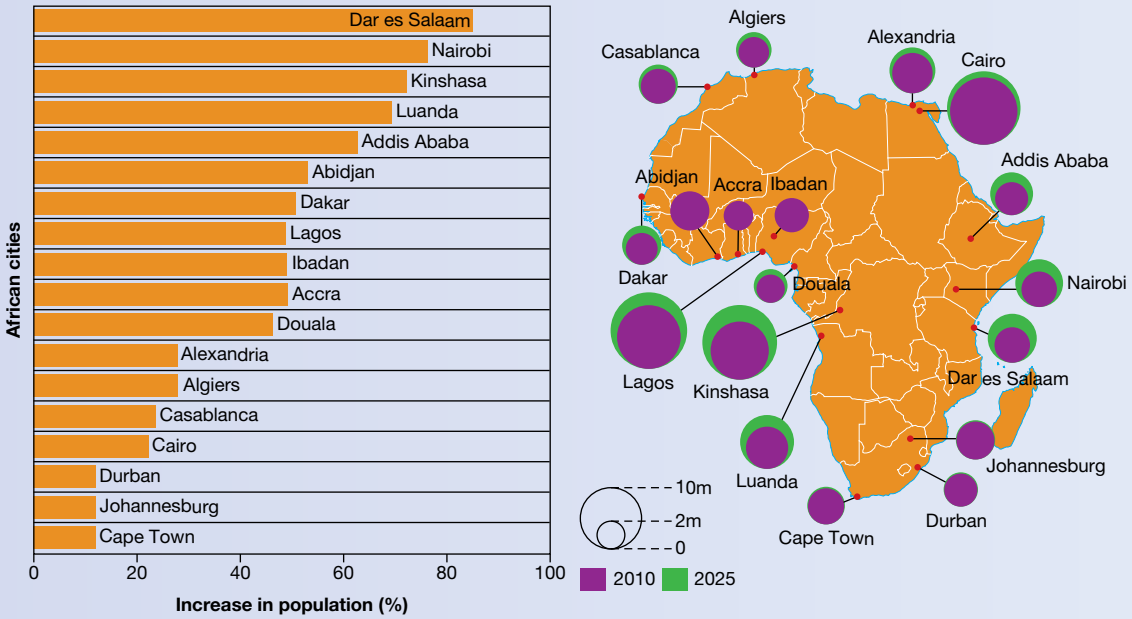
Continent	Gateway city/cities
North America	Toronto, Vancouver, New York, Los Angeles, Chicago, Boston, Washington DC, Miami, Dallas, Houston, San Francisco, Riverside
South America	Buenos Aires
Europe	London, Paris, St Petersburg, Moscow
Africa/Middle East	Jeddah, Riyadh, Dubai, Tel Aviv – Yafo
Asia	Hong Kong, Singapore
Oceania	Sydney, Melbourne

CASE STUDY 2

Growth of cities in Africa

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. Africa's urban population is expected to double between 2000 and 2030. By 2050, the urban population is expected to triple from 400 million people to 1.2 billion. Over half of the urban population is below the poverty line in Angola, Chad, Madagascar, Malawi, Mozambique, Niger, Sierra Leone and Zambia. In many other countries, including Burundi, Gambia, Kenya and Zimbabwe, 40–50 per cent of the population are living below the poverty line.

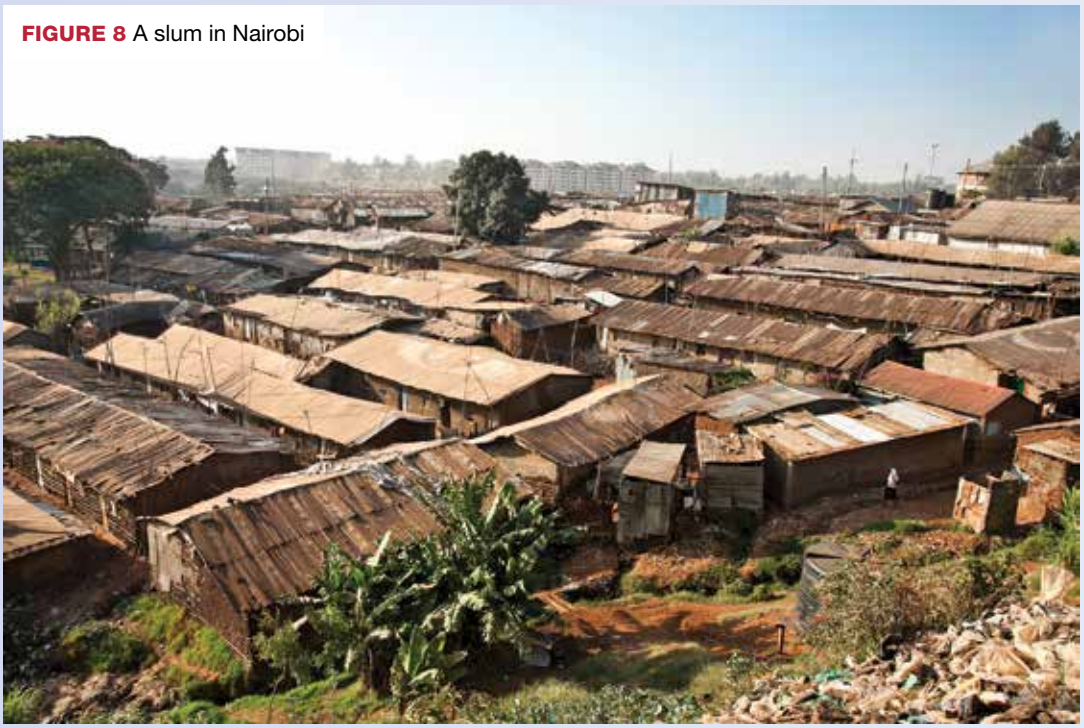
FIGURE 7 The projected growth of African cities from 2010 to 2025



Source: Based on data from The UN habitat, UN DESA World population prospects report and Africastrictlybusiness.com.

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 Kigali 60–70 per cent of the population live in slum conditions, which occupy about five per cent of the land.

FIGURE 8 A slum in Nairobi



9.5.4 Regional differences

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 the number of deaths was higher than the number of births, and migrants provided most of the population growth. London was a typical example of this, as was New York, where urban growth has slowed.

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.

In the cities people can access basic services, such as health and education, more easily than in rural places. 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.

ACTIVITIES

IDENTIFY

1 What are push factors? What are pull factors? Give two examples of each.
2 Match each of the images in figures 1 and 2 with the push or pull factors listed in the captions.
3 What is a gateway city? Why are people attracted to them?

EXPLAIN

4 What does figure 3 tell you about the urban and rural movement of Indian people?

eBook*plus*

Interactivity
Urban push and pull factors
Use this interactivity to check your understanding of push and pull factors.
Searchlight ID: int-3118

5 Figure 4 shows a relationship between the movement of people and the wealth (indicated by GDP) of the states they are moving to and from.
- **a** Have people moved to or from low-GDP states? Give two examples.
- **b** Where are the main flows of people occurring? How many people moved to Maharashtra?
- **c** What might be the main reason for movements from poor states to rich states?

6 Study figure 7 and refer to an atlas map of Africa.
- **a** Name the three largest African cities in 2010 and the three predicted to be largest in 2025. In which countries are they located?
- **b** 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? List the countries that do not have large cities.
- **c** What does it mean to live below the poverty line? Locate the cities in which more than half the population is living below the poverty line.

7 What is the difference between urban population increase from migration and from natural increase? Which of these is more likely to occur in a city located in a developing country? Why?

APPLY

8 Use an atlas to locate all the gateway cities mentioned in table 1, and then mark their locations on a blank map of the world. When your map is complete, describe the distribution of the major gateway cities around the world.

9 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? List all the ways in which living in one of these Indian cities might be different to life in your local city.

INVESTIGATE

10 Look at figure 8. Draw a sketch of this scene and annotate it with geographical questions you would like answered about the ***environment*** and the people living there.

11 What do you think is the future ***sustainability*** of the ***place*** shown in figure 8, especially if the population of this city is going to increase?

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9.6 How do urban areas affect people's ways of life?

9.6.1 The wealth of cities

Both small and large urban areas can provide people with positive and negative experiences.

Cities attract people to them with the opportunity of work and the possibility of better housing, education and health services. There is a strong interconnection between the wealth of a country and how urbanised it is. Generally, countries with a high **per capita income** tend to be more urbanised, while low-income countries are the least urbanised.

per capita income average income per person; calculated as a country's total income (earned by all people) divided by the number of people in the country

This happens because people grouped together create many chances to move out of poverty, generally because of increased work opportunities. There are often better support networks from governments and local councils. It is also cheaper to provide facilities such as housing, roads, public transport, hospitals and schools to a population concentrated into a smaller area.

9.6.2 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.

sanitation services provided to remove waste such as sewage and rubbish

Slums

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:

slum a run-down area of a city characterised by poor housing and poverty

> … 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.

Water and sanitation

Many cities cannot keep up with more and more people living in urban areas, which means it is difficult to provide water and toilets for everyone (see table 1). Without these services, more people suffer from diseases and poor health and are unable to go to work or school.

TABLE 1 Availability of water and sanitation in selected regional cities around the world

	Water on premises (%)		Flush toilets (%)	
	Urban poor	Urban non-poor	Urban poor	Urban non-poor
Latin America	59	74	44	67
Sub-Saharan Africa	31	46	20	32
South, Central and West Asia	59	74	48	60
South-east Asia	36	50	67	88

9.6.3 Transport and pollution

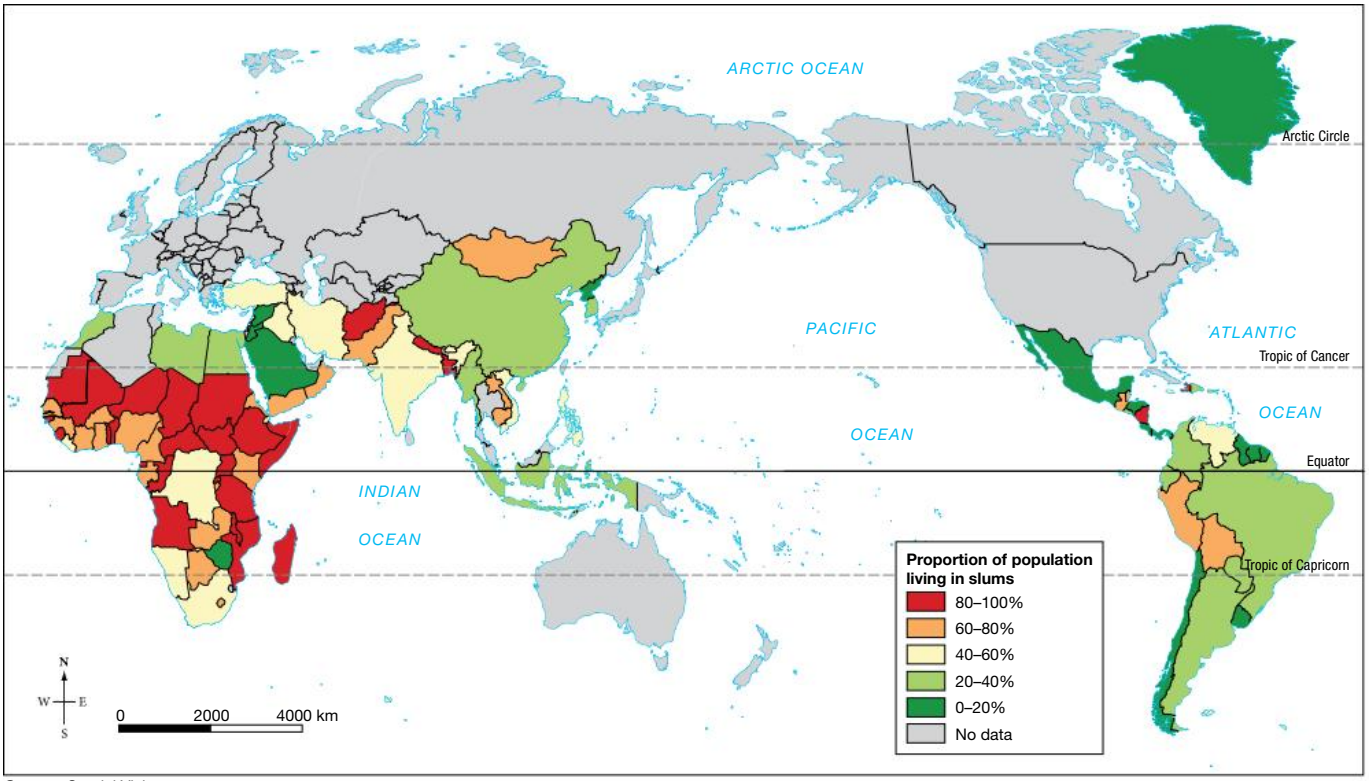
In cities that can't keep up with rapid population growth, traffic congestion and overcrowded public transport mean that many people must travel for hours to get to and from work (see figure 1).

Pollution is also a problem that affects the health of people living in cities. Most 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 Bank, 16 of the world's 20 cities with the worst air are in China. The burning of coal is the main source of air pollution in China.

FIGURE 1 Traffic congestion and smog in Beijing's Central Business District

FIGURE 2 World urban population living in slums



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 What is a slum? Make a list of some other names for slums.

2 Why are transport and pollution often problematic in large urban areas?

EXPLAIN

3 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 using Google Maps or Google Earth.

4 Study figure 2.

a In which continent are the most urban slums found?

b Name three countries in this continent with very high numbers of slums.

c Describe the general pattern shown in the map.

5 **a** Draw a graph to illustrate the water and sanitation data for urban areas given in table 1.

b Describe the relationship between poor and non-poor people in urban areas and their access to clean water and toilets.

APPLY

6 Use figure 3 in subtopic 9.2 and the *myWorld Atlas* statistical mapper to find the relationship between urbanisation and wealth. Give five examples of countries from different continents that are highly urbanised and wealthy, and five that are not urbanised and poor. Do any countries not fit this pattern? Name them.

7 Which Australian city do you think would have the worst:

a transport problems

b pollution?

Justify your choice. Conduct some research to find out which city has the worst data for these two urban problems.

8 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.

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. ➲ Mexico City

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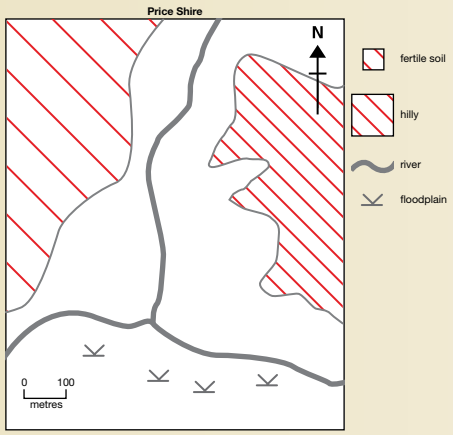
9.7 SkillBuilder: Constructing a basic sketch map

What is a basic sketch map?

A basic sketch map is a map drawn from an aerial photograph or developed during fieldwork 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.



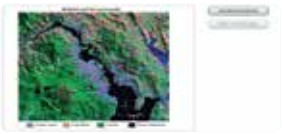
eLesson

Watch this video to learn how to construct a basic sketch map.

Searchlight ID: eles-1661

Interactivity

Try this interactivity to learn how to construct a basic sketch map.



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9.8 Where are the world's megacities located?

9.8.1 What is a megacity?

Over the next century, urbanisation is predicted to increase at an even greater rate than it has in the past. Forty years ago, only one third of the world's population lived in urban areas — now this figure is just over one half. Many of these people are attracted to cities with huge populations, and increasingly these cities are becoming megacities.

A **megacity** is a city with more than 10 million inhabitants. When you consider that Australia's population is around 23 million — with around 4.5 million of those living in our largest city, Sydney — it is hard to imagine what it would be like to live in a megacity.

megacity city with more than 10 million inhabitants

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 2015 there were 34 megacities. In another 15 years it is predicted that there will be 26 megacities. Many of these cities exceed the megacity definition and have a population greater than 15 million.

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 2015, 17 of the 29 existing megacities were found in Asia, home to 53 per cent of the world's urban population (see figure 2). It is predicted that by 2030 there will be 41 megacities in the world.

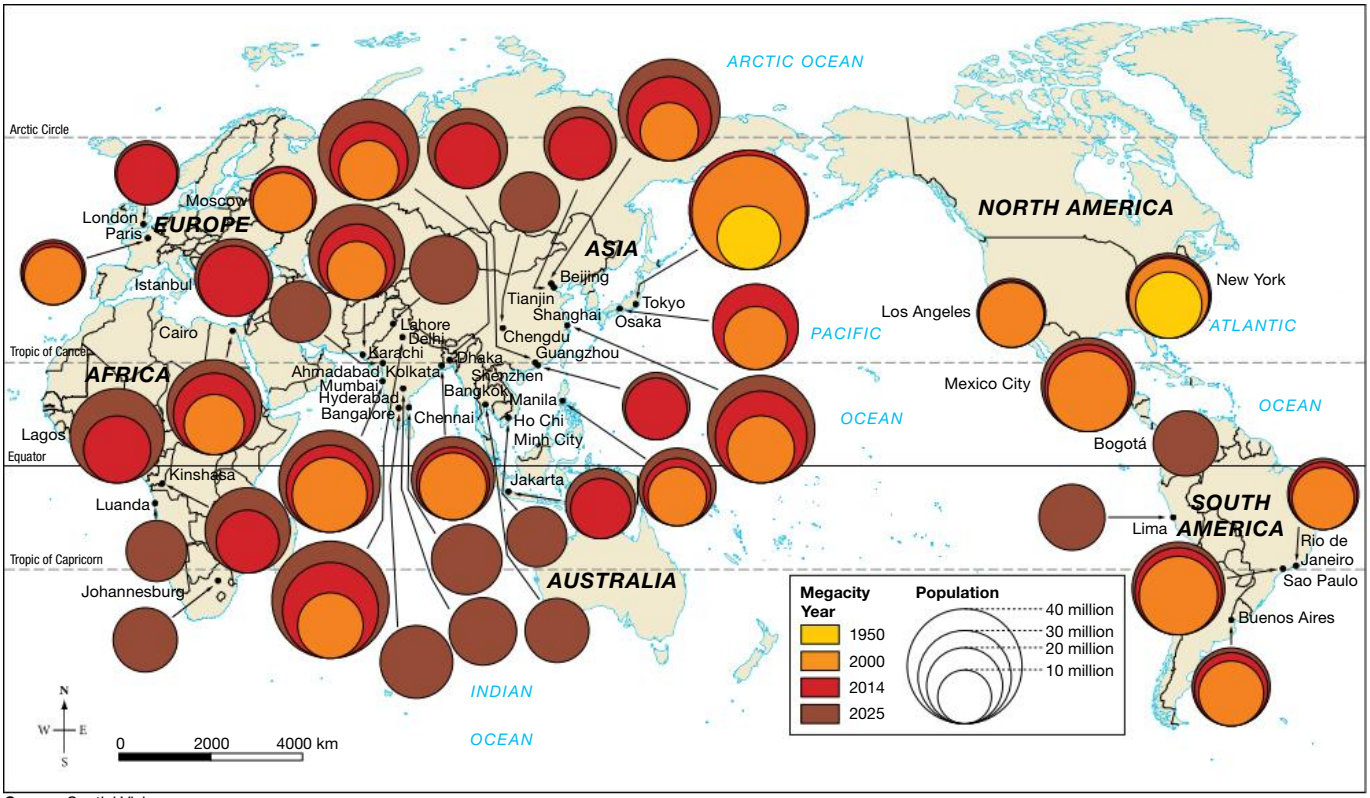
The never-ending city

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 around 120 million people
- Nagoya–Osaka–Kyoto–Kobe in Japan, expected to be home to around 60 million people by 2015
- Rio de Janeiro–São Paulo in Brazil, with a population of 43 million people.

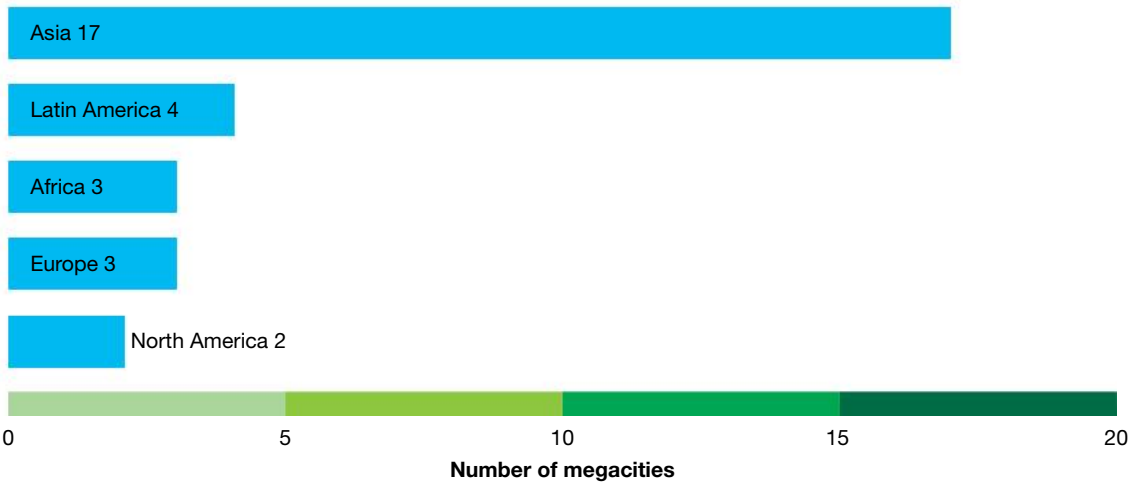
megaregion area where two or more megacities become connected as increasing numbers of towns and ghettos develop between them

FIGURE 1 The growth of megacities over time



Source: Spatial Vision

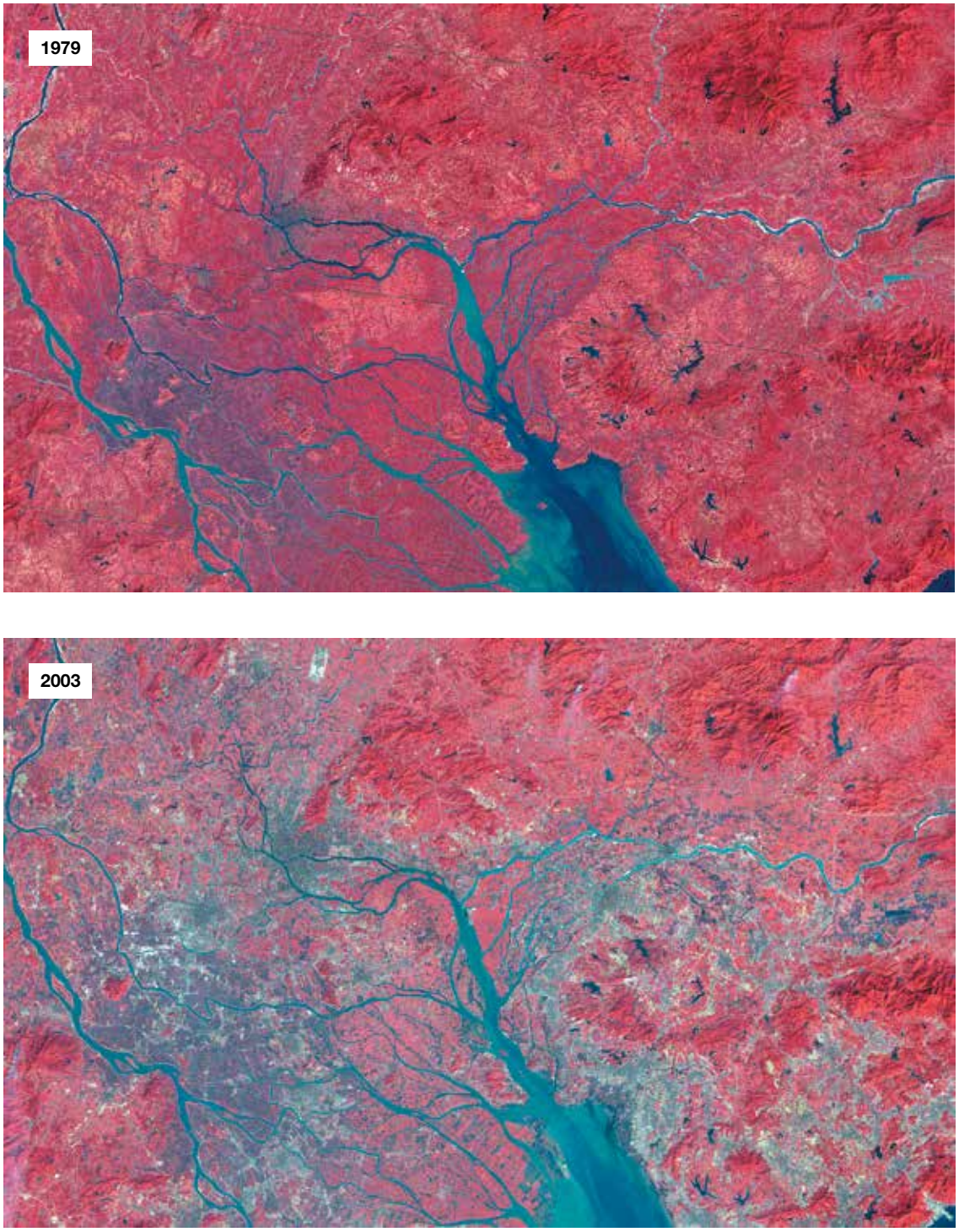
FIGURE 2 Most megacities are located in the Asian region.



Hong Kong–Shenzhen–Guangzhou

This region is located in southern China on the South China Sea. The three main cities are Hong Kong, Shenzhen and Guangzhou, which are linked by transport routes and provide great economic opportunities. Until 1979, Shenzhen was a fishing village. In 1980 the government declared the area to be a special economic zone, 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 3).

FIGURE 3 Change between 1979 and 2003 in the Pearl River delta. In these false-colour images, red indicates vegetation, blue indicates water, pale blue indicates shallow or sediment-laden water, and grey indicates buildings and paved surfaces.



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.

FIGURE 4 The city of Shenzhen, in the Pearl River delta, in the twenty-first century

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Interactivity
Megacity march
Use this interactivity to see the dramatic growth of megacities over time.
Searchlight ID: int-3119

ACTIVITIES

IDENTIFY

1 What is a megacity? How many megacities were there in 2015?
2 Name the first two megacities and the countries where they are located.
3 What is a megaregion?

EXPLAIN

4 Refer to figure 1. Describe how the number and distribution of megacities has ***changed*** over time.

APPLY

5 Use an atlas to locate the three megaregions mentioned in this section. Why do these regions develop?
6 Study figure 3. Research the 'dead zone' in the sea at the mouth of the Pearl River. What does this mean, and what is its cause?

PREDICT

7 Describe the ***changes*** that have occurred in the Hong Kong–Shenzhen–Guangzhou 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.
8 What impact will this urban area have on people and the ***environment***?

INVESTIGATE

9 Work with another student to produce a Prezi or PowerPoint presentation or an animation showing the world's megacities in 2010 and as predicted in 2025. Include images from the internet and data from figure 1. You may like to choose appropriate music to accompany the presentation.

9.9 What are the characteristics of cities in South America?

9.9.1 Urbanisation in South America

Megacities are primarily a phenomenon of the developing world, where their populations are increasing by between one and five per cent every year. If this continues, it is predicted that 41 megacities will exist by 2030 — and most will be located in the developing world, including countries in South America.

In recent years, the pace of urbanisation has been more rapid in South America than in North America and Europe. One hundred years ago, Buenos Aires was the only South American city with a population larger than one million. By 2015 there were 45 cities of this size. The five largest cities are São Paulo, Rio de Janeiro, Buenos Aires, Lima and Bogotá, with the first three defined as megacities.

These cities are a typical result of the urbanisation process occurring in South America, where the fastest population growth occurred between 1950 and the 1990s. The combined urban population of these five cities is just over 60 million, one-fifth of South America's total urban population.

FIGURE 1 South America's urban population has kept up with total population growth.

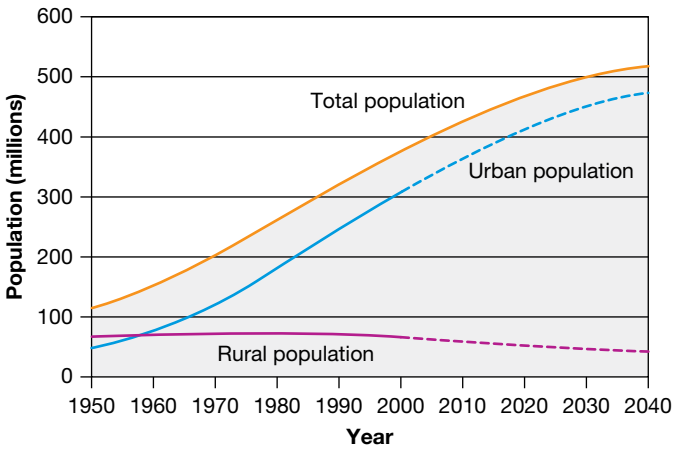
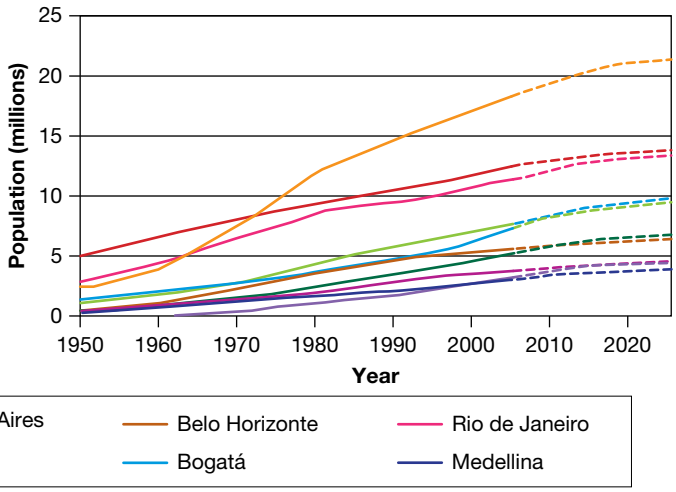


FIGURE 2 There are a number of very large cities in South America, which continue to increase in size.



CASE STUDY

São Paulo

São Paulo is the most populated city in Brazil located on a plateau on the south eastern coast of Brazil in South America (see figure 3). From 1950 to 1980, São Paulo's population quadrupled from two million to more than eight million people. Its population is sprawled over an area of 7951 square kilometres (the city centre alone takes up an area of 1502 square kilometres). Compare this with Melbourne, which covers a total of 1705 square kilometres, and Sydney, with an area of 1120 square kilometres.

FIGURE 3 The sprawling city of São Paulo

TABLE 1 Growth of São Paulo's population from 1950 to 2025 (predicted)

Year	Population	Percentage of Brazil's urban population
1950	2 528 000	12.8
1955	3 521 000	13.7
1960	4 876 000	14.7
1965	6 380 000	14.8
1970	8 308 000	15.3
1975	10 333 000	15.5
1980	12 693 000	15.6
1985	13 844 000	14.4
1990	15 100 000	13.7
1995	16 469 000	13.2
2000	17 962 000	13.0
2005	19 591 000	12.9
2010	20 262 000	12.5
2025 (predicted)	21 651 000	12.0

metropolitan region an urban area that consists of the inner urban zone and the surrounding built-up area and outer commuter zones of a city

The population density of São Paulo is 2420 people per square kilometre in the **metropolitan region** and 7216 in the inner-city district. São Paulo's population was 20 262 000 in 2010.

An average of 36 per cent of people in South America live in favelas (a term commonly used in Brazil meaning 'slums'). This is a real challenge for these countries as they try to provide adequate housing, sanitation and other services to the urban poor.

FIGURE 4 Traffic congestion is a challenge for residents of São Paulo.

Coffee production has attracted many workers and investors from throughout Brazil and many other countries to São Paulo. Today, many of the city's residents are direct or indirect descendants of immigrant groups including Italian, Portuguese, African, German, Lebanese and Japanese. São Paulo is home to the largest number of Japanese people outside Japan and the largest Lebanese population outside Lebanon.

Urban problems

São Paulo has grown rapidly and in an unplanned manner, leaving little space for highways and parks. Six million cars contribute to crippling traffic congestion and choking levels of air pollution in the city. Some residents in outer city areas in São Paulo can spend between two and three hours each way commuting to and from work.

Air pollution levels in São Paulo are twice as high as those of New York City and London, even though Paulistanos (the name for people who live in São Paulo) have relatively low carbon emissions per capita. The city also faces a severe shortage of fresh water. Some residents tap into underground water reserves in a desperate bid to access a supply of fresh water.

Strategies to manage the problems

Extreme wealth, as well as extreme poverty, exists in São Paulo, the most populated city in the southern hemisphere. A number of wealthy elite live in luxury and avoid traffic congestion by travelling to and from work in helicopters. São Paulo has 193 heliports across the city (see Figure 3). The rate of helicopter ownership in São Paulo is the highest per capita in the world. There is increasing use of drone technology in São Paulo for security purposes. Air quality issues are being addressed by number plate rationing of the number of cars allowed to travel on São Paulo's roads each week.

FIGURE 5 The location of São Paulo in Brazil

Source: Spatial Vision

Living in poverty

Brazilian and overseas migrants who move to São Paulo with hopes of a better life often find it very difficult to find work and end up living in poverty. Around 3 million people live in favelas in São Paulo and surrounding areas. These favelas are located near gullies, on floodplains, on riverbanks, along railways, beside main roads and next to industrial areas.

Floods are common in São Paulo because there are very few green spaces to soak up the water. Air pollution is high and the two major rivers crossing the city are severely polluted, although these rivers are currently being cleaned up. The shortage and condition of the water supply are serious problems, especially for the urban poor living in favelas in São Paulo.

FIGURE 6 Extremes of wealth and poverty in São Paulo. The Paraisópolis favela, home to 60 000 people, is situated next to the gated complexes of the wealthy Morumbi district.

ACTIVITIES

IDENTIFY

1 Why have people been attracted to São Paulo?

EXPLAIN

2 Refer to figure 1 to describe South America's population growth. How does this compare to the population ***change*** in cities within the continent, shown in figure 2?

3 Study figure 5. Describe São Paulo's location within both South America and Brazil.

4 Use table 1 to draw a graph showing the growth of São Paulo's population. When did the greatest growth take place? What percentage of Brazil's urban population lives there?

5 What is a favela? In which general areas are favelas located in São Paulo? Why do you think they are located in these ***places***?

6 Look at figures 3 and 6. What do you think it would be like to live in such ***environments***?

PREDICT

7 Use the **Growth of São Paulo** weblink in your eBookPLUS to learn how this city has grown over time. Where might future growth occur? Use the maps and images in this section to help you.

INVESTIGATE

8 Use the **BubbleUs** weblink in your eBookPLUS to brainstorm the urban problems experienced in São Paulo. Refer to the text and photographs in this section to help you get started.

9 Use the **São Paolo** weblink in your eBookPLUS to watch the video.

a Make a list of the projects that are trying to reduce urban problems in São Paulo. Rank these from 1 to 5, with 1 being the most effective and 5 the least. Justify your choices.

b Compare your rankings with those of other students and discuss any similarities or differences.

eBook*plus*

Weblinks

- Growth of São Paulo
- BubbleUs
- São Paulo

9.10 What is the city of São Paulo like?

9.10.1 The biggest city in the southern hemisphere

São Paulo is a large, vibrant urban centre located in the South American country of Brazil. It is considered to be the most populated city in the southern hemisphere and the wealthiest state of Brazil. São Paulo is very multicultural and many parts of the city reflect the rich cultural heritage of Italian, Portuguese, Spanish, and Japanese influences. Japan Town is a popular tourist destination offering traditional Japanese food and markets in streets decorated with distinctive architecture.

São Paulo is located in the south east of Brazil on elevated land more than 800 metres in altitude. Figure 1 shows the sprawling urban spread of São Paulo and nearby Santos, South America's largest port area. Despite the extensive growth of the city, the last area of coastal rainforest has been preserved in the Parque Trianon.

FIGURE 1 The built up-area can clearly be seen in this satellite image of São Paulo.

ACTIVITIES

IDENTIFY

1 Give the area reference for Guarulhos International airport.
2 Give the grid reference for four mine sites shown on the map.
3 Give the direction of Santos from the central part of São Paulo.
4 Record the highest and lowest elevations in São Paulo's built-up area.
5 What evidence supports the fact that São Paulo is located on a plateau?

EXPLAIN

6 Name one river that flows from the plateau to the sea and one that flows inland.
7 Describe where the steepest land is located.
8 Describe the rail and road routes from the coast to São Paulo. How can you explain the pattern shown?

APPLY

9 Use tracing paper to make a sketch of the built-up area of São Paulo, including the grid squares. Shade the built-up area and use the ***scale*** to calculate the area covered by one grid square on the map. Calculate the total area of São Paulo.

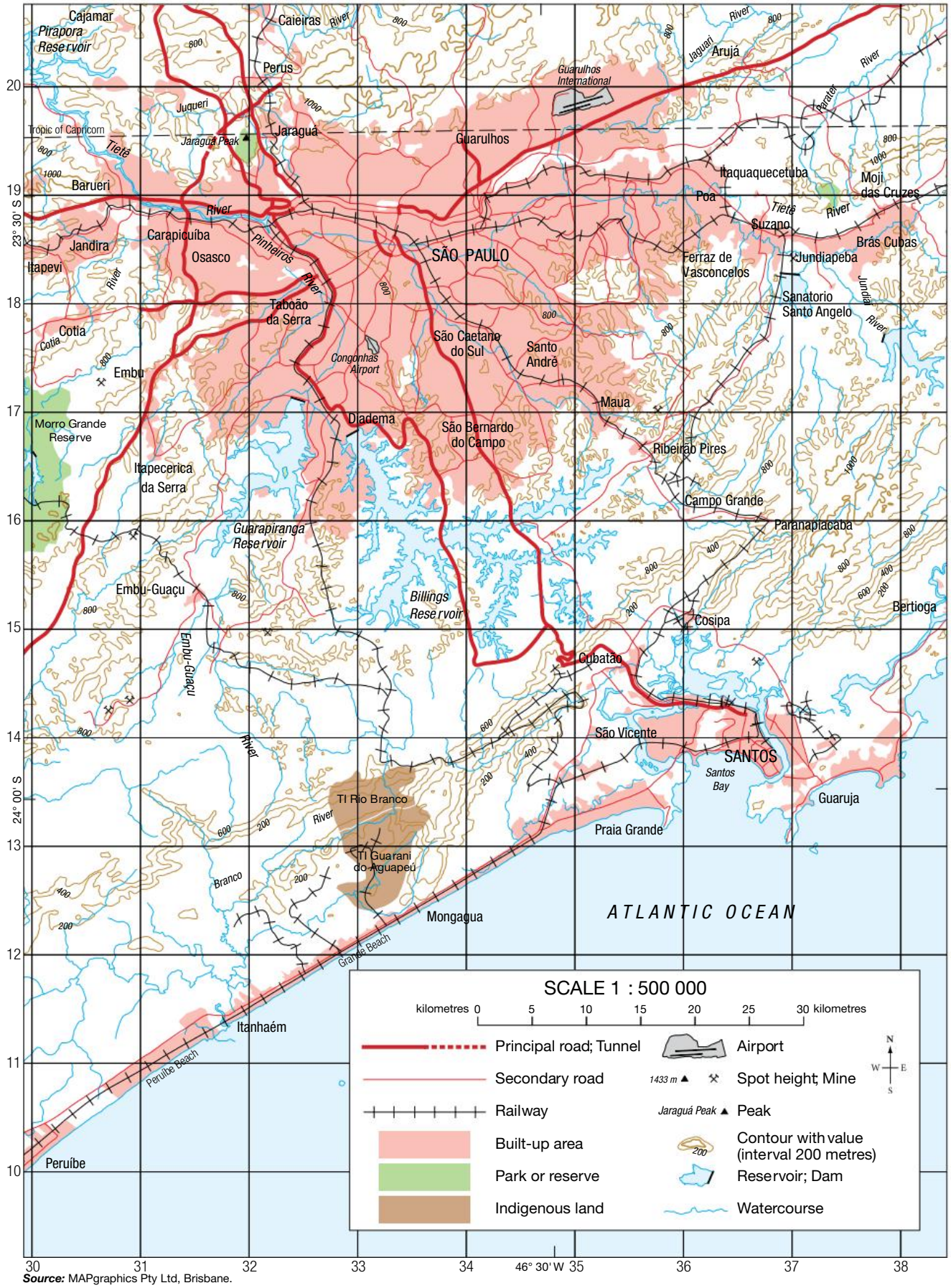
PREDICT

10 Describe the physical limitations to the growth of São Paulo. Predict where future urban growth will occur by shading areas on your map. Make notes on your map to justify why growth will occur in these locations and not in others.

INVESTIGATE

11 Compare the area of São Paulo to that of the capital city in your state or territory. Trace an atlas map of your chosen city and add a ***scale***. Now use the ***scale*** to draw an area of 90 square kilometres over the city area. This is the area of São Paulo. How does it compare to your city?
12 Study figure 1. Describe the location of São Paulo, and draw a sketch of the satellite image showing the area of the city. If Melbourne and Sydney were grid-shaped, they would measure 40 and 33 square kilometres respectively. Now calculate the area that Melbourne or Sydney would take up and draw this over São Paulo. Compare the size of São Paulo with that of Melbourne and Sydney — write two statements to describe the differences.

FIGURE 2 A topographic map of São Paulo, Brazil



Source: MAPgraphics Pty Ltd, Brisbane.

9.11 What are the characteristics of cities in the United States?

9.11.1 Cities in the United States

The United States has a number of major cities distributed across the country. The largest of these is New York, one of the world's megacities.

The distribution of major cities across the United States, including the 10 largest cities (by population), is shown in figure 1. The largest is New York City, New York, which is home to over 8 million people. The second-largest city is Los Angeles, California, with a population of almost 4 million; and the third-largest is Chicago, Illinois, with nearly 3 million people.

9.11.2 New York City

In 1950 there were only two megacities, and New York was one of them (Tokyo in Japan was the other). In 2015 New York was the sixth-largest city in the world, but by 2025 it is expected to be only sixtieth on this list. There are only 11 states in the United States that are home to more people than New York City.

FIGURE 1 The distribution of major cities in the United States

Source: Spatial Vision

New York City is located on the eastern Atlantic Ocean at the mouth of the Hudson River. It is made up of five counties, or boroughs, separated by waterways—these are the Bronx, Brooklyn, Manhattan, Queens and Staten Island. Being located on four islands makes land very scarce and population density very high, at 10 194 people per square kilometre.

People

For many years, almost all immigrants came to the United States through New York City—and many of them remained. Many people living in New York are originally from European countries,

FIGURE 2 Manhattan Island and Central Park in New York

but there are large numbers from the West Indies, South and Central America, the Middle East and eastern Asia. Around 800 languages are spoken in New York—around 36 per cent of the city's population were born overseas.

TABLE 1 Population statistics of New York City

	2010 (census)	2014 (estimated)
New York State	19 378 102	19 746 227
New York City	8 175 133	8 491 079
Bronx	1 385 108	1 438 159
Brooklyn	2 504 700	2 621 793
Manhattan	1 585 873	1 636 268
Queens	2 230 730	2 321 580
Staten Island	468 730	473 279

Economy

New York City is a major world centre of trade, commerce and banking (New York is also home to the largest stock exchange in the world), manufacturing, transportation, finance, communications, and culture and theatrical production. It is also the headquarters of the United Nations and a leading seaport.

Boroughs

The Bronx County is the only part of New York that is connected to the US mainland. Historically there were many Irish and Italian migrants; today they are mostly Russian and Hispanic.

FIGURE 3 Geographical characteristics of New York City

Source: Spatial Vision

Brooklyn (also known as Kings County) is where most New Yorkers live; but Manhattan is the most densely populated county. It contains the highest number of skyscrapers, and includes Central Park and the village of Harlem. Central Park is nearly twice as large as the world's second-smallest country, Monaco.

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Interactivity
Urban USA
Use this interactivity to investigate patterns of size and distribution of the USA's ten largest cities.
Searchlight ID: int-3120

ACTIVITIES

IDENTIFY
1 Name the five boroughs or counties that make up New York.
2 In what year was New York one of the world's only two megacities?

EXPLAIN
3 Describe the distribution of major cities in the United States. Where are most located?
4 Describe New York's location within the United States and in terms of its natural geographical features. How have these features helped make New York a major city?

APPLY
5 Conduct some research to find images of New York that reflect its characteristics. Use the information in this section about its people and economy as well as the information in figure 3. Include images of buildings, transport, culture and businesses, and produce a collage with labels. This might be in an electronic format or produced as a poster.
6 Find the names of one newspaper, magazine, fashion brand, major bank, art gallery and theatre that are located in New York. Compare your findings with those of other students. Are these well-known businesses? How does this help make New York an important business and cultural centre?
7 Draw a sketch of figure 2. Use the map to help you label Central Park and the Hudson River. In which direction is the photographer facing?

INVESTIGATE
8 Use the data in table 1 to draw a bar graph showing the ***change*** in New York's population. Describe the pattern that you see.
9 Use figures 2 and 3 and the graph you created in question 8 to write two sentences about population density in New York and where growth might occur in the future.

9.12 What are the characteristics of cities in Europe

9.12.1 What are European cities like?

European cities are old — many were first built by the Romans, and most existed during the Middle Ages. European cities are often smaller in scale and the buildings shorter than in the huge modern cities of North America and China. European cities are often described as *romantic*, *chic* or *picturesque*, words that would rarely be used to describe the cities of the United States or China.

road intersection place where two or more roadways cross

FIGURE 1 This Italian piazza in Lucca occupies the site of a Roman amphitheatre. The curved row of buildings was built where the spectator stands once stood.

Most European cities became cities 700–1000 years ago. They grew from being small-scale marketplaces, river crossings, **road intersections**, safe refuges and places of political power into the business, industrial and cultural centres they are today. Some of the largest and best-known cities in Europe include London, Paris, Rome, Barcelona, Berlin, Milan, Vienna, Venice, Amsterdam and Prague.

A vibrant main square is a feature of European cities from Spain to Sweden and from England to Greece. The square was usually the site of a market place in medieval times, as well as being the communal and cultural centre of the city. Surrounding this square would be the most impressive buildings, such as the cathedral, town hall, concert hall, homes of the wealthiest families, museums and public monuments. It was the most prestigious place to live and to conduct business. The plaza, forum or market square was also an important meeting place for locals of all classes to mingle, gossip, find out local news and hold religious festivals.

As you can see in figure 1, this square continues to bring pleasure to the local community and tourists alike. As a car-free space it is perfect for outdoor dining; and a weekly farmers' market is also held here. Interesting shops are located in the lower levels of the buildings and apartments, hotels and small offices on the upper floors.

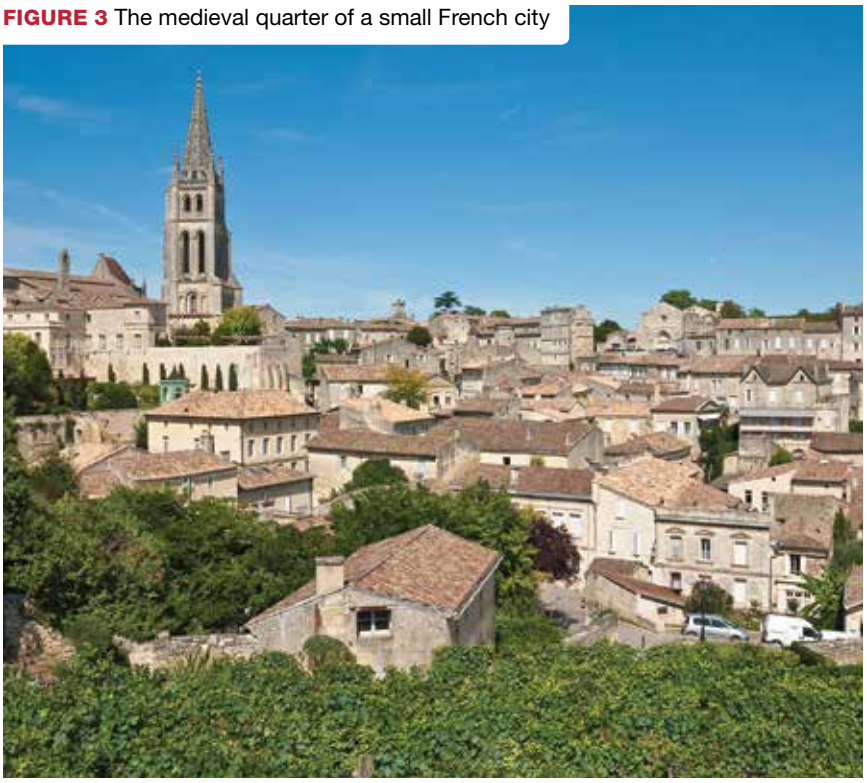
Many cities in Australia and the United States have an area they refer to as their 'Little Italy' or 'Paris End'. These places usually have European-style features (see figure 2) such as narrow laneways, outdoor dining, awnings, French or Italian restaurants and flower boxes.

In European cities, the tallest building is often a church. Even though some of the buildings crammed within the protective defences of the medieval city walls seen in figure 3 are less than fifty years old, they have been constructed to look the same as those built many hundreds of years earlier. The compact nature of European cities encourages wise use of space and encourages residents to walk, cycle or use public transport.

In Barcelona, Spain, the spires of the as-yet unfinished Basilica la Sagrada Familia, a huge Roman Catholic church that has been under construction for more than 100 years, dominate the city skyline in an older part of the city. It is being built in a region where the **population density** is greater than 50 000 residents per square kilometre (the city's highest). In a North American or Asian city, achieving a population density this great would be possible only with the building of residential skyscrapers. However, in this neighbourhood of Barcelona, the buildings are only five or six storeys high. Barcelona does have some very tall buildings, but they are found on the outer edges of the city and not in the older city centre.

FIGURE 2 A laneway of restaurants and bars in Brussels, Belgium

FIGURE 3 The medieval quarter of a small French city



9.12.2 What is the future for European cities?

As they have developed, the ancient city centres of Europe have had to add water and sewerage systems and provide electric power, telephone and internet services as well as public transport access for their residents. The biggest issue in the past thirty years has been a huge increase in the level of car ownership. In parts of Paris, local people park their cars without applying the handbrake so that the vehicles can be pushed along by other drivers trying to fit their cars into very small parking spaces. The increased number of cars, even though many are small, has resulted in congestion and increased pollution.

To try to solve some transport problems, most European cities are trying to encourage people to walk, cycle and use public transport within the city. Many European cities, including London, Amsterdam, Paris, Barcelona and Copenhagen, have introduced public bicycle sharing schemes to provide people with an alternative to motorised transport, thereby helping to reduce traffic congestion, air pollution and noise.

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

FIGURE 4 Narrow French street that was not originally designed for car access or parking

FIGURE 5 Public share bikes in London

ACTIVITIES

IDENTIFY

1 List the terms used to describe a European market square.

2 What features do most European cities have in common?

EXPLAIN

3 How does the market square encourage ***interconnections*** between people and ***place*** in a European city?

4 What makes car ownership problematic for the residents of European cities? Use the **European parking** and **European traffic** weblinks in your eBookPLUS, as well as evidence from the images in this section, to support your answer. Use the concepts of ***space***, ***change***, ***sustainability*** and ***scale*** in your response.

APPLY

5 Investigate the city nearest to where you live to see whether it has a ***place*** influenced by European city design. *Hint:* Look for an area like Chinatown but European. How does the ***environment*** of this ***place*** reflect European cities?

6 **a** Use your atlas and the internet to locate, on a base map of Europe, all the cities mentioned in this section.

b Annotate each city with its population size, the river that flows through it and one landmark found in that city.

c Use a symbol to identify which cities have a public bicycle sharing scheme.

7 Explain why all the cities mentioned in this section were built near rivers.

PREDICT

8 How could European cities solve the problem of being overrun by cars? Produce a poster, brochure or PowerPoint presentation that fully explains the ***change*** required to implement your solution.

INVESTIGATE

9 Identify the ***sustainable*** and ***unsustainable*** features of European cities. Explain your answer.

10 A European city such as Barcelona has regions of very high population density, even though the buildings are not as tall as those in a more recently developed city such as New York. How might the five-or six-storey buildings be able to contain so many living ***spaces***?

eBookplus

Weblinks
- European parking
- European traffic

9.13 How do people shape places in Australia?

9.13.1 Where do our international migrants come from?

Australia's diverse and multicultural population is shaping places across the country. Australia is built on immigration, with 300 ancestries reported in the 2011 Census and Indigenous Australian ancestry dating back 50 000 years ago to the Dreamtime. Australia's Sustainable Population Policy aims to ensure that there will be enough jobs, education opportunities and affordable housing for a growing population without compromising the quality of our environment and communities.

Immigration has contributed significantly to Australia's population growth. The Migration Program was introduced in 1945 to stimulate post-war economic development and population growth. Over the years, as the priorities of each leadership have changed, migrant numbers have fluctuated. Recent reports state that 28 percent of Australia's population was born overseas, the highest rate in 120 years.

Australia's Migration Program changes in response to national policies (e.g. inter-country adoption) and international events (e.g. racial tensions, war, terrorism and human rights abuses). Visas are used to manage the number, nationality and types of migrants allowed to enter the country. For example, Australia's current plan to develop a high performing, knowledge-based industry has led to the introduction of the Entrepreneur Visa. This policy change aims to attract high achieving foreign students and innovative talent from around the world to settle in Australia. Skilled migration currently makes up 67 per cent of total migration with factors such as age (see figure 1), English language ability and work experience used in the selection process.

Australian patterns of migration have also been shaped by historical events and policy here and around the world. Waves of migration since World War II, have contributed to the multicultural make-up of our current population. In recent years, there has been a decline in the proportion of the overseas born population from Europe and an increase in the proportion of migrants born in Asia (figure 2).

Ongoing tension in the Middle East and North Africa led to large-scale displacement of people in 2015. The Syria conflict triggered the world's largest humanitarian crisis since World War II. More than 13.5 million people moved into neighbouring countries and across Europe to seek refuge (figure 3). The Australian government responded to these events by increasing the number of humanitarian visas offered. Priority was given to the most vulnerable people located in Lebanon, Jordan and Turkey.

FIGURE 1 Age and gender distribution of recent arrivals and Australian-born (2011)

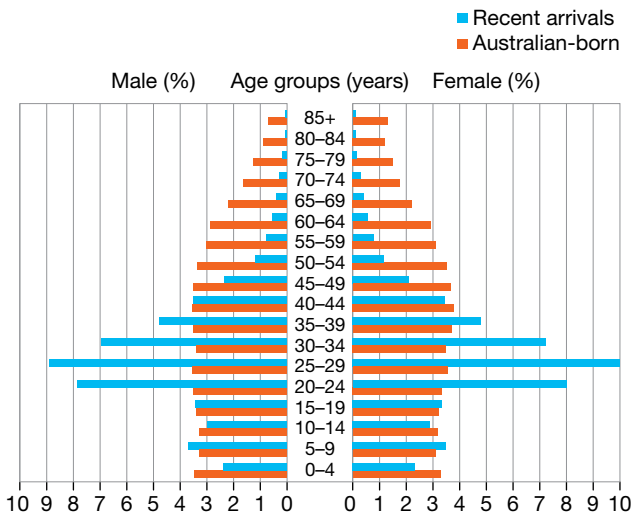


FIGURE 2 Overseas-born residents of Australia 1996 and 2014 (country of birth)

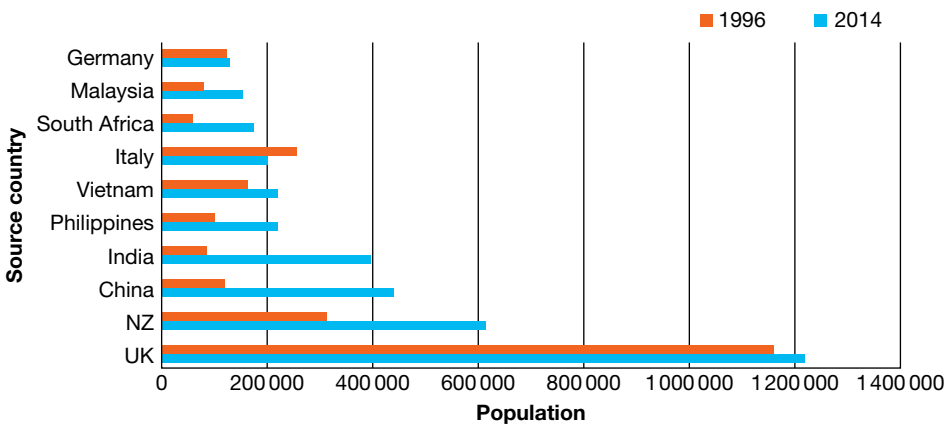
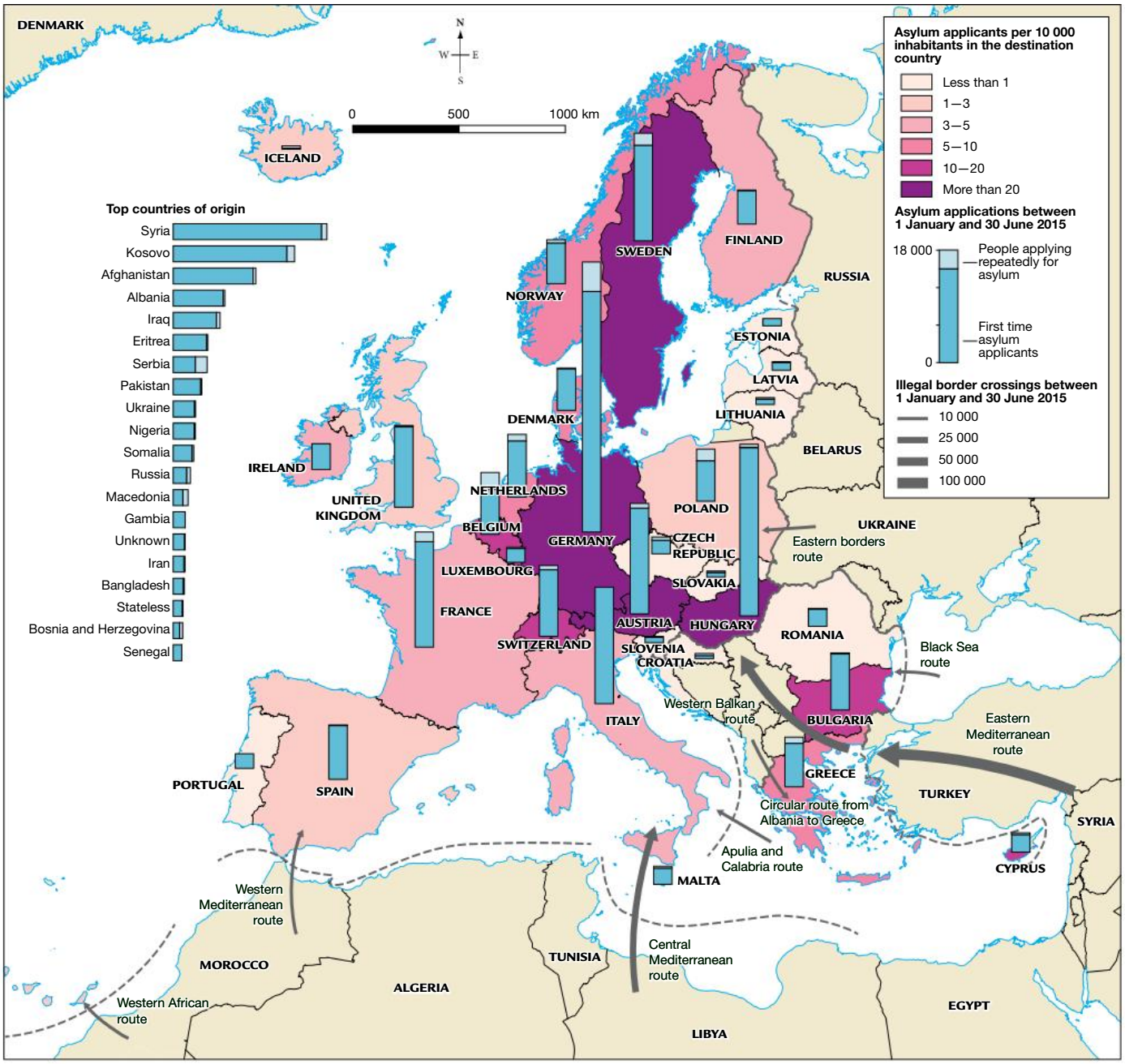
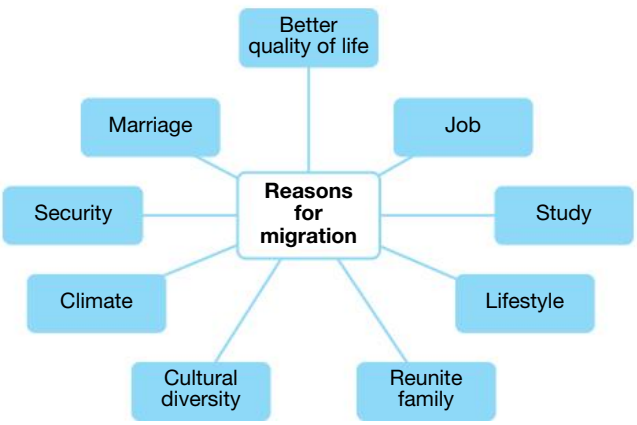


FIGURE 3 Large-scale migration into Europe from areas of conflict.



Source: Eurostat, Worldometers.info, Frontex.

FIGURE 4 Reasons for migration



9.13.2 Where do migrants choose to settle?

Australia is a popular destination for international migrants. Some of the reasons may include a combination of factors listed in figure 4.

Recent reports show that the majority of those born overseas settle in NSW and Victoria (figure 5), with 85 per cent choosing to live in major urban areas.

Some of the factors that influence where migrants choose to settle include:

- employment opportunities
- point of entry into Australia
- location of family members
- existing ethnic concentrations.

New South Wales has the highest proportion (35 per cent) of overseas born residents. Sydney attracts most of this growth with many suburbs displaying visible evidence of cultural diversity. Figure 6 shows the concentration of ethnic groupings across Sydney. Chippendale is an inner city suburb of Sydney with a high number of Chinese residents (10.6 per cent). 'Hawker Lane', an Asian-inspired eating precinct, is seen in figure 7 close to international student accommodation.

The influence of cultural groups within an urban area shapes and generates change within communities. Interconnections develop between the local residents and their homelands, as shops and services cater to local tastes and preferences. Community groups provide social opportunities for migrants to engage in and to contribute to Australian society. Multicultural festivals and events such as Harmony Day (21 March), aim to promote respect, a sense of belonging and a celebration of Australia's diversity (figure 8). The concentration of support services near the Sydney suburb of Auburn, attracts large numbers of new migrant arrivals whilst the location of religious centres may account for clusters of cultural groups (figure 9).

FIGURE 5 Place of residence of international migrants 2014

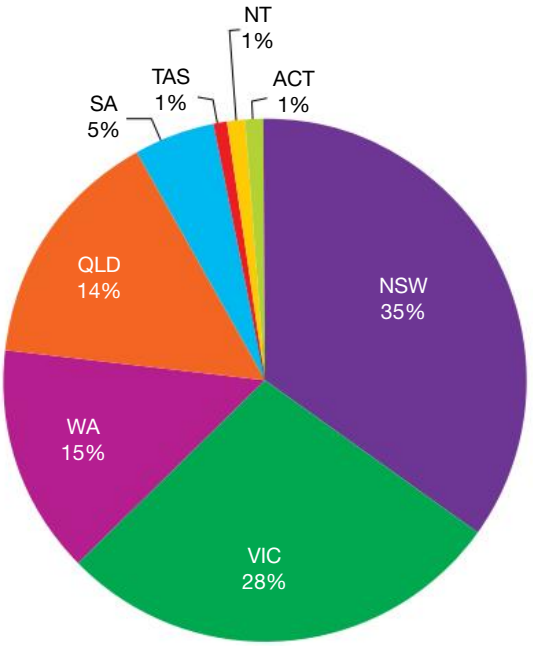
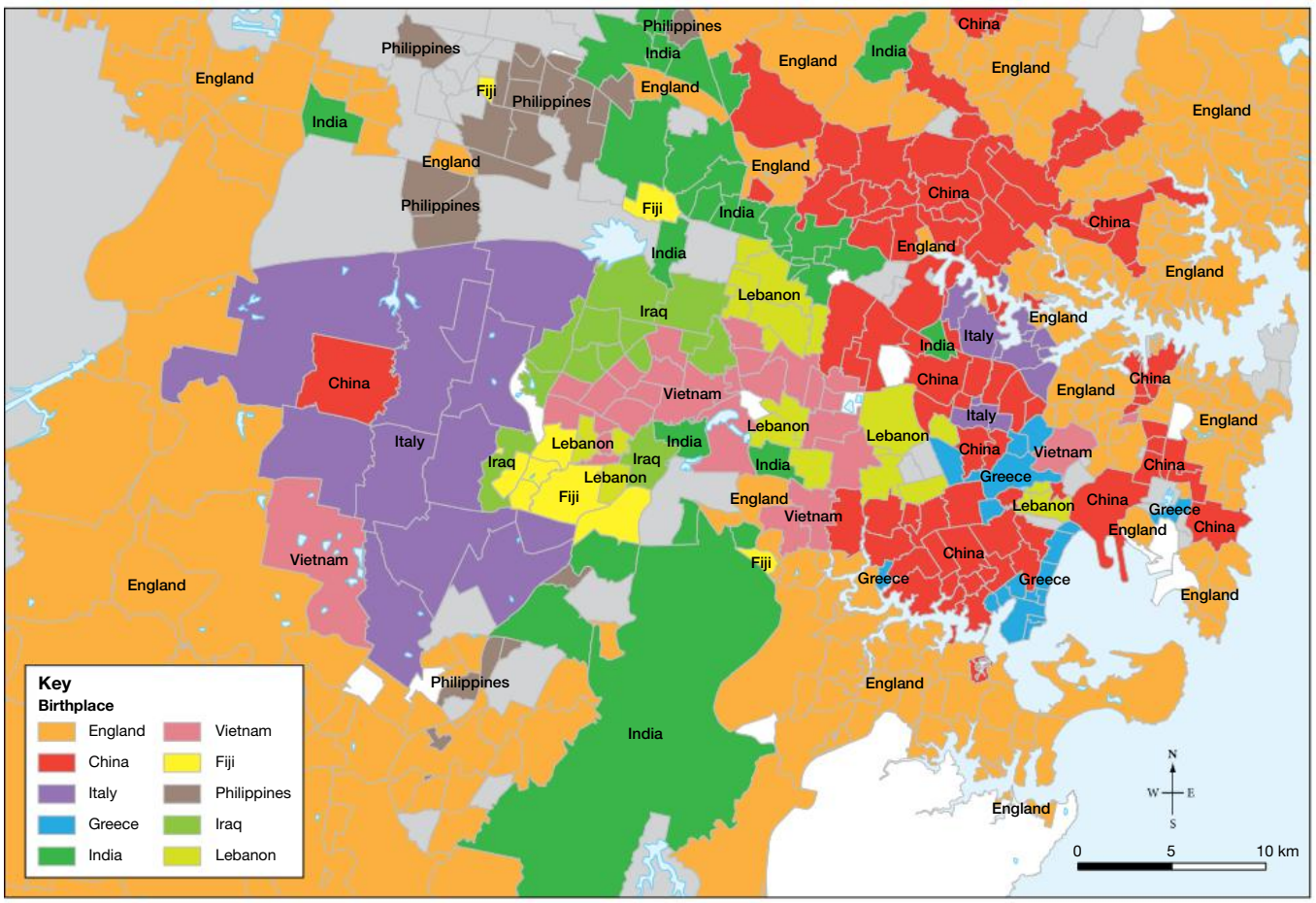


FIGURE 6 The spatial pattern of birthplace in Sydney



Source: www.sbs.com.au/news/map/where-australias-immigrants-were-born-sydney

FIGURE 7 Asian-inspired eating precinct in Sydney's inner city

FIGURE 8 Multicultural celebrations aim to promote a sense of belonging and respect.

FIGURE 9 Cultural groupings may be located near prayer centres.

FOCUS ON FIELDWORK

A visit to a local supermarket will reveal the most popular foods and ingredients demanded by local customers. It is interesting to investigate differences in places by comparing the range of food categories based on ethnicity (figure 10). Study the Australian Bureau of Statistics population data before you visit a store. What is the largest cultural group? In the fresh food section of a supermarket, there will be fruits and vegetables that reflect the diet of the local population. Record your observations and photograph the fruits and vegetables that you are not familiar with. Research their origin when you return to class and map the results of your investigation.

FIGURE 10 Many ethnic communities are represented in this Sydney supermarket.

ACTIVITIES

IDENTIFY

1 How many ancestries were reported in the 2011 census of Australia?
2 Why was the Migration Program introduced into Australia?
3 What percentage of Australia's population are born overseas?

EXPLAIN

4 Australia's Migration Program ***changes*** in response to what events?
5 Examine figure 1.
  a Describe the main age categories of Australia's population of recent arrivals.
  b Why does Australia attract this age group?
  c Niamh is from Ireland and her family wants to visit and work in Australia for 4 years. Her family have a 457 visa. What are the conditions of her stay?
6 Examine figure 2.
  a List the countries that have declining rates of migration in Australia.
  b Suggest two reasons for the large increases shown for India and China between 1996 and 2014.

APPLY

7 Using the **Where were Australian immigrants born?** weblink in your eBookPLUS, locate your suburb or town in Australia and compare it with another suburb or town of your choice.
  a Compare the proportion of overseas born residents using statistics
  b Suggest reasons why this location has attracted migrants
  c What contributions have these cultural groups made to each location?
8 Debate the statement: 'Australia should change its current migration policy'. Carefully research the latest policies and world events to prepare for this discussion.

eBookplus

Weblink
Where were Australian immigrants born?

eBookplus ONLINE ONLY

9.14 How can cities become sustainable?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

eBookplus ONLINE ONLY

9.15 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

9.3 SkillBuilder: Describing photographs

9.3.1 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 has 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.

Model

Where is the city shown in figure 1? This ground-level photograph of a city 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 summer or autumn day, as 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, as 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 10 years, because the man in the foreground wears earphones and is listening to music while he walks.

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 — comparisons with people or building heights

FIGURE 1 A modern city environment

- 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.

9.3.2 Show me

How to interpret photographs

eBookplus

eLesson
Refer to this SkillBuilder to learn how to describe photographs.
Searchlight ID: eles-1660

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 his eye can see. Look at figure 2 — is the story the same in both images?

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

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

9.3.3 Let me do it

Developing my skills

eBookplus

Weblink
Kibera slum

Use the **Kibera slum** weblink in the Resources tab to look at the photograph of the Kibera slum in Nairobi, Kenya. Using the online tool, explore the details of the photograph. Interpret the image by answering the following questions.

Questions

eBookplus

Interactivity
Refer to this SkillBuilder to learn how to describe photographs.
Searchlight ID: int-3156

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

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 — 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 bias from the photographer, especially with the size of the image.

Skills questions

1. Descriptions of photographs are used to:
   a. tell a story
   b. provide information about a place
   c. record details of past times
   d. show the time of day.
2. Photographing an environment needs to be done without:
   a. time
   b. people
   c. bias
   d. colour.
3. If the photograph of the Kibera slum was taken as a vertical aerial image, how would this alter the information you could gain?
4. If the Kibera slum was shown as a map, what information might not be available to the viewer?

9.4 SkillBuilder: Creating and reading compound bar graphs

9.4.1 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.

Model

TABLE 1 World population 2011

Region	Population	Percentage of total
Asia	4 140 336 501	60
Africa	994 527 534	15
Europe	738 523 843	11
North America	528 720 588	5
South America	385 742 554	9
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

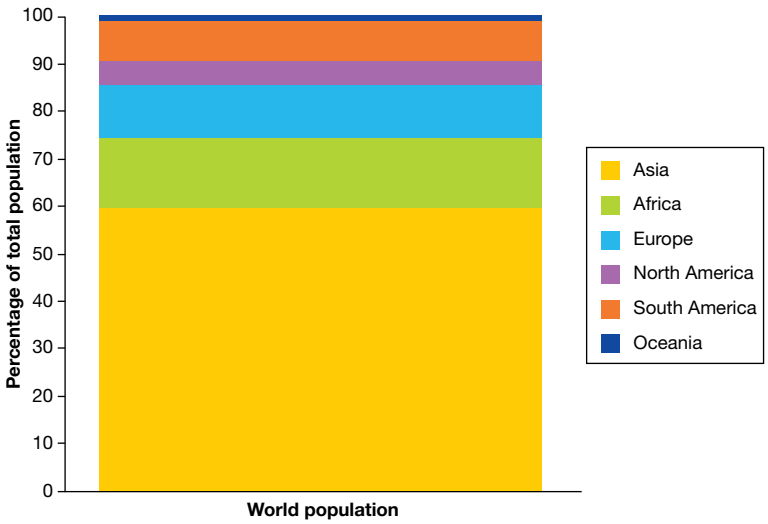


Figure 1 clearly shows that the greatest percentage (60 per cent) of the world's population lived in Asia in 2011. Africa was the second most populated continent, with 15 per cent of the population. Europe was home to fewer people than Africa, with 11 per cent of the population. North and South America 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).

A good compound bar graph has:

- been drawn in pencil
- ruled lines to clearly represent and communicate data
- used colour according to a key or legend
- 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.

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eLesson
Creating and reading compound bar graphs
Searchlight ID: eles-1705

9.4.2 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.

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 and length for the bar graph — this will depend on the amount of space available and the complexity of the data being graphed. The width is not 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. This means that each millimetre represents 1 per cent, or 10 millimetres represents 10 per cent. Draw your bar 10 centimetres long. Add a scale alongside your bar (see figure 2).

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 (e.g. Oceania's population, 36 102 071) by the total figure (total world population, 6 823 953 091) and multiply the result by 100.

STEP 3

Check your data before beginning to graph. The percentages you have should add up to 100 per cent (see table 2). You don't want to finish colouring your bar and find that one data piece won't fit.

Region	Population
Asia	4 140 336 501
Africa	994 527 534
Europe	738 523 843
North America	528 720 588
South America	385 742 554
Oceania	36 102 071
Total	**6 823 953 091**

FIGURE 2 Draw your bar so that the total length represents 100 per cent.

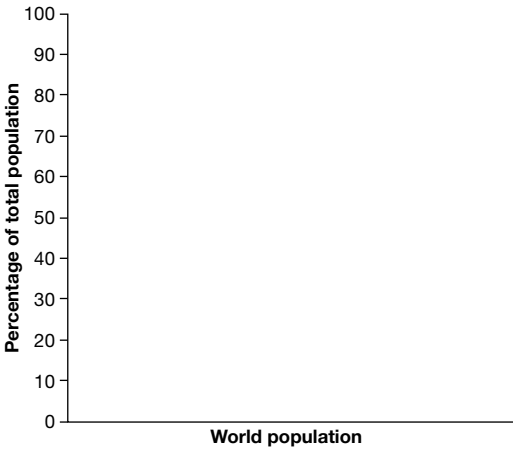


TABLE 2 Convert your set of data to show percentages of the total.

Region	Population	Percentage of total*
Asia	4 140 336 501	60
Africa	994 527 534	15
Europe	738 523 843	11
North America	528 720 588	8
South America	385 742 554	5.5
Oceania	36 102 071	0.5
Total	**6 823 953 091**	**100**

*Figures have been rounded to total 100.

Since this is a compound graph, all numbers compound, or 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 per cent = 60 millimetres if your total bar length is 100 millimetres. Colour this segment and add a key or legend near your graph, with appropriate labelling (see figure 3). Data will usually be graphed in order from the largest to the smallest.

STEP 4

Add the next percentage to the percentage for the first piece of data. In this example, add 15 per cent to the previous 60 per cent and you have a total of 75 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 per cent = 75 millimetres if your total bar length is 100 millimetres). Shade the segment in a different colour and add this colour to the key (see figure 4).

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

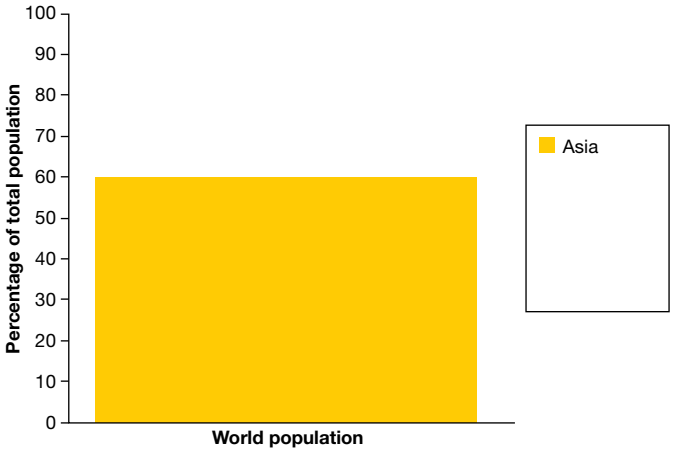
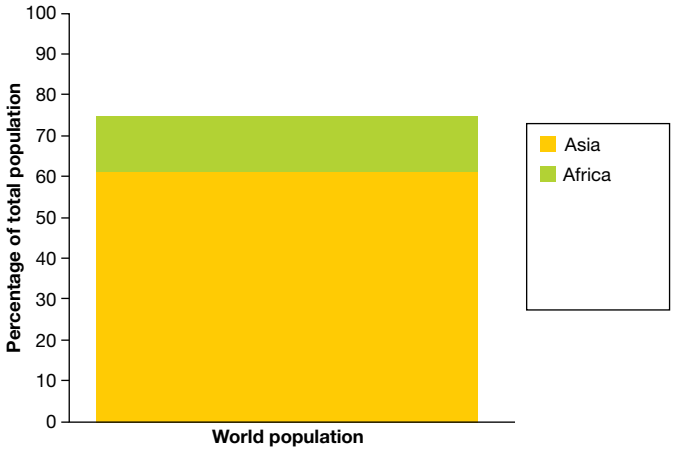


FIGURE 4 Colour the second section of your bar and add the new colour to the key.



STEP 5

Having previously checked that all the data will fit your graph (step 3), complete 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.

STEP 6

Now you can interpret the information displayed in your compound bar graph. Write a description to describe 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 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 (14 per cent) is smaller than that of Africa. The text following figure 1 gives a sample description of the data.

9.4.3 Let me do it

Developing my skills

- Using the data provided in table 3, create a compound bar graph to show the proportion of the world's population that was urban in each continent in the year 2000, and another to show the proportion of the world's population that is expected to be urban in each continent by the year 2030. *Hint:* The numbers you need to create the graph are percentages, which you will need to calculate.

eBook*plus*

Interactivity
Creating and reading compound bar graphs
Searchlight ID: int-3285

TABLE 3 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*

Questions

Carefully analyse your two completed compound bar graphs to answer the following questions.

1. Which continent had the second highest proportion of people living in urban areas in 2000? What ranking is that continent expected to have in 2030?
2. Which continent is predicted to have the greatest increase in urban population by 2030?
3. What do you notice about the expected change in the urban population of Europe between 2000 and 2030?
4. Compare the expected change in the urban population in Asia and Africa between 2000 and 2030.
5. Give two other interesting facts your two compound graphs show about the expected changes to the world's urban population between 2000 and 2030.

Checklist

I have:

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

Skills questions

1. Compound bar graphs are used to show:
   a. numbers from a table
   b. the percentage parts of a whole
   c. fifths of a total number
   d. unequal numbers.
2. Compound bar graphs can be compared to show changing:
   a. numbers over time
   b. opinions
   c. characteristics
   d. colours.
3. Why do you need to make careful calculations before drawing the data segments?
4. How can compound bar graphs be used for showing change over time?

9.7 SkillBuilder: Constructing a basic sketch map

9.7.1 Tell me

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. It 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 also useful for:

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

Model

FIGURE 1 Sketch map of land use in Price Shire

Source: Price Shire Council

A basic sketch map has:

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

9.7.2 Show me

How to construct a basic sketch map

eBookplus

eLesson
Constructing a basic sketch map
Searchlight ID: eles-1661

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.

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).

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.

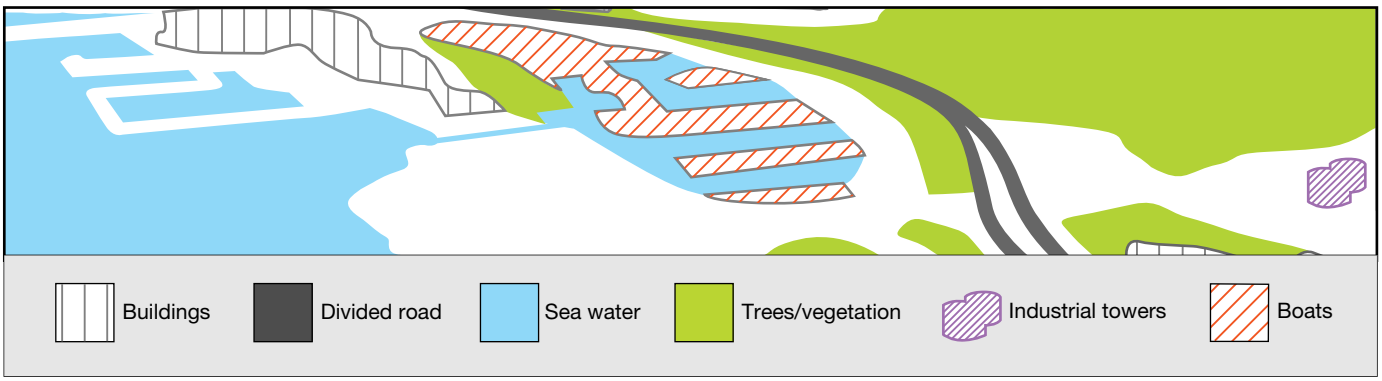
STEP 4

Create a colour coded key/legend 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 suitable symbol to represent a hospital. You can add to your key/legend 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.

FIGURE 4 The base features are drawn.



STEP 6

Individually, take each of the features that you have identified and mark onto your base map the approximate area that it covers (figure 4). 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. Do this neatly and horizontally.

STEP 8

Complete the simplified sketch map with BOLTSS.

9.7.3 Let me do it

Developing my skills

Using the aerial photograph of Darwin shown in figure 2, complete a basic sketch map of the city and its environments.

Questions

1. Describe the natural environment of Darwin. Mention the base features that you used to make your sketch.
2. What type of buildings make up the greatest proportion of the built environment of Darwin?
3. Suggest two reasons for the focus of the city on marine activities.
4. 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.
5. 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/legend
- included BOLTSS.

eBook*plus*

Interactivity
Constructing a basic sketch map
Searchlight ID: int-3157

Skills questions

1. Basic sketch maps are used to show:
   a. detailed information
   b. generalised information
   c. complex information
   d. limited information.
2. A basic sketch map includes information about:
   a. land use
   b. soils
   c. slope
   d. rainfall.
3. Why are basic sketch maps a great tool for geographers?
4. What information can you get from looking at a basic sketch map?

9.14 How can cities become sustainable?

9.14.1 Sustainable urban solutions

Cities are huge consumers of goods and services. To be sustainable, cities need to develop so that they meet present needs and leave sufficient resources for future generations to meet their needs.

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.

9.14.2 Sustainable urban projects

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.

food miles the distance food is transported from the time it is produced until it reaches the consumer

FIGURE 1 The urban greening program in Sri Lanka has been a success in many communities.

Beekeeping in urban areas

A worldwide movement of urban beekeeping has had beekeepers in partnership with businesses and property owners in major cities to place beehives on rooftops. The movement makes a strong connection between urban areas and food supply. This is happening in cities such as London (the Lancaster Hotel in London has its own hives, as does Buckingham Palace), New York, San Francisco, Paris, Berlin and Toronto. In Australia, there is a growing number of hives on city rooftops in Melbourne, Sydney and Brisbane.

FIGURE 2 Beehives on city rooftops, from where bees collect city pollen to make honey.

Solar panels in Vatican City and Japan

Vatican City, Italy

Vatican City is the world's smallest independent state and is hoping to become the first solar-powered nation in the world. It plans to create Europe's largest solar power plant, which will provide enough energy to power all of the state's 40 000 households. The roof of the Paul VI Hall is now covered in photoelectric cells (see figure 3).

FIGURE 3 Solar panels cover the roof of the Paul VI Hall, as seen from the dome of St Peter's Basilica.

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 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. 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 supplied to 190 000 homes and 4200 public buildings, including Vienna's largest hospital. 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.

The Loading Dock, Baltimore

The Loading Dock is an organisation based in Baltimore, Maryland, in the United States, that recycles building material that was destined for landfill. The material is reused to help develop affordable housing while preserving the urban environment. The organisation works with non-profit housing groups, environmental organisations, local government, building contractors, manufacturers and distributors and uses human resources from within the community, improving living conditions for families, neighbourhoods and communities.

Since 1984, The Loading Dock has saved low-income housing and community projects more than US$16.5 million and has rescued over 33 000 tons of building materials from landfill. There has been interest in the project from 3000 other cities within the United States and in Mexico, the Caribbean, Hungary, Germany and five countries in Africa. All these projects will have a positive impact on people's lives and the urban environment.

FOCUS ON FIELDWORK

How sustainable are the local projects in your area?

Select one project at school and one project at home, designed to manage the environment more sustainably. It may be the introduction of a walking bus stop, the installation of a water tank system in your home (see figure 6), or even the creation of a community garden. Using primary research techniques (e.g. interview, photographs or survey) and secondary research techniques (e.g. website, maps or data) investigate the following:

1 What does each project seek to achieve over a period of time?
2 Which project is more sustainable? What makes you say that?
3 What improvements are needed to improve the sustainability of each project?

FIGURE 6 Water tank system at a townhouse in Australia.

ACTIVITIES

EXPLAIN

1 The projects described in this section have been completed on a local ***scale***. Why do you think this is the case? Do you think any of these ***sustainable*** city projects would work on a suburb-wide or city-wide ***scale***? Why or why not?

INVESTIGATE

2 Work in pairs to identify one urban problem and design a ***sustainable*** program that would help to improve the condition. You will need to conduct some research to find similar problems and ways in which they have been tackled. Your program should include responses to the following.

- What is the urban problem? Include statistics (graphs or tables).
- Where is the problem located? Describe the location and include city/state/country map/s.
- What are the aims of your project? Describe what you hope to achieve.
- How will you achieve your aims? Describe your program or idea.
- Which individuals or groups are to be involved?
- What results would reflect success for your project?

Present your program to the class in the form of a Prezi or multimedia presentation, panel discussion or other format of your choice. Alternatively, you could share your programs through a class blog or wiki.

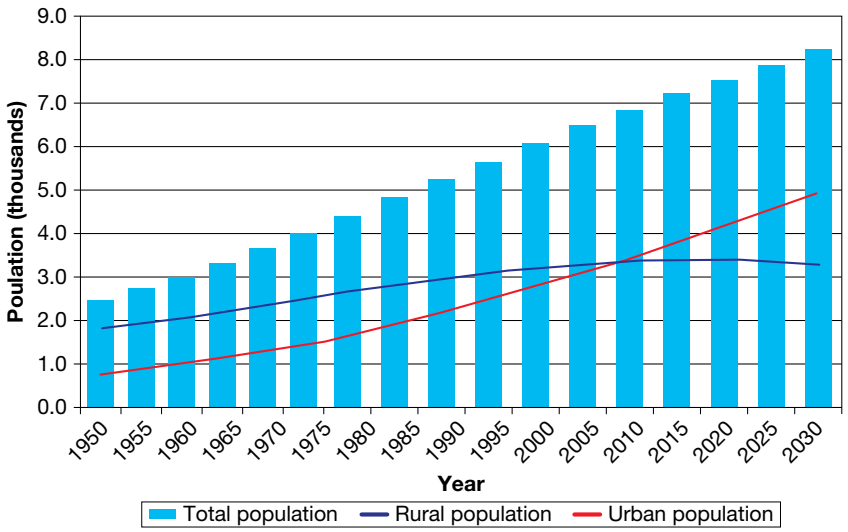
9.15 Review

9.15.1 Review

The growth of urban areas

1. Study the graph in figure 1.
   a. Describe the ***changes*** in world rural and urban populations from 1950 to the present.
   b. What percentage of the world's population now lives in urban areas?
   c. In which year were there more people living in urban than rural areas?
   d. What is the projection for this pattern to 2030?

FIGURE 1 The urban and rural population of the world, 1950–2030



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

2. Describe the push factors and pull factors that have resulted in urbanisation.
3. Study figures 2 and 3. Use these images to describe the push and pull factors that might result in people moving to urban areas.

FIGURE 2 High-rise accommodation in São Paulo

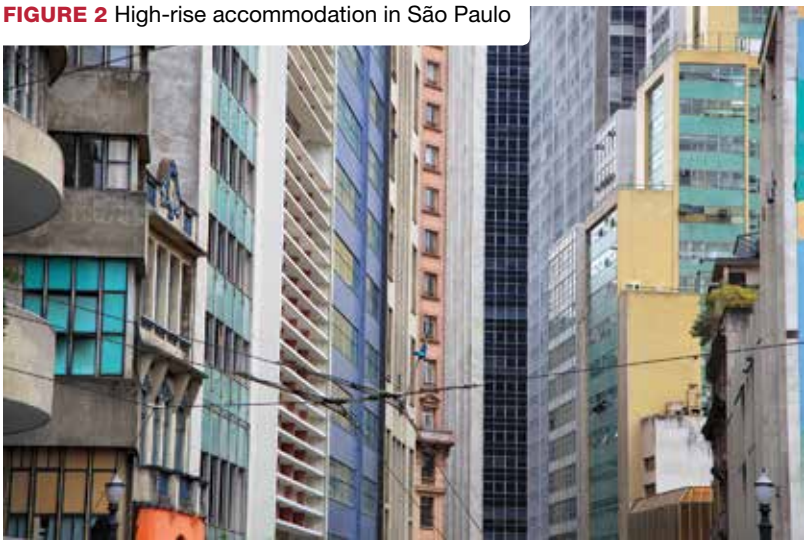
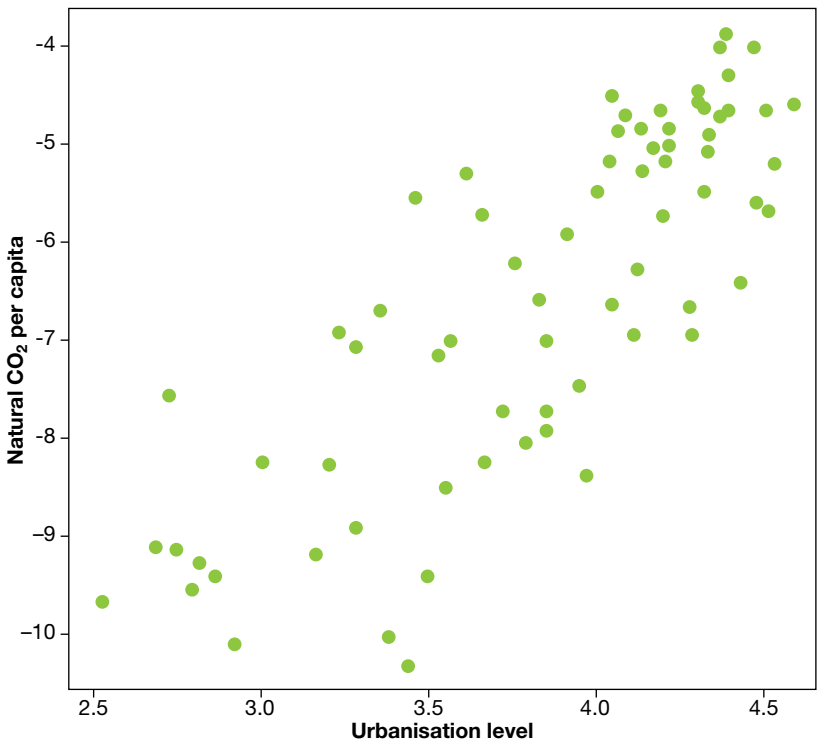


FIGURE 3 Shacks in an African village

Problems associated with urban areas

4. Summarise the problems associated with living in very large, rapidly-growing cities. Complete your summary by ranking the problems from most to least important. Justify your ranking.
5. What are *favelas* and where are they found? What are some other names for these areas?
6. Study figure 4. What does this graph show about the relationship between CO_2 levels and levels of urbanisation? Choose the correct statement below:
   a. The greater the level of urbanisation, the lower the CO_2 output per capita.
   b. The lower the level of urbanisation, the higher the CO_2 output per capita.
   c. The greater the level of urbanisation, the higher the CO_2 output per capita.

FIGURE 4 The relationship between urbanisation levels and CO_2 emissions per capita



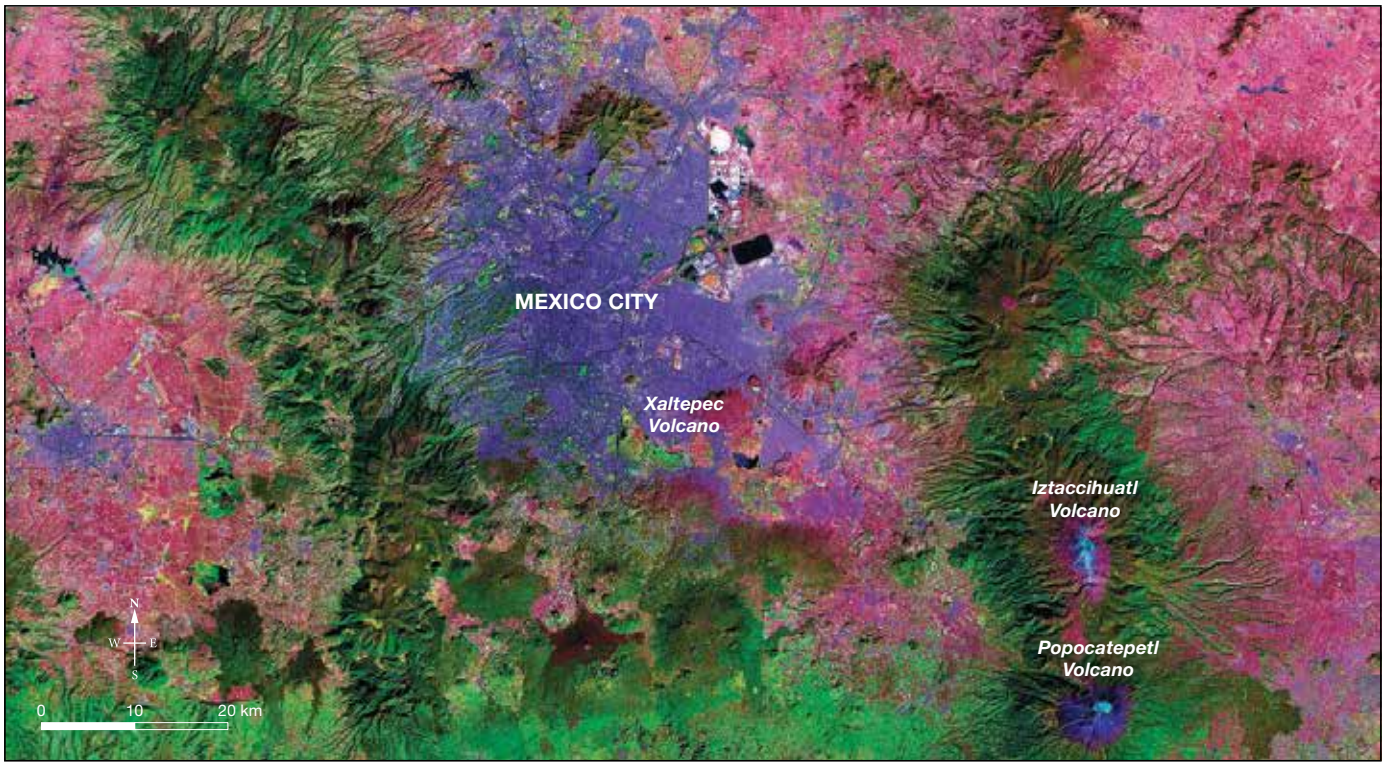
Source: © P. Romero-Lankao, D. Nychka and J.L. Tribbia, 2008: Development and greenhouse gas emissions deviate from the 'modernization' theory and 'convergence' hypothesis. *Climate Research* **38**, 17–29.

9.15.2 Reflect

Mexico City — a growing city

Mexico City has a growing population of around 21 million people. The megacity has experienced rapid urbanisation, and has a unique location in the crater of an extinct volcano. It is also located near active volcanoes. Air pollution (it is one of the most polluted cities in the world) and pressure on underground water supplies have resulted in environmental problems for the people of Mexico.

FIGURE 5 Satellite image of Mexico City



Source: MAPgraphics Pty Ltd, Brisbane

Increased incidence of flash flooding in Mexico City

The greater metropolitan area of Mexico City is one of the largest and most densely populated urban settlements in the world, containing an estimated 20.2 million residents at a population density of 9,800 (2016) persons per square kilometre in 2010. The city and its residents have become increasingly vulnerable to flooding and related impacts of climate change over the past century. Annual rainfall in Mexico City increased from 600 mm during the early twentieth century to over 900 mm towards the end of the century. Likewise, the annual incidence of flash flooding has increased from one to two annual floods, to six to seven annual floods over the same time period. On 2 August 2006, for example, a rainfall of 50.4 mm in only 36 minutes caused severe flooding in the southern and western parts of the city. The incidence of flash flooding is expected to continue to rise due to climate change-related increases in the frequency of heavy precipitation.

Higher precipitation is associated with an increased frequency of flash flooding, which encompasses a wide range of conditions that threaten life and property, including submerged roads, overflowing rivers and mud- or rock-slides. Flooding damage including injury, death, property loss and water contamination are exacerbated by the infrastructure and development patterns in Mexico City. Informal settlements are often located in areas prone to flooding and landslides and, thus, particularly vulnerable. Inadequate drainage in these areas results in the accumulation of trash and debris that poses serious hazards to human health when flooding occurs. Poorly maintained and aging water drainage and sanitation systems throughout the city worsen the impacts of heavy rains and flash flooding, and make it more difficult for communities to recover.

Source: © Ibarrarán, M. (2011) 'Climate's long-term impacts on Mexico's city urban infrastructure', unpublished case study prepared for the *Global Report on Human Settlements 2011*, www.unhabitat.org/grhs/2011. Reproduced with permission from the author.

7. What is a megacity? Name the top five megacities in the world.
8. How has the number of megacities ***changed*** over time? What is the prediction for megacity numbers in the future?
9. Refer to an atlas and describe the location of Mexico City in Mexico — draw a sketch map to help you.
10. Refer to the satellite image of Mexico City in figure 5. Use the ***scale*** to measure the extent/area of this city. How far does it spread from north to south and from east to west?
11. List the physical features that limit the spread of this city. Use Google Earth to explore this in more detail and add to your list.
12. Read the boxed text about flash flooding in Mexico City.
    a. How much has flash flooding increased in Mexico City? How much has annual rainfall increased?
    b. What reason is given for this ***change***?
    c. What are the consequences of increased flooding on people and the environment?
    d. What is an 'informal settlement'?
    e. Work with another person to brainstorm all that could be done to decrease the effects of flash flooding.

Creating sustainable housing is one way of meeting our current needs while providing for future generations.

CHAPTER 10

Planning Australia's urban future

10.1 Overview

10.1.1 Introduction

We often hear the word *sustainable*, but what does it mean? Sustainability means meeting our own current needs while still ensuring that future generations can do the same. To make this happen, human and natural systems must work together without depleting our resources. Ultimately, sustainability is about improving the quality of life for all — socially, economically, and environmentally — both now and in the future. In the words of HRH The Prince of Wales, 'Remember, our children and our grandchildren will ask not what our generation said, but what they did'.

Starter questions

1. From what you already know, do you think Australia's urban communities need to be planned more carefully? Why or why not?
2. What do you think the terms *harmony* and *balance in nature* mean?
3. How can the principles of harmony and balance be applied to human ***environments*** such as cities?
4. Why is it important to think about and plan for the future of our cities?
5. In what ways does the way we live today affect how people will live in the future?

Inquiry sequence

		Syllabus outcomes
10.1 Overview		
10.2 What do sustainable cities look like?		GE5-5
10.3 Are there sustainable cities in Australia?		GE5-5
10.4 Are growing urban communities sustainable?		GE5-5
10.5 SkillBuilder: Reading and describing basic choropleth maps	eBookplus ONLINE ONLY	GE5-7
10.6 Should we manage our suburbs?		GE5-5
10.7 How can we manage traffic?		GE5-5
10.8 SkillBuilder: Drawing a line graph using Excel	eBookplus ONLINE ONLY	GE5-8
10.9 Welcome to Sustainaville	eBookplus ONLINE ONLY	GE5-3
10.10 Where are the world's sustainable cities?	eBookplus ONLINE ONLY	GE5-3
10.11 Can we plan to 'live vertically'?		GE5-3
10.12 Is Auroville a sustainable community?	eBookplus ONLINE ONLY	GE5-3
10.13 How do we plan for a liveable future?		GE5-5
10.14 Review	eBookplus ONLINE ONLY	
Key terms	eBookplus ONLINE ONLY	

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Watch this video
Making our cities sustainable
Searchlight ID: eles-1630

10.2 What do sustainable cities look like?

10.2.1 A common purpose

Our cities are facing an important challenge. Some predict that Australia's population will reach 42 million by 2050. If this is the case, then our cities must change and adapt to become more efficient in order to maintain or improve our current quality of life. How will we cope with a growing population?

FIGURE 1 Perth, Western Australia. Building sustainable communities means we have to work at various scales.

Source: Spatial Vision

Sustainable communities share a common purpose of building places where people enjoy good health and a high quality of life. A sustainable community can thrive without damaging the land, water, air, natural and cultural resources that support them, and ensures that future generations have the chance to do the same. The basic **infrastructure** should be designed to minimise consumption, waste, pollution and the production of greenhouse gases. Sustainable urban areas strike a delicate but achievable balance between the economic, environmental and social factors.

A sustainable city is one that has a small **ecological footprint**. The ecological footprint of a city is the surface area required to supply a city with food and other resources and to absorb its wastes. At the same time, a sustainable city is improving its **quality of life** in health, housing, work opportunities and liveability.

We can address the challenges and opportunities for sustainable communities at two different scales: neighbourhood and city level.

infrastructure the facilities, services and installations needed for a society to function, such as transportation and communications systems, water and power lines

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

quality of life your personal satisfaction (or dissatisfaction) with the conditions under which you live

FIGURE 2a An inner-city organic community urban farm in Perth, Western Australia

FIGURE 2b An aerial view of the Swan River and the city of Perth, Western Australia

ACTIVITIES

IDENTIFY

1 Complete the following sentence: Some organisations have projected that Australia's population will reach __ million by ____.
2 What are the two main aims of a ***sustainable*** community?

EXPLAIN

3 Explain the term *ecological footprint* in your own words.
4 What are the two ***scales*** at which we can work to improve the ***sustainability*** of our communities? What are some of the differences between the two?

APPLY

5 a How is an ecological footprint measured? Use the **Ecological footprint** weblink in your eBookPLUS, or a teacher recommendation, to work through the steps to determine your own ecological footprint.
b After using the calculator, compare your ecological footprint with those of your classmates by creating a continuum on the board. It should start from smallest footprint (least planets consumed) to largest footprint (most planets consumed). Discuss which areas you think contributed to the wide variety of footprints.

INVESTIGATE

6 What might a ***sustainable*** home look like to you?
7 Consider the areas listed in which a neighbourhood can become more ***sustainable***. Create a table and, from your own perspective, detail the ways in which you believe your own suburb or neighbourhood is meeting these aims. Add another column and use the internet to research how your local council is trying to make your suburb more ***sustainable***. Conclude by writing a few sentences to answer the following questions:
a Is my neighbourhood ***sustainable***?
b How will liveability be improved?
c What needs to ***change*** in order to make it even more ***sustainable***?

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Weblink
Ecological footprint

eBookplus

Interactivity
Ecological footprint
Use this interactivity to look at ways of making cities and local areas more sustainable.
Searchlight ID: int-3121

10.3 Are there sustainable cities in Australia?

10.3.1 Measuring city sustainability

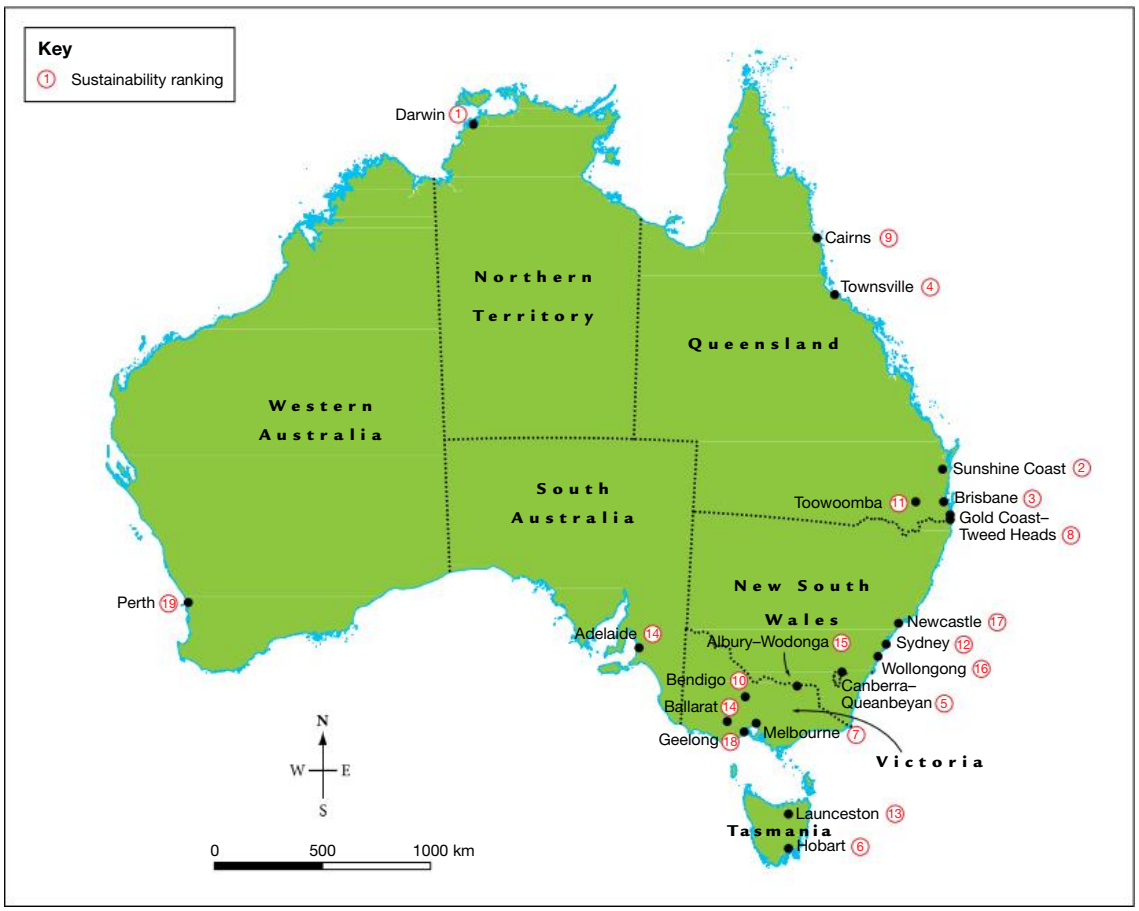
Australian cities often perform well in worldwide rankings of liveability. In one survey in 2015 four Australian cities were ranked in the top 10 — Melbourne (1), Adelaide (=5), Sydney (7) and Perth (8). Liveability is an assessment of the quality of life in a particular place — living in comfortable conditions in a pleasant location. But being liveable is not the same as being sustainable, which involves living in a way that sustains the environment and conserves resources into the future.

What makes a city sustainable? 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.

The results showed that Darwin was the most sustainable city in Australia in 2010. It performed best in terms of the economic indicators of employment and household repayments. Figure 1 shows the ranking for other cities.

FIGURE 1 A sustainability ranking of Australia's cities



Source: Spatial Vision

FIGURE 2 Darwin, the most sustainable city in Australia in 2010

10.3.2 Local urban communities

In most cities, it is often action at a local community scale that can make the most difference in improving city sustainability. State governments and local councils have responsibility for improving complex infrastructure (for example transport and water supply) for whole cities, but change at a local level can have positive results.

Sustainable communities in cities may have some of the following in common:

- friendly and social communities
- consume less energy and water and produce less waste
- have **medium-** to **high-density** rather than **low-density housing**
- are within walking distance of some public facilities and have excellent public transport links for longer trips
- include public places that people can walk to
- have good landscaping
- dwellings have been built to a budget to make them affordable.

medium-density housing residential developments with around 20–50 dwellings per hectare

high-density housing residential developments with more than 50 dwellings per hectare

low-density housing residential developments with around 12–15 dwellings per hectare; usually located in outer suburbs

For example Central Park in Sydney, designed by architects from Sydney, London, Paris and Copenhagen, is a residential, business and retail development, built with sustainability in mind (figure 3). Ninety-three per cent of the demolition waste has been recycled. The development has an on-site water recycling plant. The recycled water will come from a variety of sources such as rainwater collected from the roofs, groundwater and sewage water. This water will be used for such things as toilets, washing machines and irrigating the rooftop gardens and green walls.

As well as a water recycling plant, Central Park has its own low-carbon natural gas power plant, which will produce thermal energy for the residents and businesses at the park. This plant will be twice as energy efficient as an energy plant powered by coal.

Finally, Central Park has a 6400 square metre park at its centre, an area that is mainly grassed to allow for recreational activities. It has shade and BBQ areas for all the residents to enjoy.

FIGURE 3 The green walls of One Central Park, a sustainable development in Sydney

CASE STUDY

Christie Walk, Adelaide

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 4 One of the sustainable buildings in Christie Walk

FIGURE 5 A plan of Christie Walk in Adelaide

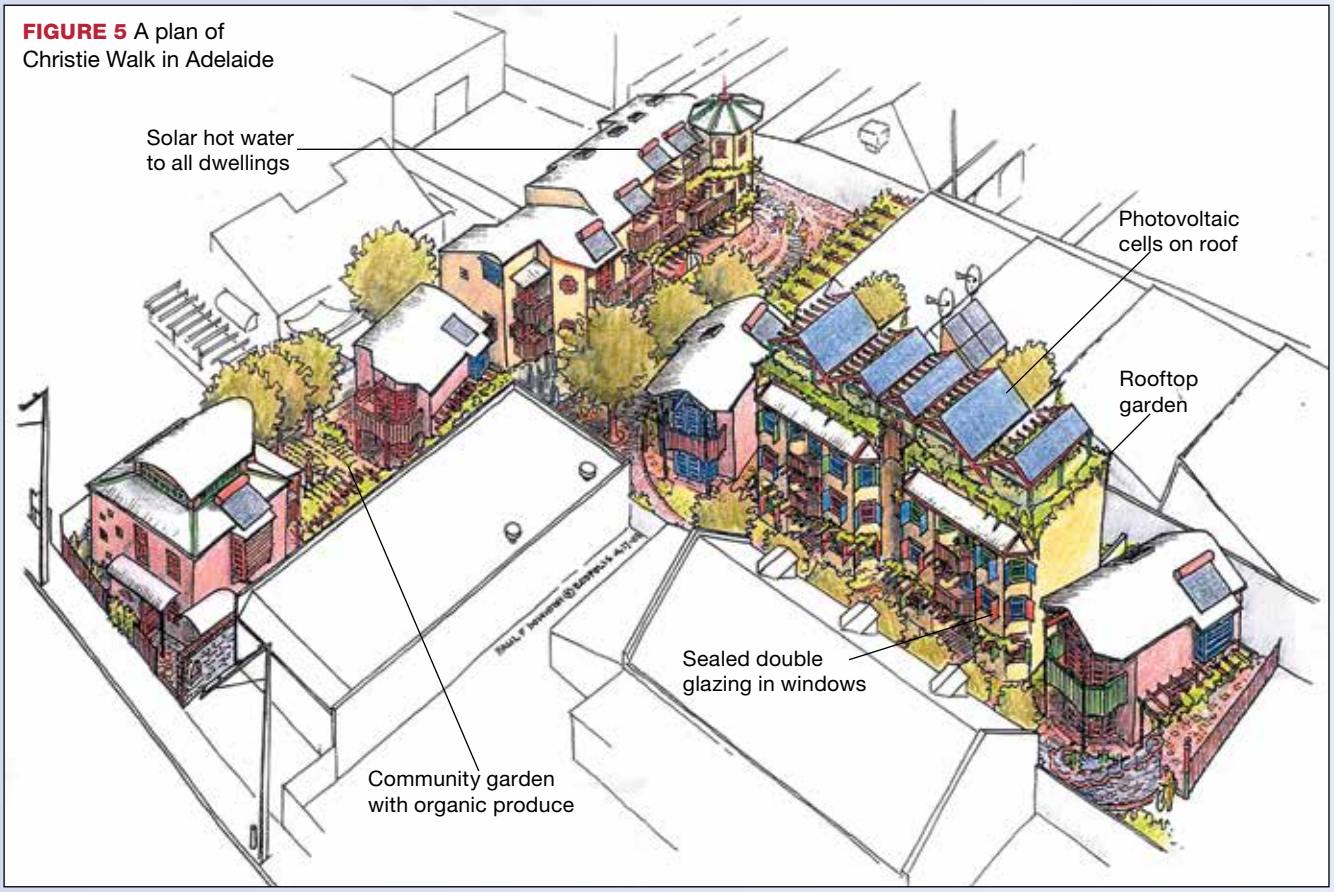
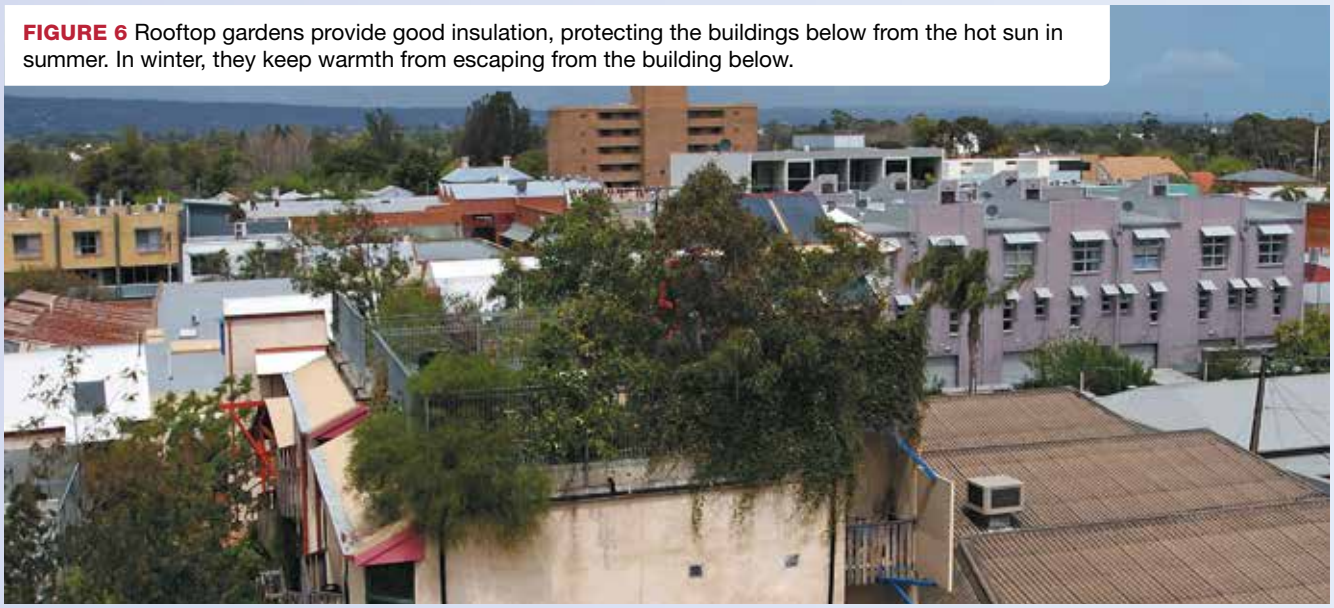


FIGURE 6 Rooftop gardens provide good insulation, protecting the buildings below from the hot sun in summer. In winter, they keep warmth from escaping from the building below.



FOCUS ON FIELDWORK

A hectare is equivalent to 10 000 square metres, or about 2.5 acres. In urban Australia, most houses were traditionally built on quarter-acre blocks (about 12 house blocks per hectare).

1 Walk around your neighbourhood or school area and pace out 100 × 100 metres. This gives you an idea of what one hectare looks like.
2 Use Google Earth or Google Maps to count or estimate the number of dwellings in your local area.
3 Compare your data with the definitions for low-, medium- and high-density housing. What type of housing density is in your local area?

FOCUS ON FIELDWORK

Local sustainable planning

Visit local examples of sustainable urban planning and take photographs of each strategy in action. The local council site will promote many of these projects. Prepare a sketch and trace the main features of the project using a draw function or label the strategies using text boxes and shapes (see figure 7). How does this strategy manage water use or to grow food. Video a presentation to the class demonstrating the merits of the project to the local community and to the wider community.

FIGURE 7 Sustainable urban planning strategies in a densely populated urban area

ACTIVITIES

EXPLAIN

1 In your own words, describe the difference between a liveable and a ***sustainable*** city.
2 Research and list the similarities and differences between the Woolloongabba neighbourhood plan in Brisbane and the Christie Walk development in Adelaide.

APPLY

3 Use the **Sustainable Cities Index** weblink in your eBookPLUS to find out how cities in your state or territory have performed in

eBookplus

Weblink
Sustainable Cities Index

measurements of ***sustainability***. List five things that could improve ***sustainability*** in these cities. Is there anything you personally can do to make a difference?

INVESTIGATE

4 Work in groups of three. Use the **Sustainable Cities Awards** weblink in your eBookPLUS to learn about projects that have won Sustainable Cities Awards in Australia. Each group member should read about three awards and summarise the projects to the others. Using a diamond ranking chart, rank the projects from most to least important for ***sustainability***. Write the name or description of the best project in the top space of the diamond and the least ***sustainable*** at the bottom. Add the other projects to the chart after your group has discussed and agreed on the ranking.

5 Use ideas from this section and further research to design a small ***sustainable*** urban neighbourhood. You may choose to work in groups or individually. You may like to use photographs of examples you find in your city/town or on the internet to draw your plan. Alternatively, video some examples and incorporate them into your design. Justify the inclusion of all the features you choose by annotating the plan or writing some notes to explain your choices. Present your final plan to the class as a panel presentation or on a class blog or wiki.

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Weblink
Sustainable Cities Awards

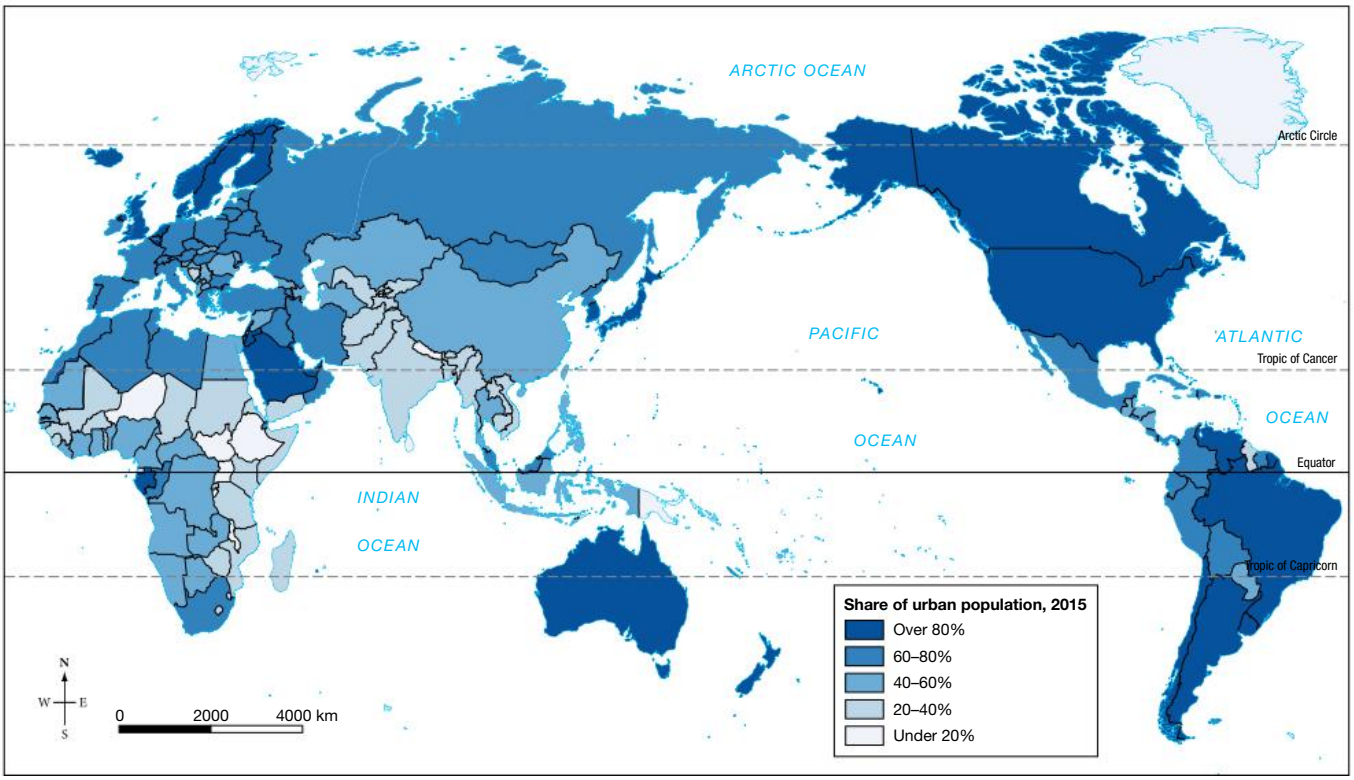
myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › **Brisbane: an eco-city**

10.4 Are growing urban communities sustainable?

10.4.1 The urban explosion

The world's urban population has grown rapidly and now outnumbers its rural population. Fifty-four per cent of the world's population now lives in urban areas. By 2050 the world's population is expected to reach 9.2 billion with 66 per cent living in urban areas. 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?

FIGURE 1 Percentage of population in urban areas, 2015



Source: United Nations Department of Economic and Social Affairs.

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.

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).

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.

livelihood job or skill that supports a person's existence, so that they can have the necessities of life

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

10.4.2 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. This will build communities in which all Australians live and prosper.

affordability the quality of being affordable — priced so that people can buy an item without inconvenience

FIGURE 2 Change in Australian urban and rural populations over time

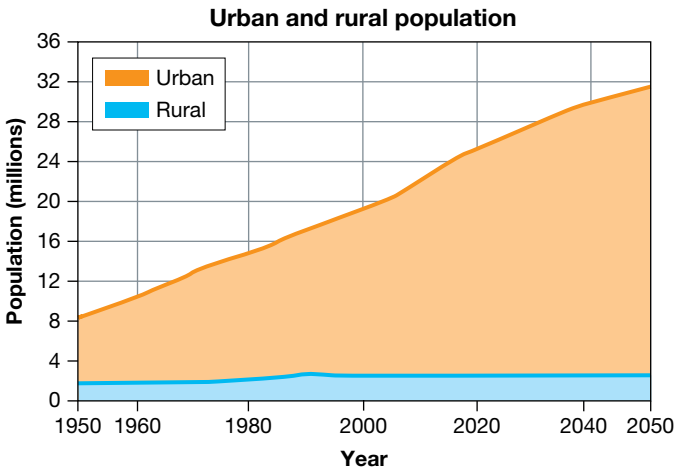
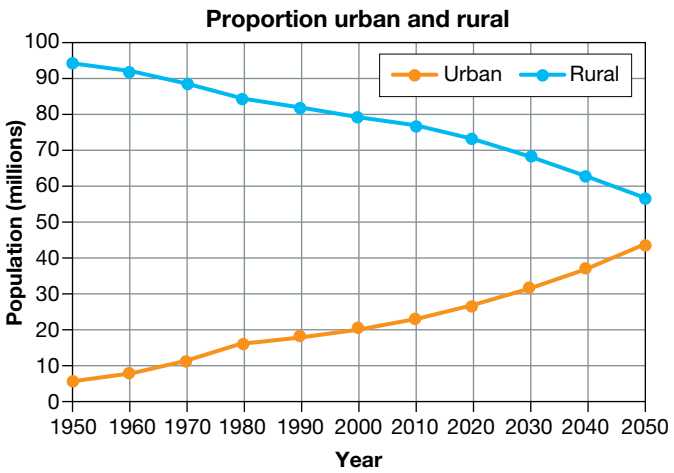


FIGURE 3 The narrowing gap between rural and urban populations, Afghanistan



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 still 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.

ACTIVITIES

IDENTIFY

1 a The global population is ***changing***. Where will most of the world's population live in the future?

b Is the pattern of population ***change*** the same or different in Australia?

EXPLAIN

2 Refer to table 1.

a Which countries will be the most and least urbanised in 2050?

b Which 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? Why might this be the case? (You may need to conduct some additional research using the internet.)

3 Examine table 1. Create a bar graph that shows the ***change*** over time for four countries of your choice.

APPLY

4 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 small groups, brainstorm some of the impacts that growing communities may have on (a) the ***environment*** and (b) the economy.

5 Young people leave rural areas in search of employment and education. What factors could contribute to you leaving the area where you live?

INVESTIGATE

6 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 effects you have listed as positive or negative.

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10.5 SkillBuilder: Reading and describing basic choropleth maps

What is a choropleth map?

A 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 usually show the highest concentration, and the lightest colours usually show the lowest concentration.

eLesson

Watch this video to learn how to read and describe basic choropleth maps.

Searchlight ID: eles-1706

Interactivity

Try this interactivity to learn how to read and describe basic choropleth maps.

Searchlight ID: int-3286

10.6 Should we manage our suburbs?

10.6.1 Living on the edge

There is much at stake on the rural–urban fringe, with the conflict between farming and urban residential development reaching a critical point on the outskirts of Australia's cities. Australia is the driest inhabited continent on Earth, and just six per cent of its total area (45 million hectares) is **arable** land. The areas targeted by our state governments for residential development continue to expand. When some of our most fertile farmland is lost to **urban sprawl**, we reduce our productive capacity. Is this a recipe for sustainability?

arable describes land that is suitable for growing crops

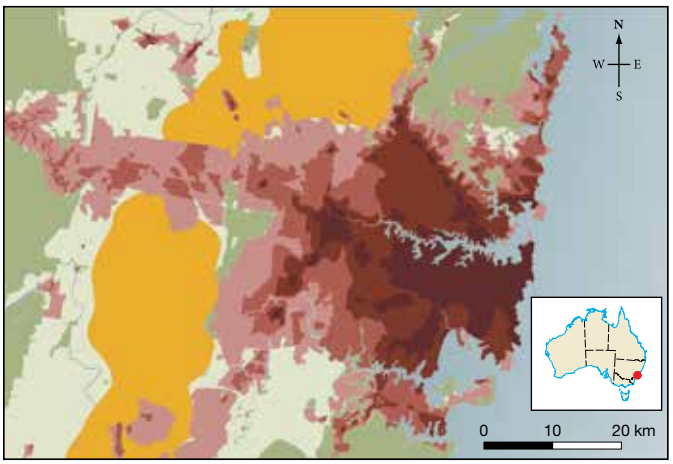
urban sprawl the spreading of urban areas into surrounding rural areas to accommodate an expanding population

On the edge of many Australian cities, new homes are being built as part of planned developments. These were previously wildlife habitats and productive farmland on the urban fringe and are now known as greenfield sites. Accompanying these housing developments are plans for kindergartens, schools, parks, pools, cafés and shopping centres (often called amenities and facilities).

Having an 'affordable lifestyle' is the main attraction for people who purchase these brand new homes. They like the idea of joining a community and having the feeling of safety in their newly established neighbourhood.

Most new houses on the rural–urban fringe are bought by young first-home buyers, attracted by cheaper housing and greener surroundings. Generally the residents of these fringe households feel that the benefits of their location outweigh the poor public transport provisions and long journeys to work and activities — trips that are usually made in a car.

FIGURE 1 The history of Sydney's urban sprawl



Source: Spatial Vision

10.6.2 Feeding our growing cities

Market gardens have traditionally provided much of a growing city's food needs, supplying produce to central fruit and vegetable markets. These 'urban farms' were located on fertile land within a city's boundaries but close to its edge, with a water source nearby and often on floodplains. They have been in existence in and around Australia's major cities since the 1800s, and some (such as La Perouse market gardens in Sydney) are now listed on the National Trust heritage garden register.

Fifty per cent of Victoria's fresh vegetable production still occurs in and around Melbourne, on farms such as those at Werribee and Bacchus Marsh. More than 60 per cent of Sydney's fresh produce is grown close to the city, with the bulk of it coming from commercial gardens such as those in Bilpin, Marsden Park and Liverpool.

These farms are important because:

- they provide us with nutritious food that does not have to be transported very far
- they provide local employment
- they preserve a mix of different land uses in and around our cities.

Currently, we can obtain our food from almost anywhere because we have modern transportation (such as trucks and planes), better storage technology (refrigeration and ripening techniques) and cheap sources (not necessarily the closest). However, this fails to recognise that Australia's population may double by 2050 and food will become more scarce on a global level. The eradication of our local food providers may be at our own peril.

Land use zoning is generally the responsibility of state planning departments but cooperation is required by all three levels of government: local, state and federal. We need to ensure that our green wedges are protected from becoming **development corridors**. The needs on both sides of the argument are valid. How can we house a growing population and provide enough food for them? Can we do both?

development corridor area set aside for urban growth or development

FIGURE 2 The battle at our urban fringe: housing or farmland?

ACTIVITIES

IDENTIFY

1 List the groups involved in the conflict over our rural–urban ***spaces***.

EXPLAIN

2 Why it is important for people to have rural ***spaces***, such as market gardens, close to the city?

3 Why it is important for cities to have access to more land for urban development?

4 Refer to figure 1. Describe how Sydney's urban sprawl has ***changed*** in direction and pace.

APPLY

5 Use the internet to research some companies that sell house and land packages in your state. What are some of the marketing messages that are used to sell the properties? Do you think they are able to deliver on their promises?

6 Many new homes on the urban fringe are built with six-star or seven-star energy efficiency. Use the internet to help you find out what this means.

7 Sydney's growth has occurred around a series of urban precincts. New suburbs include: Ropes Crossing, Jordan Springs and The Ponds. Use Google Earth to locates and 'placemark' each of these ***places***. Use the ruler tool to measure the distance from each suburb to Sydney's CBD. Alternatively, you may be able to complete this activity in your own state by researching new suburbs added to your city.

INVESTIGATE

8 Housing and agriculture demands on land are two of the biggest dilemmas of the twenty-first century. A growing population needs to be housed, but it also needs to be fed, and the cost of relying on imported food can be very high. Set up a debate with your classmates on the following statement: 'Green belts close to the city should be preserved and protected.' The affirmative team will argue for this, while the negative team will argue that green belts should be removed and used for new housing developments.

9 'Sprawl is created by people escaping sprawl.' Discuss this statement with a small group.

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Interactivity
The 20-minute city
Use this interactivity to learn more about designing a sustainable city.
Searchlight ID: int-3122

10.7 How can we manage traffic?

10.7.1 The way forward

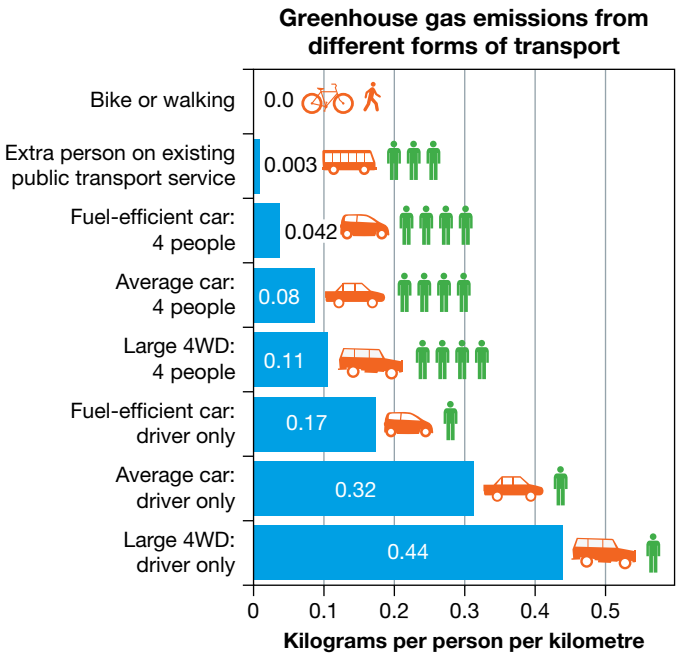
How did you get to school today? How long did you spend in the car? Were you stuck in a traffic jam? Australians who live in cities are experiencing longer commuting times than ever before, and this is only going to get worse. A growing population will mean an increase in cars — unless we start to tackle the problem from a sustainable perspective.

Transport is one of the largest sources of greenhouse gas emissions in Australia (34 per cent), with passenger cars contributing more greenhouse gases than any other part of the transport sector. Some of the big issues in improving the sustainability of our transport systems are listed below.

Improving our infrastructure

Better public transport infrastructure will help improve the sustainability of our communities. Some cities have excellent rail systems or electrified tramways that were installed many years ago. But as cities grow and change, costly extensions may be required. Buses are much cheaper and quicker to upgrade. In Curitiba, Brazil, **bi-articulated buses** travel in dedicated bus lanes, and 70 per cent of the population uses the service. Public transport systems are cost-effective because it costs the same to run a bus or train with one passenger as it does with 1000 passengers (see figure 1). The more people who travel, the less it costs to transport each person.

FIGURE 1 Greenhouse gas emissions from different forms of transport



bi-articulated bus an extension of an articulated bus, with three passenger sections instead of two

Technologically advanced transportation

Over the years there have been many improvements in car design, fuel efficiency and vehicle safety. Sustainable transportation methods have not attracted the same interest or **investment**. However, times are changing. China hopes to sell 500 000 electric or hybrid cars annually; Paris, in 2011, started installing electric-car charging stations around the city; two thirds of the world's 665 000 electric vehicles are found in China, Japan and the US. Adelaide has demonstrated great leadership with the world's first solar-powered electric bus, recharged using 100 per cent solar energy. The bus (Tindo) is able to travel 200 kilometres between each charge and has wi-fi capability so passengers can access free internet while travelling.

investment an item that is purchased or has money dedicated to it with the hope that it will generate income or be worth more in the future

FIGURE 2 The Tindo bus in Adelaide runs on solar energy.

eBook*plus*

Interactivity
Smog buster
Use this interactivity to learn more about reducing air pollution in cities to make them more liveable.
Searchlight ID: int-3123

Denser urban settlements

When an urban area is dense, the buildings are more compact, and more people live there. Dense urban settlements have 'efficiencies' already built in. Older cities, such as those in Europe, were established long before the invention of motor vehicles, meaning that they were built for walking. The older parts of European cities have narrow streets and laneways, and cannot cope with congestion. Europeans are less likely to own cars because they live close to their daily destinations, and this reduces the need for cars. In Manhattan, New York, 82 per cent of people (1.3 million) travel to work by public transport, bicycle or foot—this is 10 times the rate of the average American.

FIGURE 3 Priority parking spaces

10.7.2 Changing our behaviour

Did you use a sustainable form of transport to get to school today? Cycling and walking are forms of mass urban transportation. Providing safe bike paths and walking routes makes people more likely to change their behaviours. If you have to travel by car, one way of increasing the effectiveness of each trip is car pooling. Governments or workplaces may also provide **incentives** for individuals to make a more sustainable transport choice.

incentive something that motivates or encourages a person to do something

FIGURE 4 Pedestrian and road traffic can be surveyed

Positive changes are happening, even if it is a little slow. The most recent figures show that more Sydney residents are walking and riding to work. The inner city suburb of Marrickville has the highest level of residents (4.3 per cent) commuting to work by bike in NSW.

The toll we pay

Travel, particularly in our own cars, has increased at a rapid rate over the past fifty years. We have increased our mobility, independence and opportunities, and this has transformed the way in which land is used and people live. But as well as these benefits, car travel has created many health problems. Accidents and injury, climate change, air, water, soil and noise pollution, reduction in social interaction, and declining physical activity are all negative effects of car travel that take their toll on our health.

FOCUS ON FIELDWORK

What mode of transportation did you use to come to school today? How long did it take? How did your family members travel to their place of work or their school or university today? Use an internet mapping tool to help you work out how many kilometres your family travelled and by what means.

ACTIVITIES

IDENTIFY

1 Study figure 1. Which mode of transportation contributes the most greenhouse gas emissions and which contributes the least?

APPLY

2 Tally the results for your class's responses to the focus on fieldwork questions. Present the information in graph format. If possible, compare your results with another class.

3 What is car pooling? As a class, work out the minimum number of cars it would take to efficiently transport your entire class to school.

4 Create a mind map of the way car travel affects your health, and then create a corresponding mind map of the way public transport affects your health. Include as many positive and negative points as you can with a brief explanation.

PREDICT

5 Consider the four areas for improvement listed in this spread. Which do you think will be the most important for (a) individuals and (b) the government to focus on in the next five years?

6 Download a map of your suburb and print it out. Annotate it with current public transport options, such as trains, buses, bike paths and footpaths. Use different colours and a key to suggest improvements to existing options in your local ***space***.

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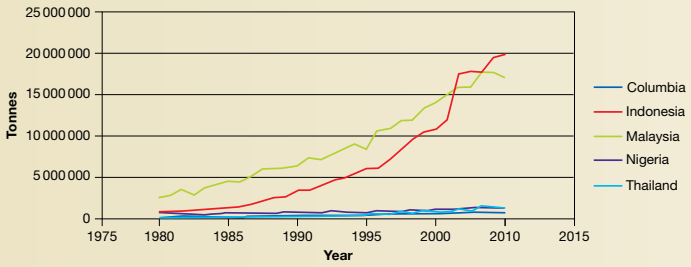
10.8 SkillBuilder: Drawing a line graph using Excel

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.



eLesson

Watch this video to learn how to draw a line graph using Excel.

Searchlight ID: eles-1662

Interactivity

Try this interactivity to learn how to draw a line graph using Excel.

Searchlight ID: int-3158

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10.9 Welcome to Sustainaville

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

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10.10 Where are the world's sustainable cities?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

10.11 Can we plan to 'live vertically'?

10.11.1 Higher-density living, smaller households

Australian cities are experiencing an apartment revolution. More people are choosing to live near the centre of cities in high-rise apartments rather than in houses on big suburban blocks. Urban life now sees families and individuals moving to the inner city for a variety of reasons, such as seeking to make a smaller ecological footprint, or avoiding long commutes to school, work and shops.

family household two or more persons, one of whom is at least 15 years of age, who are related by blood, marriage (registered or de facto), adoption, step-relationship or fostering

Australian households are changing in structure all the time, and recent data suggests the greatest increase will be in **family households**, which will grow from 5.6 million in 2006 to 8 million households in 2031. Family households are projected to remain the most common type in Australia. Although they show the greatest increase in numbers, single-person households are projected to experience the greatest percentage increase—63 per cent—over the next 25 years, from 1.9 million in 2006 to 3 millon in 2031. This is due to the ageing of Australia's population and the fact that older women are more likely to live alone than men. It will be a challenge to provide enough accommodation and make residences as sustainable as possible.

FIGURE 1 Projected number and type of households in Australia, 2006–2031

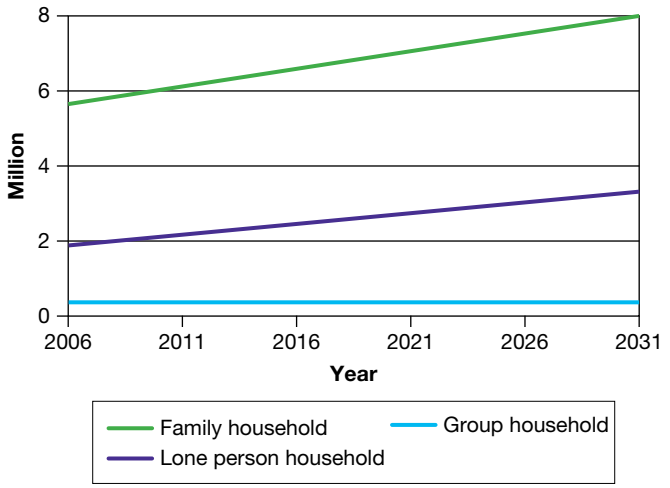
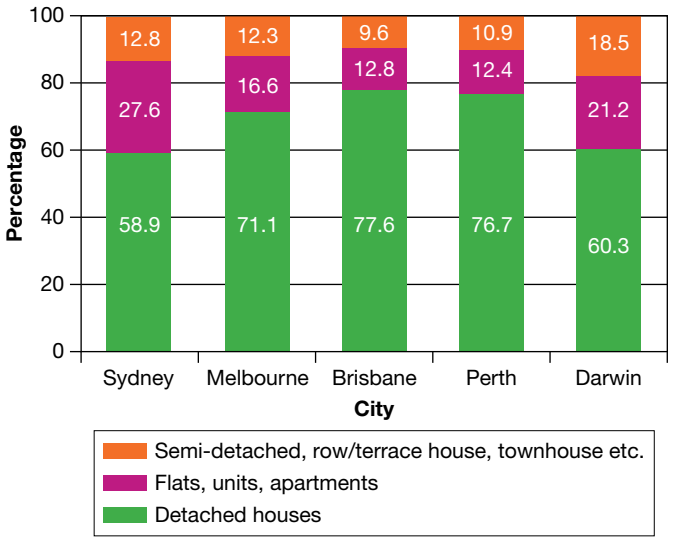


FIGURE 2 Dwelling types in major capital cities



10.11.2 Going green

All housing can be designed to be sustainable. However, medium- and higher-density housing can offer the greatest opportunity for energy savings. Buildings with shared walls and more than one storey (such as two-storey and semi-detached homes, terraces and apartments) use less energy for heating and cooling than single-storey detached homes.

In Australia, people have started to value being able to walk to facilities and workplaces, so our urban centres are increasing in population density. For business and residential purposes, urban sprawl is far less sustainable than high-rise buildings. A sustainable building may include on-site energy generation (such as solar panels and wind turbines) and passive energy design (such as insulation), reducing the need for air-conditioning and heating. 'Green' or recycled building materials can also lower the environmental costs of construction.

Green roofs and walls

FIGURE 3 The ACROS Building in Fukuoka, Japan, has a fully grown forest on one terraced roof.

Green roofs and walls have a history dating back thousands of years. People are rediscovering the benefits of creating healthy, green buildings. A green, or living, roof is a roof surface that is planted partially or completely with vegetation over a waterproof layer. They may be extensive, with simple ground-cover vegetation, or intensive, with soil more than 200 millimetres deep and planted with trees. Green walls are external or internal walls of buildings that include vegetation, either in stacked pots or in growing mats.

Green roofs are now an accepted part of modern buildings in Europe. Approximately 10 per cent of German roofs have been greened, and the city of Linz, in Austria, requires green roofs on all new residential and commercial buildings with rooftops over 100 square metres. (To see how big this is, pace out an area 10 metres long by 10 metres wide.)

Green roofs have several benefits. They:

- are aesthetically pleasing
- provide a cooling effect on local microclimate
- reduce carbon dioxide (CO_2)
- reduce air pollution
- provide insulation for buildings
- provide recreational space for local residents and workers.

The high life

In the last century, Europe has transformed itself from a largely rural to a mostly urban continent. It is estimated that around 70 per cent of the **EU** population — approximately 350 million people — lives in urban centres of more than 5000 inhabitants. About two thirds of energy demand is linked to urban consumption and up to 70 per cent of CO_2 emissions are generated in cities. The urban way of life is both part of the problem and part of the solution. The density of urban areas allows for more energy-efficient forms of housing, transport and other services. Consequently, measures to address climate change may be more efficient and cost-effective in big, compact cities than in less densely built spaces.

EU European Union — an economic and political union of 27 member states, mostly in Europe. (In 2016 Great Britain voted to exit the EU. At the time of publishing they were still officially a member.)

ACTIVITIES

IDENTIFY

1 Study figure 1. How are Australian households predicted to ***change*** over the next 20 years? What type of household do you live in?
2 What type of dwelling is your residence?

EXPLAIN

3 Explain why the types of households are going to ***change*** in the next 20 years in Australia.

APPLY

4 Using a program such as Google Earth, visit Linz in Austria. Can you locate any green roofs or other green spaces? Conduct a flyover of your capital city. How many green roofs can you find in the central business district?

INVESTIGATE

5 As a teenager, what do you think are some of the advantages and disadvantages of living in a high-rise or apartment building?
6 Green roofs can be built anywhere. Select a rooftop on a building at your school, and create a plan for your own green roof. To find inspiration, conduct research on successful green roofs around the world. You will need to include a design, information on size and materials needed, and how and why it would be accessed. Present your design using a program such as Prezi or PowerPoint.

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10.12 Is Auroville a sustainable community?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

10.13 How do we plan for a liveable future?

10.13.1 The role of governments

Managing and planning Australia's future urban areas will take the efforts of many. We, as citizens of Australia and the world, must be prepared to make significant changes to the way we live if we wish to enjoy a good quality of life in the future. Sustainability and liveability must be on the agenda for governments, communities and individuals.

rebate a partial refund on something that has been bought or paid for

retrofitting adding a component or accessory to something that did not have it when it was originally built or manufactured

Governments can commit to sustainability in a number of ways. They may offer incentives such as **rebates** on solar panels or water-efficient showerheads. They can fund research into sustainable technologies. Governments can adopt strict planning regulations and well-defined urban growth boundaries. They can have clear policies on levels of air quality, business sustainability, and the construction or **retrofitting** for sustainability of 'green' buildings. They can develop land use plans that encourage sustainability and biodiversity.

10.13.2 The role of communities

Communities and organisations are working with governments, businesses and individuals to respond to global challenges such as climate change. There are many measures in place to improve transport and mobility, develop effective use of our land, and plan and develop appropriate policies.

Communities maintain and improve infrastructure and open spaces, and can help us work at the neighbourhood level to build a more sustainable community. An example of this is the Sustainability Street program run by many councils, where residents are encouraged to work together with their neighbours on improving local liveability. They might establish community gardens or purchase solar systems in bulk. Some great examples of communities working with governments to improve liveability and sustainability are shown in figures 1, 2 and 3.

FIGURE 1 In Brunswick, Victoria, an old garbage dump was converted into the Centre for Education and Research into Environmental Strategies (CERES), comprising a community garden and resource and environment education centre.

FIGURE 2 A disused railway in New York was converted into the High Line public park.

FIGURE 3 A vertical garden disguises a five-storey car park at Southbank, Victoria.

10.13.3 The role of the individual

We can all seek to enjoy a quality of life that does not damage the environment. Although you might feel powerless, in the next decade you will be making your own contribution to society and thinking about what kind of world you would like to grow old in. You will need to consider your sustainable choices in the action areas shown below. What is *your* personal sustainability plan? Ultimately, if you want to improve your quality of life and the environment, make your choices sustainable ones. You could get involved by:

- riding or walking to school each day
- establishing an eco-classroom at your school
- learning more about the connections between Indigenous people and their land
- installing solar hot water or solar panels at your residence
- growing your own food.

FIGURE 4 Action areas

Energy

Indigenous knowledge

Waste

Community

Transport

Sustainable purchasing

FOCUS ON FIELDWORK

Make your own personal sustainability plan, using a mind map to help categorise your ideas. Consider how you could make changes in various areas of your life (school, home, sport, hobbies). List the actions that you would take, and identify what the outcome would be. For example, 'I could ride to soccer practice after school instead of being driven'. Outcome: reduced GHGE from family car.

FOCUS ON FIELDWORK

How sustainable is your lifestyle?

- Download a mobile device app, such as Oroeco or a similar 'Ecological footprint calculator', to assess your impact on the environment throughout a day. How does it compare with the class?
- Make your own personal sustainability plan, using a mind map to help categorise your ideas.
- Consider the changes you could make to your daily routine.
- Suggest ways the mobile device app could be made more user friendly.

ACTIVITIES

IDENTIFY

1 Who are the three key groups making our urban areas more sustainable?

EXPLAIN

2 Study figures 1 to 4.
   - a What are some ways in which governments can make changes to create a more liveable future?
   - b What are some ways in which you, as a high-school student, can make changes to create a more liveable future?

3 Use the internet to find out how a building can be made more ***sustainable***.

APPLY

4 Use the internet to find information about Central Park, an environmentally sustainable urban village located in central Sydney. Explore some of the ways in which the building works, not only in conserving resources but also in improving the wellbeing of its workers.
   - a Which feature of the building is most interesting to you? Why? How does it work?
   - b Could this feature, or any others, be applied to your home? Would any of the features be more suited to larger buildings such as your school?
   - c Would you like to work in a building like this? Why or why not? Justify your explanation.

5 Research the ways in which your local council is working at a local level to improve ***sustainability***. Most councils have a section on their website dedicated to actions for ***sustainability***. Work in a small group to create a short presentation on the various programs at work. What kind of programs can individuals participate in?

PREDICT

6 As you get older, your needs, wants and priorities will ***change***. Imagine you have now completed Year 12 and are ready to move out into your first share house. In a small group (representing your new housemates), agree on a list of 10 ways that you and your housemates could live more sustainably.

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10.14 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

10.5 SkillBuilder: Reading and describing basic choropleth maps

10.5.1 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.

Model

The population density across Brazil varies considerably from the coast to the inland regions. The population density is greatest (over 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 less than 10 people per square kilometre.

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.

10.5.2 Show me

How to read and describe a basic choropleth map

You will need:

- a basic choropleth map.

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 next. 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.

eBookplus

eLesson
Reading and describing basic choropleth maps
Searchlight ID: eles-1706

FIGURE 1 Population density in Brazil

Source: 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 other 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 as these appear to be isolated clusters of higher population, whereas most of the area contains fewer than 10 people per square kilometre.

10.5.3 Let me do it

Developing my skills

Read and interpret figure 1 in subtopic 8.2, a basic choropleth map of Australia's population density, by answering the following questions.

Questions

1. Which region(s) of Australia have a pattern indicating the highest population density? Provide statistics or numbers (quantification) in your answer, such as percentage (%), size or area (square kilometres, km^2).
2. Which region(s) of Australia have a pattern indicating the lowest population density? Include quantification in your answer.
3. Are there any places that do not fit the expected pattern? State the locations of these anomalies.
4. Which Australian state is most densely populated?
5. Give two reasons that large parts of Australia have a low population density.

Checklist

I have:

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

Skills questions

1. Basic choropleth maps are used to show:
   a. the height of the land across a region
   b. a range of colours
   c. the distribution of one factor
   d. the distribution of many factors.
2. A basic choropleth map includes information about:
   a. numbers
   b. colours
   c. species
   d. ground cover.
3. Why do you give a general summary of the map first?
4. Why do you identify any anomalies?

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Interactivity
Reading and describing basic choropleth maps
Searchlight ID: int-3286

10.8 SkillBuilder: Drawing a line graph using Excel

10.8.1 Tell me

What is a line graph?

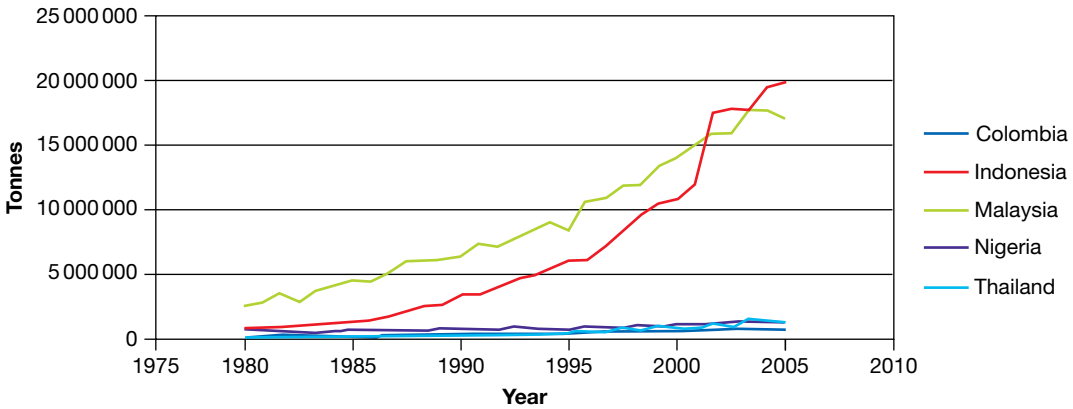
A line graph is a clear method of displaying information so it can be easily understood. It is best used to show changes in data over time.

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 (see figure 1).

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.

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

Model

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.

10.8.2 Show me

How to draw a line graph using Excel

You will need:

- Excel software
- a set of data.

Procedure:

To draw a line graph using Excel, complete the following steps.

STEP 1

Enter the data into the 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.

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

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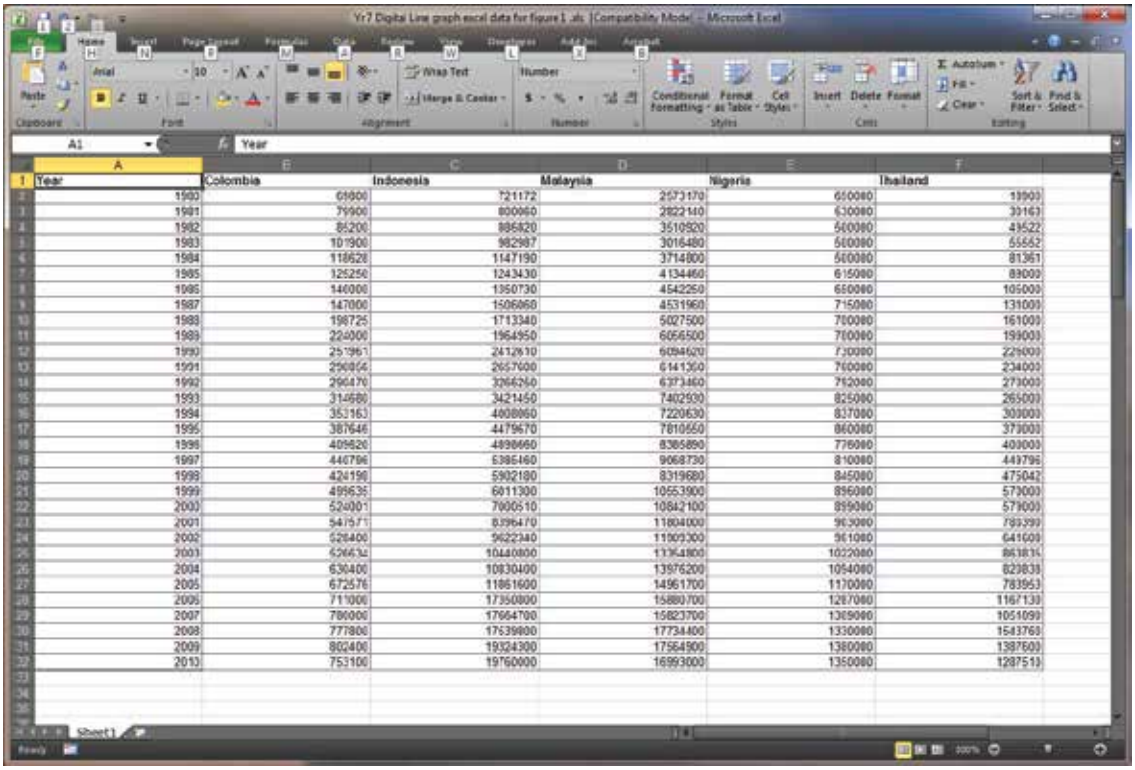
eLesson
Drawing a line graph using Excel
Searchlight ID: eles-1662

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



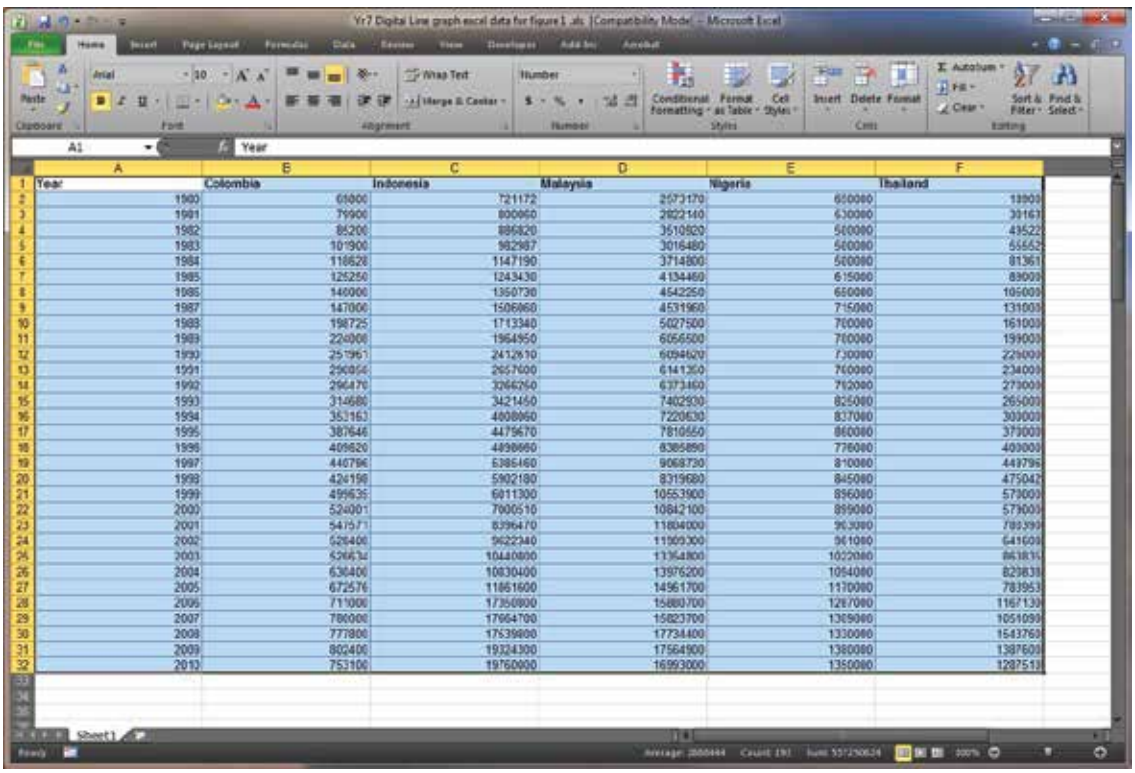
Year	Colombia	Indonesia	Malaysia	Nigeria	Thailand
1980	61000	721172	2573170	650080	13900
1981	79900	800960	2822140	630080	30163
1982	86200	886820	3510920	560080	43522
1983	101900	982987	3016480	560080	55652
1984	118628	1147190	3714800	560080	81361
1985	125250	1243430	4134460	615080	83000
1986	146000	1350730	4542250	660080	105000
1987	147000	1506860	4531960	715080	131000
1988	198725	1713340	5027500	700080	161000
1989	224000	1964950	6056500	700080	199000
1990	257961	2412610	6094620	730080	229000
1991	290856	2657600	6141360	700080	234000
1992	296470	3266250	6373460	710080	273000
1993	314680	3421450	7402930	825080	265000
1994	353163	4008860	7220630	837080	303000
1995	387646	4479670	7810650	860080	373000
1996	409626	4898660	8365890	776080	403000
1997	446796	5386460	9068730	810080	449796
1998	424196	5902180	8319680	845080	475042
1999	499635	6011300	10553900	896080	573000
2000	524001	7000510	10842100	899080	579000
2001	547571	8396470	11804000	963080	780399
2002	526406	9622340	11909300	961080	641609
2003	526634	10440800	13364800	1022080	863834
2004	630400	10830400	13976200	1054080	823838
2005	672576	11861600	14961700	1170080	783953
2006	711000	17350800	15880700	1287080	1167139
2007	786000	17664700	15823700	1369080	1051099
2008	777800	17639800	17734400	1330080	1543760
2009	802400	19324300	17564900	1380080	1387600
2010	753100	19760000	16993000	1350080	1287513

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.

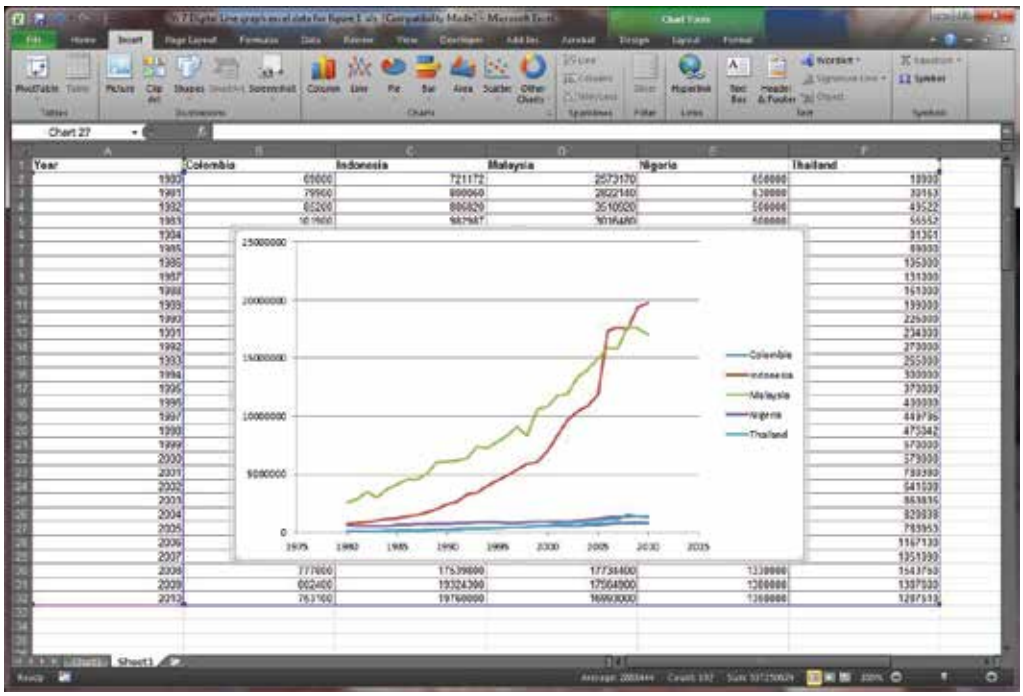
FIGURE 3 The required data (all values in the example shown here) is selected.



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.

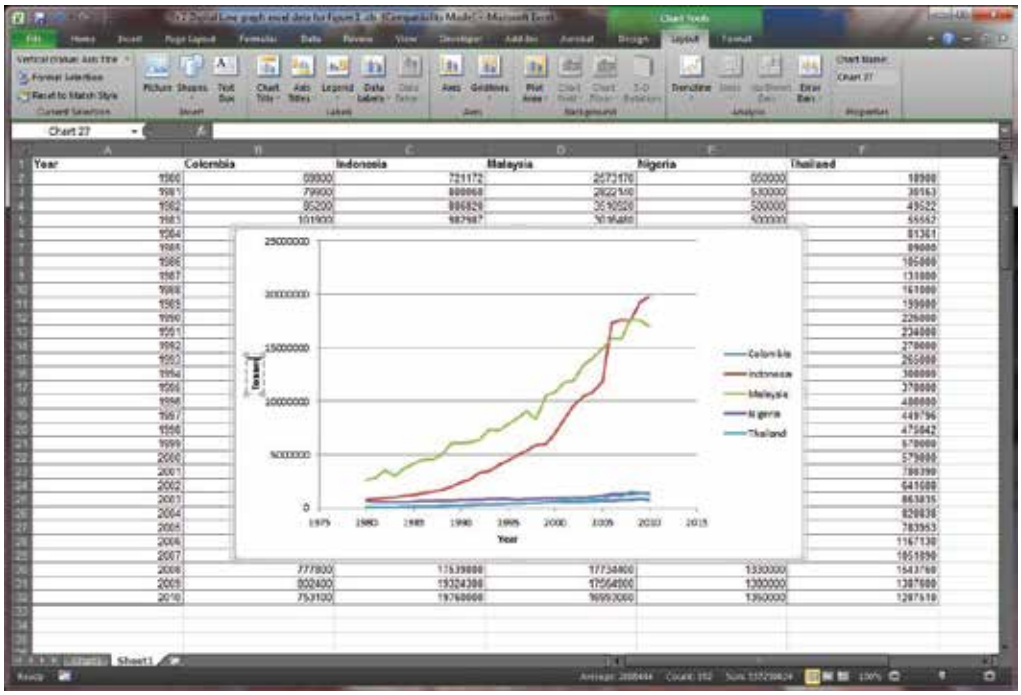
FIGURE 4 Select the 'Scatter with Straight Lines' option to produce a graph with a line for each of the variables in your data set.



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.

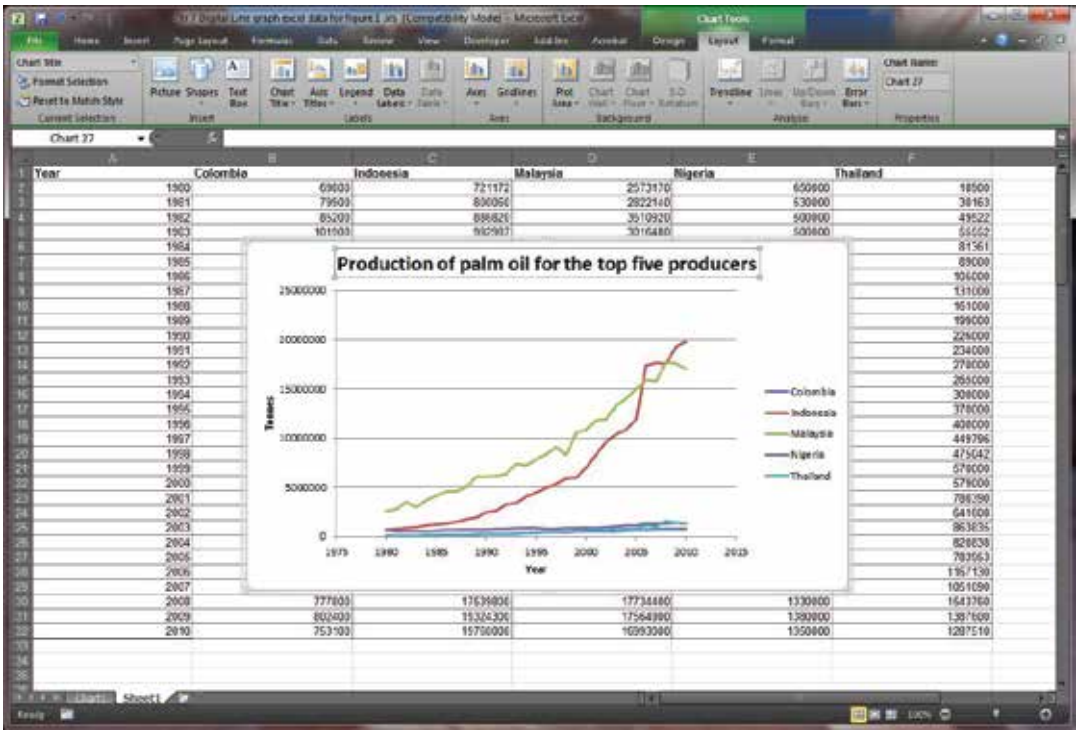
FIGURE 5 Label the axes on your graph.



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 third option, 'Above Chart', for placement of your title. Type an appropriate title for your graph in the text box that appears.

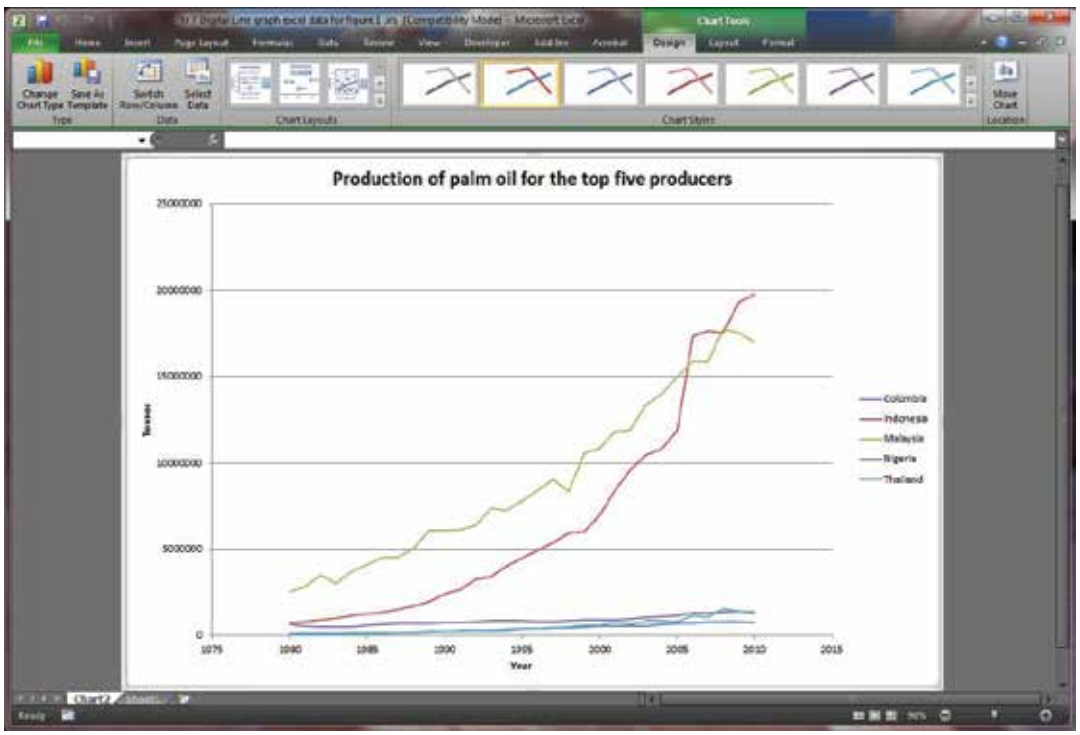
FIGURE 6 Add a title to your graph.



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.

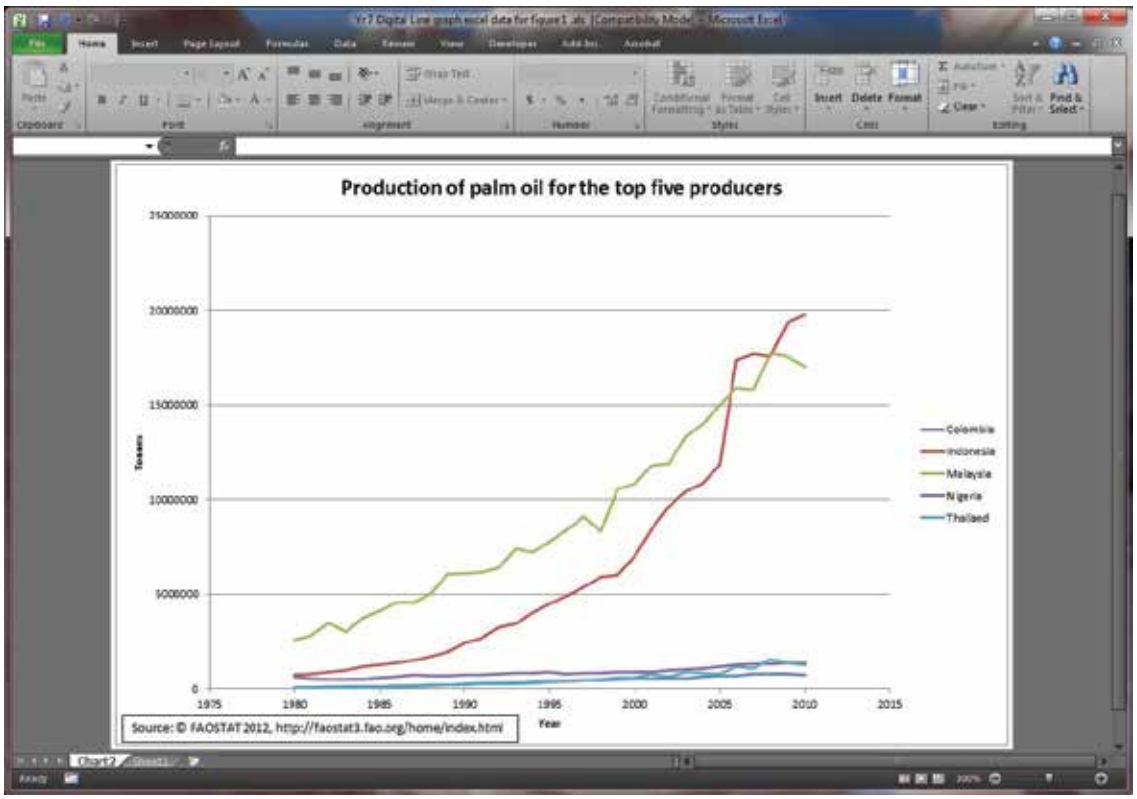


STEP 7

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've used in your graph.



10.8.3 Let me do it

Developing my skills

TABLE 1 Palm oil production in Malaysia, 1980–2010

Year	Tonnes of palm oil produced
1980	2 573 170
1981	2 822 140
1982	3 510 920
1983	3 016 480
1984	3 714 800
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

(*continued*)

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Interactivity
Drawing a line graph using Excel
Searchlight ID: int-3158

TABLE 1 Palm oil production in Malaysia, 1980–2010 (*continued*)

Year	Tonnes of palm oil produced
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

Questions

1. Refer to figure 1. Which country was the biggest producer of palm oil in 2010?
2. Refer to your graph, drawn using the data in table 1.
   a. What unit of measurement is used in this graph? How many kilograms of palm oil were produced in 2010 in Malaysia?
   b. Describe the general trend of palm oil production from 1980 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.

Skills questions

1. Line graphs are used to show:
   a. the location of a place
   b. the shape of the landscape
   c. height above sea level
   d. change over time.
2. A multiple line graph such as that in figure 1 is useful to:
   a. confuse people
   b. compare data over time
   c. show a trend in one data set
   d. add colour and excitement to a report.
3. Explain why is it useful to construct a line graph using a spreadsheet program such as Excel.
4. Is it important to label the vertical axis? Why or why not?

10.9 Welcome to Sustainaville

10.9.1 Why don't we just build more roads?

In an ideal world, a sustainable transport system would have a fast, clean, reliable and regular train service with waiting times of no more than 10 minutes, day or night. Trams and buses would link into the train network, bringing people to the main parts of the system. Trams and buses would have priority over other traffic and run on the weekends. Station staff would be present at all times and the services would be safe and clean. What are some of the costs, other than financial, of using our cars instead of public transport?

Contrary to popular belief, building new roads and freeways does not actually ease **congestion**. This is because a new road simply becomes an opportunity for people to make new journeys that they may not have contemplated before; or they make the same journey more often; or they drive instead of taking public transport; or travel longer distances to accomplish the same task. All these things result in increased traffic on the new road, so the road system ends up just as congested as before. More energy and resources are consumed, and more pollution is generated.

congestion the state of being overfilled or overcrowded

FIGURE 1 Traffic jams slow down people and the economy.

FIGURE 2 This cyclist in China may be wearing a mask to reduce the effects of air pollution.

10.9.2 The benefits of an efficient public transport system

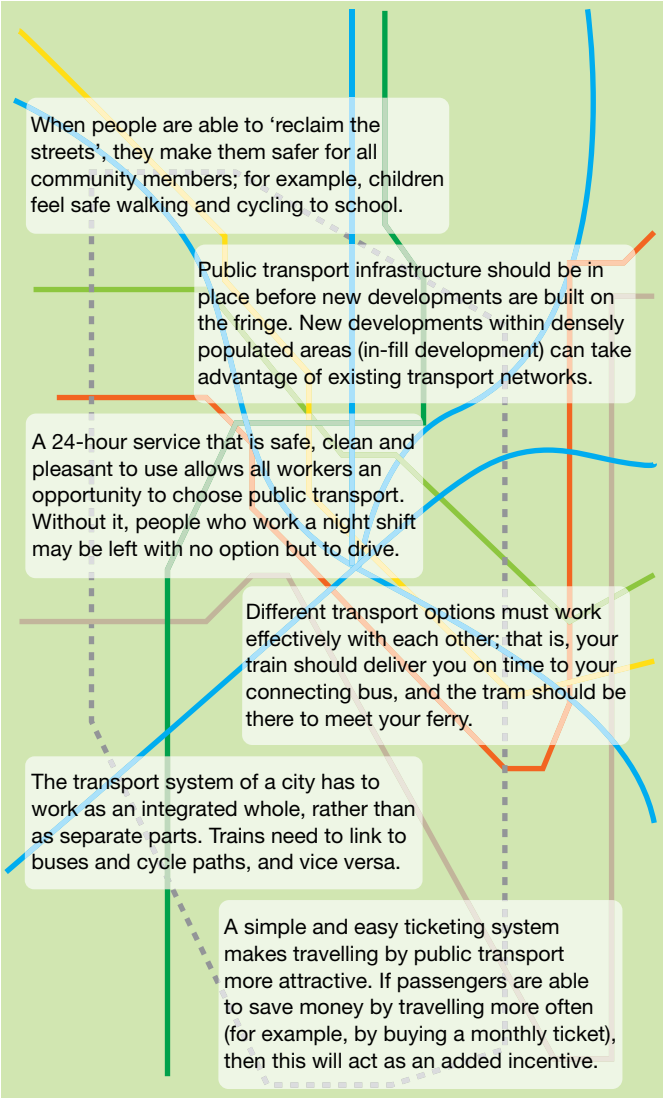
By shifting from car trips to public transport we can improve our **triple bottom line**. In other words, we improve economic efficiency, help the natural environment and do something good for society.

However, we also know that people will not get out of their cars and use public transport until public transport offers a high-quality, convenient and affordable service. Australia needs to make huge improvements in service frequency, connections and coverage. This formula has worked in other cities around the world and could work here in Australia.

Here in Australia we must look to develop Sustainaville — a community with its focus on public transport, walking and cycling.

triple bottom line an accounting term for measuring the success of a city, country or organisation by the health of its environment, its society and its economy

FIGURE 3 A model for transport in a sustainable city



ACTIVITIES

IDENTIFY

1 Study figure 3. What does a public transport system need to be like in order to be a success?

2 Which three areas does the triple bottom line concern?

EXPLAIN

3 The benefits of an efficient public transport system are many. If we were to discuss its impact on the ***environment***, we would see less air and noise pollution, conservation of green spaces (public transport uses less space than roads), and reduced greenhouse gas emissions (GHGE). A full train produces about five times less GHGE than the cars needed to move the same number of people. Explain how an efficient public transport system would benefit the economy and society, following the example above to assist you.

INVESTIGATE

4 Curitiba in Brazil has installed a very successful bus rapid transit system (BRT), which has buses running about every 90 seconds and is used by 70 per cent of Curitiba's residents. Conduct some internet research using the **Urban habitat** weblink in the Resources tab or other sites, or view one of the many videos available online about the BRT system. Make a list of the unique features of the BRT and include some facts about the effect the system has had on the triple bottom line of Curitiba. How does this system compare to those you are aware of in your local community here in Australia?

PREDICT

5 Use the **Crank busters** and **Transport urban myths** weblinks in the Resources tab to find information that will help you create a 'True or

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Weblinks
- Urban habitat
- Crankbusters
- Transport urban myths

false?' quiz about public transport for your classmates.

APPLY

6 What kind of public transport system would you like to use? Design your own regional public transport option, using your local council area borders. Create a brochure showcasing the many benefits and features of the service. Include a map that details the routes of the service, frequency of service, hours of operation and cost. Use figure 3 to assist you.

7 There are many arguments for getting out of our cars and onto trams, trains, buses or bikes. Use the **Crank busters** and **Transport urban myths** weblinks in the Resources tab and other resources to prepare a class debate on one of the following topics.

- People who own cars won't use public transport.
- Bringing back tram conductors and station staff would increase fares.
- Cars are more efficient than public transport.
- Freeways reduce traffic congestion and pollution.

You may be able to share the topics listed above among different groups and then present to the entire class.

10.10 Where are the world's sustainable cities?

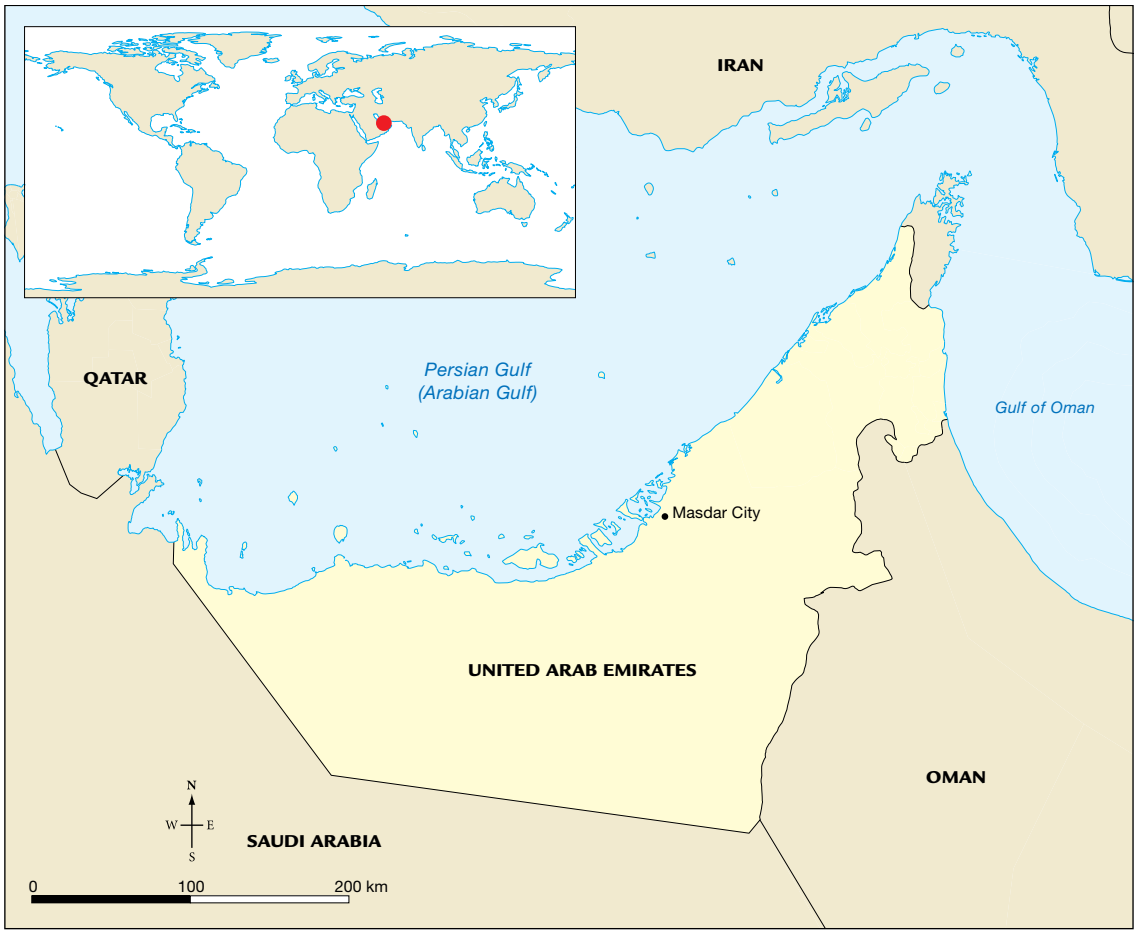
10.10.1 Sustainability and the city

It may seem a little unusual to find a place like Masdar City in the Arabian Gulf. Masdar City, in the United Arab Emirates (UAE), was founded in 2006 to provide cutting-edge research into renewable and clean energy technologies. In this harsh and unforgiving climate, survival is all about sustainability, and resources must be used wisely in order to ensure a **viable** future.

viable capable of working successfully

The UAE possesses eight per cent of the world's oil reserves. By economic standards, it is a strong and stable country. The UAE government has recognised that although it may have 100 years' worth of oil supplies left to sell to the rest of the world, it needs to ensure that, by the end of this century, its economy does not rely on its natural resources alone.

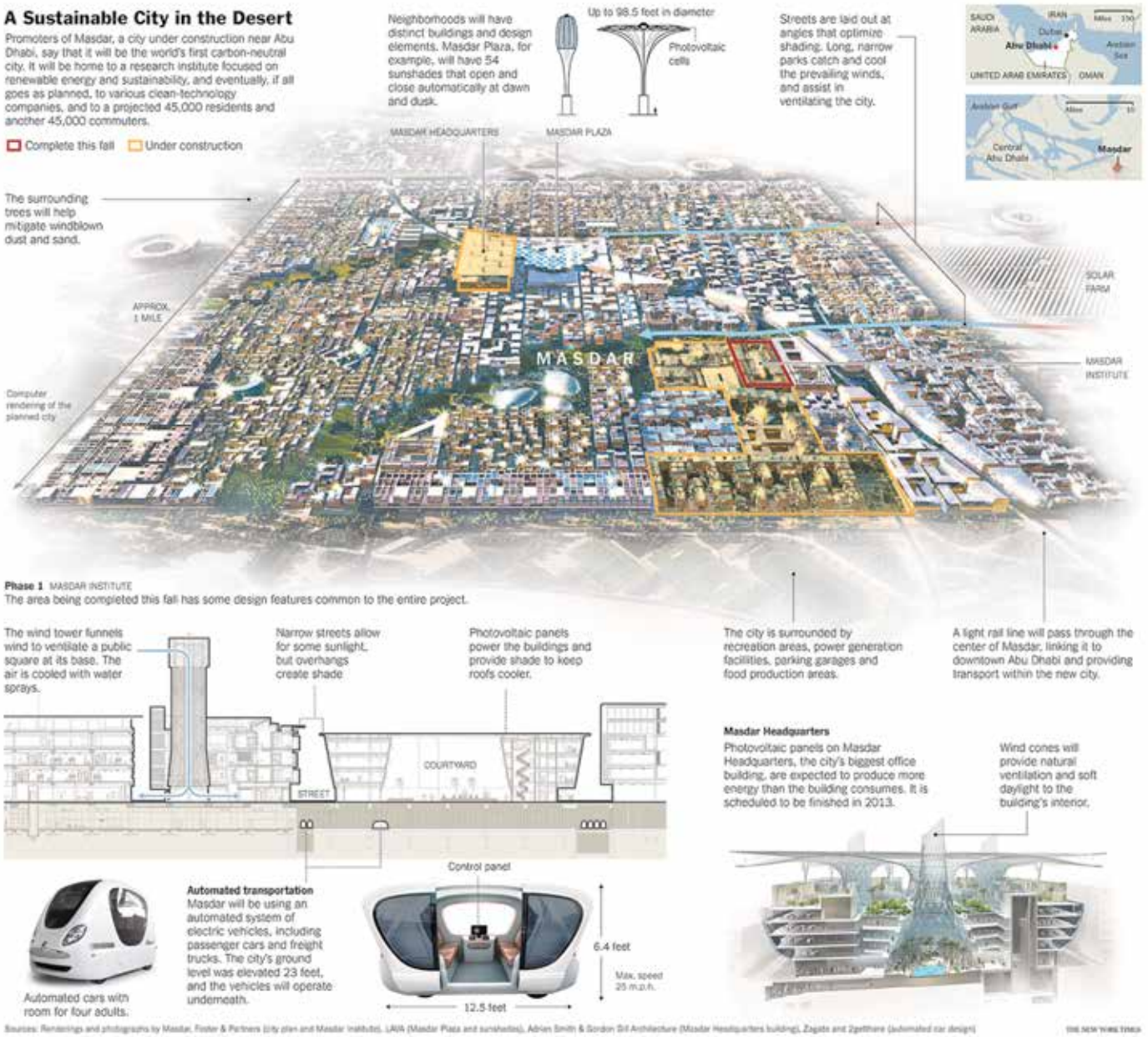
FIGURE 1 Location map of Masdar City



Source: Spatial Vision

The plan is for Masdar City to become a global leader in sustainability. Sustainable city-scale technologies and systems will be tested and then shared with other cities. This approach is intended to reduce the local and global ecological footprint of cities across the world.

FIGURE 2 Masdar City: a sustainable city in the desert (see the Masdar City infographic, doc-11470, in your Resources tab to view this image at a larger size)



Source: From *The New York Times*, September 26, 2010 © 2010 The New York Times. All rights reserved. Used by permission and protected by the Copyright Laws of the United States. The printing, copying, redistribution, or retransmission of this content without express written permission is prohibited.

It is intended for the city to have a population of 45 000 residents, and to make people, not cars, the focus. Pedestrians are king: streets are shaded by buildings or trees, and pleasant shaded walkways encourage walking. Masdar Plaza has 54 30-metre-wide sunshades that open and close automatically at dawn and dusk. All these features aim to provide the highest quality working and living experience with the lowest possible environmental footprint.

FIGURE 3 A newly completed courtyard in Masdar City

ACTIVITIES

IDENTIFY

1 Which countries border the United Arab Emirates?

2 In what activities might the residents of Masdar City be engaged?

EXPLAIN

3 The Arabic word *masdar* means 'the source'. Why do you think the city was given this name?

4 Masdar City was master-planned with many efficiencies built into the design. Is it easier to design a city from scratch or to make ***changes*** to an existing city in order to make it ***sustainable***?

INVESTIGATE

5 Locate Abu Dhabi and your home town or city on a world map. Describe the location of each ***place***, including the latitude and longitude of each.

6 What type of climate exists in Abu Dhabi? How does it compare with the climate of where you live?

PREDICT

7 What do you think it would be like to be a teenager living in Masdar? Would you like to live there? Why or why not?

8 Study figure 2, also available as the 'Masdar City infographic' resource (doc-11470) in the Resources tab. Create a table that shows the economic, social and ***environmental*** benefits of Masdar City.

APPLY

9 Design your own sustainable city, using the image of Masdar City in figure 2 as a guide. Ensure you provide:

- a map of the city, noting important features
- an inset map showing potential location (country and continent, with some reference to climate)
- information on scale
- information on how the city generates its own energy sources
- a list of water efficiency measures
- descriptions of green spaces
- an outline of transport options provided to residents.

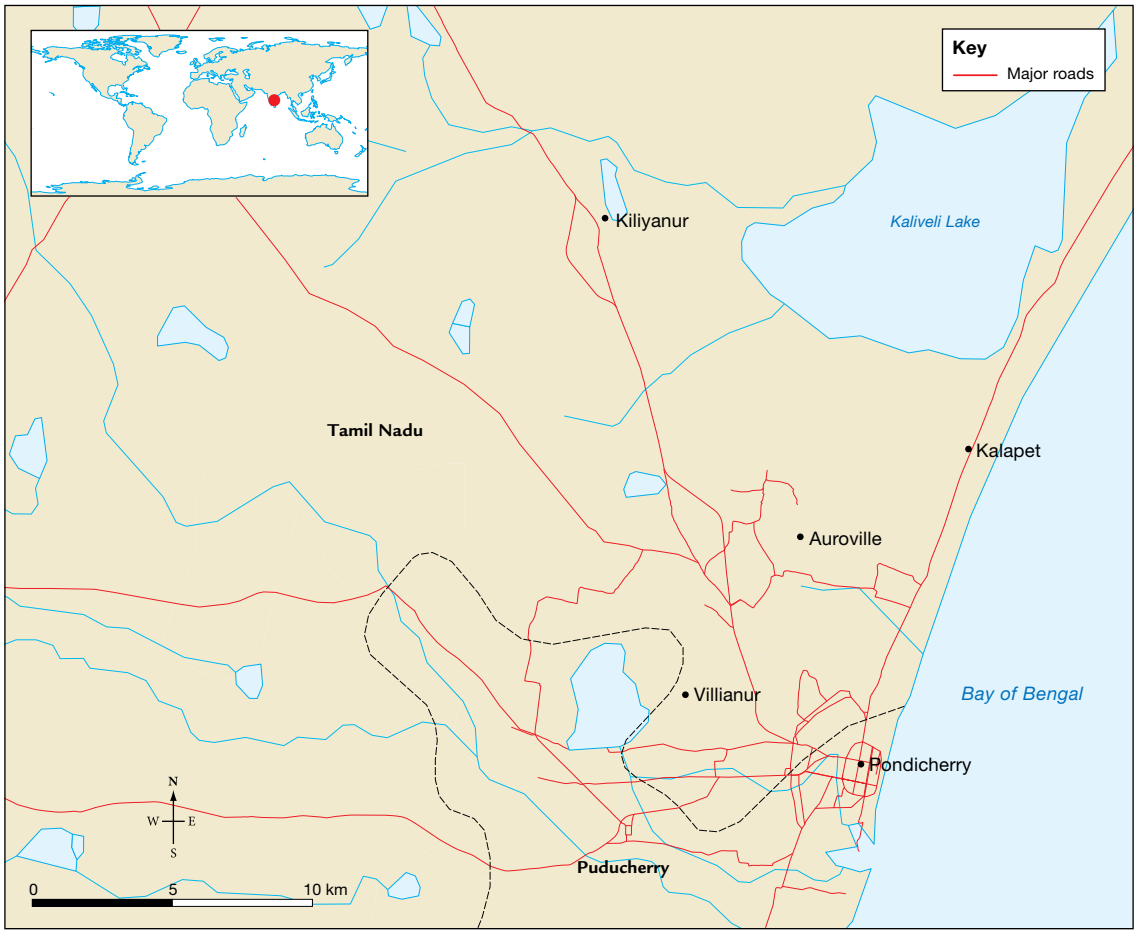
You could choose to create a model in a small group or a blueprint on paper, using ICT to assist you.

10.12 Is Auroville a sustainable community?

10.12.1 What and where is Auroville?

Auroville is a planned 'universal' community for up to 50 000 people under development in south-east India. It is located close to the Coromandel Coast, 10 kilometres north of Pondicherry and 150 kilometres south of Chennai (see figure 1).

FIGURE 1 Location of Auroville, India



Source: Spatial Vision

10.12.2 A vision

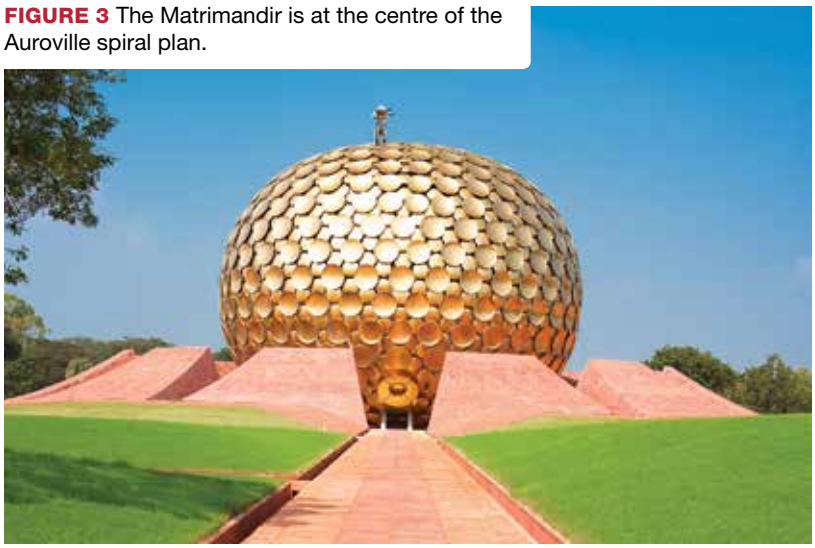
> Auroville wants to be a universal town where men and women of all countries are able to live in peace and progressive harmony above all creeds, all politics and all nationalities. The purpose of Auroville is to realise human unity.
>
> ***Source:*** Mirra Alfassa, the 'Mother' of Auroville

The grand plan for Auroville (see figure 2) was to create two geographical regions around the Matrimandir — a gleaming dome-shaped building that is the spiritual centre of Auroville (see figure 3). The city area contains residential houses and community centres. The planned green belt is a forest that surrounds the city area. It has two functions: adding greenery and beauty and

as a source of food and raw materials. Residential quarters within the city area are organised into self-contained communities with shared local water and wastewater systems (although the entire city shares an electricity supply).

FIGURE 2 A plan of Auroville, India

FIGURE 3 The Matrimandir is at the centre of the Auroville spiral plan.



Solar technology

- Water pumping and heating, street lighting and electricity generation all use solar power.
- A 1000-meal per day solar kitchen is powered by a solar concentrator. The design uses hundreds of mirrors to focus sunlight onto a heat receiver. The coils around the heat receiver are filled with water and, when the water turns to steam, it is used for cooking.

Water technology

- Waste water is treated at individual households and local communities, rather than at large sewage treatment plants.
- Rainwater harvesting is an important source of fresh water.

Revegetation

- The site chosen for Auroville was an eroded plateau that was suffering from desertification. Two million trees have been planted, and the area is now a green and forested landscape.

Community recycling and reuse projects

- Examples of recycling projects include the Auroville central exchange shop. Instead of dumping old and unwanted items in the rubbish, community members are encouraged to exchange or donate these items to the shop, since another person may find the item useful.
- Auroville has provided social and economic benefits for the surrounding villages. More than 5000 villagers are hired from nearby villages as cleaners, construction workers and maintenance workers, and are given job training. This has increased family incomes substantially and improved the standard of living within the communities.

ACTIVITIES

IDENTIFY

1 What was the Auroville site like before 1965? How has the site ***changed*** over time?

EXPLAIN

2 Explain the principles behind developing the community of Auroville. Is this how most cities or communities are planned? Why or why not?

INVESTIGATE

3 Conduct internet research to find out more about the solar kitchen at Auroville, or other examples around the world. Create a diagram that shows how heat is generated by the solar bowl concentrator, which cooks the meals in the shared kitchen.

4 Would a solar kitchen be useful in a school setting? Justify your response.

5 What is the climate like in Auroville? *Hint:* Try searching for climate data for Chennai.

APPLY

6 How is the development of Auroville different from that of Masdar (see subtopic 10.10)? Are they both trying to achieve the same outcome? How are they each proposing to reach their goals? Use a Venn diagram to compare and contrast.

7 Would a community like Auroville succeed here in Australia? Why or why not?

8 Use the **Journey to the city of dawn** weblink in the Resources tab to find out more about Auroville.

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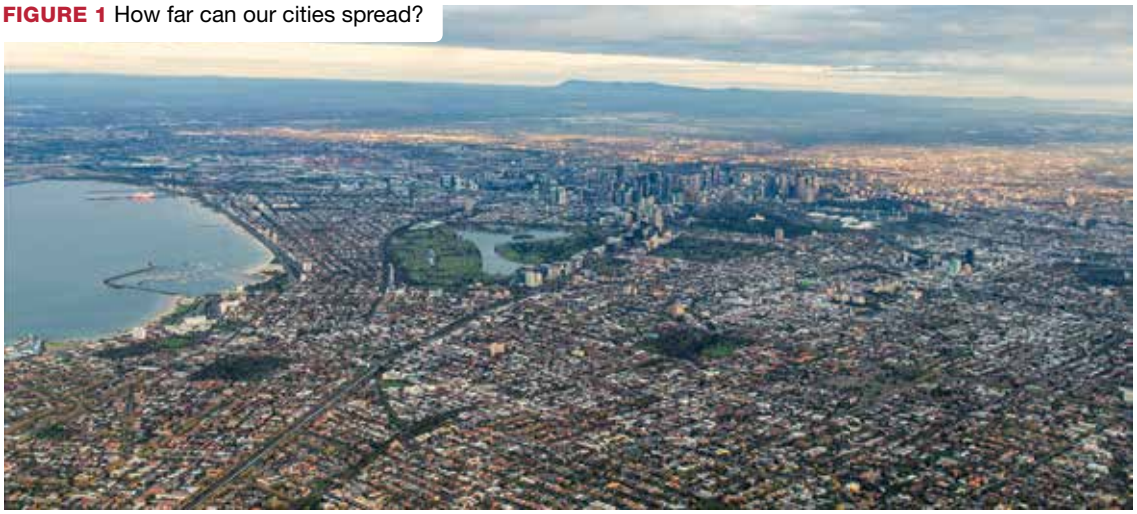
Weblink
Journey to the city of dawn

10.14 Review

10.14.1 Review

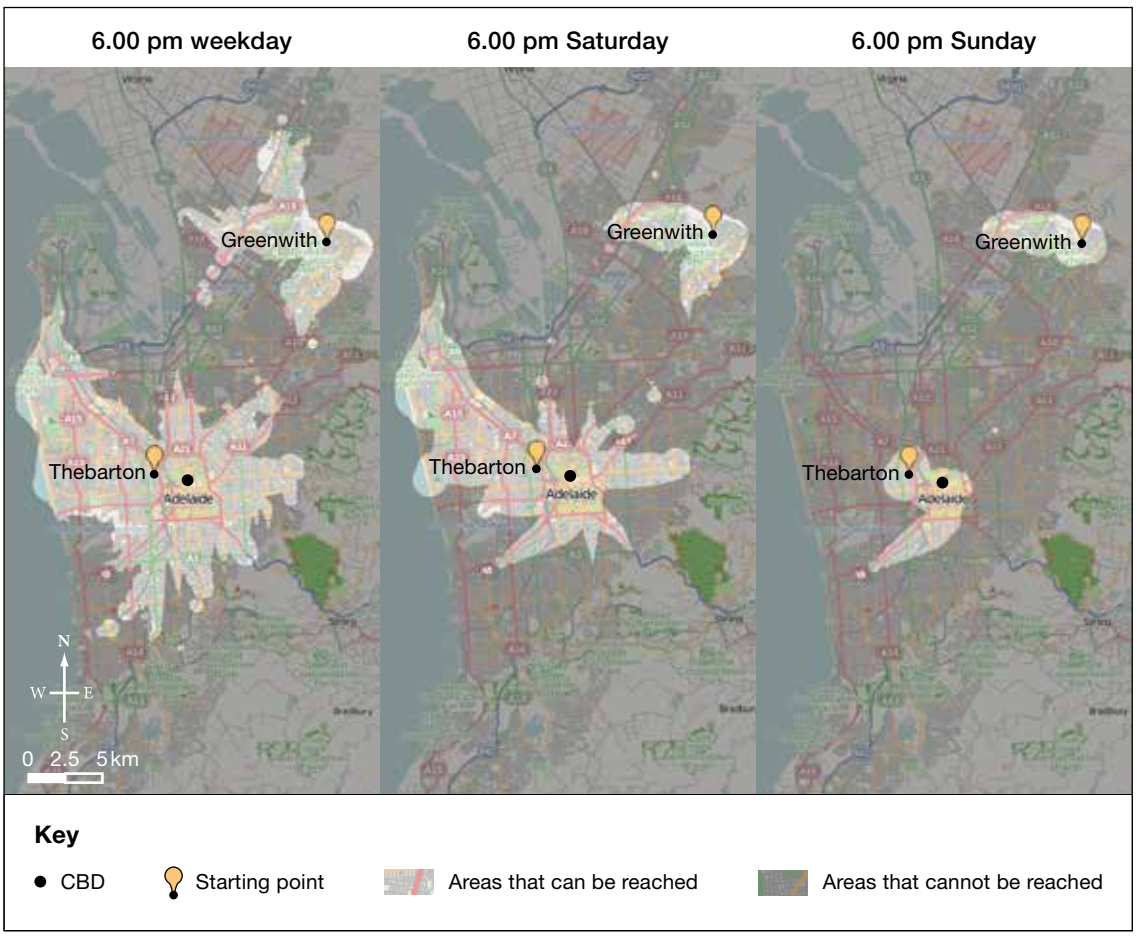
1. What are some of the ***environmental*** impacts of urban sprawl?

FIGURE 1 How far can our cities spread?



2. Conduct internet research to find out how other cities in the world are dealing with urban sprawl. How does this compare to the city in which you live?

FIGURE 2 How far can you travel from two different starting points in Adelaide at different times?



Source: Spatial Vision

3. Refer to figure 2 and answer the following questions.
   a. Explain what is shown in the three maps.
   b. What does this tell you about the public transport services provided in Adelaide?
   c. On a Sunday at 6.00 pm, what alternatives do you think might be available to people wanting to move from one ***place*** to another?
   d. How would you improve the services currently on offer?
4. Refer to figure 3 and answer the following questions.
   a. What does this graph show?
   b. Does wellbeing increase or decrease with a longer commuting time?
   c. Cities are ***changing*** constantly, and many of them are growing rapidly in size. Cities in the United States and Australia are especially afflicted by urban sprawl. What do you predict will happen to commuting times in Australia in the future?
   d. In your class, conduct a quick survey of your parents' journeys to work. First, find out how many minutes it takes them to travel from home to work. Second, ask them to rate their wellbeing on a scale from 0 to 100. Compile the data and create a graph. Do the graphs created by your class members show a similar result?
   What kind of solutions could you offer to improve the wellbeing of commuters?

FIGURE 3 Wellbeing and commuting time, United States, 2009

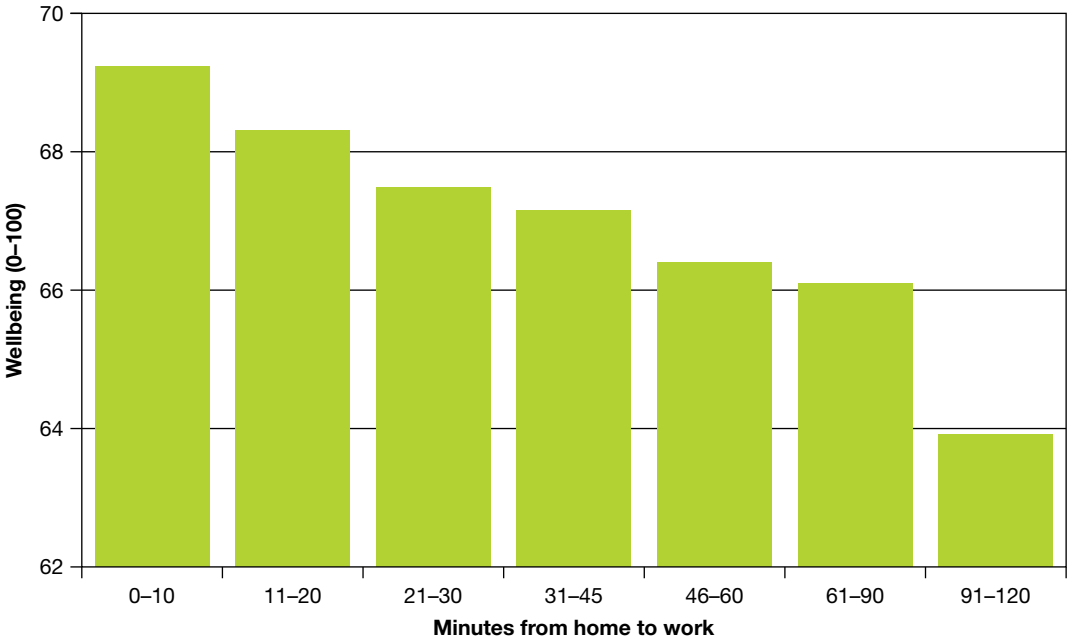


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FIGURE 4 Indian girls riding to school

10.14.2 Reflect

5. You are now a little more familiar with the idea of a personal ecological footprint. Do you think cities have an ecological footprint? Make a list of 10 things you could measure in order to establish the size of a city's footprint.
6. Conduct some research on some of the world's cities that are experiencing urban sprawl. (You will find many examples in the United States.) Find out the land area covered by the city and the city's population density. Compare this data with that of the city in which you live or the city that is closest to where you live.
7. Conduct a survey within your class (asking students, parents or guardians, and teacher) or your school community (asking students, parents or guardians, and teachers) to find out how many of them use public transport to get to and from school

or work. You can use a traditional pen-and-paper survey method or construct an online survey, using a program such as Survey Monkey. Your questions may include the following:

- Are you a student, teacher, parent or guardian? Circle the most appropriate response.
  Student/Teacher/Parent/Guardian
- Do you use public transport to get to work or school?
  Yes/No
- How often do you use public transport?
  Daily/3–4 times a week/1–2 times a week
- Approximately how long is your trip using public transport to get to your destination?
  0–15 minutes/16–30 minutes/31–60 minutes/More than 1 hour

Remember to thank your survey participants for their time.

Present your survey findings in a short report that includes an electronically generated graph. Include a recommendation in your report that recommends how you could encourage more people to:

a. use public transport to get to school and work each day
b. use their cars less often.

8. Bicycles are an excellent choice for personal transport. Create a mind map that demonstrates all the benefits of using a bike for your daily transport. (Ensure you include economic, social and ***environmental*** benefits.)
9. The '20-minute city' is now being promoted as the ideal place to live. A 20-minute city is one in which you can get to your work, school and any general daily services you might need in a maximum of 20 minutes.
   a. Do you live in a 20-minute city? If not, what is the 'size' of your city in commuting minutes?
   b. How could the government help your city become a 20-minute city? What kind of services would need to be changed in order to make everything you need only 20 minutes away?
10. There are many initiatives that encourage people to live more ***sustainably*** and to make our communities more liveable. For those of us who live 'vertically' in an apartment, the challenges can be a little different. Use the internet to research and create a simple 10-point plan to make high-rise residences more ***sustainable*** for the people who live in them. Try to provide low-cost or free ***sustainable*** alternatives, and present your 10-point plan in a colourful brochure or flyer format.
11. Buy Nothing New Month is a global movement for collective, conscientious consumption. It is an idea that challenges us to buy nothing new (with the exception of food, hygiene and medicines) for one month. It forces people to ask 'Do I really need it?' before they buy. If they do, they then ask 'Can I get it second hand, or can I borrow or rent it? What are my alternatives? Can I borrow from a friend? Can I swap with my neighbour?' It encourages us to ask where our stuff comes from, where it goes when we have finished with it (often into landfill) and what alternatives are out there to extend the life of our 'stuff'.
    a. How is this concept related to the idea of a ***sustainable*** community'?
    b. Do you think you could buy nothing new for a month? Why or why not? What would make it a difficult challenge for you?
    c. When is Buy Nothing New Month? Would you, as a class, consider participating in it?

CHAPTER 11

Geographical inquiry: Investigating Asian megacities

11.1 Overview

11.1.1 Scenario and task

Task: Create a website designed to inform the residents of an Asian megacity about its characteristics.

The latest liveability report for Asian megacities has been released, and residents are concerned. Populations are increasing by between one and five per cent every year, putting city infrastructure under extreme pressure.

City authorities have commissioned your team to put together a website increasing awareness of the characteristics of an Asian megacity and informing residents of current and newly proposed sustainable development planning initiatives.

Your task

Your team has been put in charge of creating a website designed to inform the residents of an Asian megacity about its characteristics. Each city will be different depending on its location, wealth or poverty, size and climate. Your investigations need to ensure that the audience can gain a comprehensive understanding of both population characteristics and city characteristics, and that any urban problems are presented. A key feature of your website will be to cover any urban solutions and innovations that are currently being implemented in your megacity.

11.2 Inquiry process

11.2.1 Process

Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button and set up your project group. You can complete this project individually or invite members of your class to form a group. Save your settings and the project will be launched.

- **Planning:** You will need to research the characteristics of your chosen Asian megacity. Navigate to your Research Forum. Research topics that have been loaded in the system to provide a framework for your research include: location and city characteristics (main economy, tourism, culture); population characteristics (migrants and migration, languages, religion); and urban problems, solutions and innovations. Choose a number of these topics to include in your website and ensure you add your own. Divide the research tasks among the members of your group.

11.2.2 Collecting and recording data

Begin by discussing with your group what you might already know about your chosen Asian megacity. Then discuss the information you will be looking for and where you might find it. To discover extra information about life in your Asian megacity, find at least three sources other than the textbook. At least one of these should be an offline source such as a book or an encyclopaedia. Remember that you will need to choose specific keywords to enter into your search engine to find other data. The weblinks in your Media Centre will help you get started. You can view and comment on other group members' articles and rate the information they have entered.

11.2.3 Processing and analysing your information and data

You now need to decide what information to include in your website. Maps to show location, graphs, tables and lists to illustrate data, and images and photos with annotations (descriptive notes) should all be included. Each of these should also have

a written description. You should make sure that you have addressed each of the following points:

- Describe the pattern of distribution on each of the maps or satellite images you have drawn or collected.
- What are the main characteristics of your city?
- How has your city changed over time? Is information available on how it is predicted to change in the future?
- For what reasons are people attracted to move to this city?
- What are the main problems in this city? Are there any solutions being introduced to try to overcome these problems?

Visit your Media Centre and download the website model and website-planning template to help you build your website. Your Media Centre also includes images and audio files to help bring your site to life.

Use the website-planning template to create design specifications for your site. You should have a home page and at least three link pages per topic. You might want to insert features such as 'Amazing facts' and 'Did you know?' into your interactive website. Remember the three-click rule in web design—you should be able to get anywhere in a website (including back to the homepage) with a maximum of three clicks.

11.2.4 Communicating your findings

Use website-building software to build your website. Remember that less is more with website design. Your mission is to inform people about your Asian megacity in an informative and engaging way. You want people to take the time to read your entire website.

11.3 Review

11.3.1 Reflecting on your work

Think back over how well you worked with your partner or group on the various tasks for this inquiry. Determine strengths and weaknesses and recommend changes you would make if you were to repeat the exercise. Identify one area where you were pleased with your performance, and an area where you would like to improve. Write two sentences outlining how you might be able to do this.

Print out your Research Report from ProjectsPLUS and hand it in with your website and reflection notes.

Your ProjectsPLUS application is available in this chapter's Resources tab in your eBookPLUS. Visit **www.jacplus.com.au** to locate your digital resources.

Suggested software

- ProjectsPLUS
- Microsoft Word or any other word processing tool
- FrontPage, Dreamweaver, iWeb or other website-building software

Media Centre

Your Media Centre contains:

- a website model
- a website-planning template
- a selection of images and audio and video files to add richness to your website
- weblinks to sites to assist in your megacity research and to see website-building software
- an assessment rubric.

The future is in our hands

TOPIC 3

ENVIRONMENTAL CHANGE AND MANAGEMENT

In the twenty-first century, Australia and the world face many environmental challenges which people have a variety of viewpoints about. Challenges range from a local scale, such as degradation of a nearby creek, through to a global scale, such as the threat of global warming. Comparing and evaluating management responses in different places can help us achieve more sustainable management of our environments.

KEY INQUIRY QUESTIONS

- How do environments function?
- How do people's worldviews affect their attitudes to and use of environments?
- What are the causes and consequences of change in environments and how can this change be managed?
- Why is an understanding of environmental processes and interconnections essential for sustainable management of environments?

CHAPTER 12

Introducing environmental change and management

Human-induced climate change has led to increased severe weather events such as drought. Rivers can dry up, with consequent loss of plant and animal life.

12.1 Overview

12.1.1 Introduction

Across the world there are many environmental changes that have been caused by humans, such as pollution, land degradation and impacts on aquatic environments. People have different points of view, or worldviews, on many of these changes. Climate change is a major environmental change as it affects all aspects of the environment, such as our land; inland water resources; and coastal, marine and urban environments. It is vital that we respond intelligently to, and effectively manage, all future environmental changes.

Starter questions

1 The ***environment*** supports all life on Earth — humans, plants and animals. As a class, brainstorm examples of ***environmental changes*** people have caused, and discuss where these are occurring.
2 Choose one ***environmental change*** from question 1 and discuss the various viewpoints different people, groups or organisations have about it.
3 Brainstorm specific examples of ***environmental changes*** people have caused that have been positive, and that have come about by people deliberately and efficiently managing the ***change***.

Inquiry sequence

		Syllabus outcomes
12.1 Overview		
12.2 How do environments function?		GE5-2, GE5-3, GE5-4, GE5-7
12.3 What are the lithospheric processes that form and transform environments?		GE5-2, GE5-3, GE5-4, GE5-7
12.4 What are the biospheric processes that form and transform environments?		GE5-2, GE5-3, GE5-4, GE5-7
12.5 What are the hydrological and atmospheric processes that form and transform environments?		GE5-2, GE5-3, GE5-4, GE5-7
12.6 How do people's worldviews affect the use of environments?		GE5-2, GE5-3, GE5-4, GE5-7
12.7 SkillBuilder: Evaluating alternative responses	eBook plus ONLINE ONLY	GE5-7
12.8 Why do environments change?		GE5-2, GE5-3, GE5-4, GE5-7
12.9 What is sustainable management?		GE5-5, GE5-8
12.10 What is an ecological footprint?		GE5-5, GE5-8
12.11 Investigating topographic maps: How is Jindabyne affected by environmental change?		GE5-5, GE5-7, GE5-8
12.12 SkillBuilder: Drawing a futures wheel	eBook plus ONLINE ONLY	GE5-7
12.13 Is climate change heating the Earth?		GE5-2, GE5-3, GE5-4
12.14 Can we slow climate change?	eBook plus ONLINE ONLY	GE5-2, GE5-3, GE5-4
12.15 How can we reduce the impact of climate change?	eBook plus ONLINE ONLY	GE5-2, GE5-3, GE5-4
12.16 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

eBook*plus*

Watch this video
What are we doing?
Searchlight ID: eles-1707

12.2 How do environments function?

12.2.1 The environment

geographic processes the physical forces that form and transform our world

The four spheres of the environment are the atmosphere, lithosphere, hydrosphere and biosphere. The atmosphere is the layer of gases enveloping the Earth. The lithosphere is all the rocks, soils and crust on the Earth's surface. The hydrosphere is all the water on Earth including in the oceans, lakes, rivers and glaciers. The biosphere is all living things on Earth, such as plants and animals. Places and environments are formed and transformed by a range of natural **geographic processes** and influences related to each sphere.

FIGURE 1 The interaction of the four spheres of the environment

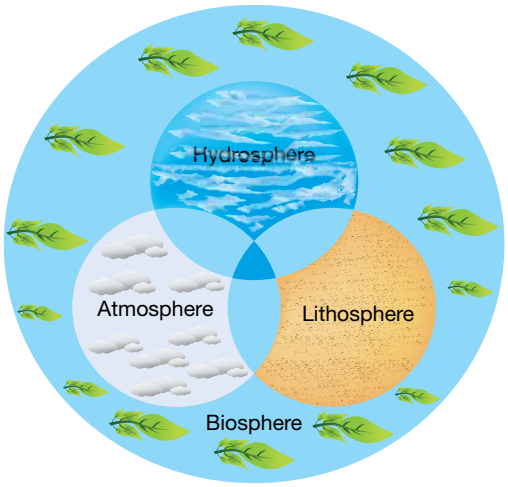


TABLE 1 Geographical processes that form and transform environments

Biospheric processes	Lithospheric processes	Hydrospheric processes	Atmospheric processes
		Carbon cycle	
Oxygen cycle	Erosion	Precipitation	Carbon cycle
Food chains	Weathering	Infiltration	Absorption (light)
Photosynthesis	Nitrogen and phosphorous cycle	Runoff	Reflection (light)
Evolution	Tectonic processes	Evaporation	Scattering (light)
Extinction		Transpiration	Aeolian (winds)
Migration		Condensation	Transportation
		Transportation	Deposition
		Deposition	

FOCUS ON FIELDWORK

Conducting a geographical inquiry

Primary data is original information that you create yourself. Think of it as 'first-hand' data. Examples of primary data include interviews, surveys, observations, water testing, vegetation transects and soil testing.

Secondary data sources have been created by someone else. Think of it as 'second-hand' data. Secondary sources should be checked for bias and all sources should be acknowledged. Examples of secondary sources include newspapers, magazines and journal articles, websites, books, DVDs, television and radio.

1. Choose one natural environment that you can easily visit, to conduct a geographical inquiry about.
2. Formulate a research question that relates to how the environment functions. Ensure that the question is specific enough that you will be able to conduct the research in a short period of time, but general enough that you will be able to find supporting information about it.
3. Collect secondary data that relates to your chosen environment:
   - **a** Choose two newspaper articles or websites. Select the key points from the source and record the information in a word document.
   - **b** Find a map of your chosen environment.
4. Collect primary data that relates to your chosen environment.
   - **a** Take photographs of your chosen environment. This is a source of primary data. Import your photographs into your word document and annotate them with important features of the environment.
   - **b** Collect another type of primary data that shows evidence of how your chosen environment functions. Write a paragraph about the method you used and the results of your fieldwork.
5. Review the research you have undertaken so far. Do you have enough data to answer the research question that you formulated in question 2? What other data would you need to collect? Make a list of other sources of information and fieldwork techniques to enhance your research.

FIGURE 2 Natural processes create a range of unique environments.

ACTIVITIES

IDENTIFY

1 Construct a diagram of a natural environment. Label key features of the environment and, in brackets, state whether each feature is part of the hydrosphere, lithosphere, atmosphere or biosphere.

APPLY

2 Examine the photographs in figure 2.

a Identify any geographical processes occurring in any of these photographs.

b Select a geographical process in one of the photographs and explain how you were able to identify the process.

INVESTIGATE

3 Using the internet, investigate one of the natural geographical processes listed in table 1. Describe the process and explain the role of each sphere in that process.

12.3 What are the lithospheric processes that form and transform environments?

12.3.1 Erosion and weathering

Erosion is the wearing away of earth by wind, water or ice. Moving water and rain carry away soil and rock fragments. Waves crash against shorelines and move sand. Wind can carry lighter sediments, such as dust, sand and ash, away from their source. In dry areas with high winds these materials can also blast against rocks, intensifying erosion. Moving glaciers can also carry away sediments and large rocks. As they move they rub against the ground, further eroding soils and breaking boulders.

Weathering is the physical and chemical disintegration of rocks and minerals. It occurs through physical processes such as water freezing and expanding, seeds germinating and cracking rocks, and

when rocks are exposed and expand. Chemical weathering occurs when minerals react with oxygen and form oxides, acids dissolve minerals in rocks or when rocks expand as their minerals combine with water.

12.3.2 Tectonic processes

The Earth's crust is divided into tectonic plates which float around on top of the semi-molten rock of the mantle. Where plates have collided huge mountain ranges have been formed. Along plate boundaries, volcanoes and earthquakes are common. Fold mountains, like the Himalayas, form when the Earth's plates crunch into each other, and layers of the crust are pushed up into loops and bumps.

Fault mountains are made when part of the crust is forced up or collapses between two cracks in a plate. These cracks are called faults.

FIGURE 1 Fold mountains are created by pressure pushing the Earth's plates from both sides.

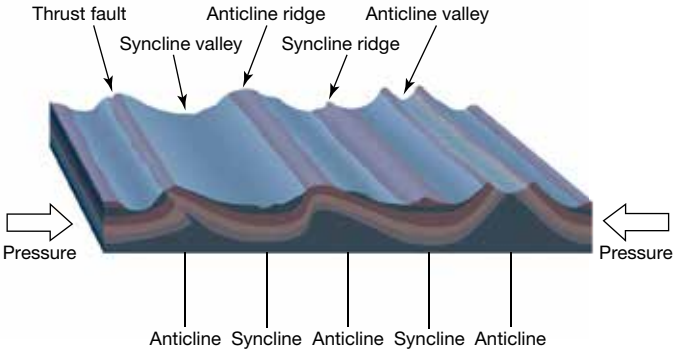
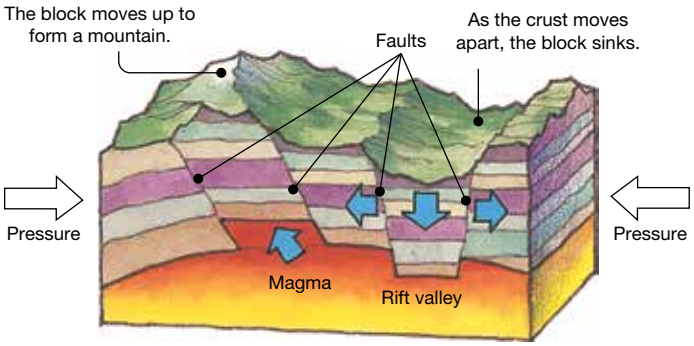


FIGURE 2 Fault mountains are created by pressure pushing the Earth's plates from both sides.



Earthquakes occur as a result of movement between sections of the Earth's crust. They commonly occur along fault lines and along plate boundaries. Sections of tectonic plates can be forced upwards exposing new sections. Volcanoes involve the process of molten rock from the mantle being forced up onto the Earth's surface, building continents.

FIGURE 3(a–b) A range of geographical processes form rocks and landforms.

12.3.3 The nitrogen and phosphorous cycle

Living things need nitrogen for growth. The basic nitrogen cycle begins when green plants take in chemicals such as nitrogen and phosphorous from the soil. Plants use these chemicals to build

proteins for growth. When plants die, decomposers, such a bacteria and fungi, break down the proteins into ammonium compounds. Animals also eat the plants and animal waste and dead animal carcasses are broken down into ammonium compounds. Bacteria in the soil converts the ammonium back into nitrates.

GEOskills TOOLBOX

Contour lines and spot heights

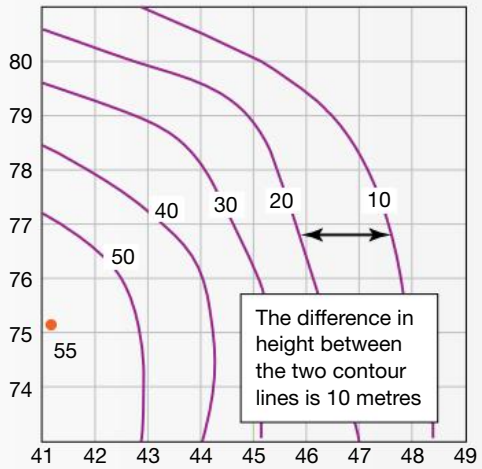
- A ***contour line*** is a line joining places of equal height above sea level.
- A ***spot height*** is a point on the map that shows the exact height above sea level at that place.
- A ***contour interval*** is the difference in height between two contour lines on the map. Each map will have a different contour interval.

1 What is the height of the following grid references in figure 4?
- **a** GR425775
- **b** GR468793
- **c** GR482796

2 How can contour lines and spot heights help you interpret a map?

3 What is a contour interval, and how might you use this information when interpreting topographic maps?

FIGURE 4 A basic topographic map



ACTIVITIES

IDENTIFY

1 List the different ways that sediments can be moved from one location to another.

2 Describe the difference between erosion and weathering.

APPLY

3 Construct an annotated diagram of the nitrogen and phosphorous cycle.

INVESTIGATE

4 Using the internet, research the process of plate tectonics.
- **a** With the aid of diagrams, describe how this process occurs.
- **b** Describe one landform that has been created by plate tectonics. Include images and diagrams to support your answer.
- **c** Discuss one source of evidence that supports the theory of plate tectonics.

12.4 What are the biospheric processes that form and transform environments?

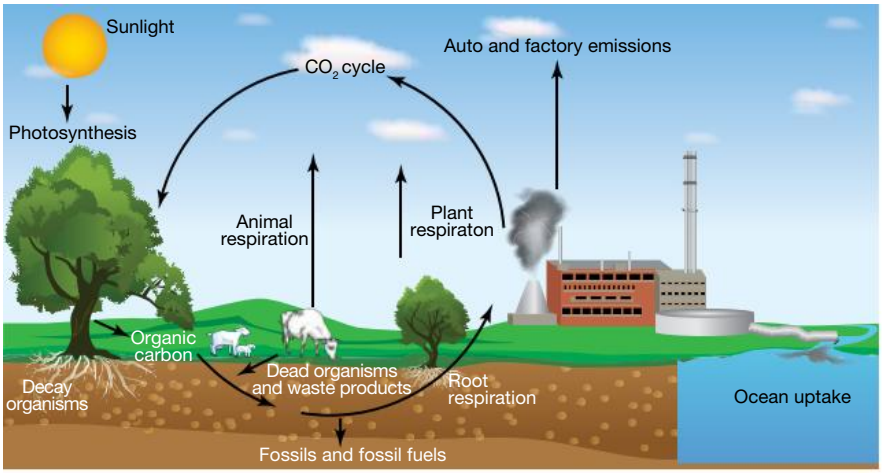
12.4.1 What is the biosphere?

The biosphere is all the living things on Earth. Processes related to the biosphere are central in the creation of environments. These processes impact on the type of vegetation in an environment, how large and how densely the vegetation grows, the quality of the soil, the levels of oxygen and moisture in the air and rates of erosion. Some of the processes related to the biosphere include the carbon cycle, the oxygen cycle, food chains and food webs, photosynthesis, evolution, and population fluctuations and movements.

12.4.2 The carbon cycle

Carbon is one of the most basic elements that make up all living things. It is a process that involves all the spheres. The carbon cycle is the process where carbon is transferred through the environment.

FIGURE 1 The carbon cycle



Carbon dioxide exists in the air, and is used by plants to photosynthesise and make food. Animals eat plants and obtain carbon and then use carbon from plants for energy and growth. Animals produce waste and decompose when they die. Decomposers, such as bacteria and fungi, feed on the dead matter and release carbon dioxide into the air as they respire.

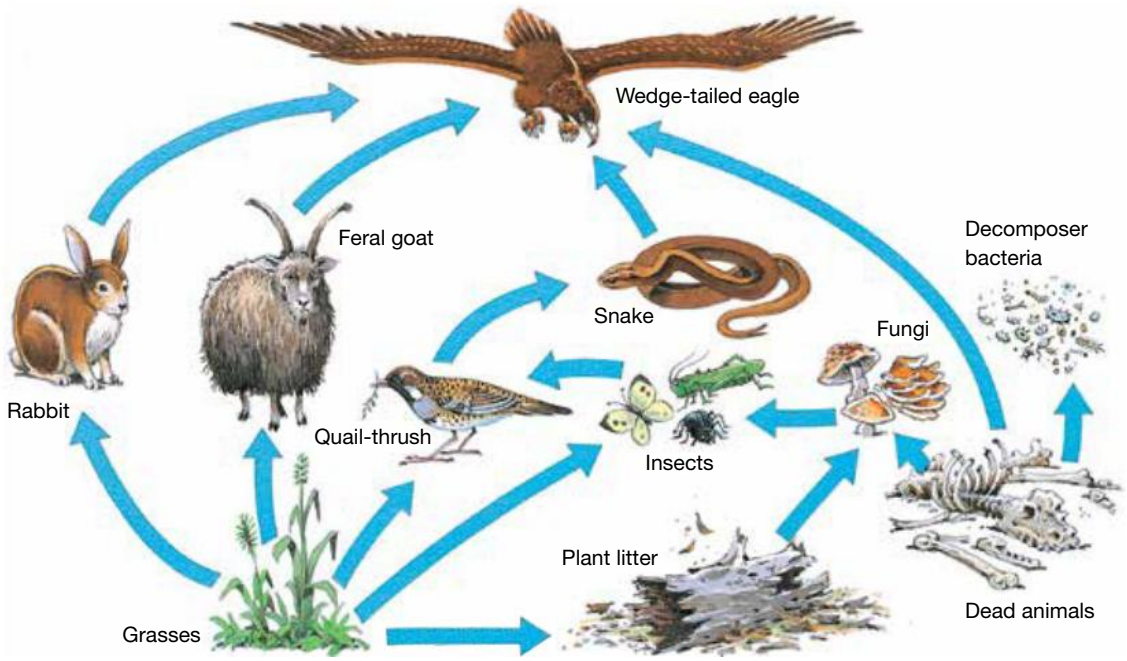
12.4.3 The oxygen cycle

The oxygen cycle begins with the oxygen that exists in the air. Animals obtain oxygen by breathing and plants produce oxygen and release it through their pores.

12.4.4 Food chains

A food chain is a series of organisms, each eating or decomposing the preceding one. Food webs are a more complicated branching diagram which shows the feeding relationships of all living things in an ecosystem or particular area. In nearly all ecosystems the source of energy is the Sun (hydrothermal vents provide energy in some rare ecosystems). Every food chain begins with a producer organism, a plant that can photosynthesise. Consumers are organisms that eat other organisms. Decomposers breakdown dead organisms. Energy is transferred from one animal to another through food chains and food webs, and flows in the direction of the arrows on the diagram. Some energy is lost at each step in the food chain as heat.

FIGURE 2 A desert food web



12.4.5 Photosynthesis

Plants make food in their leaves, which contain a special green pigment, or colouring, called chlorophyll. The chlorophyll uses energy absorbed from sunlight to convert carbon dioxide from the air, and water from the ground, into a sugary form called glucose.

12.4.6 Evolution

Evolution is the long-term process where species have changed and developed from earlier forms of species to become more suited to particular environments. Survival of the fittest means that organisms

that are most suited to a particular environment (colour, shape, etc.) are more likely to live a long life and reproduce. Organisms which are not suited to a particular environment are more likely to be killed, be eaten or starve, and are less likely to reproduce. In this way organisms with the most suitable genes pass them on to future generations. Each successive generation contains a greater number of individuals with suitable genes. As time goes on the species becomes more and more specialised.

12.4.7 Population fluctuations and movements

Changes in the size and distribution of plant and animal species impacts greatly on the functioning of environments. Changes to climate, natural hazards and human interactions are some of the factors which impact on population numbers.

Many species of animals migrate from place to place. Some migrations are seasonal, where animals move looking for the best food sources, to avoid extreme heat or cold and to find suitable breeding grounds. The migrations of some species don't follow any particular patterns, while others simply move on when they have exhausted the food source. Animals that live in mountainous regions move to higher or lower regions to avoid snowfalls. If an environment becomes inhospitable, organisms may permanently migrate from an area.

Extinction is a process where all individuals of a species have died. This is a natural process that occurs when a species can't adapt to the changes in an environment. Humans have greatly accelerated the number of extinctions through modifications of ecosystems.

FIGURE 3 Plant species in the Daintree rainforest have adapted to suit the specific climatic and soil conditions of the region.

FIGURE 4 Crabs moving en masse

ACTIVITIES

IDENTIFY

1 Outline some of the biospheric processes that form and transform ***environments***.
2 Describe the difference between a food chain and a food web.
3 Construct a simple diagram showing the relationship between producers, decomposers, consumers and the sun in a simple food chain.

EXPLAIN

4 Explain the process of evolution.

PREDICT

5 Explain how the migration of a species might transform an ***environment***.

INVESTIGATE

6 Using the internet, investigate one species that is well adapted to its ***environment***.
   a Describe the unique conditions of the ***environment*** (climate, soils, vegetation, etc.).
   b Describe the characteristics this species has that enables it to live and flourish in this ***environment***.
   c Discuss how a similar organism might have different characteristics if it lived in a different ***environment***.
   d Describe a related species that lives in a different ***environment***. Outline the differences between the two species.
7 Investigate one migratory species.
   a Why does the species migrate?
   b What migration patterns does it follow?

12.5 What are the hydrological and atmospheric processes that form and transform environments?

12.5.1 What is the hydrosphere?

The hydrosphere is water in all its forms including rain, ice, sleet, and vapour. The atmosphere is the gaseous layer surrounding the Earth. Many of the geographic processes that form and transform environments involve an interaction between the hydrosphere and atmosphere.

precipitation water droplets or ice crystals become too heavy to be suspended in the air and fall to Earth as rain, snow, sleet or hail

infiltration water that is absorbed into the ground, flows downward and collects above an impermeable layer or rock

runoff water that is unable to be absorbed into the ground, flows over its surface and collects in nearby waterways or reaches stormwater drains

evaporation the process in which water contained in water bodies is heated by the sun, causing the liquid to change into a gaseous state and rise into the atmosphere

transpiration the process in which water contained in plants is heated, changes from a liquid into a gaseous state and rises into the atmosphere

evapotranspiration the process including evaporation from water storage areas as well as evaporation from trees

condensation the process in which water in the atmosphere cools and changes from a gaseous state into a liquid state; this occurs when the water vapour clusters around a solid particle (such as dust)

12.5.2 The water cycle

The water cycle relates to all four of the spheres, but specifically connects the hydrosphere and atmosphere. The water cycle is the continuous movement of water which begins in water storage areas such as the oceans, lakes and rivers. Water then evaporates from water storage areas into the air, or transpires from trees. In the atmosphere the water vapour begins to form clouds and when it condenses it falls to the ground as **precipitation**. Some water will run over the surface of the ground, collecting in low areas, or joining rivers, lakes and oceans. Some water will soak into the ground and join groundwater. The processes associated with the water cycle are precipitation, **infiltration**, **runoff**, **evaporation**, **transpiration**, **evapotranspiration** and **condensation**.

12.5.3 Heating and cooling

Solar radiation is the heat that is received from the sun's rays. The atmosphere plays an important role in distributing this heat around the planet.

In some locations there is more heat received from the sun than is reflected by the Earth. These locations are mainly in the tropics. In contrast, in polar regions and at high altitudes, less heat is received from the sun than is reflected by the Earth. The atmosphere scatters the sun's rays helping to distribute heat, but most excess of heat that results in the tropics is transferred to the poles and high altitudes by air movements.

The atmosphere absorbs some incoming radiation which helps to balance temperatures overnight when no direct radiation is received. Some radiation is reflected which helps to regulate temperatures in areas of extreme heat.

FIGURE 1 Solar radiation from the sun is concentrated at the poles and dispersed at the equator.

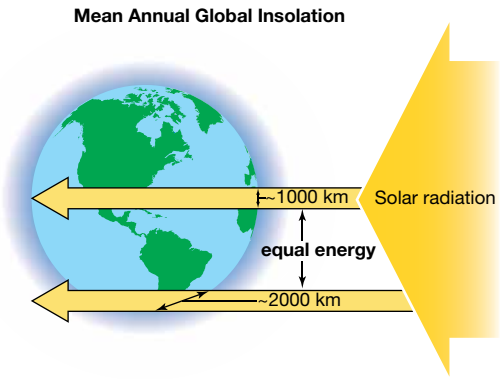


FIGURE 2 Oceans also play an important role in absorbing heat.

ACTIVITIES

EXPLAIN

1 Describe how the water cycle links the hydrosphere and the atmosphere.
2 Describe the role of the biosphere and lithosphere in the water cycle.
3 Describe how the atmosphere distributes heat around the globe.

INVESTIGATE

4 Using the internet, investigate the water cycle and explain the role it plays in forming and transforming ***environments***.

12.6 How do people's worldviews affect the use of environments?

12.6.1 Humans and the environment

If you gathered together all 7 billion humans from around the world and gave each person a space of one square metre, the island of Cyprus, which is approximately 8000 square kilometres, would provide standing room for everyone (see figure 1). Clearly this would be impractical, and providing services to ensure human wellbeing in an area with a density of 1 000 000 per square kilometre would be impossible.

While this idea is unrealistic in suggesting that 0.005 per cent of the total space on Earth is sufficient for humanity, it suggests we need to think about how little personal space we actually occupy, and how greatly we impact on the Earth and its natural systems.

12.6.2 How do humans interact with the environment?

Over 200 years ago, an English scholar named Thomas Malthus proposed that England's population growth would eventually outstrip agricultural production. Malthus's environmental worldview foretold of problems with supplies of food and warned that there would be more deaths due to famine and wars over resources. This message has even more relevance today as many environments have become overloaded with the growing demands for food, land and other resources. This pressure on biomes and ecosystems has led to land degradation, with a consequent loss of habitats and biodiversity. Further consequences of this change are a reduction in human wellbeing and a struggle for social justice as lands become unproductive as a result of overuse. Nevertheless, it should be remembered that change can be a natural process as well as human-induced.

FIGURE 1 Humanity crowded onto the island of Cyprus

Source: Spatial Vision

12.6.3 What are environmental worldviews?

People have different perceptions or views about how the world works and how they fit into the world. This is known as an **environmental worldview**. An environmental worldview helps a person make decisions about how he or she will behave towards their environment and **environmental ethics** will determine their beliefs about right or wrong behaviour.

Some people see themselves and their needs as the most important factor to consider; this is known as egocentric. This might mean that a person would choose their own financial gain as being more important than the functioning of an ecosystem.

Another environmental worldview that values the needs of humans is the anthropocentric worldview, which acknowledges that humans have a variety of needs and wants that often must be placed above the desire to protect environments. The anthropocentric worldview values environments for the use they provide for all humans.

The stewardship worldview recognises that although humans need to make use of environments for survival and development, they have a responsibility to care for the Earth to ensure that future generations will have access to environments of similar quality. Stewardship is often associated with the religious beliefs and environmental worldviews of indigenous cultures around the world, including Australian Aborigines and Native Americans.

A biocentric worldview recognises the significant role that the Earth and its environments play in sustaining life, including human life. It strives to minimise the impact of human activities on environments and species.

Ecocentric is a worldview that places the preservation of environments above all other needs and wants. An ecocentric may choose to protect an environment despite the long-term income and jobs that using the environment may create for a whole community.

FIGURE 2 Ecocentric and egocentric worldviews are at opposing ends of the continuum.

environmental worldview varying viewpoints of how the world works and where people fit into the world. The worldview will form the assumptions and values that guide an individual's actions towards the environment.

environmental ethics an individual's beliefs about what is right or wrong behaviour in relation to the Earth and its environments and communities

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Interactivity
Nature's bounty
Use this interactivity to find out how humans use the environment.
Searchlight ID: int-3287

ACTIVITIES

EXPLAIN

1 Egocentric and ecocentric ***environmental*** worldviews are extremes of a range of views. Explain what you think the difficulties would be in believing in either of these extremes.

APPLY

2 Define what an ***environmental*** worldview is. Justify your own ***environmental*** worldview.

3 What are the similarities and differences between the following ***environmental*** worldviews: anthropocentric, stewardship and biocentric?

INVESTIGATE

4 Using the internet, investigate the concept of *technological optimism* in relation to ***environmental change*** and population pressure.
- **a** What does the term mean?
- **b** Which ***environmental*** worldview do you think it most relates to? Explain your answer.
- **c** What is your personal view of technological optimism?

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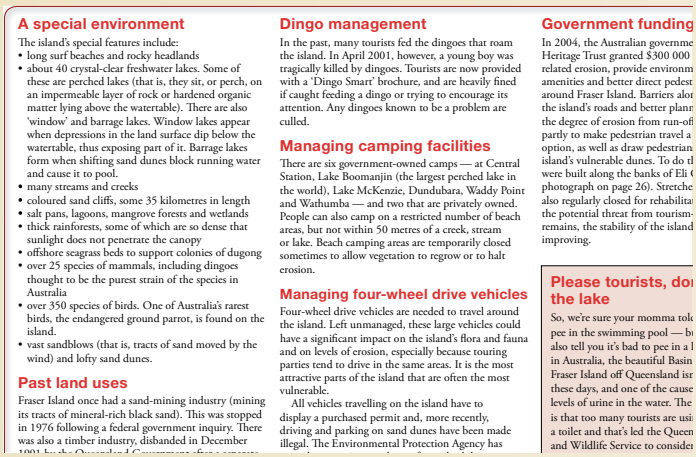
12.7 SkillBuilder: Evaluating alternative responses

What is involved in evaluating alternative responses?

Alternative responses are a range of different ideas or opinions on an issue. Evaluating ideas involves weighing up and interpreting your research to reach a judgement or a decision based on the information.



A special environment

The island's special features include:
- long surf beaches and rocky headlands
- about 40 crystal-clear freshwater lakes. Some of these are perched lakes (that is, they sit, or perch, on an impermeable layer of rock or hardened organic matter lying above the watertable). There are also 'window' and barrage lakes. Window lakes appear when depressions in the land surface dip below the watertable, thus exposing part of it. Barrage lakes form when shifting sand dunes block running water and cause it to pool.
- many streams and creeks
- coloured sand cliffs, some 35 kilometres in length
- salt pans, lagoons, mangrove forests and wetlands
- thick rainforests, some of which are so dense that sunlight does not penetrate the canopy
- offshore seagrass beds to support colonies of dugong
- over 25 species of mammals, including dingoes thought to be the purest strain of the species in Australia
- over 350 species of birds. One of Australia's rarest birds, the endangered ground parrot, is found on the island.
- vast sandblows (that is, tracts of sand moved by the wind) and lofty sand dunes.

Past land uses

Fraser Island once had a sand-mining industry (mining its tracts of mineral-rich black sand). This was stopped in 1976 following a federal government inquiry. There was also a timber industry, disbanded in December

Dingo management

In the past, many tourists fed the dingoes that roam the island. In April 2001, however, a young boy was tragically killed by dingoes. Tourists are now provided with a 'Dingo Smart' brochure, and are heavily fined if caught feeding a dingo or trying to encourage its attention. Any dingoes known to be a problem are culled.

Managing camping facilities

There are six government-owned camps — at Central Station, Lake Boomanjin (the largest perched lake in the world), Lake McKenzie, Dundubara, Waddy Point and Wathumba — and two that are privately owned. People can also camp on a restricted number of beach areas, but not within 50 metres of a creek, stream or lake. Beach camping areas are temporarily closed sometimes to allow vegetation to regrow or to halt erosion.

Managing four-wheel drive vehicles

Four-wheel drive vehicles are needed to travel around the island. Left unmanaged, these large vehicles could have a significant impact on the island's flora and fauna and on levels of erosion, especially because touring parties tend to drive in the same areas. It is the most attractive parts of the island that are often the most vulnerable.

All vehicles travelling on the island have to display a purchased permit and, more recently, driving and parking on sand dunes have been made illegal. The Environmental Protection Agency has

Government funding

In 2004, the Australian governme
Heritage Trust granted $300 000
related erosion, provide environm
amenities and better direct pedest
around Fraser Island. Barriers alo
the island's roads and better plan
the degree of erosion from run-off
partly to make pedestrian travel a
option, as well as draw pedestrian
island's vulnerable dunes. To do t
were built along the banks of Eli
photograph on page 26). Stretche
also regularly closed for rehabilita
the potential threat from tourism-
remains, the stability of the island
improving.

**Please tourists, do
the lake**

So, we're sure your momma tol
pee in the swimming pool — b
also tell you it's bad to pee in a
in Australia, the beautiful Basin
Fraser Island off Queensland is
these days, and one of the cause
levels of urine in the water. The
is that too many tourists are usi
a toilet and that's led the Queen
and Wildlife Service to consider

eLesson
Watch this video to learn how to evaluate alternative responses.

Searchlight ID: eles-1744

Interactivity
Try this interactivity to learn how to evaluate alternative responses.

Searchlight ID: int-3362

12.8 Why do environments change?

12.8.1 What are causes of environmental change?

Environments change as a result of a range of natural and human-induced factors. Natural changes to ecosystems can be severe and drastic, resulting in an ecosystem having to adapt or change in a short period of time in order to survive. More often, natural changes occur over an extended period allowing ecosystems to gradually change to suit changing conditions. Examples of natural changes to ecosystems include drought, flood, fire, volcanic eruptions, storm surge, cyclone, changes in climate, movement of species, and adaptation to changes. There are also more gradual, natural changes to ecosystems such as weathering and erosion.

Humans have the ability to simplify natural ecosystems in order to grow food, build habitats and remove or extract resources. Unwanted species are removed and other species are provided with

an environment made favourable for their survival by human intervention. Human-induced change can be intentional, inadvertent, or through negligence.

12.8.2 Why do humans change environments?

Humans have changed environments since prehistoric times. Early humans domesticated animals, hunted and undertook basic irrigation. As the size of the world's population has increased over time, so too has the demand on resources to provide for it.

What are the consequences of human-induced environmental change?

Large-scale agriculture has changed environments through the clearing of land to introduce a monoculture of crops, the introduction of livestock and subsequent overgrazing, the removal of native species, ongoing activities such as ploughing and the use of pesticides, insecticides and fertilisers to maximise harvests.

Urbanisation and urban growth have resulted in the replacement of natural environments with roads, buildings and manicured parklands. In many places waterways have been straightened or covered and riverbanks have been cemented.

FIGURE 1 Humans have modified environments for agriculture.

FIGURE 2 Like many rivers around the world, the Arno River in Florence, Italy has been modified from a natural river system to a system dominated by human development.

Industrial land uses have resulted in the leaking of toxic substances, while mining has changed vast areas of land and left sinkholes, contaminated surface water, chemical leakage, mine dumps and tailing dams.

Over a longer period of time, human-induced environmental change can have long-term and sometimes irreversible impacts. Consequences can include salinisation and soil waterlogging, compaction and erosion, pollution, habitat loss, species loss, introduction of exotic species and reduced biodiversity.

12.8.3 How can environments change at different scales?

Change can occur at different levels or scales. On a map we use a scale to give an idea of the size or focus of the map and to allow us to take accurate measurements. Issues, or environmental changes are also examined at a range of scales. Most commonly we examine change at a local, regional, national or global scale. Examples include climate change at the global scale, cyclones in the Great Barrier Reef and deforestation in the Amazon at the regional scale, and land degradation on a single farm at local scale.

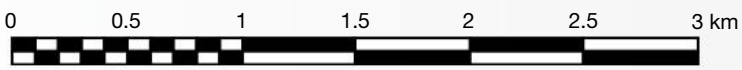
GEOskills TOOLBOX

Scale

Scale describes the relationship between the size of an object in real-life compared to the size of an object on a map. Scale can be shown in three ways (see below).

The most common scale is 1:100 000. This means that 1 cm represents 1 00 000 cm, OR 1000 m OR 1 km. This means that if you measure 4 cm on the map it will represent 4 km.

Linear scale



Scale – One centimetre represents half a kilometre
Ratio – 1:50 000

CASE STUDY

Environmental change as a result of energy production

National case study: energy production in Australia

Black coal energy production in Australia increased by 8 per cent in 2013–2014. This is despite an increase in renewable energy production of 4 per cent in 2013–2014, and a decrease in brown coal production by 3 per cent. This increase in black coal production was largely the result of increased production in Ulan, Beltana, and Ravensworth North open cut operations. Renewable energy sources accounted for only 1.8 percent of total energy production in 2013–2014. Many of the natural resources that are extracted in Australia are exported for consumption in other countries.

Australians consume more resources per person than most other nations.

Over the last 30 years, Australia's energy consumption from all forms of fuel has increased by over 200 per cent with most of it coming from non-renewable energy sources.

Australia is fortunate to have large reserves of coal, natural gas and uranium, but the use of these non-renewable energy sources has significant environmental impact. There is a concern about how Australia will satisfy its energy needs in the future.

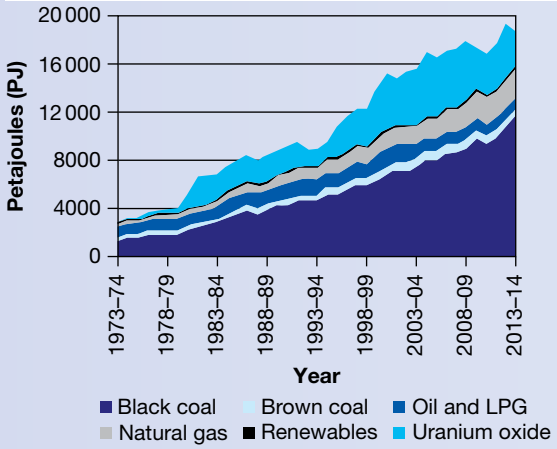
Regional/state case study: wind farms

Many locations throughout Australia have strong winds that can be used to produce clean, sustainable energy. Wind farms require wind speeds of 15 to 90 kilometres per hour to drive the turbines, so operators look for locations where wind speeds are generally high. Woolnorth in Tasmania has 62 wind turbines, each 60 metres high, which take the force of the Roaring Forties, the prevailing westerly wind in southern latitudes. The electricity generated at Woolnorth goes to the Smithtown power station.

Local case study: displacement of communities in Mualadzi, Mozambique

Communities are often displaced and forced to resettle in new areas when large-scale mining operations develop. This can often occur without consultation and can impact on livelihoods, access to food and water and isolation for the communities affected.

FIGURE 3 Australian energy production by fuel type



Source: Department of Industry and Science (2015) *Australian Energy Statistics*, Table J.

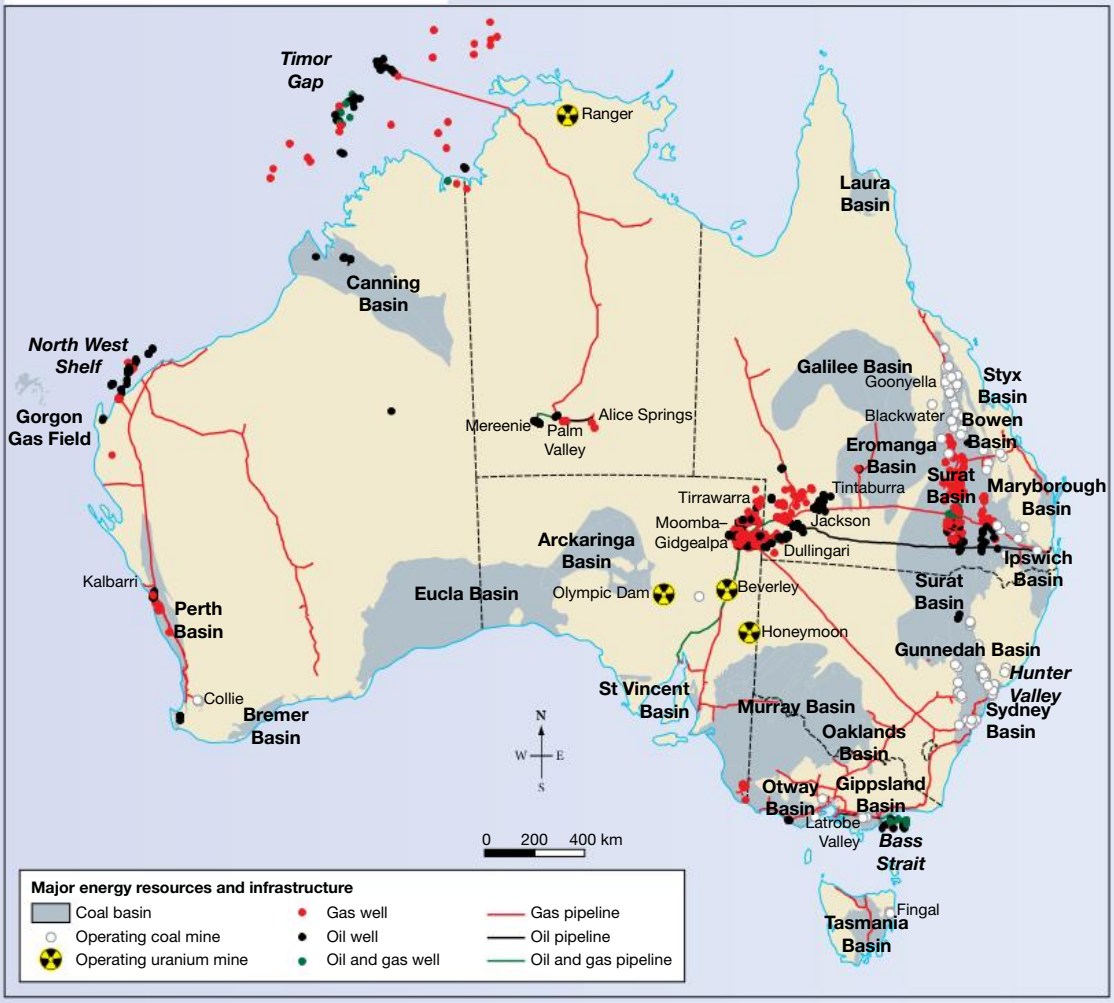
FIGURE 4 A Glencore Xstrata coal mine in Queensland

FIGURE 5 Wind turbines in Tasmania

FIGURE 6 Some communities in Mozambique are forced to travel long distances in order to access drinking water.

Large-scale mining in Tete Province of Mozambique caused local environmental change, making the area uninhabitable for local communities. This resulted in a Resettlement Action Plan to move affected communities to Mualadzi. The initial families who were moved to Mualadzi did not have basic amenities available such as water pumps, boreholes or storage tanks. Water was temporarily trucked into the resettlement. The soil quality at the new site also made food production difficult. Social networks and livelihood patterns were also fractured.

FIGURE 7 Energy resources in Australia



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 Using examples, describe the two categories of causes of ***environmental change***.

EXPLAIN

2 Explain how population growth and ***environmental change*** have been ***interconnected*** in the past.

INVESTIGATE

3 Investigate one human-induced ***environmental change***. Create a multimedia presentation that includes the following information:
- **a** Describe the biophysical processes that relate to the ***environment***.
- **b** Examine the causes of the ***environmental change***.
- **c** Explain the short- and long-term consequences of the ***change***.
- **d** Suggest possible management strategies to address the ***environmental change***.

4 Using Google Earth and the internet, examine an example of ***environmental change*** at a regional ***scale***. Create a Google Tour that examines evidence of the ***environmental change*** over various locations.

PREDICT

5 Describe whether you think population growth continues to be a major factor in ***environmental change***. Provide reasons how and/or why.

12.9 What is sustainable management?

12.9.1 What is environmental sustainability?

Sustainability refers to something's ability to continue into the future. It means living within the resources of the planet without damaging the environment now or in the future. Sustainability refers to taking the long-term view of how our actions affect future generations and making sure we don't cause pollution or deplete resources at rates faster than the Earth is able to renew them.

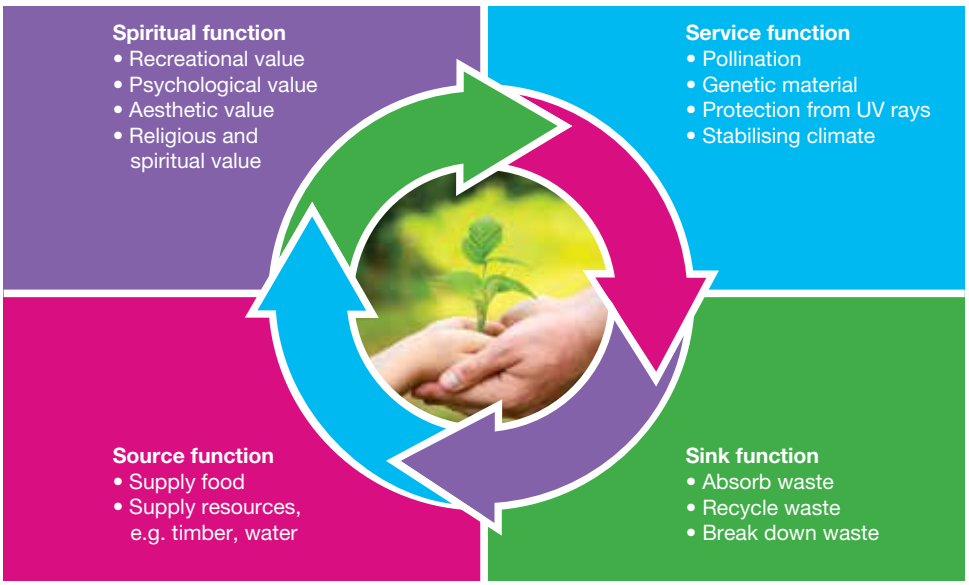
Types of sustainability include economic and political, social and cultural and environmental. All of the different types of sustainability are important in a functioning society. However, environmental sustainability is the most relevant when investigating the effectiveness of management strategies. Environmental sustainability emphasises the importance of ecosystems and environments to be able to continue to function effectively into the future.

Environmental sustainability is based on the idea of preserving the Earth's capacity to support human life and maintain the four S functions: source, sink, service and spiritual.

- The **source function** refers to the capacity of the environment to provide us with materials we rely on such as timber, water, and soil.
- The **sink function** refers to the ability of the environment to remove and breakdown waste.
- The **service function** refers to the processes that occur that enable our existence, such as pollinating food crops and stabilising the climate.
- The **spiritual function** refers to how environments can provide us with psychological benefits or spiritual connections.

Effective management of environments will preserve the processes within them and their ability to perform the four functions. In turn this will ensure the well-being of people.

FIGURE 1 The four functions associated with environmental sustainability



12.9.2 What is a sustainable world?

A range of indices have been developed in recent years to examine the link between **ecological services**, human wellbeing and sustainability. These include the Human Development Index (HDI), the Sustainable Society Index (SSI) and the Happy Planet Index (HPI), and each gives a slightly different perspective on human activity and/or sustainability.

The Sustainable Society Index says that sustainable human action must:

- meet the needs of the present generation yet not compromise the ability of future generations to meet their own needs
- ensure that people have the opportunity to develop themselves in a free, well-balanced society that is in harmony with nature.

It is worthwhile studying these indices as they put forward many sound ideas about human well-being and the sustainability of the ecological services of the natural world.

The Sustainable Society Index gives values to 21 factors across a range of social, political, economic and environmental considerations. For example, Australia rates highly in clean air and sufficient food but lower in renewable energy and consumption. In another example, Burundi rates extremely low

ecological services any beneficial natural process arising from healthy ecosystems, such as purification of water and air, pollination of plants and decomposition of waste

in organic farming, genuine savings, GDP, good governance and population growth, but highly in greenhouse gases, energy use and renewable water resources.

GEOskills TOOLBOX

Radar or spider charts

Radar graphs, also known as spider charts, are used to show a large number of variables in a simplistic way. For each aspect or variable, if the line is close to the centre of the graph it has a low rating. If the line is closer to the outside of the graph it has a high rating.

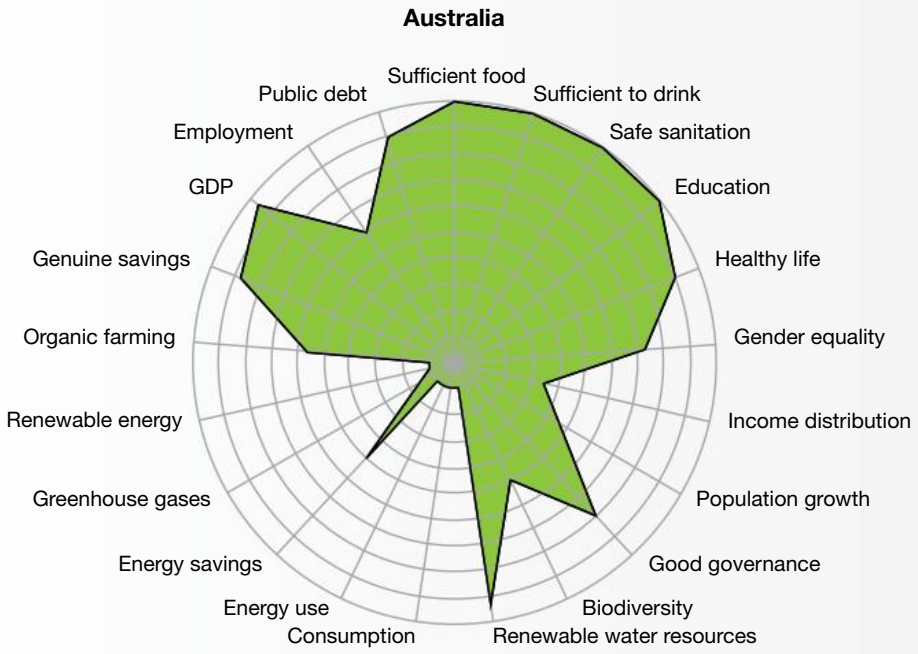
Figure 2 shows Australia's performance in various aspects of the Sustainable Society index on a rating of 1 to 10.

1 State the rating that Australia received for each of the following:
   - **a** Employment
   - **b** Education
   - **c** GDP.

2 State the five variables that Australia scored highest in for the Sustainable Society Index.

3 Use the **Sustainable Society Index** weblink in your eBookPLUS to find out more about the Index. Then answer the following questions.
   - **a** Divide the various factors shown around the circle into the categories human wellbeing, environmental wellbeing and economic wellbeing.
   - **b** Explain how these factors are interconnected.
   - **c** List the factors that Australia needs to change to be a more sustainable nation. Consider environmental, social and economic criteria from the index to inform your recommendations.
   - **d** Suggest reasons why Australia rates poorly in some of these factors.
   - **e** In what factors with respect to human wellbeing does Australia rate highly? Why would this be so?

FIGURE 2 Australia's situation based on the Sustainable Society Index



eBookplus
Weblink
Sustainable Society Index

ACTIVITIES

IDENTIFY

1 Describe how ***environmental sustainability*** is different to other types of ***sustainability***.

2 Outline the four main components of ***environmental sustainability***.

EXPLAIN

3 Describe how different measures are used to evaluate ***sustainability***. Do these measures only monitor ***environmental sustainability***?

APPLY

4 Use the **Forest depletion** weblink in your eBookPLUS to explore information on this topic.
   - **a** What aspects of ***sustainability*** and the concept of stewardship can you draw from this information?
   - **b** Make a list of nations that have an ***unsustainable*** level of forest depletion.

eBookplus
Weblink
Forest depletion

12.10 What is an ecological footprint?

12.10.1 What is the ecological footprint?

The ecological footprint is one means of measuring human demand for ecological services. The footprint takes into account the regenerative capacities of biomes and ecosystems, which are described as the Earth's **biocapacity**. The footprint is given as a number, in hectares of productive land and sea area, by measuring a total of six factors, as shown in figure 1. The ecological footprint is a useful indicator of environmental sustainability.

biocapacity the capacity of a biome or ecosystem to generate a renewable and ongoing supply of resources and to process or absorb its wastes

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular

Figure 2 compares the ecological footprint with biocapacity. The elephants represent each region's footprint (per capita) and the balancing balls represent the size of the region's biocapacity (per capita). The dark green background represents the gross footprint of regions that exceed their biocapacity, and the light blue background represents those regions that use less than their biocapacity.

In 2011 the total **ecological footprint** was estimated at 1.5 planet Earths, which means that humanity used ecological services at 1.5 times the biocapacity of the Earth to renew them. The 1.5 ecological footprint figure represents an average for all regions of the Earth. However, the United States and Canada, which have an ecological footprint of 7.9, are well above this average. This level of resource use is not sustainable into the future, and raises questions of economic viability, environmental benefit and social justice.

FIGURE 1 Measuring the Earth's ecological footprint

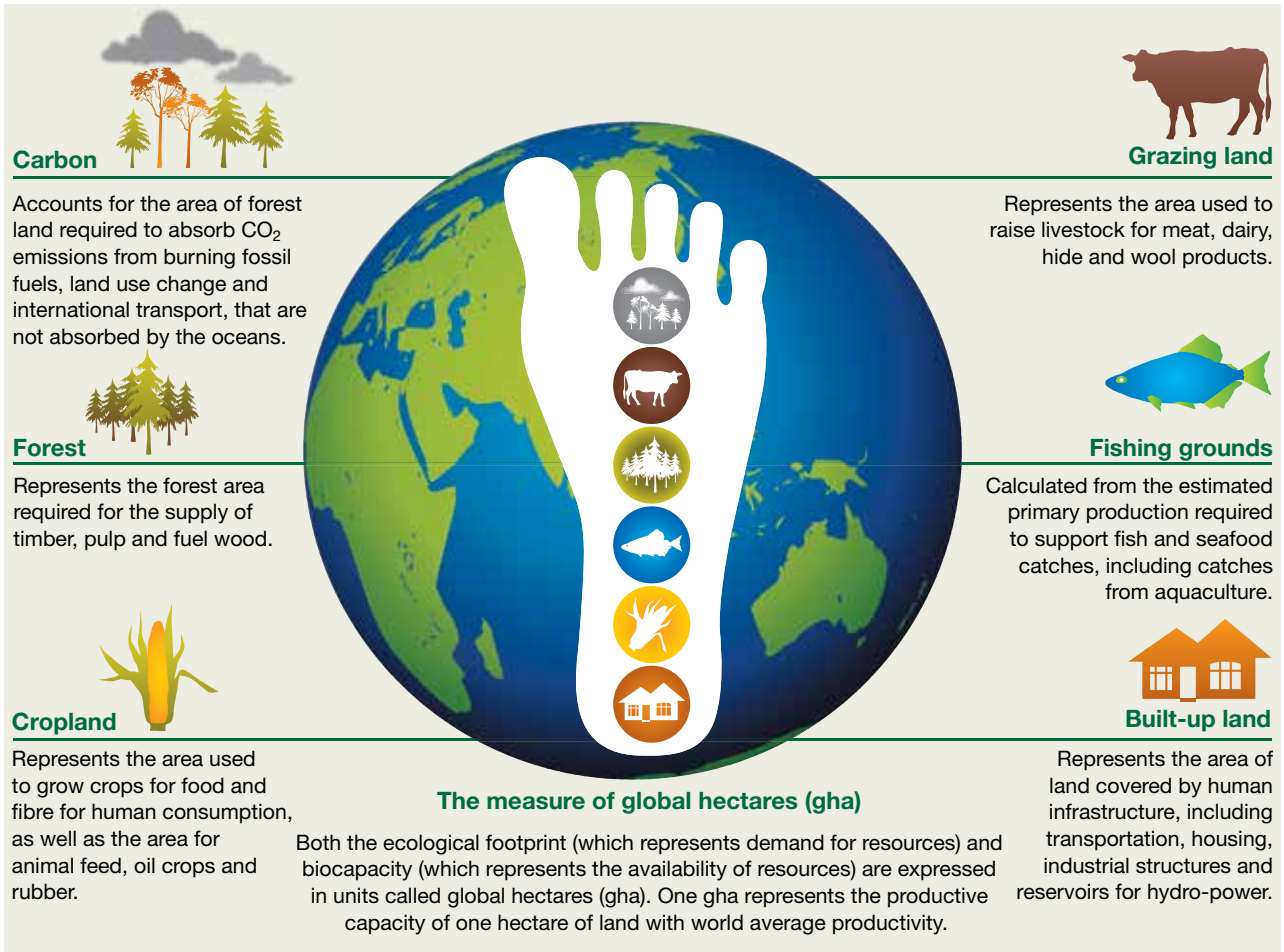
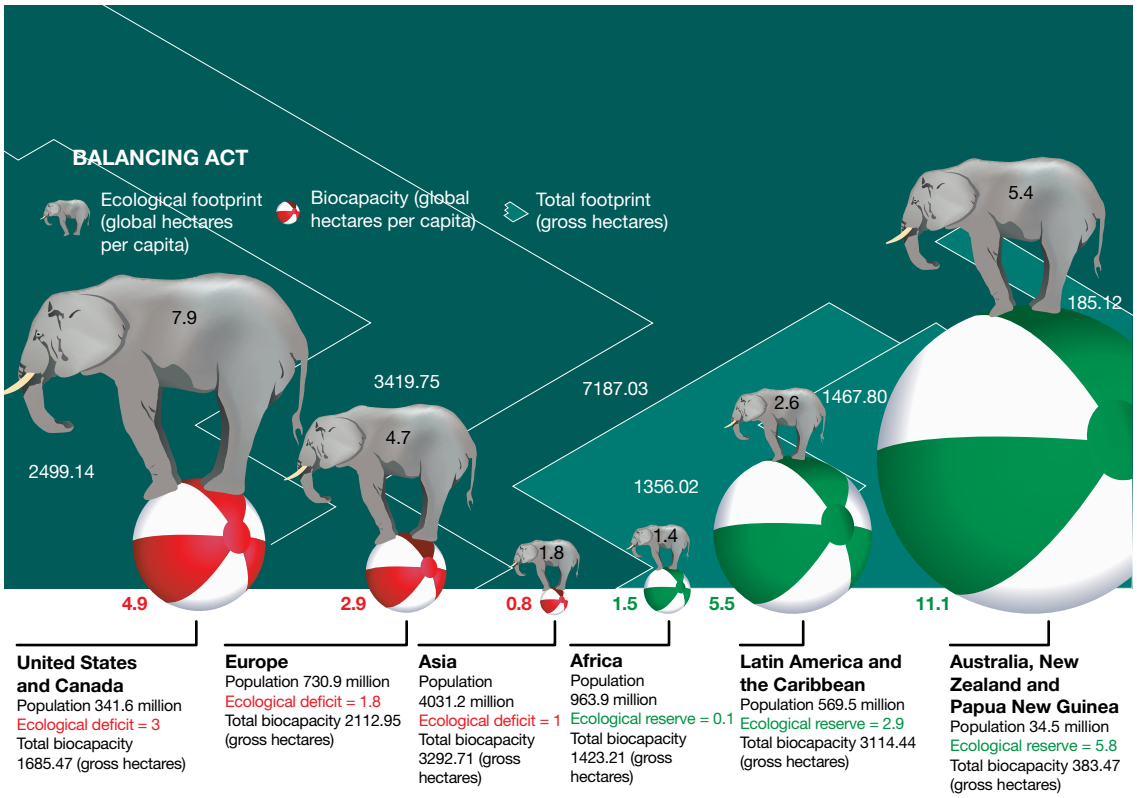


FIGURE 2 Biocapacity and ecological footprint



FOCUS ON FIELDWORK

Investigating the sustainability of your school

In groups of three, carry out a sustainability audit on your school. You may choose to investigate areas such as energy and water use, travel, recycling and waste, food or goods, paper, stationery, etc.

1 Plan out your investigation. Consider the best research techniques to use. Examples could be a rubbish tally, a computer count, an analysis of school spending on stationery, text books, digital resources (you can often find some of this information in the school's annual report on their website), observations of students and teachers using public transport or cars, an interview with a canteen volunteer or observations of environmentally friendly initiatives.

Your teacher may ask someone to visit the class so that you can interview them. This could be the principal, computer technicians, the general assistant or a teacher or student in the school's environmental group.

2 Carry out your fieldwork. In addition to your chosen techniques, visit areas of the school which are relevant to your topic. Take photographs and record notes of your observations.

3 Once you have completed your fieldwork share your results with your class. Compile your results as a class to get a thorough understanding of the sustainability of the school overall.

- **a** To what extent do you think your school is environmentally sustainable?
- **b** What initiatives have been put in place to improve your school's environmental sustainability?
- **c** What suggestions can you make to further improve your school's environmental sustainability?

ACTIVITIES

EXPLAIN

1 Refer to figure 2.

- **a** What reasons can you suggest for the very high ***environmental*** or ecological footprint for the United States and Canada?
- **b** How might the three regions with the dark green very high gross footprint improve their biocapacity?
- **c** Why is Australia in such a good position in terms of ecological footprint compared to biocapacity?

12.11 How is Jindabyne affected by environmental change?

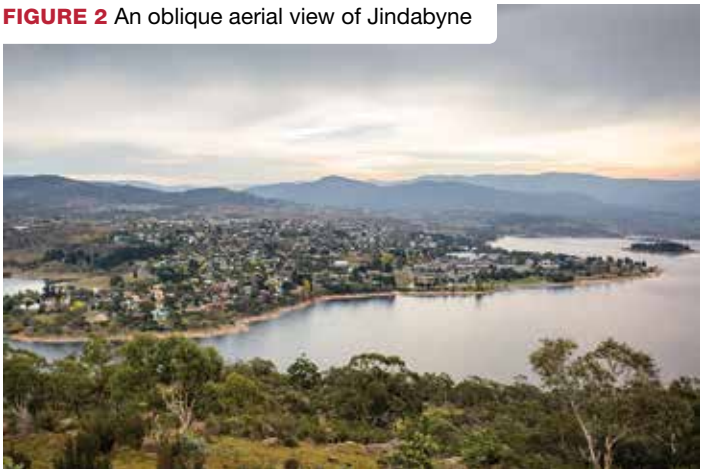
12.11.1 How is Jindabyne affected by environmental change?

Jindabyne was originally located under the current location of Lake Jindabyne. It was moved in the 1960s when the Snowy River was dammed as part of the Snowy Mountains Scheme.

This alpine region is popular for its mountain peaks, which are used for snow activities such as skiing, snowboarding and tobogganing. It is a holiday destination that is popular as a base for skiers visiting ski resorts, such as Perisher and Thredbo, but also offers a range of other nature-based activities year round. The increasing numbers of tourists is another environmental change that could impact on the fragility and value of the alpine environment. In addition, natural snowfalls in the region are likely to be affected by warmer conditions associated with climate change. This could have flow-on impacts for businesses and communities in the area.

FIGURE 1 A ski field accessible from Jindabyne

FIGURE 2 An oblique aerial view of Jindabyne



ACTIVITIES

IDENTIFY

1 Identify the grid reference of the following.
- **a** Redlands High Country Campus
- **b** Cobbon Farm
- **c** Loch Brae
- **d** Mill Ridge
- **e** Jindabyne Golf Club

2 Write the ***scale*** of the map as a ratio, sentence and draw it as a linear ***scale***.

3 Identify the direction, bearing and straight line distance from:
- **a** Banjo Paterson Park to Pats Patch Caravan Park
- **b** Jindabyne Dam to Bungarra Alpine Centre
- **c** Carinya Alpine Village to Lion Island
- **d** Round Hill to Windarra
- **e** Tryolean Village to Pats Patch Caravan Park.

4 Identify the altitude of the following.
- **a** The trig station in AR4266
- **b** Pine Grove in AR4562
- **c** The trig station in AR4766
- **d** The trig station in AR4768
- **e** The trig station in AR4472

5 Calculate the local relief in:
- **a** AR4668
- **b** AR4770
- **c** AR4365.

APPLY

6 Examine the features of the map and figures 1 and 2. Consider an ***environmental change*** that you could study in this location.
- **a** Identify an aim for research.
- **b** Suggest some fieldwork methods you could use to observe, measure, collect and analyse data related to this ***environmental change***.
- **c** Identify any fieldwork instruments that you might use in your investigation.
- **d** Suggest ***environmental*** management strategies that could be implemented to address this ***environmental change***.

FIGURE 4 Topographic map of Jindabyne

Source: Spatial Vision

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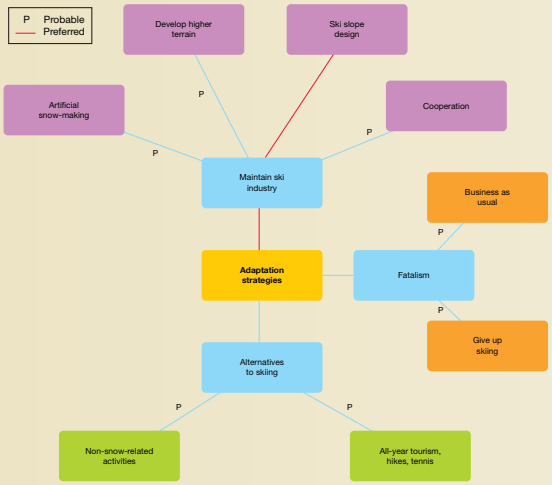
12.12 SkillBuilder: Drawing a futures wheel

What is a futures wheel?

A futures wheel is a series of bubbles or concentric rings with words written inside each to show the increasing impact of change. It helps show the consequences of change.



eLesson

Watch this video to learn how to draw a futures wheel.

Searchlight ID: eles-1745

Interactivity

Try this interactivity to learn how to draw a futures wheel.

Searchlight ID: int-3363

12.13 Is climate change heating the Earth?

global warming increased ability of the Earth's atmosphere to trap heat

enhanced greenhouse effect the observable trend of rising world atmospheric temperatures over the past century, particularly during the last couple of decades

climate change any change in climate over time, whether due to natural processes or human activities

12.13.1 Climate change and global warming

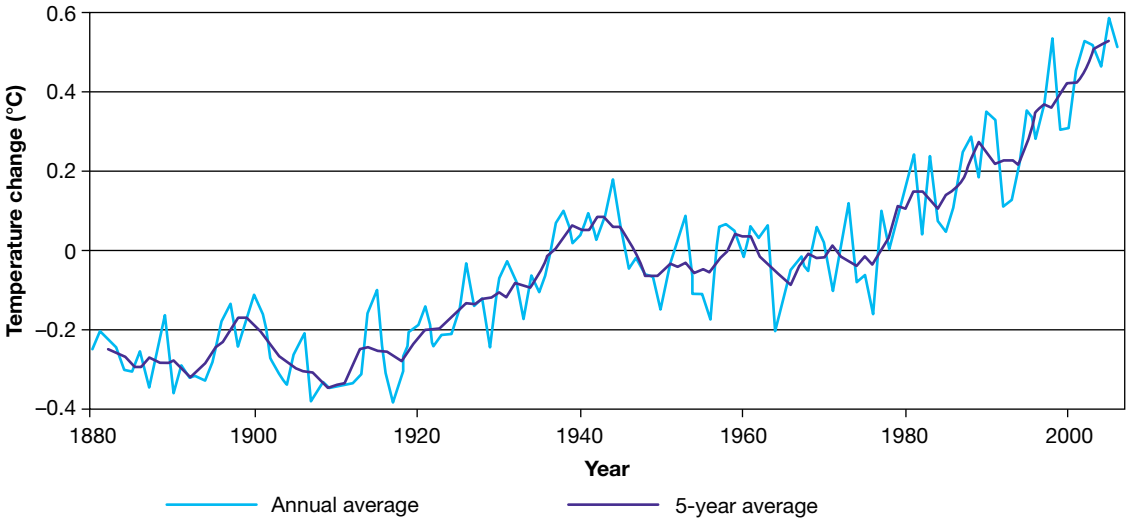
The world's climate has been changing for millions of years, but more recently there has been an increase in the concentration of greenhouse gases in the atmosphere, leading to **global warming**. It is believed that human activity, particularly the burning of fossil fuels such as coal and oil, have led to what is known as the **enhanced greenhouse effect**, which is heating the Earth and its atmosphere.

Climate, which can be defined as the yearly changes in the Earth's atmosphere, is highly variable over the Earth's surface. As such, climates in the tropics contrast markedly with climates near the poles. Climate also varies over extensive periods of time, and scientists have described these changes, which date back millions of years, long before the emergence of the human species, as warm periods and ice ages. Currently the Earth is in a warm period, having moved out of ice age conditions as recently as 6000 years ago. Today it is realised that human activity is increasing the rate of global warming leading to **climate change**, particularly in the last few hundred years, and this can have serious consequences for the planet (see figure 1).

The greenhouse effect

The greenhouse effect is the mechanism whereby solar energy is trapped by water vapour and gases in the atmosphere, thereby heating the atmosphere and helping to retain this heat, as in a glasshouse. The three most important gases responsible for the greenhouse effect are carbon dioxide, nitrous oxide and methane. Without this greenhouse effect the atmosphere would be much cooler, and ice age conditions would prevail over the planet, making life as we know it impossible (see figure 2).

FIGURE 1 Average global temperature, 1880–2010

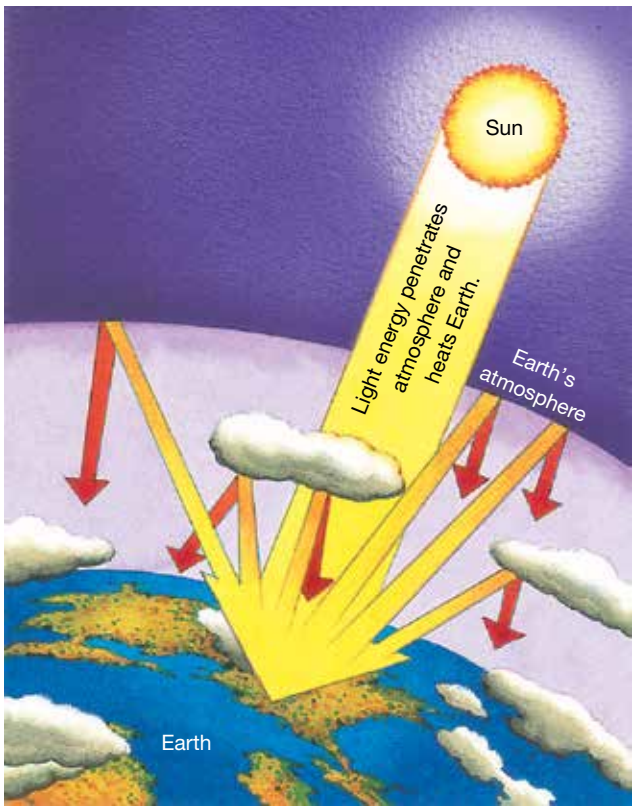


Human activity and the enhanced greenhouse effect

Changes in the balance of the greenhouse gases are a natural event, leading to the different climatic conditions on the planet as experienced over geological time. The issue today is how much impact human activity is having on the natural cycle of events, and how this activity is leading to climate change and global warming.

The term 'the enhanced greenhouse effect' has been developed to show that heating of the atmosphere is moving at a rate that is above what could be expected by natural processes of change (see figure 3). Recent research by government and non-government organisations has indicated that all parts of the world are vulnerable to the impacts of the enhanced greenhouse effect and associated climate change. Six key risks that have been identified in Australia alone include higher temperatures, sea level rise, heavier rainfall, greater wildfire risk, less snow cover, reduced run-off over southern and eastern Australia, and more intense tropical cyclones and storm surges along the coast.

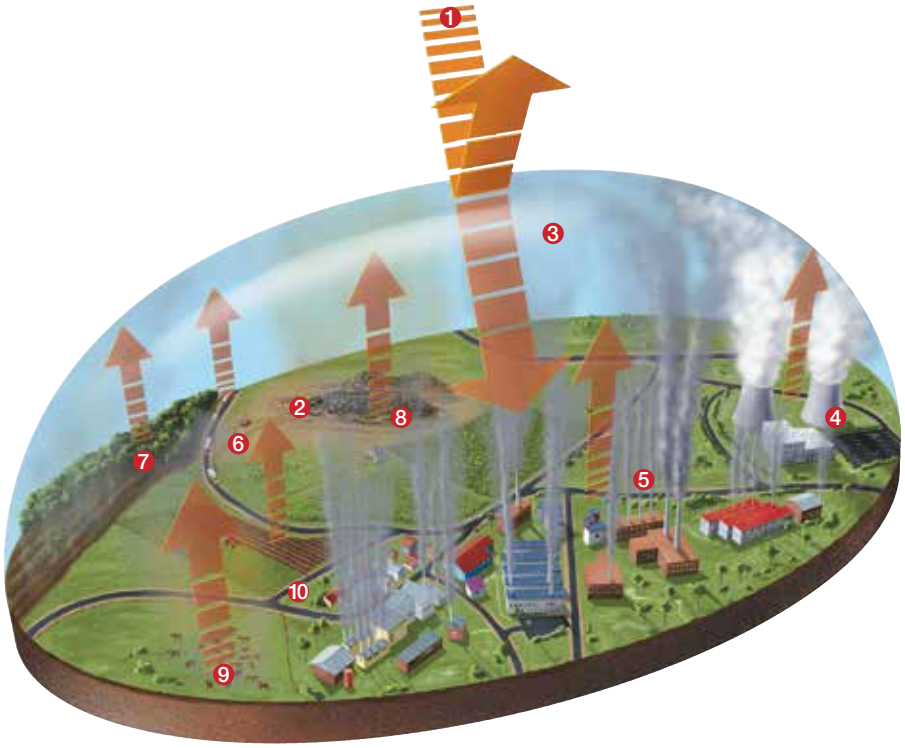
FIGURE 2 How the greenhouse effect works



12.13.2 What can we do?

A switch to renewable energy sources such as solar, wind, water (hydro) and geothermal (heat from inside the Earth's crust) will lead to sustainable energy use in the future, reduce carbon emissions into the atmosphere and thereby reduce the enhanced greenhouse effect. At the household level, simply by using energy-efficient light bulbs and appliances and by purchasing solar panels to produce hot water and electricity, there can be a significant reduction in greenhouse gas emissions. You could even think of purchasing a new motor vehicle that uses electricity or has a higher fuel efficiency rating.

FIGURE 3 The enhanced greenhouse effect



1. Heat from the sun
2. Heat trapped by greenhouse gases
3. Heat radiating back into space
4. Greenhouse gases produced by power stations burning fossil fuels
5. Greenhouse gases produced by industry burning fossil fuels
6. Greenhouse gases produced by transport burning fossil fuels
7. Greenhouse gases released by logging forests and clearing land
8. Methane escaping from waste dumps
9. Methane from ruminant (cud-chewing) livestock, e.g. cattle, sheep
10. Nitrous oxide released from fertilisers and by burning fossil fuels

ACTIVITIES

IDENTIFY

1 What are the differences between climate ***change*** and global warming?
2 What is the greenhouse effect and what are the three atmospheric gases responsible for this effect?
3 What would happen to the Earth if there was no greenhouse effect?

EXPLAIN

4 What ***changes*** have occurred to the Earth's climate over geological time?
5 Why would sea levels be much lower in an ice age period?

INVESTIGATE

6 What role do trees play in the carbon cycle and in controlling the level of greenhouse gases?
7 What impacts will global warming and in particular higher water temperatures have on a marine ecosystem such as the Great Barrier Reef?

PREDICT

8 Refer to figure 1, which shows average global temperatures.
- **a** What is the time period shown in the graph?
- **b** In which year did the highest average temperature and lowest average temperature occur?
- **c** What would the projected average surface temperature be in 2100?
- **d** What is the general trend shown by the graph?

APPLY

9 In groups, prepare a report that explains how the enhanced greenhouse effect operates, based on the information in figure 3. Prepare a presentation for the class that includes your suggestions about what we can do to reduce the impacts of the enhanced greenhouse effect.

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

- Causes of climate change
- Larsen Ice Shelf break-up
- Impacts on polar bears
- Climate change and Australia
- Global warming and Antarctica

12.14 Can we slow climate change?

eBookplus ONLINE ONLY

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

12.15 How can we reduce the impact of climate change?

eBookplus ONLINE ONLY

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

12.16 Review

eBookplus ONLINE ONLY

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

12.7 SkillBuilder: Evaluating alternative responses

12.7.1 Tell me

What are alternative responses?

Alternative responses are a range of different ideas/opinions on an issue. These ideas may have advantages or disadvantages, be positive or negative, have strengths or weaknesses and costs or benefits. You may or may not agree with the alternative responses. Evaluating ideas involves weighing up and interpreting your research to reach a judgement or a decision based on the information.

Why are alternative responses useful?

Evaluating alternative responses is useful because it ensures that you have thought of a range of possibilities or options and made a judgement about each possibility. To help with your decision making, you can consider ideas from a range of perspectives, such as economic, environmental, social justice, historic, political or technological viewpoints. These perspectives act as thinking tools for your analysis of a topic. They are also useful for:

- providing input to a discussion
- ensuring that all aspects are considered
- assisting in decision making
- justifying an action taken.

Model

A careful evaluation of alternative responses:

- considers a wide range of alternative responses and weighs up the advantages and disadvantages of each
- examines a wide range of data on a topic
- undertakes open-minded discussion
- makes a decision on which is a better option and justifies it.

Alternative responses to be considered include:

- allowing tourism to develop without restraint
- restricting tourist numbers to the island
- restricting tourist numbers only in the peak season
- banning tourists from the island
- introducing tighter rules on tourist movements on the island.

FIGURE 1 Alternative responses to the question 'Should tourist numbers on Fraser Island be limited?'

A special environment

The island's special features include:

- long surf beaches and rocky headlands
- about 40 crystal-clear freshwater lakes. Some of these are perched lakes (that is, they sit, or perch, on an impermeable layer of rock or hardened organic matter lying above the watertable). There are also 'window' and barrage lakes. Window lakes appear when depressions in the land surface dip below the watertable, thus exposing part of it. Barrage lakes form when shifting sand dunes block running water and cause it to pool.
- many streams and creeks
- coloured sand cliffs, some 35 kilometres in length
- salt pans, lagoons, mangrove forests and wetlands
- thick rainforests, some of which are so dense that sunlight does not penetrate the canopy
- offshore seagrass beds to support colonies of dugong
- over 25 species of mammals, including dingoes thought to be the purest strain of the species in Australia
- over 350 species of birds. One of Australia's rarest birds, the endangered ground parrot, is found on the island.
- vast sandblows (that is, tracts of sand moved by the wind) and lofty sand dunes.

Past land uses

Fraser Island once had a sand-mining industry (mining its tracts of mineral-rich black sand). This was stopped in 1976 following a federal government inquiry. There was also a timber industry, disbanded in December 1991 by the Queensland Government after a separate inquiry.

Tourists

Hundreds of thousands of tourists now visit the Fraser coast region every year, injecting some $366 million into the region in 1999. It is estimated that 32 per cent of this visitor expenditure was contributed by tourists to Fraser Island itself. The most obvious risks that tourism brings to the national park have to do with land-clearing, waste, increased traffic and disturbance of the island's flora and fauna.

Ecotourism facilities

The island's Kingfisher Bay Resort and Village has the highest level of accreditation as an ecotourism facility. An environmental impact statement was prepared before the proposed facility was approved for construction.

Dingo management

In the past, many tourists fed the dingoes that roam the island. In April 2001, however, a young boy was tragically killed by dingoes. Tourists are now provided with a 'Dingo Smart' brochure, and are heavily fined if caught feeding a dingo or trying to encourage its attention. Any dingoes known to be a problem are culled.

Managing camping facilities

There are six government-owned camps — at Central Station, Lake Boomanjin (the largest perched lake in the world), Lake McKenzie, Dundubara, Waddy Point and Wathumba — and two that are privately owned. People can also camp on a restricted number of beach areas, but not within 50 metres of a creek, stream or lake. Beach camping areas are temporarily closed sometimes to allow vegetation to regrow or to halt erosion.

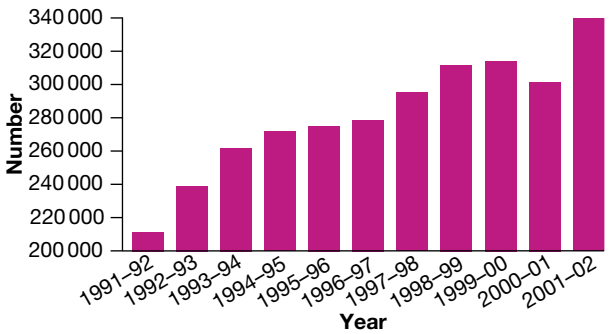
Managing four-wheel drive vehicles

Four-wheel drive vehicles are needed to travel around the island. Left unmanaged, these large vehicles could have a significant impact on the island's flora and fauna and on levels of erosion, especially because touring parties tend to drive in the same areas. It is the most attractive parts of the island that are often the most vulnerable.

All vehicles travelling on the island have to display a purchased permit and, more recently, driving and parking on sand dunes have been made illegal. The Environmental Protection Agency has started a campaign to educate four-wheel drivers about the impacts their vehicles have on the island's environment.

Government funding

In 2004, the Australian government's Natural Heritage Trust granted $300 000 to reduce road-related erosion, provide environmentally friendly amenities and better direct pedestrian movement around Fraser Island. Barriers along the sides of the island's roads and better planning have reduced the degree of erosion from run-off. The idea was partly to make pedestrian travel a more attractive option, as well as draw pedestrians away from the island's vulnerable dunes. To do this, boardwalks were built along the banks of Eli Creek (see the photograph on page 26). Stretches of dunes are also regularly closed for rehabilitation. Although the potential threat from tourism-related erosion remains, the stability of the island's sand dunes is improving.



Visitor numbers to Fraser Island

Please tourists, don't pee in the lake

So, we're sure your momma told you not to pee in the swimming pool — but did she also tell you it's bad to pee in a lake? Down in Australia, the beautiful Basin Lake on Fraser Island off Queensland isn't doing well these days, and one of the causes is high levels of urine in the water. The official word is that too many tourists are using the lake as a toilet and that's led the Queensland Parks and Wildlife Service to consider closing one of the access tracks to reduce visitor numbers. Right now 35 000 people visit the lake every year and since there's no in- or outflow from the lake; whatever goes in, stays in. Our alternative suggestion is to simply stick up a big notice advertising the current urine levels in the lake. We're fairly sure most people would skip the swim.

Source: Fraser Island Travel Guide, 17 October 2008.

The following is an evaluation of the alternative responses to the Fraser Island tourism question. Figure 1 details the data and alternative responses upon which this evaluation is based.

'After considering the impacts on Fraser Island by tourists, I consider that tourist numbers should be limited, especially in the peak tourism season (*evaluation*). The risk of damage to the special environment that may be caused by tourists, such as destruction of the rainforest and pollution of lakes, outweighs the economic gains made by the tourism industry. (More than 32 per cent of tourism in the region revolves around Fraser Island.) With the government acknowledging this special environment by making greater funding available, particularly to reduce road-related erosion, I believe that limiting the tourist numbers (340 000 tourists in 2001–02) will ensure that the ecotourism is

not put under pressure; that dingoes and people can co-exist along with camping facilities; and that four-wheel drive vehicles can be managed with driver education and specific regulation for Fraser Island. Fraser Island in the past has not always been well managed but I believe restricting tourism numbers will allow this special environment to be sustained into the future.'

12.7.2 Show me

How to evaluate alternative responses

eBookplus

eLesson
Evaluating alternative responses
Searchlight ID: eles-1744

You will need:

- a wide range of data on a topic
- a range of responses to an issue involved in that topic.

Procedure:

To evaluate alternative responses, you will need a wide range of data on a topic, like that shown in figure 1 on Fraser Island.

STEP 1

You need to read through all the data, seek clarification of ideas, and develop a viewpoint on the information. Read about the environment's special features, past and present uses, including eco-tourism, camping and four-wheel-drive vehicles. Consider how the area might be managed, both locally to control dingoes and by the federal government with its funding proposals and regulations.

STEP 2

Divide a page into two columns and head the columns with Advantages/Disadvantages, Positives/Negatives, Strengths/Weaknesses, Costs/Benefits. In each column, list the information from the data that you believe is important in determining your viewpoint on the issue (the number of tourists visiting Fraser Island).

You need to consider a range of perspectives:

- economic — money is the basis of this viewpoint
- environmental — consider how the environment will be affected
- social justice — consider people and their cultures in a fair and just manner
- historic — look at how the past has affected decision making
- political — governments play a role in community environments
- technological — examine whether there are any technological implications
- sustainable — how the decision will affect the future and provide for people in the long term.

STEP 3

Consider your completed columns. Which column outweighs the others? Are there more points in one column than another? Are some arguments stronger than others? Use the answers to these questions to shape your opinion and help you decide which responses are better than others.

TABLE 1 Table of alternative responses

Alternative responses	Advantages	Disadvantages
1 Allow tourism to develop without restraint		
2 Restrict tourist numbers to the island		
3 Restrict tourist numbers only in the peak season		
4 Ban tourists from the island		
5 Introduce tighter rules on tourist movements on the island		

STEP 4

Refer to the evaluation that follows figure 1. This is a considered opinion based on a range of alternative responses to the issue.

12.7.3 Let me do it

Developing my skills

eBookplus

Interactivity
Evaluating alternative responses
Searchlight ID: int-3362

Our ecological footprint is one means of measuring human demand for ecological services. Using the information in figure 1 in section 12.10.1 evaluate whether all six aspects — carbon, forests, cropland, grazing land, fishing grounds and built-up land — have an equal role in determining the measure of global hectares (gha).

Questions

1. Is there one aspect that is more important to you? Is there any aspect that seems to have little relevance to you? Justify your answer.
2. Which alternative response has the most advantages? Which has the fewest advantages?
3. In which response do the advantages outweigh the disadvantages?
4. What perspectives dominate a consideration of the ecological footprint?
5. Survey the class to see if the class shares an opinion on the ecological footprint idea. Has the class adopted a similar viewpoint to the ecological footprint?

Checklist

I have:

- considered a wide range of alternative responses and weighed up the advantages/disadvantages of each
- examined a wide range of data on the topic
- undertaken open-minded discussion
- made a decision on which is the best option and justified my decision.

Skills questions

1. Evaluating alternative responses is used to show that:
   a. one person is always right on a topic
   b. people need to have the same view on a topic
   c. people can have different views provided they can justify their view
   d. people don't need to have views on a topic.
2. Evaluating alternative responses includes using criteria such as:
   a. emotions
   b. transport
   c. movement
   d. sustainability.
3. Why should you use a wide range of data?
4. Why do we need to evaluate responses?

12.12 SkillBuilder: Drawing a futures wheel

12.12.1 Tell me

What is a futures wheel?

A futures wheel is a series of bubbles or concentric rings with words written inside each to show the increasing impact of change. It helps show the consequences of change.

Why is a futures wheel useful?

A futures wheel is a thinking tool. It allows you to put down your ideas and to brainstorm or explore widely the implications of each idea or change. It is a method of predicting and evaluating change.

Futures wheels are useful for predicting change when you are:

- considering the implications of actions
- working with groups of people to develop ideas
- implementing policy changes in social issues
- considering impacts of natural disasters
- explaining the consequences of a change.

Model

A good futures wheel has:

- a number of concentric rings or bubbles
- more than one idea in each ring or level
- probable and preferred options
- neat presentation
- a clear title.

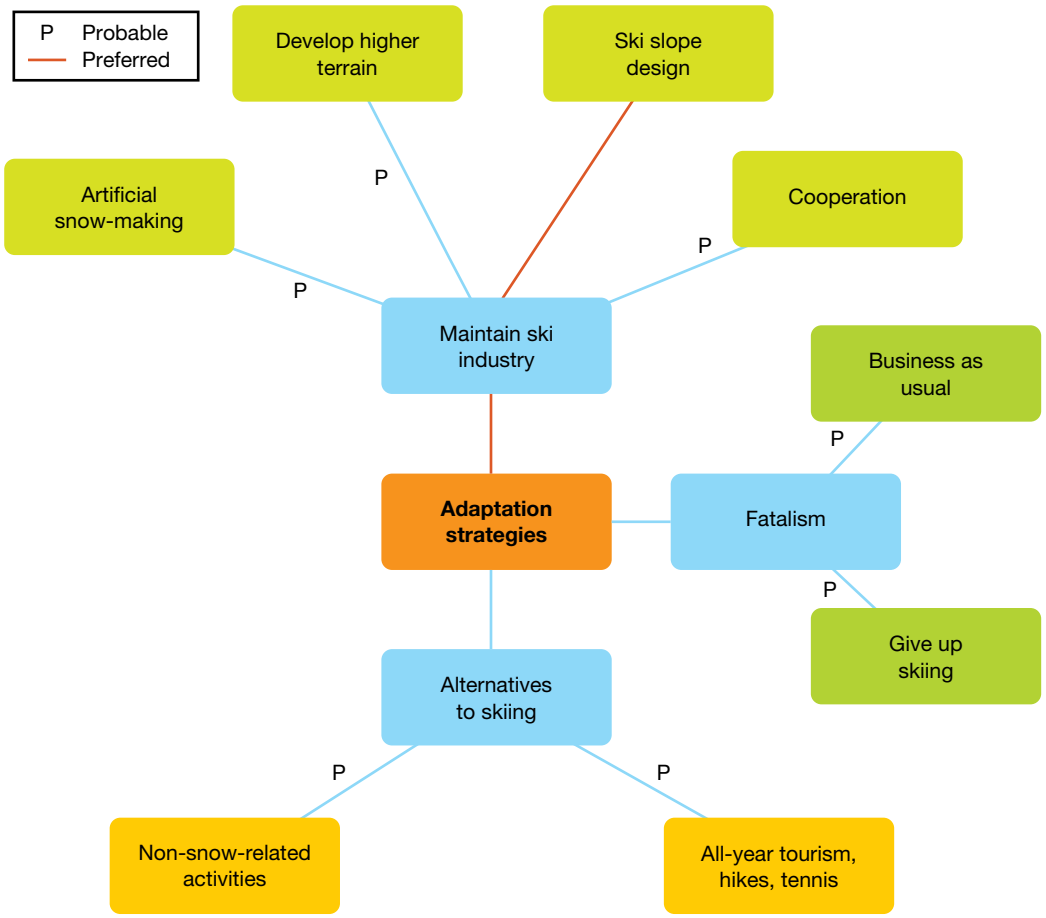


FIGURE 1 Possible responses by the ski and alpine resort industry to climate change

12.12.2 Show me

How to draw a futures wheel

You will need:

- a mathematical compass to draw concentric rings, or the **Bubbl.us** weblink in the Resources tab for creating bubbles
- a light-grey lead pencil
- coloured pencils.

eBookplus

Weblink
Bubbl.us

eBookplus

eLesson
Drawing a futures wheel
Searchlight ID: eles-1745

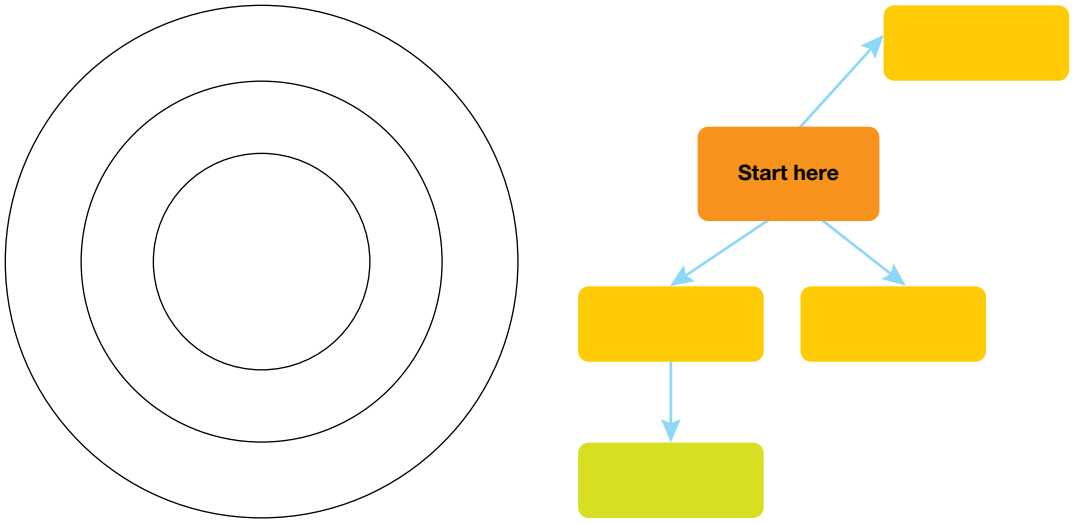
Procedure:

To complete a futures wheel, you must brainstorm a wide range of ideas. This is often best done in groups or while participating in a class discussion.

STEP 1

Draw a number of concentric rings — four is a good starting point. Make sure the inner circle is big enough to write in.

FIGURE 2 Examples of futures wheels



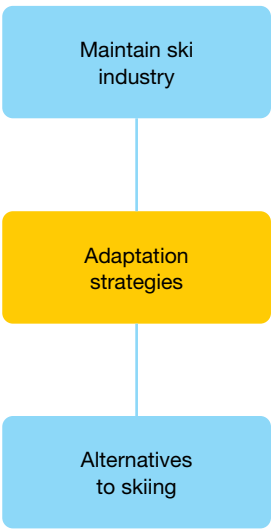
STEP 2

In the inner circle or bubble, write the issue that you are considering, such as possible responses by the ski and alpine resort industry to climate change (see figure 1).

STEP 3

In the first ring out from the centre, write the immediate thoughts that come to mind on the issue. See figure 3 for examples on the first bubble or concentric ring out from the centre. These thoughts are those that you see as most possible. Draw a square block around these possible ideas.

FIGURE 3 Starting the futures wheel



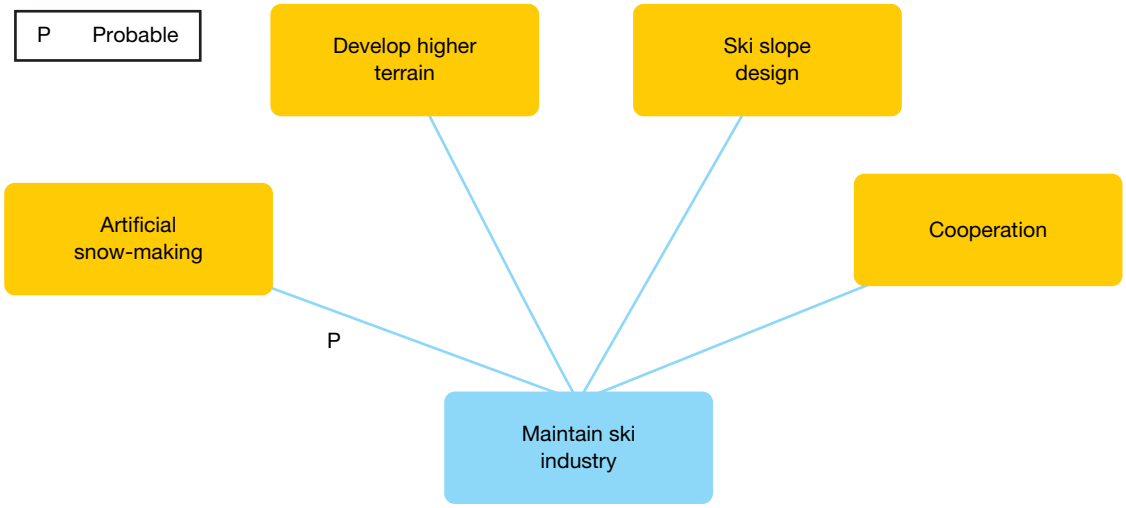
STEP 4

In the next layer out, take each of the points from the previous ring and think of two or more impacts that this change would imply. These thoughts are those that you see as most probable — a view of things that could happen. Label each of these ideas with a P. Figure 4 shows this level commencing.

STEP 5

Continue presenting ideas. The outer ring will have a whole range of ideas, whereas the rings closer to the centre of the wheel will have fewer ideas.

FIGURE 4 Some probable ideas on the futures wheel



STEP 6

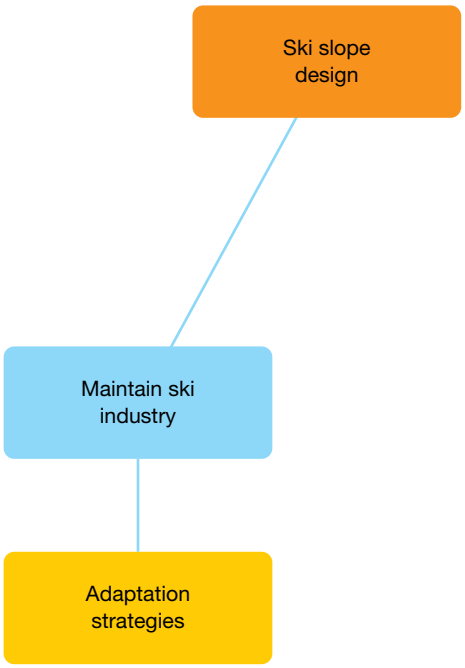
You may notice that there are interconnections between ideas. If you can see a link, you should draw a line between the interconnecting components. In figure 1, 'Business as usual' and 'Cooperation' could be linked if this is what you believed.

Consider the different connections that you have made between ideas. Find a route that you consider as the preferred option — a view that you see as most desirable. Colour this route in some way to show the thread of ideas. Can you justify your choice?

STEP 7

Give your futures wheel a title. In this case, figure 1 is titled 'Possible responses by the ski and alpine resort industry to climate change'.

FIGURE 5 Identifying a preferred option in the eyes of a ski-lift operator



12.12.3 Let me do it

Developing my skills

Using the information on climate change in topic 12, complete a futures wheel to show the consequences of climate change. Identify layers as possible, probable and preferred.

Questions

1. Is the issue explored in the futures wheel a big picture issue or a more specific idea?
2. What are two key consequences that you can see on the futures wheel?
3. Which of the consequences has been developed in greater depth? Why might this be the case?
4. Which of the consequences has been developed in the least depth? Why might this be the case?
5. Do you now have a greater understanding of the consequences of change? Explain your answer.

Checklist

I have:

- included a number of concentric rings or bubbles
- put more than one idea in each ring or level
- indicated probable and preferred options
- drawn neatly
- provided a clear title.

eBookplus

Interactivity
Drawing a futures wheel
Searchlight ID: int-3363

Skills questions

1. Futures wheels are used to show effects in:
   a. the distant past
   b. current times
   c. the recent past
   d. the future.
2. A futures wheel allows us to:
   a. express ideas
   b. commit to taking action
   c. brush aside an issue
   d. organise our thinking.
3. Why are futures wheels drawn in ever-increasing layers?
4. Do the points in the outer layer refer to the activities of individual people more than the points in the inner layers do?

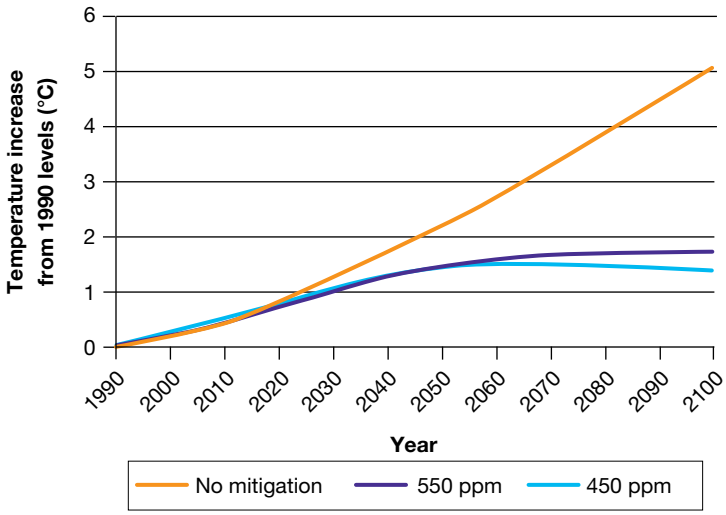
12.14 Can we slow climate change?

12.14.1 Climate change

Climate change is a global phenomenon. The greenhouse gases produced in one country spread through the atmosphere and affect other countries. Action by only a few countries to reduce greenhouse gases will, therefore, have little impact — it requires international cooperation, especially by the largest polluters.

Since the 1990s, countries have met at United Nations Intergovernmental Panel of Climate Change (IPCC) conferences and agreed to take steps to reduce emissions of greenhouse gases. An early conference developed the **Kyoto Protocol**, an agreement that sets targets to limit greenhouse gas emissions, and 128 countries have agreed to this Protocol. Further conferences in 2009 in Copenhagen, Denmark, 2010 in Cancun, Mexico, and Paris 2015 led to an important new direction, with all countries agreeing to contain global warming within 2 °C. This means that emissions of CO_2, which were at 395 parts per million (ppm) in 2013, must be kept below 550 ppm to reach this target. If no actions (mitigation measures) are taken, temperatures could increase by 5 °C, as shown in figure 1. To date, 192 of the world's 196 countries have signed the Kyoto Protocol, however close to half have modified their commitment to reach targets for greenhouse emission reductions set for 2020. The USA has signed the Protocol but has not ratified emission targets and Canada has withdrawn from the Protocol.

FIGURE 1 Global average temperature outcomes for three emissions cases, 1990–2100



Source: The Garnaut Climate Change Review 2008, p. 88.

To meet the greenhouse gas emissions targets defined by these agreements, countries must make changes that reduce their level of emissions. They can also meet the targets in two other ways:

1. A country can carry out projects in other countries that reduce greenhouse gas emissions and offset these reductions against their own target.
2. Companies can buy and sell the right to emit carbon gases. For example, a major polluter, such as a coal power station, is allowed to emit a certain amount of greenhouse gases. If it is energy efficient, and emits less than its limit, it gains **carbon credits**. It has the right to sell these credits to another company that is having difficulty reducing its emissions. Companies can also gain credits by investing in projects that reduce greenhouse gases (such as renewable energy), improve energy efficiency, or that act as carbon sinks (such as tree planting and underground storage of CO_2).

12.14.2 Australia's action

The Garnaut Report 2011 and the findings of the IPCC state that it is in Australia's national interest to do its fair share in a global effort to mitigate climate change (see table 1). The findings of this report were confirmed at the IPCC meeting in Paris in 2015. The introduction in 2012 by the Australian Government of an **emissions trading scheme** with a fixed price on carbon for three years and then a floating price led to the introduction of a carbon tax set at $23 per tonne of carbon dioxide emissions. Big businesses and industries that use large amounts of fossil fuels have complained that the tax will affect profits and force the price of goods and commodities higher. In 2015, the new Australian government reversed the decision to support the previously established emissions trading scheme, based on social and economic criteria stating that the carbon tax had increased costs of power to households and businesses.

Kyoto Protocol
an internationally agreed set of rules developed by the United Nations aiming to reduce climate change through the stabilisation of greenhouse gas emissions into the atmosphere

carbon credits
term for a tradable certificate representing the right of a company to emit one metric tonne of carbon dioxide into the atmosphere

emissions trading scheme
a market-based, government-controlled system used to control greenhouse gas as a cap on emissions. Firms are allocated a set permit or carbon credit and they cannot exceed that cap. If they require extra credits, they must buy permits from other firms that have lesser needs or a surplus.

TABLE 1 Potential impacts for each of the three emissions cases by 2100

Emissions case	450 ppm	550 ppm	No action
Likely range of temperature increase from 1990 level	0.8–2.1 °C	1.1–2.7 °C	3–6.6 °C
Percentage of species at risk of extinction	3–13%	4–25%	33–98%
Area of reefs above critical limits for coral bleaching	34%	65%	99%
Likelihood of starting large-scale melt of the Greenland ice sheet	10%	26%	100%
Threshold for starting accelerated disintegration of the West Antarctic ice sheet	No	No	Yes

Source: The Garnaut Climate Change Review 2008, p. 102.

12.14.3 Taking personal action

Australian households produce about one-fifth of Australia's greenhouse gases through their use of transport, household energy and the decay of household waste in landfill. This amounts to about 15 tonnes of CO_2 per household per year. (A tonne of CO_2 would fill one family home.) The Australian Conservation Foundation has suggested a 10-point plan (see figure 2) that every Australian household can follow to reduce its level of greenhouse gas pollution.

FIGURE 2 The Australian Conservation Foundation Plan

1 Switch to green power
Choose renewable energy from your electricity retailer and support investment in sustainable, more environmentally friendly energies. Make sure it is accredited GreenPower [electricity produced using renewable resources] — see www.greenpower.gov.au to find out more about the program.

GreenPower®
Accredited Renewable Energy

2 Get rid of one car in your household
A car produces seven tonnes of greenhouse pollution each year (based on travelling 15 000 kilometres per year). This does not include the energy and water used to build the car — 83 000 litres of water and eight tonnes of greenhouse pollution. So share a car with your family.

3 Take fewer air flights
A return domestic flight in Australia creates about 1.5 tonnes of greenhouse emissions (based on Melbourne to Sydney return). A return international flight creates about 9 tonnes (based on Melbourne to New York return). Holiday closer to home.

4 Use less power to heat your water
A conventional electric household water heater produces about 3.2 tonnes of greenhouse pollution in a year. Using less hot water will reduce your pollution. Using the cold cycle on your washing machine will save 3 kg of greenhouse pollution. Switching off your water heater when you're away will also reduce your energy use.

5 Eat less meat
Meat, particularly beef, has a very high environmental impact, using a lot of water and land to produce it, and creating significant greenhouse pollution. If you reduce your red meat intake by two 150-gram serves a week, you'll save 20 000 litres of water and 600 kg of greenhouse pollution a year.

6 Heat and cool your home less
Insulate your walls and ceilings. This can cut heating and cooling costs by 10 per cent. Each degree change can save 10 per cent of your energy use. A 10 per cent reduction is 310 kg of greenhouse pollution saved.

7 Replace your old showerhead with a water-efficient alternative
This will save about 44 000 litres of water a year and up to 1.5 tonnes of greenhouse pollution from hot water heating (on average).

8 Turn off standby power
Turning appliances off at the wall could reduce your home's greenhouse emissions by up to 700 kg a year.

9 Cycle, walk or take public transport rather than drive your car
Cycling 10 kilometres to work (or school) and back twice a week instead of driving saves about 500 kg of greenhouse pollution each year and saves you about $770. Besides, it's great for your health and fitness!

10 Make your fridge more efficient
Ensure the coils of your fridge are clean and well ventilated — that will save around 150 kg of greenhouse pollution a year. Make sure the door seals properly — this saves another 50 kg. Keep fridges and freezers in a cool, well-ventilated spot to save up to another 100 kg a year. If you have a second fridge, turn it off when not in use.

ACTIVITIES

IDENTIFY

1 Where has the United Nations convened conferences on climate ***change*** over the past 20 years?
2 What is the Kyoto Protocol?

EXPLAIN

3 Explain why the two basic strategies developed by the Kyoto Protocol can ***sustainably*** reduce the amount of greenhouse gases in the atmosphere.
4 Explain why organisations such as the Conservation Council of Australia would have different views from business companies that produce electricity on the topic of 'climate ***change*** and global warming'.

INVESTIGATE

5 Investigate the idea of an eco-friendly house using the internet. Start with the **Eco system homes** weblink in the Resources tab. In a team of four, design an eco-friendly house of the future. Present your design to the class.
6 Find what the Garnaut Report 2011 and the State of the Climate 2014 Report, produced by the Australian Government and the CSIRO, have to say about the impacts of climate ***change*** on Australia's ***environment***.
7 Use the **Ecological footprint** weblink in the Resources tab to find out more about an ecological footprint. Which of your activities could be changed to reduce your footprint?
8 Find out how the carbon tax works using the **Carbon tax** weblink in the Resources tab.
9 Find out more about Australia's situation with respect to climate change by looking at the State of the Climate 2014 report, which can easily be located on the internet.

PREDICT

10 Refer to figure 1. How much will temperatures increase by 2070 with no mitigation? Which action will reduce temperature ***change*** the most by 2100?
11 Refer to table 1 and the 450 ppm case. What is the percentage of species at risk of extinction? What might happen to the Great Barrier Reef under the 550 ppm case?

APPLY

12 What part do international forums play in helping to solve climate ***change***?
13 Create a poster to communicate the main points of the Australian Conservation Foundation's 10-point strategy to reduce greenhouse gases.

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Weblinks
Eco system homes
Ecological footprint
Carbon tax

12.15 How can we reduce the impact of climate change?

12.15.1 Fossil fuels

It has been recognised by climate authorities that global warming is possibly the most important issue impacting on life on Earth at this time and into the future. The burning of **fossil fuels**, which generate greenhouse gases, is causing the atmosphere to heat up, and it is believed that a sustainable future, in terms of energy use, can be achieved only by reducing the consumption of energy and/or switching to renewable energy forms. While use of fossil fuels is a significant factor in global warming, it should also be realised that there are a number of other human activities that lead to greenhouse gas emissions.

Fossil fuels have been widely used for energy production by human societies since the **Industrial Revolution**. Burning of wood in fires was the earliest use of fuels, and today coal, oil and gas are the fossil fuels of choice. Much of the energy used in society today for transport, domestic use and all forms of industry is from electricity generated by power stations that are fired by fossil fuels (see figures 1 and 2).

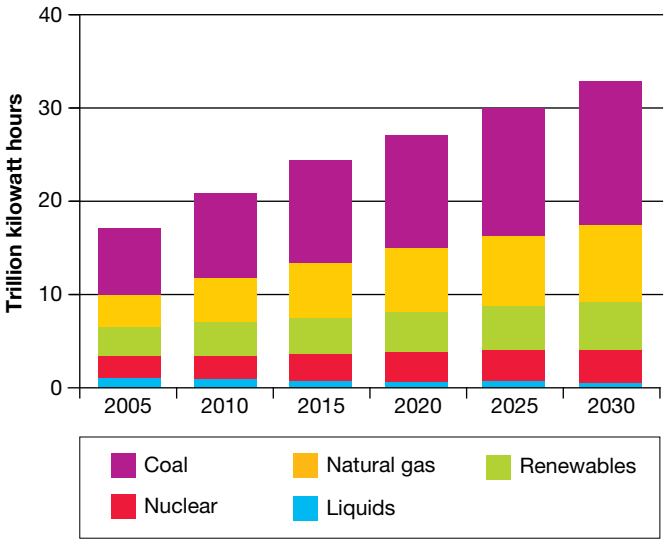
fossil fuels carbon-based fuels formed over millions of years, which include coal, petroleum and natural gas. They are called non-renewable fuels as reserves are being depleted at a faster rate than the process of formation.

Industrial Revolution started in approximately 1750 in the United Kingdom, eventually spreading to the rest of the world. It brought major technological changes in agriculture, manufacturing, mining and transportation. A major invention of the era was the application of coal and eventually oil and gas power to industry.

12.15.2 Renewable energy

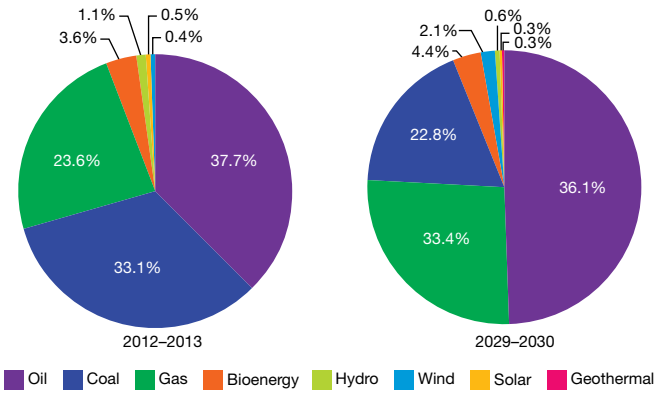
The alternative and environmentally friendly option to fossil fuels is renewable energy. This includes hydro-power, solar, wind, wave and tidal, **geothermal**, and bioenergy sources to generate electricity. These sources do not produce greenhouse gases and are replenished in relatively short periods of time (see figure 3). These actions represent a significant change from a human-centred to an earth-centred worldview. This change will lead to a more sustainable use of energy with a significantly lower impact of greenhouse gas emissions on the environment.

FIGURE 1 World electricity generation by fuel, 2005–30



Source: Energy Information Administration (EIA).

FIGURE 2 Australia's primary energy consumption



Source: BREE 2014, Australian Energy Statistics, Tables A, D
Source: ABAR 2009

geothermal (power) describes power that is generated from molten magma at the Earth's core and stored in hot rocks under the surface. It is cost-effective, reliable, sustainable and environmentally friendly.

FIGURE 3 Some sources of renewable energy: (a) solar, (b) wind, (c) hydro-electric and (d) geothermal

Many countries throughout the world are now using or developing sustainable energy industries. The USA, for example, has established the Clean Energy Plan and currently produces 0.54 per cent of its energy needs from solar power, with renewable energy sources comprising 13 per cent of its total electricity generation. In Europe, Germany has made great progress in harnessing renewable energy sources, which today provide 78 per cent of its power needs. Solar energy alone provides 50 per cent of this amount.

In Australia, with expansive desert regions, there is huge potential to generate solar power. In recent years, the installation of solar panels for domestic households has increased, and this has been supported by a Federal Government subsidy scheme; however, currently solar energy accounts for only 0.1 per cent of Australia's total energy requirements. In other renewable energy fields, wind farms have become more widespread in southern Australia, and there are companies investigating the potential for geothermal energy production.

12.15.3 What can be done in the future?

In 2015, the United Nations Intergovernmental Panel on Climate Change (IPCC) confirmed the 2007 recommendations to reduce greenhouse gas emissions. The recommendations cover a wide range of human activities, with suggestions for management to mitigate global warming (see table 1).

TABLE 1 Reducing greenhouse gas emissions

	Ways to reduce greenhouse gas emissions
Energy supply	• Switching from coal to gas • Developing safer and cleaner nuclear energy • Increasing use of renewables such as hydro-power, solar, wind, wave and tidal, geothermal and bioenergy • Carbon Capture and Storage (CCS) at fossil fuel electricity generating facilities
Transport	• More fuel-efficient vehicles such as electric, hybrid, clean diesel and biofuels • Changing from road to rail and bus transport systems • Promoting cycling and walking to work
Buildings	• Installing more efficient lighting and day-lighting systems and electrical appliances for heating and cooling, cooking, and washing • Increased use of photovoltaic (PV) solar panels • Improved refrigeration fluids including the recovery and recycling of fluorinated gases
Industry	• More efficient electrical equipment • Heat and power recovery • Material recycling and substitution • Control of gas emissions
Agriculture	• Improved crop yields and grazing land management • Increased storage of carbon in the soil and reduction of methane gas emissions from livestock manure • Restoration of cultivated soils and degraded lands • Improved nitrogen fertiliser application techniques to reduce nitrous oxide emissions • New bioenergy crops to replace fossil fuels
Forestry/forests	• Planting new forests • Better harvested wood management • Use of forestry products for bioenergy to replace fossil fuel use • Better remote sensing technologies for analysis of vegetation and mapping land-use change
Waste	• Landfill methane recovery • Waste incineration with energy recovery • Composting of organic waste • Controlled waste water treatment • Recycling and waste minimisation

Source: UN IPCC Report 2007.

For each of the mitigation actions shown in table 1 there are economic, social and environmental consequences. For example, considering the 'developing safer and cleaner nuclear energy' action, there may be positive economic consequences, such as the creation of energy security and job opportunities, but also negative consequences, such as the cost of waste disposal. Similarly, the social and environmental consequences may be positive, such as reduced air pollution, and negative, such as nuclear accidents.

ACTIVITIES

IDENTIFY

1 What is meant by the term *fossil fuel*?
2 List some major renewable energy sources.

EXPLAIN

3 What would be the negative impacts if all fossil fuels were banned tomorrow?
4 What would be the best renewable energy source for the future? Give reasons for your selection.

INVESTIGATE

5 How is ethanol produced as a renewable energy source for power production, and is it ***sustainable*** as a renewable energy source?
6 Use the internet to find out about geothermal energy and its potential as a future energy source.

PREDICT

7 Refer to figure 2. What percentage of Australia's energy currently comes from renewable sources, and by how much is this projected to ***change*** by 2029–30?
8 Considering the range of nuclear power plant accidents in the past and their impacts on the ***environment***, how might nuclear energy be managed as a safe energy source into the future?

APPLY

9 Why isn't the use of fossil fuels ***sustainable***?
10 Select examples of recommendations from the UN IPCC Report in table 1 that you think you could apply in your everyday living to reduce global warming by greenhouse gas emissions.
11 Use the internet to access and peruse the IPCC's Climate Change 2014 Mitigation of Climate Change Report. Consider the environmental, social and economic impacts of climate change mitigation for one of the following: transport, buildings, energy systems or industry.
12 What would be the environmental, social and economic consequences of the different management strategies adopted for renewable energy use in Australia, the USA and Germany?

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Interactivity
Small acts, big changes
Searchlight ID: int-3288

12.16 Review

12.16.1 Review

1. Is it the responsibility of the ordinary citizen or the government to accept the consequences of climate change and do something about it? Explain your response.

12.16.2 Reflect

2. Mahatma Gandhi once said, 'Earth provides enough to satisfy every man's need, but not every man's greed'.

   Provide an argument with an Earth-centred viewpoint about this quote and then a counter-argument based on a human-centred viewpoint. Ensure that your arguments are logical, clearly expressed and supported by evidence.

CHAPTER 13

Land environments under threat

A severely degraded landscape in southern Queensland. Although we have a better understanding of factors that contribute to land degradation, the challenge is to manage land sustainably for the future and reverse the trends.

13.1 Overview

13.1.1 Introduction

Land is one of our most valuable resources. Left alone it exists in a state of balance, and if managed wisely can continue to do so. However, the land is under increasing pressure as a direct result of population growth — agriculture, mining and the expansion of settlements — all of which have the potential to interfere with natural processes.

Starter questions

1 What do you think is meant by the term *natural balance*?

2 Copy the following table.

How we use the land	Sustainable land use	Cause of land degradation

In column 1, list the ways in which we use the land. Then use columns 2 and 3 to record whether you think each use is a ***sustainable*** land use (compatible with your definition of natural balance), or a cause of land degradation.

3 Briefly explain how human activity can have a negative impact on natural processes.

Inquiry sequence

		Syllabus outcomes
13.1 Overview		
13.2 Why does land degrade?		GE5-2, GE5-3, GE5-7, GE5-8
13.3 What is land degradation?		GE5-2, GE5-3, GE5-7, GE5-8
13.4 SkillBuilder: Interpreting a complex block diagram	eBook plus ONLINE ONLY	GE5-7, GE5-8
13.5 Where has the soil gone?		GE5-2, GE5-3, GE5-7, GE5-8
13.6 Why are drylands drying up?	eBook plus ONLINE ONLY	GE5-2, GE5-3, GE5-5, GE5-7, GE5-8
13.7 How do we manage land degradation?		
13.8 Investigating topographic maps: How do we manage land degradation in the Parwan Valley?		GE5-5, GE5-7, GE5-8
13.9 Who are the invaders?		GE5-3, GE5-5, GE5-7, GE5-8
13.10 Would you like salt with that?		GE5-2, GE5-3, GE5-8
13.11 How do we deal with salinity?	eBook plus ONLINE ONLY	GE5-4, GE5-5, GE5-7, GE5-8
13.12 SkillBuilder: Writing a fieldwork report as an annotated visual display	eBook plus ONLINE ONLY	GE5-7, GE5-8
13.13 How do Indigenous communities manage the land?		GE5-4, GE5-5, GE5-7, GE5-8
13.14 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Watch this video
Wasting our land
Searchlight ID: eles-1708

13.2 Why does land degrade?

13.2.1 Land degradation

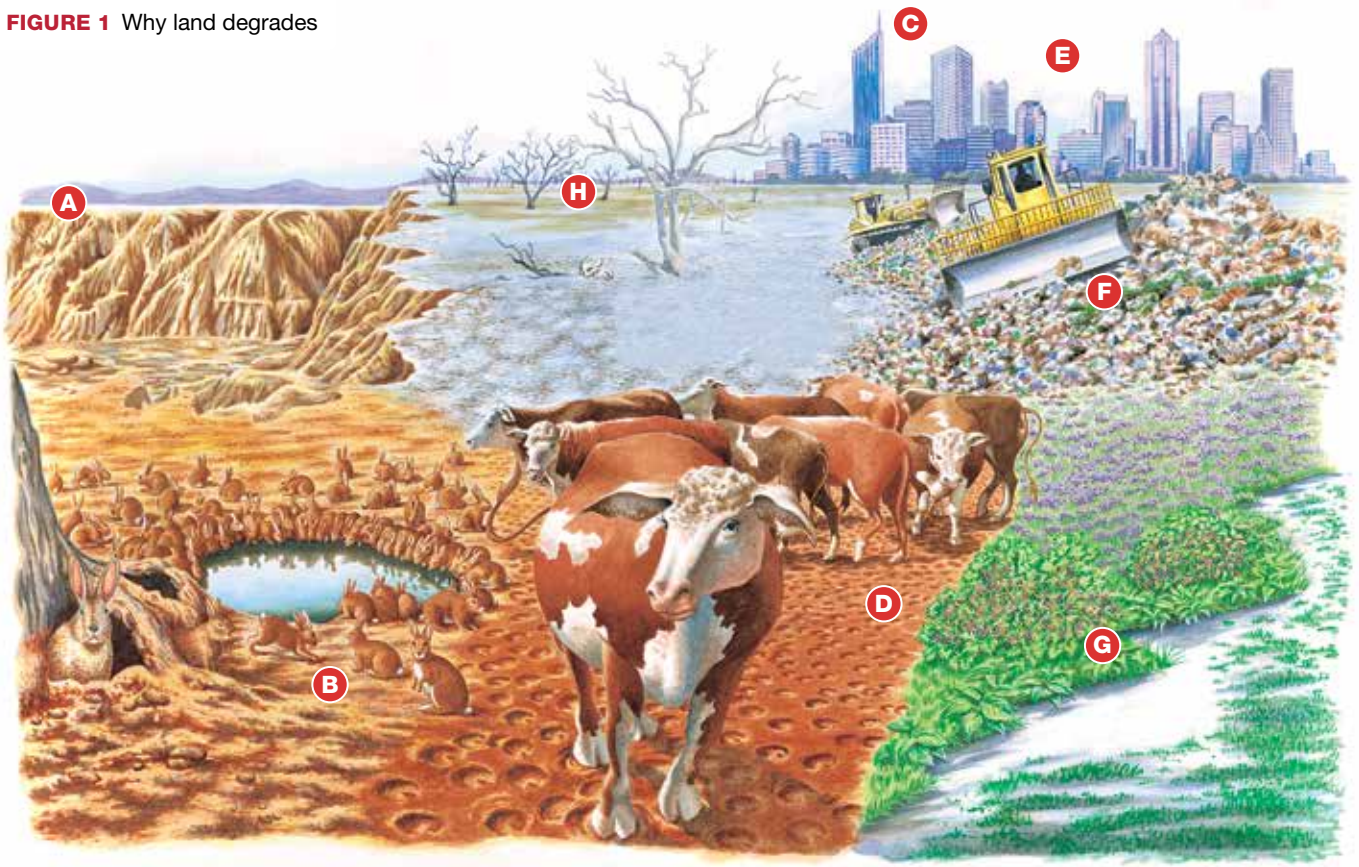
Land degradation is a serious problem all over the world. Increasingly valuable land is becoming less productive because of a decline in its quality. Land can be degraded in many ways (see figure 1), but most of the causes can be traced back to the influences of human activity on the natural environment.

Everyone on Earth relies on the land. Apart from providing us with a place to live, the land also provides most of our food and products such as oil and timber. With the world's population expected to reach over 9 billion by the year 2050, the land and its resources will be placed under even more pressure. Global food production, for example, is already being undermined by land degradation and shortages of both farmland and water resources, making feeding the world's rising population even more daunting.

The United Nations estimates that 25 per cent of the world's farmland is highly degraded. Although we have a better understanding of factors that contribute to land degradation, the challenge is to manage the land sustainably for the future and reverse the trends.

13.2.2 What are the main issues?

FIGURE 1 Why land degrades



A When land is cleared or overgrazed, it becomes vulnerable to erosion by wind and water. The nutrient-rich soil is either washed or blown away, reducing the quality and quantity of crop yields. Dust storms result and sediment transported to rivers smothers marine species.

B Introduced species such as rabbits eat grass, shrubs and young trees (saplings) down to the soil, thus exposing it to erosion. Their burrows increase erosion as they destabilise the soil. Rabbits also compete with native animals for food and burrows.

C Tourism encourages the clearing of sand dunes for high-density housing and mountain slopes for ski runs, leaving the surface exposed to erosion.

D Overgrazing leads to nutrient-rich soil being washed or blown away. Animals with hard hoofs such as sheep and cattle trample vegetation and compact the soil. This leads to increased run-off after heavy rain.

E Climate change will affect land degradation in the future. Higher sea levels will flood low-lying coastal areas. Expanding cities, removal of vegetation and use of concrete reduces the ability of the land to absorb moisture. This not only increases erosion, but can reduce the amount of rainfall in an area.

F Urban communities produce large quantities of waste which is deposited in landfills. Much of the rubbish remains toxic or, in the case of plastic bags, takes hundreds of years to break down. Liquid and solid waste seeps into groundwater and runs off into rivers and eventually into the sea, killing marine species.

G Introduced plant species such as blackberries and Paterson's Curse (Salvation Jane) choke the landscape and compete with native vegetation. Their dense ground cover prevents light from reaching the soil.

H Salinity occurs naturally in areas where there is low rainfall and high evaporation and also where the land was below sea level millions of years ago. Salinity is also caused by excess irrigation and clearing natural vegetation. In some cases the watertable rises, bringing salt to the surface.

FIGURE 2 A former freshwater lake affected by dryland salinity. The high salt levels have killed the native eucalypts; the smaller plants are more salt tolerant.

FOCUS ON FIELDWORK

Investigating land degradation in your area

Investigate your school environment or visit a popular parkland nearby to identify the level of land degradation in the area.

- Take photographs and sketches of your observations.
- Prepare a map of the area and annotate it to show areas where land degradation is evident and other areas where strategies have been used to protect the environment.
- Add your photos to the map to create a visual representation of your observations.

1 Explain what could be causing land degradation in some areas but not others.
2 Identify if anything has been done to try and help solve the problem the problem of land degradation. Has it worked?
3 Predict what will happen in the future if nothing is done to address land degradation.

ACTIVITIES

IDENTIFY

1 List the different ways in which the land can become degraded.
2 Outline the impact of land degradation on water resources.

EXPLAIN

3 Explain why land degradation is a current geographical issue.

INVESTIGATE

4 Investigate a particular type of land degradation and produce an annotated visual display to show the parts of Australia affected by it. Cover major contributing factors and possible management strategies. Add an inset diagram that examines a particular ***place***, ***scale*** and rate of ***change*** associated with this type of degradation. Include your own recommendations for ***sustainable*** use of the ***environment*** to combat the issue you have investigated.

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Interactivity
Destroying the land
Use this interactivity to deepen your understanding of ways land can be degraded.
Searchlight ID: int-3289

PREDICT

5 In small groups, prepare a fold-out educational pamphlet outlining the damage caused by the waste produced by urban communities each year. Make sure you clearly outline the ***interconnection*** between human activity and ***environmental*** harm. Devise a strategy to reduce this waste and estimate the difference that this would make to the amount of waste generated.

APPLY

6 Land degradation is often the result of lots of little actions and events, the effects of which interact and build up over time. Identify some things that you do, consciously or unconsciously, that might be helping to degrade the land where you live. Give reasons for your answer.

13.3 What is land degradation?

13.3.1 What are the effects of land degradation?

Land degradation is the process that reduces the land's capacity to produce crops, support natural vegetation and provide fodder for livestock. Of the 5 million square kilometres used for agricultural and pastoral activities in Australia, more than half has been affected by, or is in danger of, degradation (see figure 1).

FIGURE 1 Land degradation causes physical, chemical and biological changes. The natural environment deteriorates and the landscape undergoes a dramatic change. Common causes of land degradation include soil erosion, increased salinity, pollution and desertification.

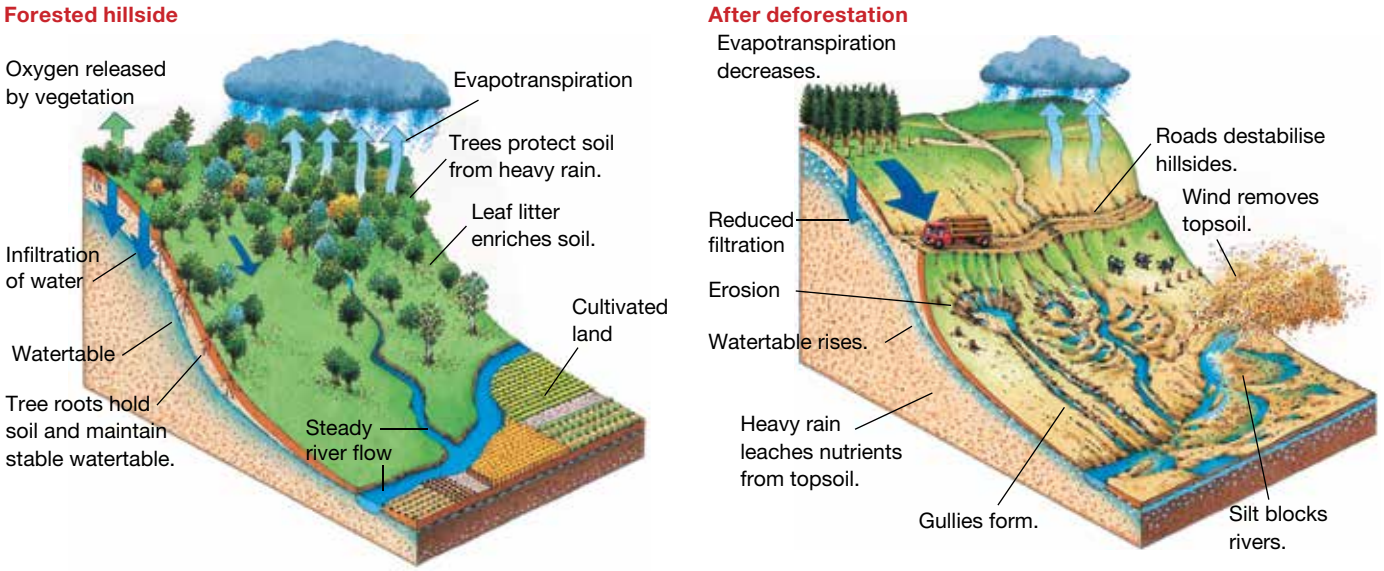
Even small changes can have dramatic effects on the land. The shortcut students take from the oval to the classroom can soon reduce a grassy area to dust. Drought can quickly reduce the productivity of an area used for farming. A farmer who neglects the land after one growing season may still be able to raise a good crop the following season, but if the land is neglected year after year it will eventually become unproductive.

The effects of land degradation are far-reaching. The productivity of farming land diminishes and yields drop because the soil becomes exhausted through overuse or deforestation (see figure 2). Expenditure increases as the land requires more treatment with fertiliser, and **topsoil** and nutrients in the soil need to be replaced. Valuable topsoil is often washed away into rivers and out to sea. Nutrients cause foul-smelling blue–green **algal blooms** that choke waterways. These blooms decrease water quality, poison fish and pose a direct threat to other aquatic life. A dog that licks itself after swimming in affected water can die. The factors affecting land degradation can be seen in figures 3 and 4.

topsoil the top layers of soil that contain the nutrients necessary for healthy plant growth

algal bloom rapid growth of algae caused by high levels of nutrients (particularly phosphates and nitrates) in water

FIGURE 2 Land clearing and deforestation leave the land vulnerable to erosion. When rain falls on a hillside that is well vegetated, it is absorbed by plant roots and held in the soil. However, if the vegetation is removed, there is nothing to stabilise the soil and hold it together — rills and gullies form (see figures 3 and 4 in subtopic 13.5) where the unprotected soil is washed away, and landslides may occur.



Factors that contribute to land degradation

- Poor management leads to the loss of nutrients vital for plant growth.
- Removal of vegetation makes the land vulnerable to erosion by wind and water.
- When urban development encroaches on agricultural land, vegetation is removed and the waste generated is disposed of in landfill.
- Poor agricultural practices, especially related to irrigation and the use of chemical fertilisers, can lead to the soil becoming saline or acidic.

Globally, around 24 per cent of the world's agricultural land is considered degraded. However, in Australia this figure is estimated to be close to two-thirds. Twenty-five years ago only around 15 per cent was considered degraded. Both figures 3 and 4 show that agricultural activities and over-grazing combined account for more than 50 per cent of this problem.

Land degradation is a global problem. If the current trends continue, our ability to feed a growing world population will be threatened.

FIGURE 3 Causes of land degradation in the Asia–Pacific region. Australia is ranked fifth in clearing of native vegetation.

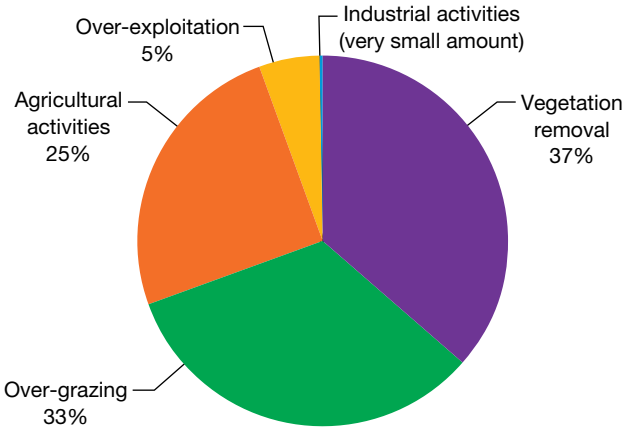
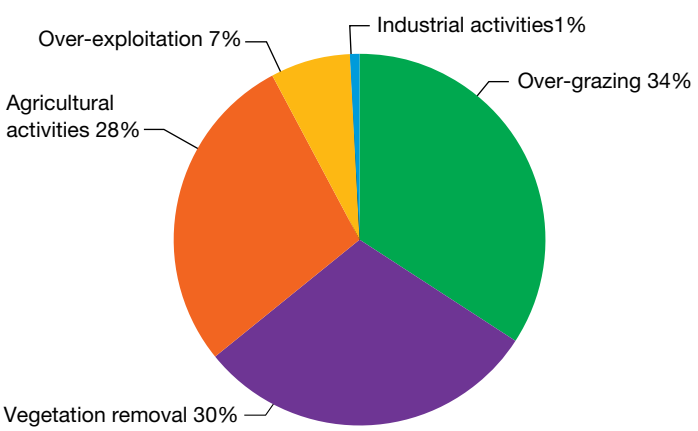


FIGURE 4 Main causes of degradation globally



13.3.2 How has agriculture degraded the Australian landscape?

Climate, topography, water supply and soil quality are the major physical factors that determine how land can be used. When white settlers first colonised Australia they brought with them seeds and animals from Europe. They intended to farm here as they had always done at home; they undertook large-scale clearing of trees and shrubs and planted crops and pasture. However, the Australian landscape is much different from what they had left behind. Australia's soils are naturally low in nutrients and have a poor structure. Much of the vegetation is shallow-rooted and easily disturbed when the land is ploughed and made ready for cultivation. Even in areas where the soil is fertile, over-irrigation can raise the **watertable** and bring salt to the surface, decreasing soil fertility. Australia also has variable rainfall, and drought can last for years. This leaves the earth dry, parched, barren and unproductive. Floods can wash away a farmer's livelihood and leave the land flooded.

watertable upper level of groundwater, below which all pores in the soils and rock layers are saturated with water

13.3.3 Where is the land degrading?

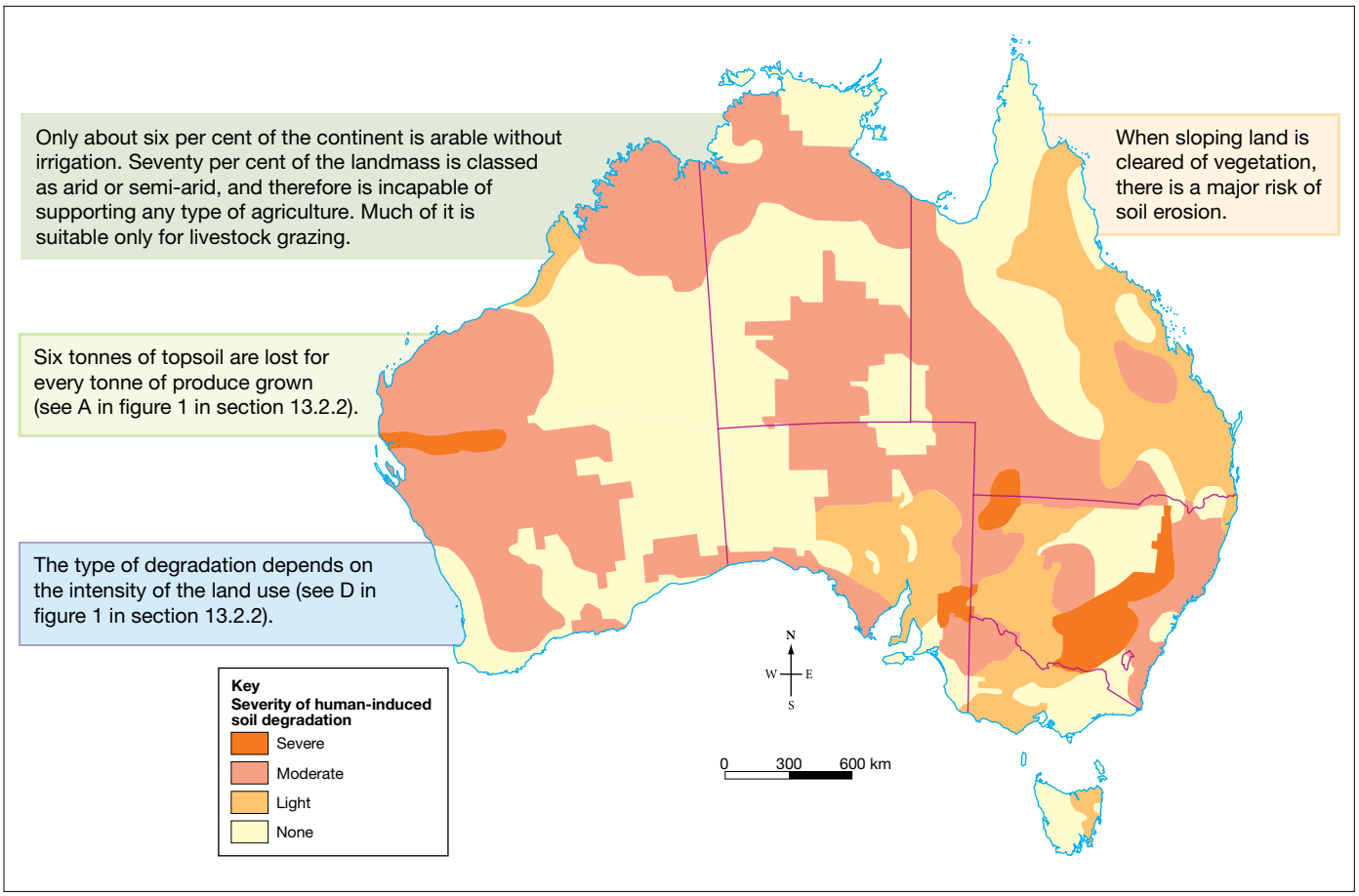
Forty years ago, on a per capita basis, there were 0.5 hectares of **arable** (productive) land available to grow food for every man, woman and child. Today this figure has more than halved to 0.2 hectares. This is due to factors such as population growth, urban sprawl, land degradation and climate change. Figures 5 and 6 show the severity of land degradation in Australia and globally.

arable describes land that is suitable for growing crops

In 2011 the world's population reached 7 billion, and it is expected to reach 9 billion by 2050. While global population is increasing, the land upon which food is grown to feed this population is degrading. Almost one-quarter of the global land is affected in some way by land degradation. Managed sustainably, this land could produce 20 million tons of grain each year.

According to the United Nations, around 42 per cent of the world's poorest people live on the most degraded lands. Areas where the land degradation is most rapid are also those where population growth is greatest. In Sub-Saharan Africa, for example, population growth is 2.3 per cent annually. This region also loses 76 square metres of arable land each year, approximately 30 square metres more than the world average.

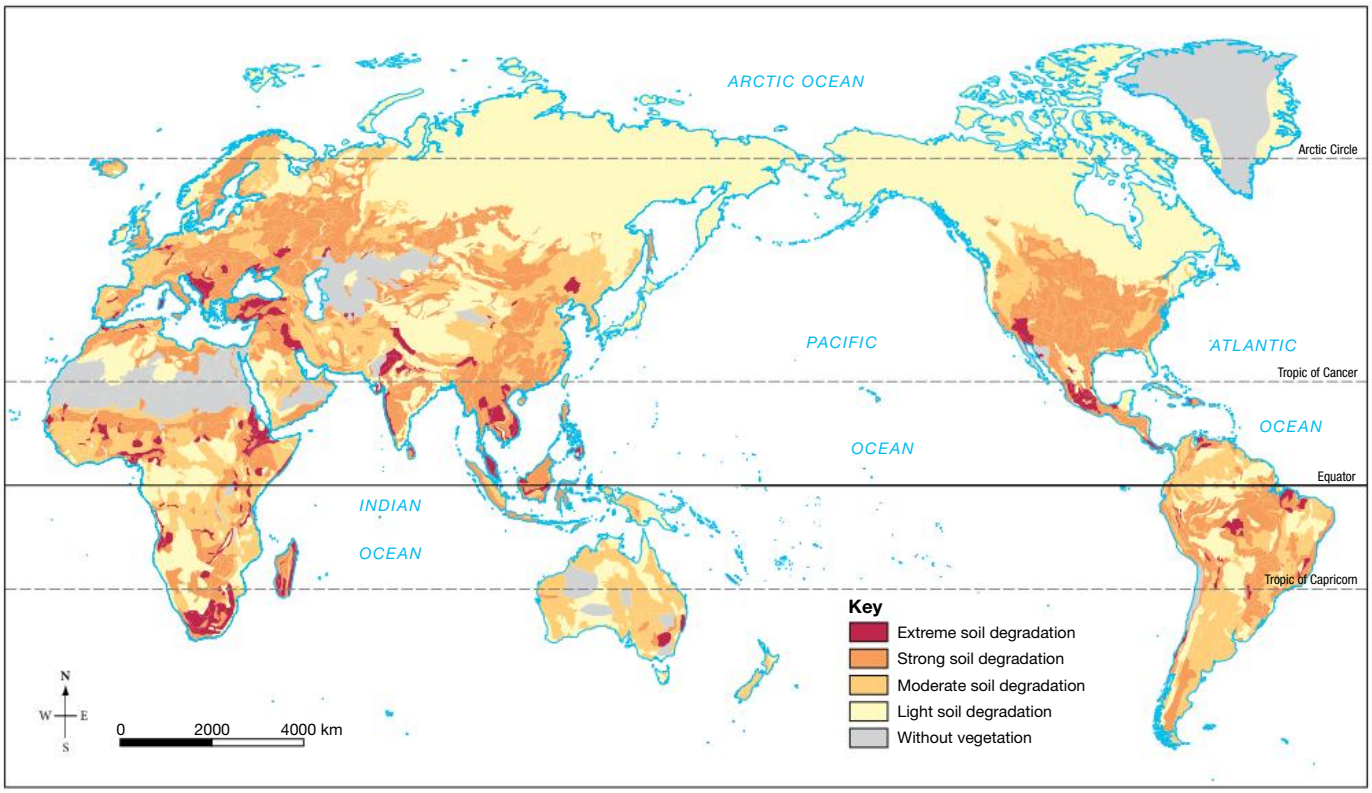
FIGURE 5 Severity of soil degradation in Australia



Source: MAPgraphics Pty Ltd Brisbane

In the last 60 years, the number of people living in developing lands has doubled. These people are dependent on the 'most fragile environment' for their survival. By 2025, this number is expected to rise from 1.3 billion to 3.2 billion.

FIGURE 6 Soil degradation is a global problem affecting every permanently inhabited continent.



Source: © Commonwealth of Australia Geoscience Australia 2013. © Commonwealth of Australia Department of Sustainability, Environment, Water, Population and Communities 2013.

13.3.4 Are kangaroos the answer?

Australia's early economic growth and development depended on the success of agriculture. The first settlers knew they had to be self-sufficient, for their own survival and that of the new colony. They had to learn quickly how to farm soil that was often hard, stony and exposed to a variety of climatic extremes. Over-grazing by heavy, hard-hoofed animals such as sheep and cattle increased the rate of land degradation, especially in arid and semi-arid regions. Kangaroo farming has been presented as an alternative sustainable solution to this problem.

Those in favour of kangaroo farming claim it would be more environmentally friendly as they are not hard-hooved (see D in figure 1 in section 13.2), and that there are added health benefits as kangaroo meat contains less fat and fewer calories than both lamb and beef. Those against the idea argue that kangaroo farming is not commercially viable in the long term (see figure 7).

FIGURE 7 Comparing commercial viability of kangaroo farming with sheep farming

- Young dependent on mother for 14 months
- Cannot be sold live
- One-off use (meat and skin)
- 18 months before meat can be harvested
- A 60 kg kangaroo yields 6 kg of prime meat; the rest is suitable only as pet food.
- Can meet only 0.5 per cent of current needs

- Young dependent on mother for a few months
- Can be sold live
- Multiple uses (wool, meat and skin)
- Breed from 12 months; multiple births possible
- Meat can be harvested from 3–6 months
- Yields 20 kg of prime meat
- Easier to herd and care for

GEOskills TOOLBOX

Constructing an overlay map

Overlay maps consist of two or more maps of the same area with different information. The maps consist of a base map of the area being studied with a transparent or series of transparent maps showing additional information of the same area. Overlay maps allow users to see relationships that exist in the area being studied, such as similar distribution patterns.

Create an overlay theme map. Prepare a base map that shows the extent of land degradation around the world. Prepare an overlay map showing land use. Annotate your overlay with any similarities and differences between the two maps.

ACTIVITIES

IDENTIFY

1 Describe in your own words what land degradation is.
2 Why were European farming methods unsuitable for the Australian ***environment***?
3 Do you think land degradation is happening on a small or large ***scale***? Explain.

EXPLAIN

4 Study figures 1 and 2.
- **a** In your own words, describe the damage that has occurred to the ***environment***.
- **b** Suggest how these ***changes*** have come about.
- **c** How would you go about trying to restore this ***place*** and manage its resources in a ***sustainable*** manner?

INVESTIGATE

5 Investigate alternatives to traditional livestock farming of sheep and cattle, such as kangaroos or emus. Use the information presented in this section as a starting point. Present a reasoned argument for or against this type of farming as a ***sustainable*** alternative.

APPLY

6 Describe an area or ***place*** that is near where you live, that you have visited recently or that you have heard about in the media, and that you think is degraded. Give reasons for your choice and suggest how and why you think this degradation came about.
7 Working in pairs, create a presentation showing the different ways people use and manage the land in another country.
- **a** Design a suitable symbol for land degradation and use this to highlight any uses you think might result in land degradation.
- **b** Add annotations to explain how highlighted activities might degrade ***environments***, and the ***scale*** of this ***change***.
- **c** Suggest a possible ***sustainable*** solution for each type of degradation identified.

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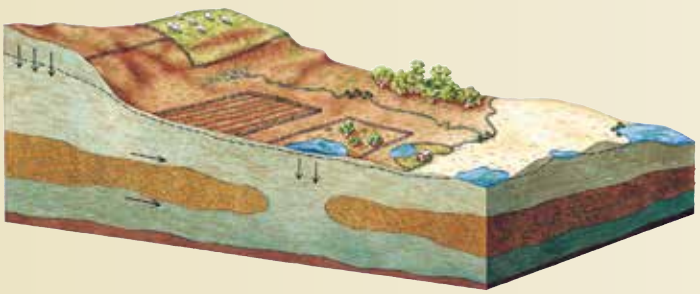
13.4 SkillBuilder: Interpreting a complex block diagram

What is a complex block diagram?

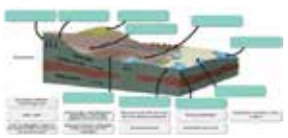
A complex block diagram is a diagram that is made to appear three-dimensional. It shows information about a number of aspects of a topic or location, such as what is happening at the surface of the land or water, what is happening above the land or water, and what is happening beneath the soil or water at a number of different locations across an area.



eLesson
Watch this video to learn how to interpret a complex block diagram.

Searchlight ID: eles-1746

Interactivity
Try this interactivity to learn how to interpret a complex block diagram.



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13.5 Where has the soil gone?

13.5.1 What is soil?

Soil formation is a complex process brought about by the combination of time, climate, landscape and the availability of organic material. In some areas it takes hundreds of years to develop, while in others soil can form in a few decades. While erosion is a natural process, human activity due to farming, land clearing and the construction of roads and buildings can accelerate the process.

Soil is a mixture of broken-down rock particles, living organisms and **humus**. Over time, as surface rock breaks down through the process of **weathering** and mixes with organic material, a thin layer of soil develops and plants are able to take root (see figure 1). These plants then attract animals and insects and when these die their dead bodies decay, making the soil rich and thick.

FIGURE 1 Wild flowers taking root in a crack in the rocks

humus decaying organic matter that is rich in nutrients needed for plant growth

weathering the breaking down of rocks

How is soil being lost?

Sheet erosion

Sheet erosion (see figure 2) occurs when water flowing as a flat sheet flows smoothly over a surface, removing a large, thin layer of topsoil. Sheet erosion might happen down a bare slope. It occurs when the amount of water is greater than the soil's ability to absorb it.

Strategies to combat this form of erosion include planting slopes with vegetation and adding **mulch** to the exposed soil so that it can absorb greater volumes of water. Alternatively, terracing creates flat surfaces on a slope. This helps to spread the surface water runoff over a larger area of land. It can also slow down the speed of the water, allowing for greater infiltration rather than washing away the topsoil.

FIGURE 2 What evidence of sheet erosion can you observe?

mulch organic matter such as grass clippings

FIGURE 3 In which direction do you think the water is flowing? How can you tell?

Rill erosion

Rill erosion (see figure 3) often accompanies sheet erosion, occurring where rapidly flowing sheets of water start to concentrate in small channels (or rills). These channels, less than 30 centimetres deep, are often seen in open agricultural areas. With successive downpours, rills can become deeper and wider, as fast-flowing water scours out and carries away more soil.

FIGURE 4 What impact will the falling water have? If you owned this land, what would you do to prevent more damage?

FIGURE 5 What do you notice about the ground around these tunnels? What do you think will happen if water flows through these tunnels? Would this ground be suitable for livestock grazing? Why?

Source: © John Rasic P/L, T/L JR's Soil Management Services

Strategies to combat rill erosion include tilling the soil (turning it over before planting crops) to slow the development of the rills. Building contours in the soil and planting a covering of grass can help slow the flow of water and hold the soil in place.

Gully erosion

Gully erosion (see figure 4) often starts as rill erosion. Over time, one or more rills may deepen and widen as successive flows of water carve deeper into the soil. Gully erosion may also start when a small opening in the surface such as a rabbit burrow or a pothole is opened up over time. Soil is often washed into rivers, dams and reservoirs, muddying the water and killing marine species. Large gullies need bridges or ramps to allow vehicles and livestock to cross.

Strategies to combat gully erosion largely involve stopping large water flows reaching the area at risk, such as planting vegetation or crops to soak up the water. Other strategies include building diversion banks to channel the water away from the area, and constructing dams.

Tunnel erosion

Sometimes water will flow under the soil's surface (for example, under dead tree roots or through rabbit burrows), carving out an underground passage or tunnel (see figure 5). The roof of the tunnel may be thin and collapse under the weight of livestock or agricultural machinery. When these tunnels collapse they create a pothole or gully.

Strategies to combat tunnel erosion include planting vegetation both to absorb excess water and to break up its flow. Sometimes major earthworks are needed to repack the soil in badly affected areas.

Wind erosion

When the surface of the land is bare of vegetation, the wind can pick up fine soil particles and blow them away (see figure 6). It is more common during periods of drought or if the land has been overgrazed. The soil can be transported large distances and deposited in urban areas. Wind erosion can also lead to desertification when the fertile topsoil has been removed from the land.

Strategies to combat wind erosion include planting bare areas with vegetation, mulching, planting wind breaks and avoiding overgrazing.

FIGURE 6 Did you know that soil from China has been deposited in the United States?

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Interactivity
Down in the dirt
Use this interactivity to check your understanding of the processes involved in soil erosion.
Searchlight ID: int-3290

ACTIVITIES

EXPLAIN

1 With the aid of a flow diagram, show the ***interconnection*** between sheet, rill and gully erosion. Use the captions and the questions that appear with each image to help you.

INVESTIGATE

2 Working with a partner, use the internet to investigate an international ***environment*** such as the Dust Bowl in the United States or the Yellow River in China that has been degraded due to soil erosion.

a Annotate a sketch of this ***environment*** to explain what has happened to the area. Include an inset sketch map that shows the location of this ***place***, and describe the ***scale*** and rate of ***change***.

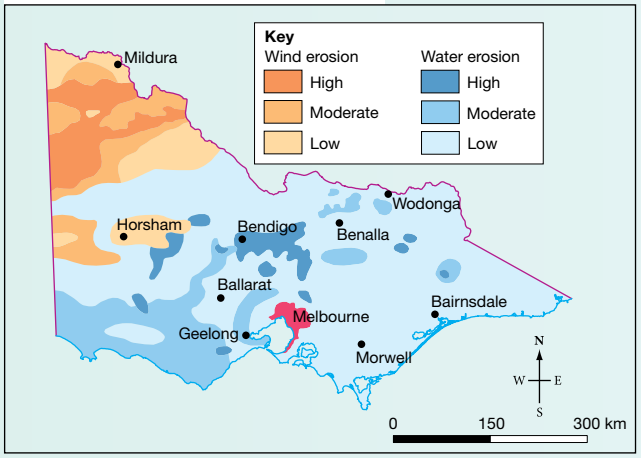
b Swap your eroded ***environment*** sketch with another pair who will devise a series of management strategies to rehabilitate the ***environment*** and allow it to be used in a ***sustainable*** manner. Add these to your annotated sketch.

APPLY

3 Why do you think soil erosion in all its forms is such a significant cause of land degradation?

4 a Look at figure 7, which depicts the types and scale of soil erosion in Victoria. In which parts of the state is erosion highest resulting from (i) wind and (ii) water?

FIGURE 7 Soil erosion in Victoria



Source: MAPgraphics Pty Ltd Brisbane

b Compare this map with a relief map of Victoria in your atlas. What conclusions can you draw about the ***interconnection*** between topography and erosion caused by water?

c Use your atlas to find a map showing vegetation in Victoria. Explain why wind erosion is more common in north-west Victoria than south-east Victoria.

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › Desertification in Mauritania

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13.6 Why are drylands drying up?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

13.7 How do we manage land degradation?

13.7.1 How has Costerfield changed over time?

The land is our most valuable resource. We depend on it for food, shelter, fibres and the oxygen we breathe. Yet the demands of an ever-increasing population place great pressure on it. To meet our needs, swamps and coastal marshes have been drained, vegetation removed and minerals extracted from the ground. Large-scale clearing and poor agricultural practices have left the land vulnerable.

Mediterranean (climate) characterised by hot, dry summers and cool, wet winters

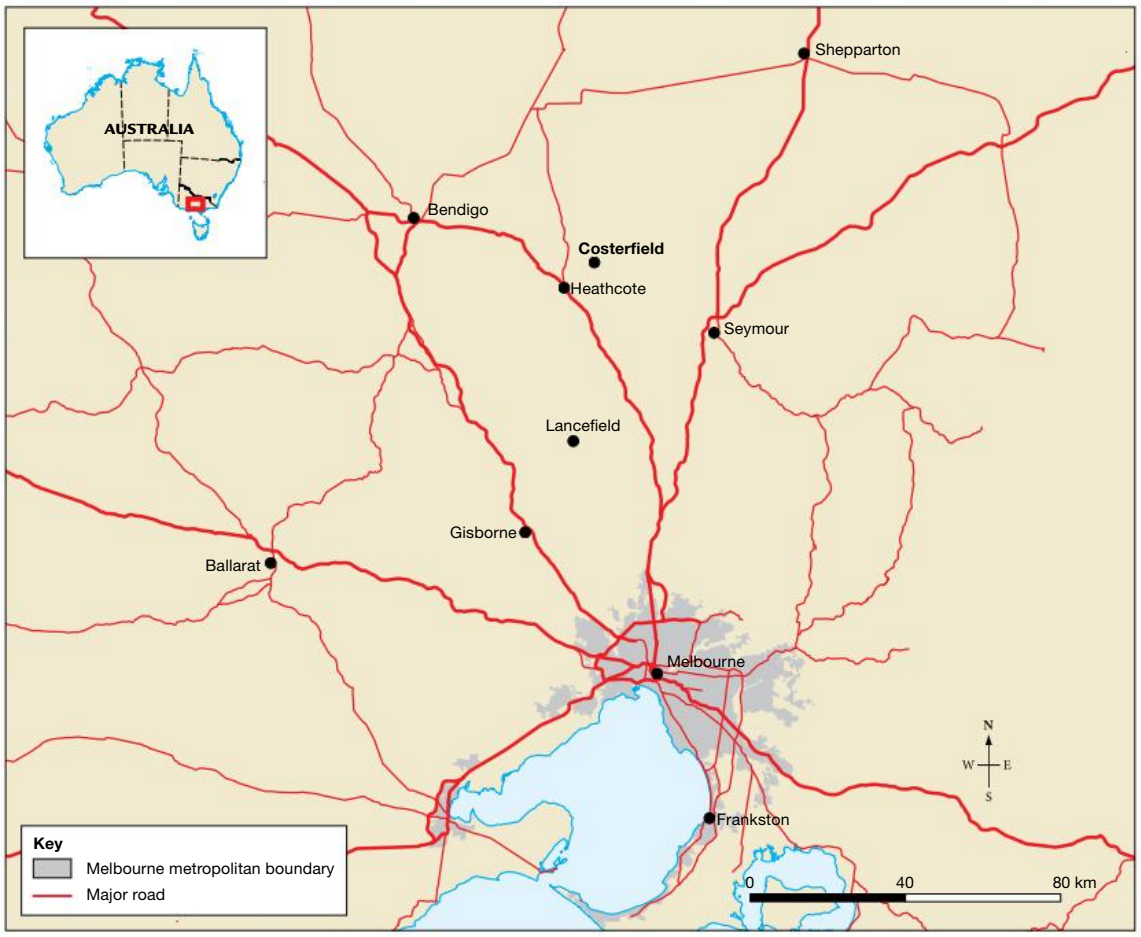
carrying capacity the ability of the land to support livestock

pastoral run an area or tract of land for grazing livestock

Costerfield is located around 100 kilometres north of Melbourne (see figure 1) and has an average annual rainfall of around 575 millimetres. The landscape is characterised by gentle slopes with undulating (wavelike) pastures. The climate is described as semi-arid or **Mediterranean**. Summers are hot and dry, and winters cool and wet. The area is also subject to climate extremes, so that heavy rain, drought, frost and dust storms are not uncommon. Costerfield once had a dense covering of trees, predominantly eucalyptus. Native grasses also dominated the area. Soils in the area are generally considered to have a low **carrying capacity** for livestock due to poor fertility levels. Bushfires were a constant threat throughout the nineteenth century.

The first **pastoral run** was established in 1835, and the land was extensively cleared. Sheep, cattle, rabbits and foxes were introduced soon afterwards. Sheep grazing soon became the dominant activity in the region. The lack of native vegetation cover allowed rainfall to flow across the surface and infiltrate the subsoil, leading to sheet, rill, gully and tunnel erosion (see figures 2 and 3, and subtopic 13.5).

FIGURE 1 Costerfield lies approximately 100 kilometres north of Melbourne.



Source: © The State of Victoria, Department of Environment and Primary Industries 2013

The problem was further exacerbated by the rabbit population. Subdivision plans were drawn up in the early 1850s; however, in 1852 gold was discovered at McIver Creek, which led to an influx of gold prospectors. It is estimated that, at its peak, there were some 40 000 diggers in the region, causing the land to become even more degraded.

Following the gold rushes and into the twentieth century, the area around Costerfield was largely used for grazing livestock, predominantly sheep. However, there is evidence that both horses and cattle were raised in the region on a much smaller scale.

FIGURE 2 A dead tree stump or old fence post can allow water to infiltrate the soil.

Source: © State of Victoria Department of Environment and Primary Industries 2013. Reproduced with permission. Photograph by Stuart Boucher.

FIGURE 3 Notice that tunnel erosion forms where the surface of the land is bare rather than vegetated. What do think is likely to happen next?

Source: © State of Victoria Department of Environment and Primary Industries 2013. Reproduced with permission. Photograph by Stuart Boucher.

turbid describes water that contains sediment and is cloudy rather than clear

13.7.2 How was land degradation managed in Costerfield?

It is much easier to prevent gully erosion than control it once it has developed. Without intervention, gullies can continue to become larger and larger. A number of measures were introduced by local Land Care groups to tackle the issues in the Costerfield area.

The gullies were stabilised through the construction of banks, gully check dams (see figure 4) and terracing, all aimed at reducing and redirecting run-off. Other strategies included:

- re-establishment of ground cover, especially plants and grasses that are native to the region (see figure 5).
- rabbit eradication programs. Their aim was to control the population of rabbits and reduce burrowing activities that can create access points for run-off to enter the subsoil and promote development of new gullies. In addition, they protect the newly sown grasses from being eaten by the rabbits.
- introduction of chemicals such as lime and gypsum to improve soil structure and pH levels to assist in the revegetation process.
- protection of revegetated areas by preventing access, especially by livestock, during the restoration process.

FIGURE 4 Permanent check dams may be constructed using logs or stone. Sometimes they are lined to prevent seepage into the ground so that the water is trapped and can be used for irrigation purposes. They also trap sediment and prevent it being washed into waterways. Additionally, some are designed to trap nutrients and so help maintain water quality. Outlet pipes allow water to be redirected and control the flow of water across the landscape.

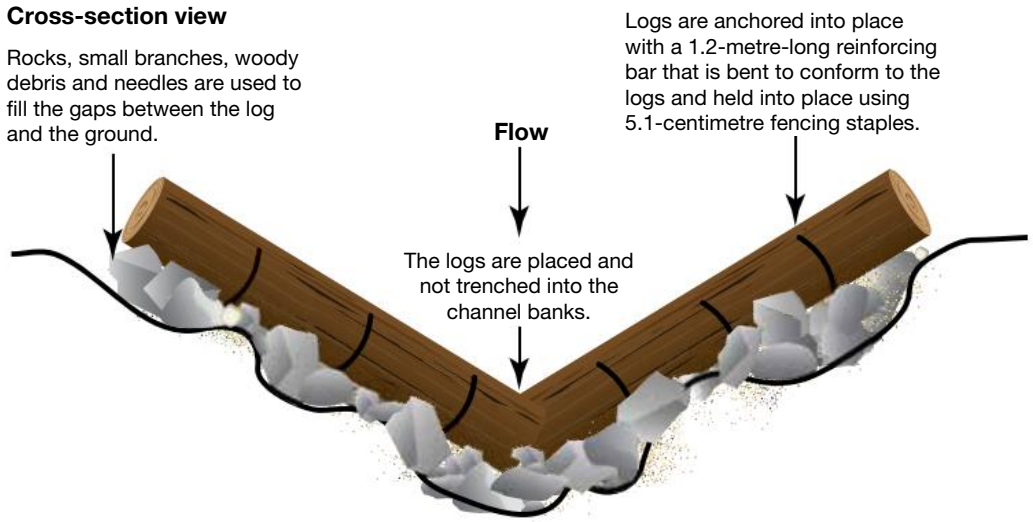
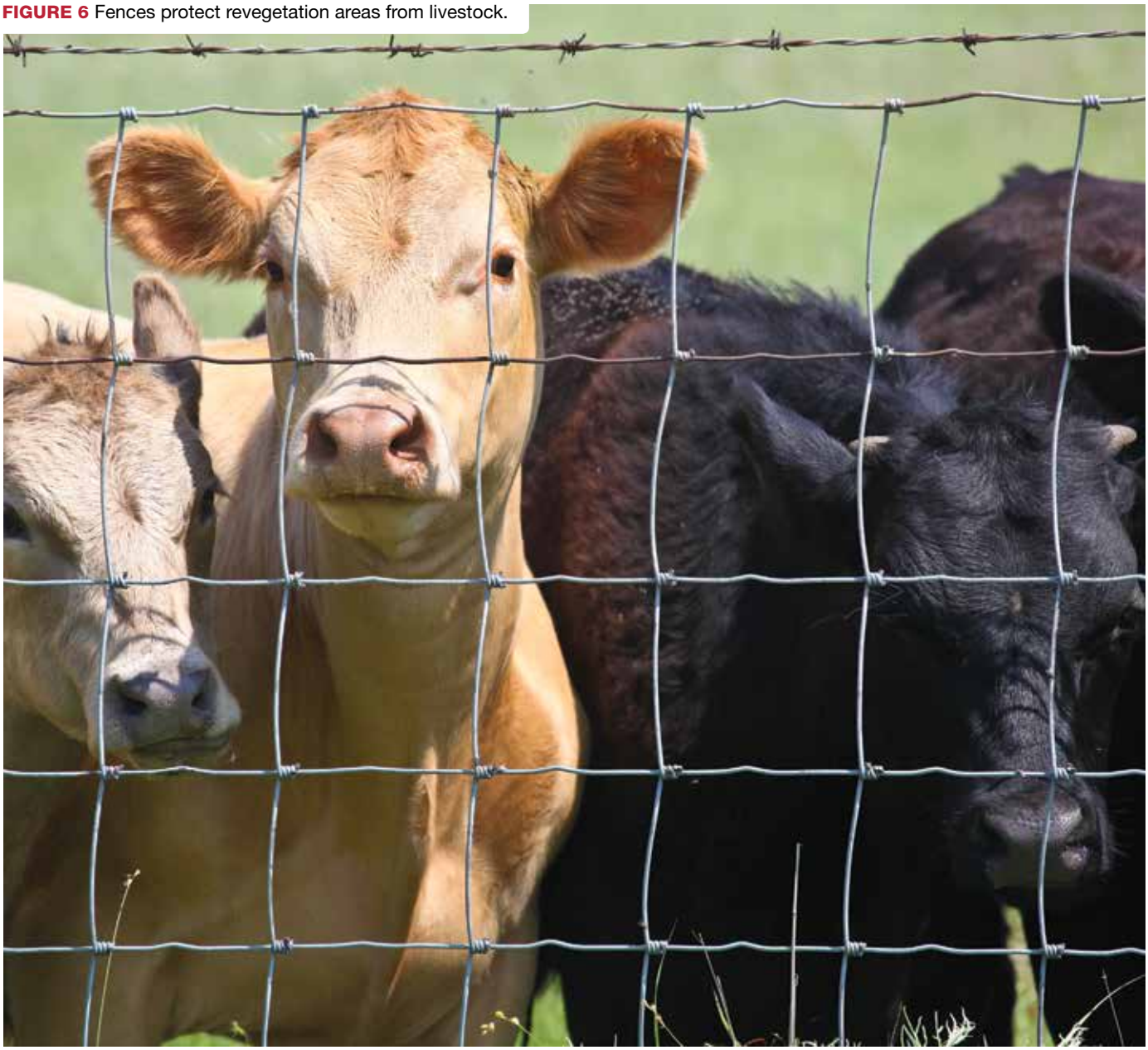


FIGURE 5 Revegetated area near Costerfield

Source: © State of Victoria Department of Environment and Primary Industries 2013. Reproduced with permission. Photograph by Stuart Boucher.

FIGURE 6 Fences protect revegetation areas from livestock.



ACTIVITIES

IDENTIFY

1 Explain the ***interconnection*** between the removal of native vegetation and land degradation.

2 In your own words, explain how the use of a check dam might reduce the development of gullies.

INVESTIGATE

3 Use the **Lake Bogoria** weblink in your eBookPLUS to watch a video that introduces the problems there.

- **a** Show the location of Lake Bogoria on a map and prepare a visual representation of the causes of land degradation and ***sustainable*** solutions that have been used to address these problems.
- **b** Identify solutions that might be adapted to the Australian context.
- **c** Identify any strategies used in the Costerfield ***environment*** that might be suitable to the Lake Bogoria ***environment***.
- **d** Suggest a reason why strategies that are ***sustainable*** in one ***place*** might not be ***sustainable*** in another.

APPLY

4 How would the arrival of gold prospectors increase land degradation? Explain the type of erosion that would most likely occur (see subtopic 13.5) and the activities relating to gold mining that might cause these ***changes*** to develop.

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Weblink
Lake Bogoria

13.8 How do we manage land degradation in the Parwan Valley?

13.8.1 Parwan Valley

The Parwan Valley, situated 60 kilometres west of Melbourne, is an area that is experiencing significant land degradation due to human interactions since European settlement. This region was one of the first areas of settlement in Victoria and was used for dairy farming. The land was cleared by the farmers which led to the erosion of the poor and unstable soil.

The land in the area was originally cleared and used for dairy farming but poor agricultural practice and legislation meant that the land soon became eroded. Gully erosion and tunnel erosion have occurred throughout the White Elephant Range within the Parwan Valley, providing a habitat for an exploding wild rabbit population which in turn caused further soil erosion. Since the 1940s, the area has been the focus of regeneration projects including the control of rabbit populations in efforts to rebuild and sustain the landscape.

FIGURE 1 Gully erosion

ACTIVITIES

Study the topographic map of Parwan Valley (figure 2) to answer the following questions.

IDENTIFY

1 What is the elevation (height above sea level) for the following locations?
   - **a** GR625251
   - **b** GR623215
   - **c** GR603213
   - **d** GR613236
   - **e** GR645234

2 What is the name of the area found in AR6225?

EXPLAIN

3 Describe the topography of the Parwan Valley.

4 Describe the built ***environment*** on the map and its location in relation to the topography.

5 Would some parts of the built ***environment*** have had a greater influence on erosion in the area than others? Explain why.

APPLY

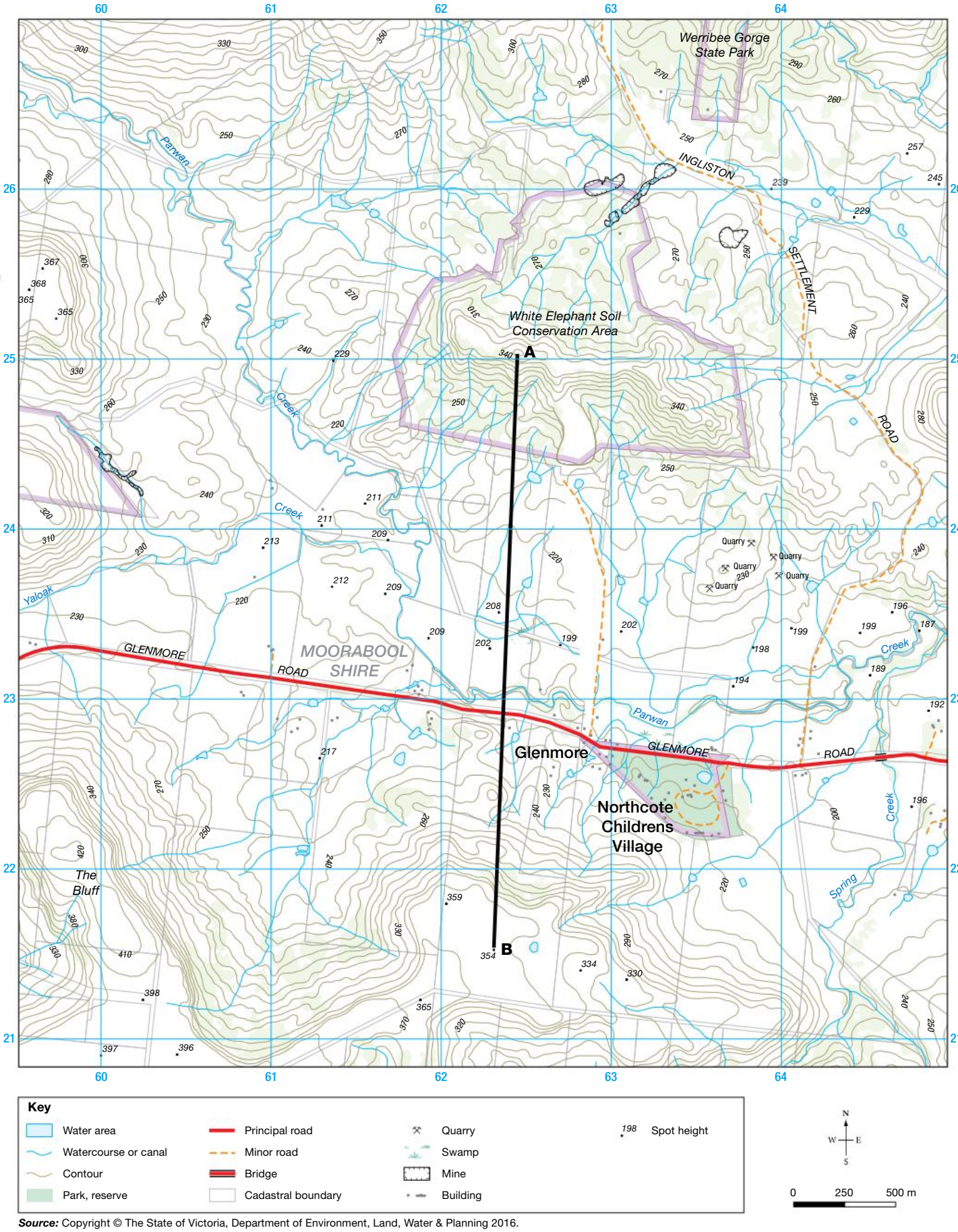
6 Draw a cross-section from point A to point B on the map.

7 Calculate the gradient from point A to Glenmore.

8 Using the cross-section and gradient calculation, explain how the topography can influence land degradation in the area.

9 Construct a proposal to help regenerate the area by suggesting strategies that could be implemented in the valley and justifying why they would work. Some strategies may be more effective, expensive or long-term than others. Consider strategies such as:
   - placing straw bales and rock filters on top of the land to reduce the speed of water running over the land, thereby reducing erosion.
   - planting trees and shrubs
   - attaching strong filter fabric wire fences to slow the flow of water
   - spreading nets or mats over the soil surface to prevent erosion
   - reducing rabbit numbers.

FIGURE 2 Topographic map of the Parwan Valley



Source: Copyright © The State of Victoria, Department of Environment, Land, Water & Planning 2016.

13.9 Who are the invaders?

13.9.1 What is an invasive species?

exotic species species introduced from a foreign country

Invasive species (sometimes referred to as **exotic species**) are a major cause of land degradation. Often introduced for a specific reason, they can soon take over the environment, threatening indigenous plant and animal species and taking over what was once valuable farming land.

An invasive species is any plant or animal species that colonises areas outside its normal range and becomes a pest. Such species take over the environment at the expense of those that occur naturally in the region, generally causing damage to native habitats and degrading the landscape.

Many of the most damaging invasive species were introduced either for sport (rabbits and foxes), as pets (cats) or as livestock (goats) and pack animals (camels and horses). Some such as the cane toad and mosquito fish were introduced to control other species (such as the cane beetle and mosquitoes), and instead became pests themselves. Others, including rats and mice, arrived accidentally as stowaways on ships. Similarly, invasive plants were introduced in a variety of ways; for example, as crops, pasture or garden plants, or to prevent erosion. However, some spread into the bush where they continued to thrive, causing immense damage to the environment.

Why are goats an issue?

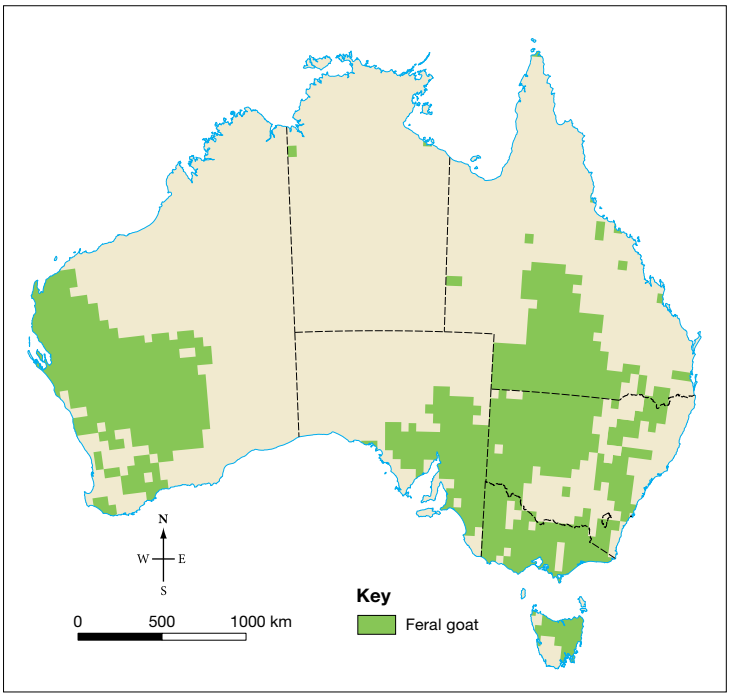
Goats were introduced into Australia with the arrival of the First Fleet in 1788 as a source of both milk and meat. Some breeds were later introduced for their hair. During the nineteenth century sailors released goats on to some of the offshore islands and mainland areas as an emergency food source. Over time, however, domestic goats escaped, were abandoned or were deliberately released and became feral, posing a threat to inland pastoral areas and native forests. More recently, they have been utilised as a method of weed control in plantation forests and in limited numbers on large pastoral runs. They are also still kept as livestock.

It is now estimated that at least 2.6 million feral goats occupy approximately 28 per cent of Australia (see figure 1), in concentrations of up to 40 animals per square kilometre. They are found in all states and territories and on offshore islands, but are most common in semi-arid regions. The absence of predators and the establishment of a water supply for sheep grazing has created ideal conditions in which goats can thrive. Their numbers have been adversely affected by drought and eradication programs; however, high fertility levels have meant they are difficult to control.

Feral goats cause widespread damage to native vegetation. They damage the soil and overgraze native grasses, herbs, trees and shrubs, causing erosion and preventing plant regeneration. They introduce weeds through seeds contained in their dung, and pollute water courses. They dramatically increase the rate of erosion on steep hillsides, where widespread gullying can quickly develop. By focusing on a favoured food source and preventing its regrowth, goats can totally remove some species of vegetation from an area, allowing more invasive plant species to take over.

During times of drought they also compete with native wildlife and domestic livestock for food, water and shelter, creating an additional imbalance in the food chain.

FIGURE 1 Spread of feral goats in Australia



Source: © Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities 2013.

The impact of feral goats is worse in regions where rabbits are also out of control; together they can reduce to bedrock what was once a well-vegetated environment, leaving it open to erosion by both wind and water.

Are introduced plants a problem?

Invasive plant species are often referred to as **weeds**. While many were introduced as garden plants, they soon spread to other areas and now pose a significant threat to both the natural environment and agricultural industries.

Paterson's Curse and Viper's Bugloss

Both Paterson's Curse and Viper's Bugloss (see figure 3) are similar in appearance and are often found in similar regions, if not together. Both were introduced in the 1850s as garden plants because of their attractive flowers. However, as their seeds germinate earlier than native plants, they are able to establish extensive root systems and spreading leaves which crowd out other plant species. Their seeds are further spread in the fur of livestock or by water in areas where erosion is already present and run-off levels are high. They thrive in areas where rainfall is high in winter and have adapted to cope with dry summers. The nutritional value of Paterson's Curse is low, and when eaten in significant quantities can be toxic to livestock, especially horses and small animals. Their stomachs cannot fully process the plant, and this leads to liver damage, loss of condition and eventually, in extreme cases, death.

Contact can also cause skin irritations and other allergic reactions in both humans and livestock. Once Paterson's Curse colonises an area, soil fertility is reduced. It is estimated that the cost to Australia's grazing industry is in excess of $250 million annually. It has been estimated that 33 million hectares of land is infested across the nation.

FIGURE 2 Goats were a food source for early settlers and sailors alike. Their size, hardiness and ability to eat a range of plants made them an ideal source of both meat and milk.

FIGURE 3 (a) Paterson's Curse has two long stamens protruding from the flower plus two shorter ones, and its flowers are more purple. (b) Viper's Bugloss has four long stamens protruding from the flower. Its flowers are more blue, and prickles are visible on the stem.

weed any plant species that dominates an area outside its normal region and requires action to control its spread

FOCUS ON FIELDWORK

Investigating invasive plant species in your area

Visit a local river or creek near your school and make a field sketch of the area. Survey the area around the creek and annotate your sketch to show the location of areas where there are invasive plant species. Add additional annotations to suggest a sustainable solution to this problem. You may need to use the **Weed species** weblink in your eBookPLUS to help you identify plant species.

1. Suggest what could be causing invasive species to exist in some areas but not others.
2. Describe strategies that have been implemented to try to help solve the problem of invasive species. Has it worked?
3. Predict what will happen in the future if nothing is done about the invasive species.

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Weblink
Weed species

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › Introduced species in Australia

13.9.2 Can one problem be part of the solution for another?

invasive plant species commonly referred to as weeds; any plant species that dominates an area outside its normal region and requires action to control its spread

Introduced species pose a serious threat to the productivity of land and diversity of natural environments. In Western Australia, trials have discovered that goats, which themselves pose a threat to both native vegetation and pasture land, can be used to control a wide variety of **invasive plant species**, such as saffron thistle (see figure 4).

While it is known that some weeds are spread by viable seeds passing through the digestive systems of animals, this has not been the case with goats. Less than 1 per cent of the saffron thistle seeds were found in the dung of goats, and these would not germinate. Similar results were found in test sites for the control of blackberries (see figure 5). Within 12 months of goats being allowed to feed on both weed types, there was a notable reduction in their spread. Goats can also be used to control hundreds of different invasive plant species such as English Ivy, Paterson's Curse and Viper's Bugloss, which are toxic to grazing livestock.

FIGURE 4 Within 3 years, saffron thistle had been almost completely eradicated by goats. Careful monitoring is needed as seeds can lie dormant for up to 10 years.

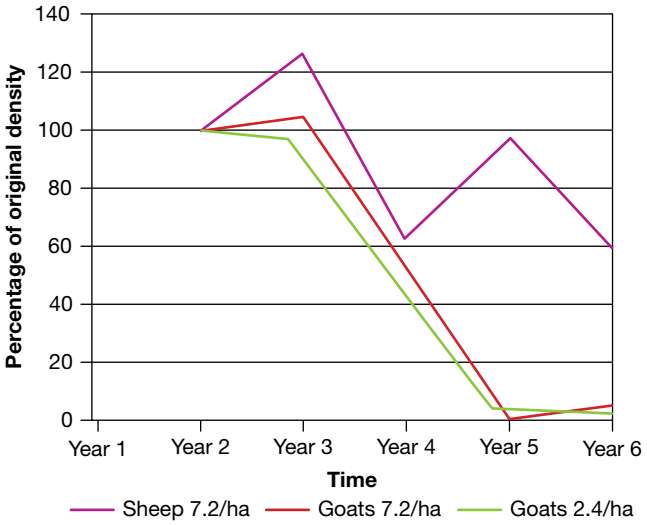
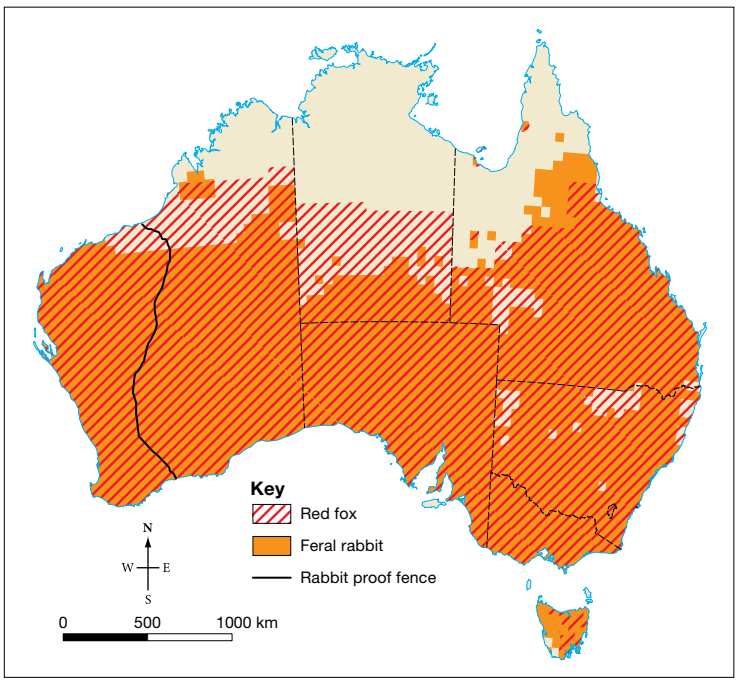


FIGURE 5 Goats have been used successfully in the Tolt River Dam region in Seattle, Washington. There, a herd of 200 goats are used to control the spread of blackberries on ground that is too steep and uneven for mowing by machinery.

FIGURE 6 Distribution of red foxes and feral European rabbits in Australia



Source: © Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities 2013.

Goats have the added advantage of being an environmentally friendly method of weed control. They eliminate the need for using herbicides and fertilisers. Soil quality is improved naturally by goat droppings. Fossil fuel burning machinery is not needed to remove the weeds, and goats can be used in environments where other control methods are not viable; for example, steep slopes.

Can we control foxes and rabbits?

Both foxes and rabbits were introduced into Australia by the early settlers. With no natural predators, each species spread rapidly.

Left unchecked, foxes pose a significant threat to agriculture and native fauna. Fox predation accounts for one-third of new lamb deaths, and native animals such as the bandicoot are easy prey. Foxes carry a wide range of diseases and parasites such as hepatitis, distemper, mange and rabies.

Feral rabbits not only degrade the environment but also compete with native wildlife for food, and

damage vegetation — eating the roots as well as the foliage. They **ringbark** trees and eat seeds and seedlings, preventing the regeneration of plants. Once eradicated from an area, the environment can regenerate (see figure 7).

Both foxes and rabbits have proven difficult to control and pose the same risks today as they did in the past. Foxes are the only natural predator of rabbits. Currently rabbits are controlled through the use of biological (introduction of viruses such as myxomatosis and calicivirus), chemical (baits and poisons) and mechanical (destroying warrens, shooting and laying traps) methods.

Hunting, baiting and shooting reduce adult fox populations in the short term; however, their populations soon recover. Scientists are now trialling biological controls and working on the development of some form of virus or birth control that will interfere with the reproductive system of the fox, making them infertile and incapable of breeding.

ringbark remove the bark from a tree in a ring that goes all the way around the trunk. The tree usually dies because the nutrient-carrying layer is destroyed in the process.

FIGURE 7 (a) Rabbits reduced Phillip Island in New South Wales to a wasteland. (b) After the rabbits were eradicated, the recovery of the island was spectacular.

ACTIVITIES

IDENTIFY

1 Using information in this section and your own general knowledge, list as many species (both plant and animal) as you can that were introduced into Australia, and why they might have been introduced. Use your atlas as another source of information.

2 Why is it said that rabbits caused the demise of native plant and animal species?

3 Describe the distribution over ***space*** of foxes and rabbits in Australia.

EXPLAIN

4 Explain why goats would be considered an ***environmentally*** friendly method of controlling invasive plant species.

5 Why do you think that foxes are not found in Australia's tropical region?

6 Examine figure 7. Describe the appearance of the ***environment*** in each image. Do these images represent the same ***place***? Suggest reasons for the ***changes*** that have occurred in this ***environment***.

7 Explain why it is easier to eradicate invasive species from island communities than from mainland Australia.

APPLY

8 Use the **Weed species** weblink in your eBookPLUS to prepare an educational leaflet that will assist people in recognising one of these plant species.

9 The invasive animal species described in this section have proven more difficult to control than the plant species. Suggest a reason for this.

10 **a** Copy the table below. In the first column (after the name of the control method), write your own definition for each of the control methods.

Method	Advantage	Disadvantage
Biological		
Chemical		
Mechanical		

b Compare the advantages and disadvantages of the three main methods of rabbit control.

c Which method do you think is the most effective? Give reasons for your answer.

11 Working in teams, devise your own ***sustainable*** and ***environmentally*** friendly strategy for controlling an invasive species.

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Weblink
Weed species

13.10 Would you like salt with that?

13.10.1 Where does the salt come from?

salinity the presence of salt on the surface of the land, in soil or rocks, or dissolved in rivers and groundwater

Salinity is not a new problem. In fact, it was an environmental issue in the earliest civilisations some 6000 years ago. Historical records indicate that the Sumerians, who farmed the land between the Tigris and Euphrates rivers in the area known as Mesopotamia, ruined their land as a result of their poorly managed irrigation practices.

Salt has become a major contributor to land degradation in Australia. Rising up from below the land surface, it is destroying native vegetation and threatening the livelihood of many Australians. As plants die as a result of salinity, other problems emerge: the soil no longer has a protective cover of vegetation, which means it is more easily blown away or eroded.

Some 140 million years ago, parts of the Australian continent were covered by shallow seas and saltwater lakes. The salt stores from these waters have lain dormant below the surface of the land, much of them in the **groundwater**. In addition, salt continues to be deposited on the land's surface by rain and winds blowing in from the oceans, and by the weathering of mineral-carrying rocks.

groundwater water held underground within waterbearing rocks or aquifers

Australia's native vegetation had built up some tolerance to the salt levels in the soil. The deep-rooted vegetation also soaked up water in the soil before it could seep down into the groundwater. This meant that the watertable stayed at a fairly constant level, and that the concentrated salt stores stayed where they were. This natural balance changed with the arrival of European settlers. The farming and land-clearing practices they introduced were, and still are, according to many experts, unsuited to Australia's generally harsh, dry climate, as well as to its geological history.

Salt has now become a serious problem. There are two ways in which the soil can become too salty: these are called dryland salinity and irrigation salinity.

What is dryland salinity?

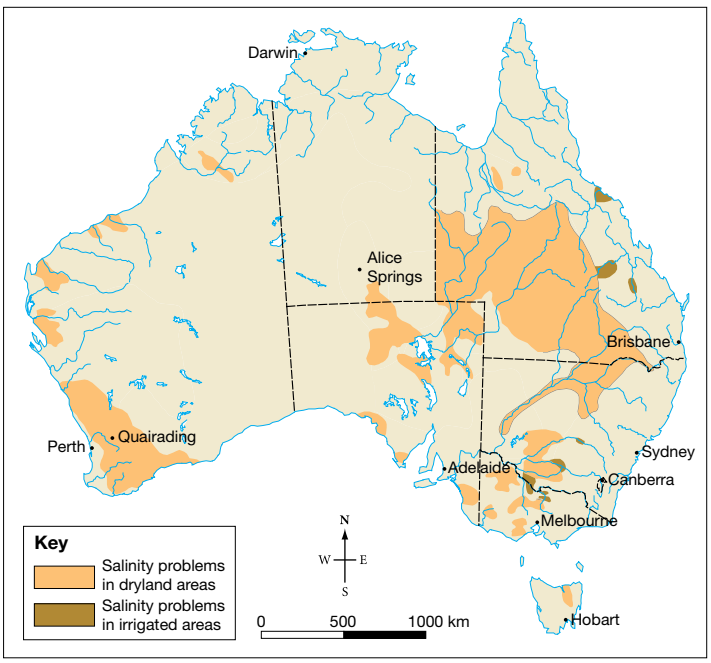
Dryland salinity occurs in areas that are not irrigated. When settlers cleared the land, they replaced deep-rooted native vegetation with crop and pasture plants. These plants generally have shorter roots and cannot soak up as much rainfall as native vegetation. Excess moisture seeped down into the groundwater, raising the watertable and bringing concentrated saline water into direct contact with plant roots (see figure 2). Vegetation, even salt-tolerant plants, started dying as the salt concentrations rose. Once the vegetation dies off, the soil is left bare and is prone to erosion. Often layers of salt, known as **salt scald**, are visible on the surface of the land. The areas in Australia affected by dryland salinity are shown in figure 1.

salt scald the visible presence of salt crystals on the surface of the land, giving it a crust-like appearance

What is irrigation salinity?

Irrigation salinity occurs in irrigated regions (see figure 1) and is a direct result of over-watering. When more water is applied to crops or pasture plants than they can soak up, the excess water seeps down through the soil into the groundwater, causing the salty watertable to rise to the surface. Some of this salt is washed into rivers, either as run-off or groundwater seepage, and transported to other places.

FIGURE 1 Salinity distribution

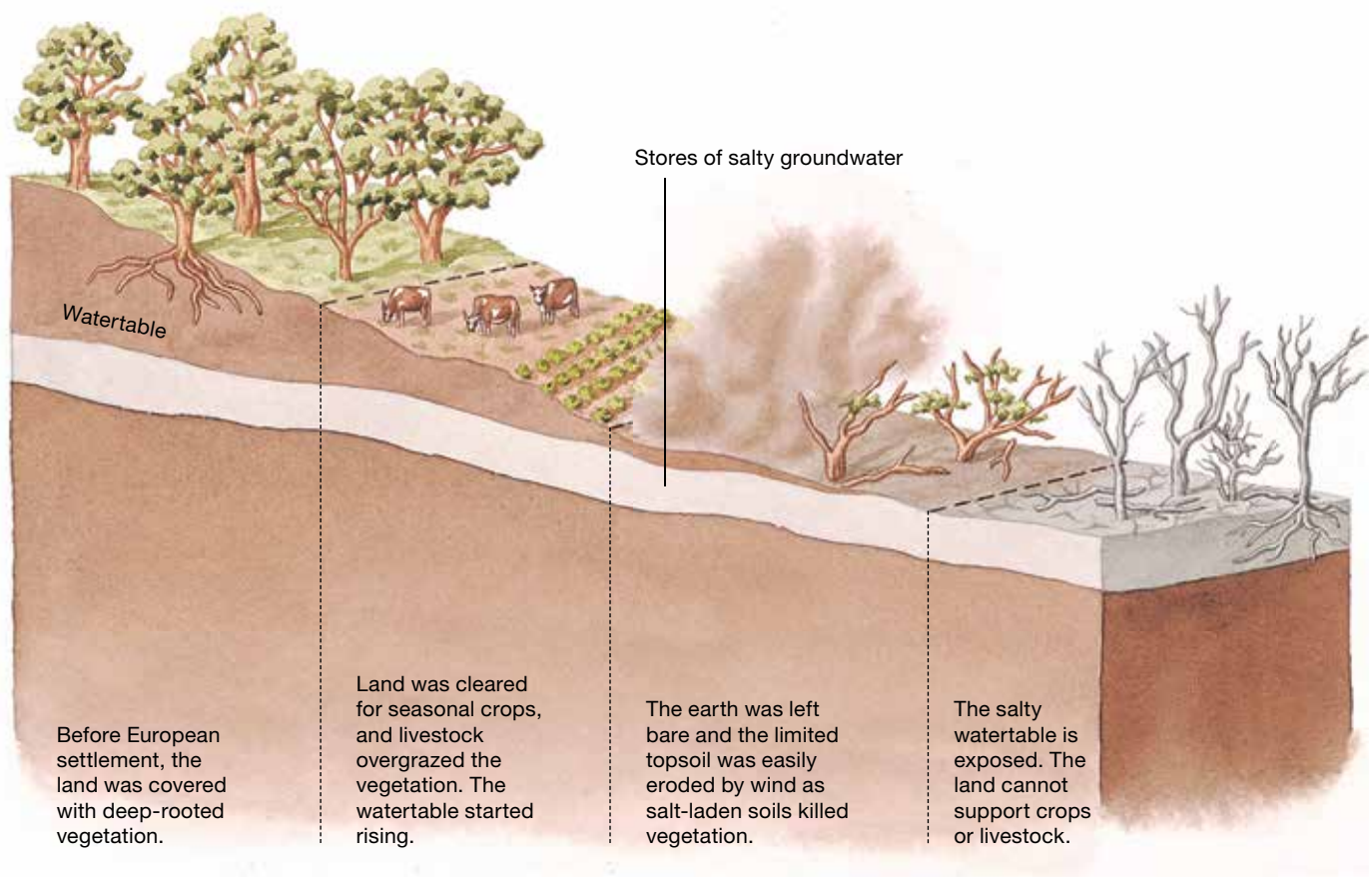


Source: MAPgraphics Pty Ltd, Brisbane.

How much land is affected by dryland and irrigation salinity around the world?

- Africa: 2 per cent of Africa's landmass
- China: 21 per cent of arid lands or around 30 million hectares of land
- Western Europe: 10 per cent of the land area
- United States: 17 states
- South America: most countries
- Australia: 2.5 million hectares
- Worldwide: It is estimated that 10 million hectares of arable land succumb to the effects of irrigation-related salinity each year. It is estimated that, without intervening action, by 2050 the affected area might triple.

FIGURE 2 The effects of a rising watertable



How do we solve the problem?

Many programs are in place to identify and monitor problem areas. Action being taken includes:

- changing irrigation practices to reduce over-watering
- planting deep-rooted native trees and shrubs in open areas
- developing new crops that are more salt tolerant, such as new strains of wheat
- replacing introduced pasture grasses with native vegetation such as saltbush (see figure 3)
- using satellite technology to map areas at risk to enable early intervention.

FIGURE 3 Native plants such as saltbush help solve the problem on Australian grazing lands.

ACTIVITIES

EXPLAIN

1 Explain the ***interconnection*** between soil salinity and land degradation.
2 Why would planting deep-rooted trees help solve the problem?
3 What actions could an irrigation farmer take to reduce the risk of salinity?

INVESTIGATE

4 Investigate the history of agriculture in an ancient civilisation, such as Mesopotamia.
   a Include a sketch map of the area. Annotate this map to show how the region was affected and why.
   b What lessons might modern farmers learn from ancient practices?
5 In groups, investigate a method of combating salinity and ***sustainable*** practices that will improve the productivity of agricultural land. Before you begin, decide as a class which groups will cover dryland salinity and which will focus on irrigation salinity. Present your findings as a news report.

PREDICT

6 Find out the total land area of Australia and the world. If areas affected by irrigation salinity are expected to triple by 2050, estimate the proportion of land that will be affected on a national and global ***scale***. Use your findings as the basis for writing a letter to the Editor, urging governments to take action and halt this trend.

APPLY

7 Salinity was not an ***environmental*** issue in Australia when Indigenous people were its sole inhabitants. With the aid of diagrams, explain how land-use practices have ***changed*** over time. Make sure you include references to Indigenous practices that promoted ***sustainable*** use of the ***environment***. Include links to how these ***changes*** would have resulted in salinity and degraded the ***environment***.

eBook*plus*

Interactivity
A pinch of salt
Use this interactivity to explore human activities that contribute to soil erosion.
Searchlight ID: int-3291

eBook*plus* ONLINE ONLY

13.11 How do we deal with salinity?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

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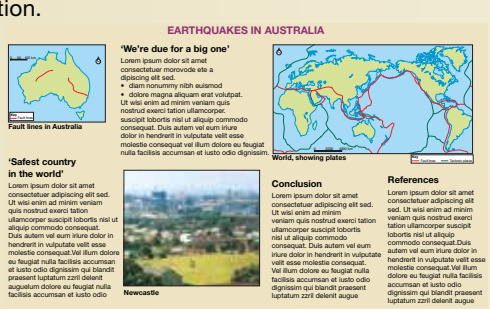
13.12 SkillBuilder: Writing a fieldwork report as an annotated visual display (AVD)

What is a fieldwork report?

A fieldwork report helps you process all the information that you have gathered during fieldwork. You sort your data, create tables and graphs, and select images, and then interpret the data as text or annotated images and synthesise all the data into a logical presentation.



eLesson
Watch this video to learn how to write a fieldwork report as an annotated visual display.

Searchlight ID: eles-1747

Interactivity
Try this interactivity to learn how to write a fieldwork report as an annotated visual display.

Searchlight ID: int-3365

13.13 How do Indigenous communities manage the land?

13.13.1 Indigenous communities

Before the arrival of European settlers, Indigenous communities had created their own system of land management. They maintained grasslands through the use of fire, which encouraged plant regrowth and attracted a variety of animals. Their life was governed by the seasons, with each change dictating a change in the use of the land and its management.

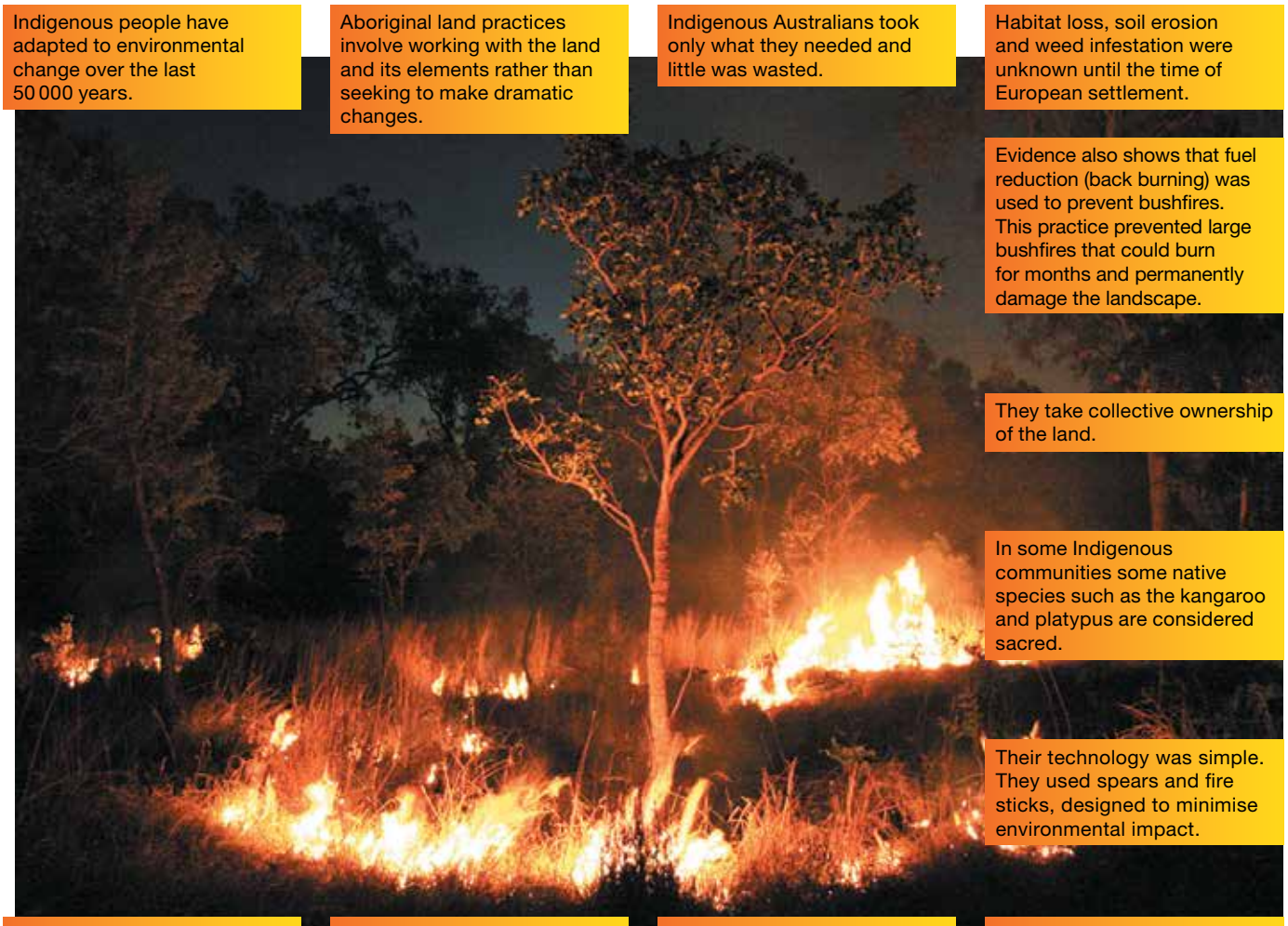
Environmental change is not new. Indigenous communities around the world, including the Australian Aborigines, have had to manage their environments carefully. In figure 1 you can see how fire was used to manage the landscape. Fire has played an important role in the lives of Australia's Indigenous people. Not only did it serve the purpose of cooking and warmth, but it also encouraged new plant growth and was an essential part of land management. Fire was only one of a variety of strategies that was used to ensure the land was used in a sustainable manner.

Use the **Wetland burning** weblink in your eBookPLUS to watch a video clip about Aboriginal wetland burning in Kakadu.

eBookplus

Weblink
Wetland burning

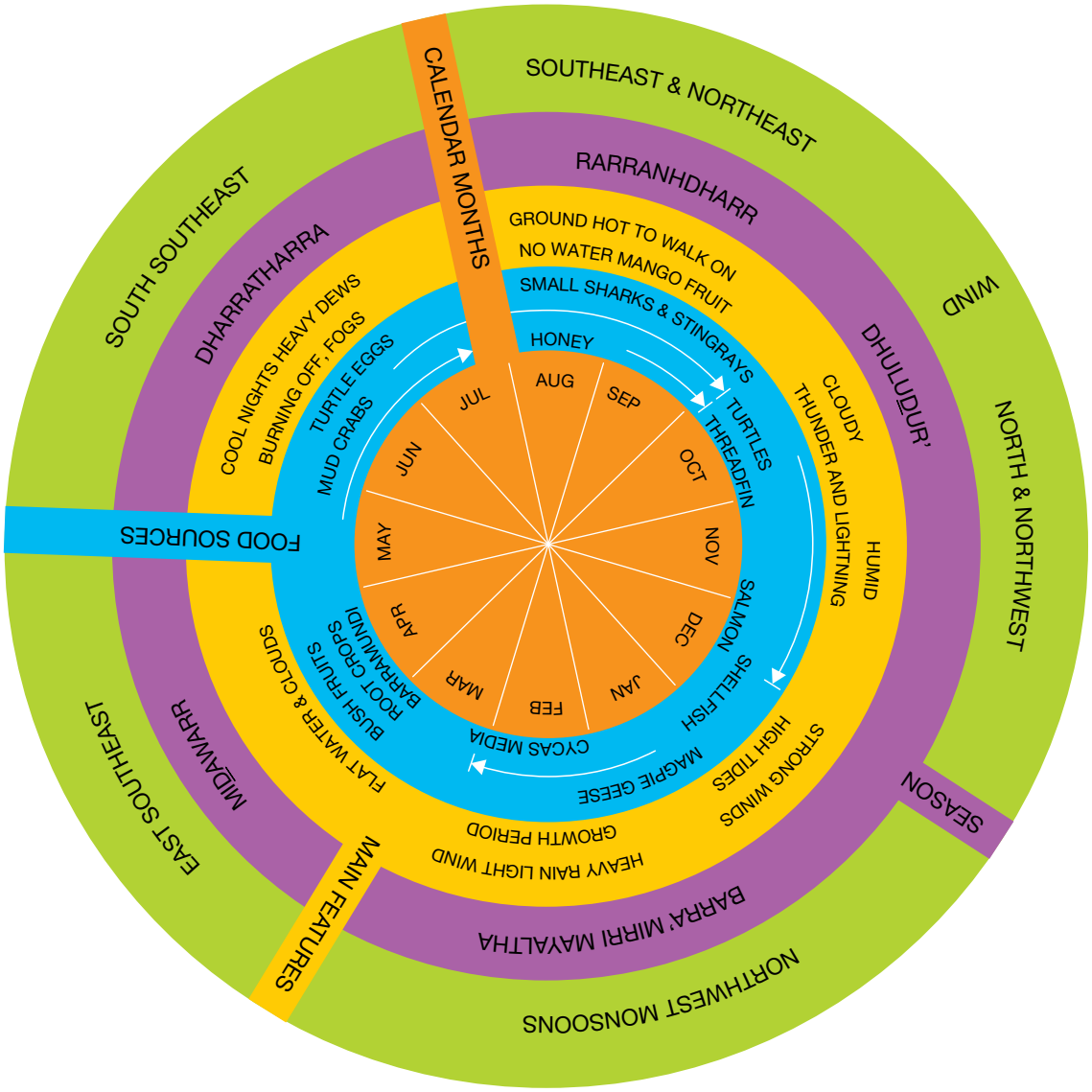
FIGURE 1 Indigenous Australians' traditional land management practices and connection to the land



What happens when?

Figure 2 is an example of an Aboriginal seasons calendar. It is for the Yolngu people who live in north-east Arnhem Land. The calendar relates the months of the year to aspects of the environment, although a traditional Indigenous community had no use for the months as we know them. Look carefully and you will see that this particular calendar includes information about the weather and the plants and animals that thrive across the year. Traditional communities were made up of hunters and gatherers. They hunted and fished for particular species and gathered bulbs, fruits and other edible vegetation at different times of the year. The calendar varied from place to place, but whatever the location it enabled Indigenous people to predict seasonal events; for instance, the arrival of march flies signalled the time to collect crocodile eggs and bush honey. The ability to link natural events to a cycle that predicts changes to the seasons is a key factor in the successful development of Indigenous communities and their sustainable use of the land.

FIGURE 2 Indigenous communities are defined by observable changes in the seasons.



ACTIVITIES

IDENTIFY

1 Why wasn't land degradation an issue prior to the arrival of European settlers?

EXPLAIN

2 Using information from this section and the **Wetland burning** weblink in your eBookPLUS, explain why fire is such an important component of caring for the ***environment***.

3 How does the Aboriginal calendar demonstrate an ***interconnection*** between their connection with the land and ***sustainable*** management of the ***environment***?

APPLY

4 The Aboriginal calendar (figure 2) demonstrates an intricate understanding of the ***environment***.

- **a** How long do you think it would have taken the Aboriginal people to have developed this understanding?
- **b** How do you think this knowledge would have been passed from generation to generation?
- **c** It has been suggested that the four seasons currently used in Australia do not adequately reflect the changing nature of our seasons. Do you agree or disagree with this suggestion? Give reasons for your opinion based upon the area in which you live.
- **d** Develop your own calendar that reflects the ***interconnection*** between the seasons and changes in your life.
- **e** Do you think the Aboriginal seasons calendar should be adopted and used as an additional strategy for the ***sustainable*** management of ***environmental*** issues? Justify your point of view.

eBookplus

Weblink
Wetland burning

eBookplus ONLINE ONLY

13.14 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

13.4 SkillBuilder: Interpreting a complex block diagram

13.4.1 Tell me

What is a complex block diagram?

A complex block diagram is a diagram that is made to appear three-dimensional. It shows a great deal of information about a number of aspects on a topic or location. It shows what is happening at the surface of the land or water, what is happening above the land or water, and what is happening beneath the soil or water at a number of different locations across an area.

Why are complex block diagrams useful?

Complex block diagrams are useful because they allow you to see the interconnection between a number of factors affecting an environment. A diagram is a visual representation of a process or processes occurring in the environment.

Complex block diagrams are useful to you because they:

- help you understand relationships between things over space
- provide you with an understanding of possible reasons for features or situations by simplifying explanations
- explain a number of factors at the same time
- show the interconnection between factors.

Model

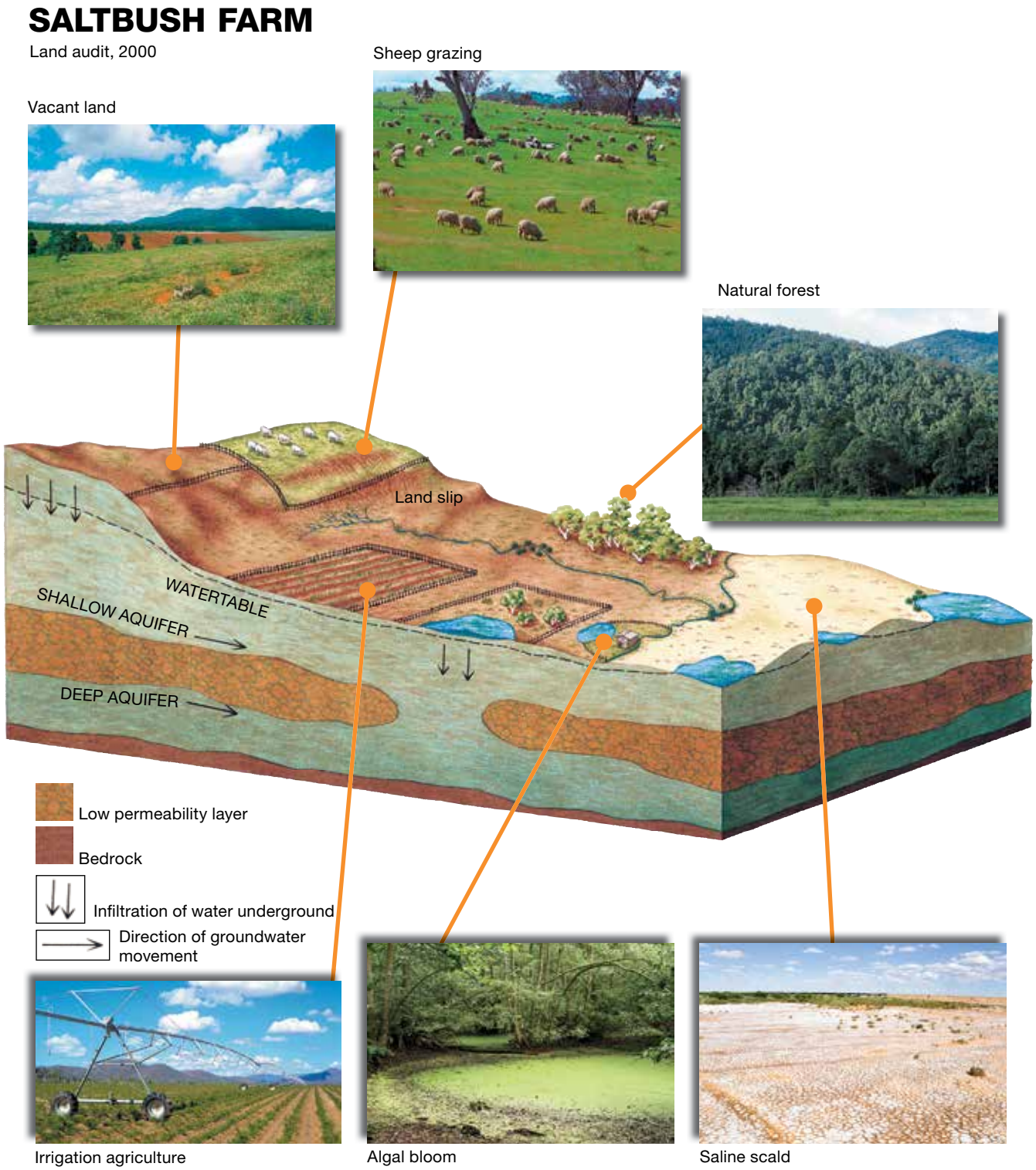
The designer of the figure 1 block diagram has translated the photographs into a drawing, shaping the land according to the contours of the area and knowledge of the region, and showing the movement of water taking place in the soil. Our knowledge allows us to interpret the arrows, which show underground water flow, and helps us to explain why the farmer has problems with saline scald on the farm.

The water movement down the slope and through the soil has brought salt to the surface. Water flowing underground, between the layers of impermeable rock, moves to a low-lying part of the farm. Here, water picks up salt and comes to the surface. When the water evaporates, it leaves the salt on the land surface, causing obvious saline scalding.

A good interpretation of a complex block diagram:

- helps identify features and patterns and possible reasons for these
- identifies and communicates key features and processes
- seeks to explain interconnection between features and spaces.

FIGURE 1 Saltbush Farm, land audit, 2012. Saltbush Farm is in the catchment of the Naangi River, a tributary of the Murray.



Source: CSIRO Land and Water/John Coppi (vacant land), CSIRO Land and Water/Greg Heath (sheep grazing), CSIRO Land and Water (natural forest), AAP Image/Bill Bachmann/Wildlight (saline scald), CSIRO Land and Water/Willem van Aken (irrigation agriculture), Getty Images/Science Photo Library/Michael Marten (algal bloom).

13.4.2 Show me

How to interpret a complex block diagram

You will need:

- a complex block diagram
- a geographic dictionary or internet access.

Procedure:

STEP 1

Read the title and identify the topic or location being studied. Saltbush Farm in figure 1 is in the catchment of the Naangi River, a tributary of the Murray River. This complex block diagram was produced as part of a land audit.

STEP 2

The complex diagram of Saltbush Farm, with its accompanying photographs, shows you what you would see if you were to visit this farm. Examine the complex diagram, carefully reading any labelling that explains the topic being covered. Figure 1 clearly indicates land uses such as sheep grazing on the higher slopes, irrigation agriculture on the flatter land, and natural forest to one side of the farm. It shows land issues, such as erosion on vacant land, land slips on the higher slopes, and saline scald on the lowest land. Water movement in the soil is evident, as well as the direction of ground water, which is moving from higher to lower land.

STEP 3

If there are any terms on the complex block diagram that you do not understand, you must seek clarification. Do you know these terms: *permeability*, *bedrock*, *infiltration*, *groundwater*, *algal bloom* and *saline scald*? Use a geographic dictionary or undertake internet research to understand the terms.

STEP 4

Saltbush Farm has a major land degradation issue caused by soil salting. A knowledge of soil salting and the movement of water shown in the complex block diagram will help you to write a short paragraph explaining the processes at work on the part of the farm that is prone to saline scald. The text below figure 1 explains this as: 'The water movement down the slope and through the soil has brought salt to the surface. Water flowing underground, between the layers of impermeable rock, moves to a low-lying part of the farm. Here, water picks up salt and comes to the surface. When the water evaporates, it leaves the salt on the land surface, causing obvious saline scalding.'

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eLesson
Interpreting a complex block diagram
Searchlight ID: eles-1746

eBookplus

Interactivity
Interpreting a complex block diagram
Searchlight ID: int-3364

13.4.3 Let me do it

Developing my skills

Using the complex block diagrams on deforestation in figure 2, subtopic 13.3, write a short paragraph explaining how an area is changed by deforestation.

Questions

1. How is the water cycle affected by deforestation of an area?
2. How can roads destabilise a hill slope?
3. Why does erosion and land slippage occur?
4. How can a dust storm pick up topsoil?
5. Where does the silt come from that blocks rivers?

Checklist

I have:

- identified features and patterns and possible reasons for these
- identified and communicated key features and processes
- explained the interconnection of features and spaces.

Skills questions

1. Complex block diagrams are used to show:
   a. the shape of the land between two places
   b. the daily weather conditions at a place
   c. what is happening on, above and below the land surface
   d. transport routes.

2. A complex block diagram always includes:
   a. wind direction
   b. well-chosen labelling
   c. slope
   d. people.
3. Why is it important to read any labelling and key/legend carefully?
4. Why is it necessary to have a context (topic knowledge) for the diagram?

13.6 Why are drylands drying up?

13.6.1 Which regions are most at risk from desertification?

As the Earth's population increases, more pressure is placed on the land to provide both food and shelter. In many parts of the world this has meant that land has been overused and become exhausted. This is especially true in **dryland** regions. Many of these areas have become so degraded that they are at risk of being turned into desert, placing the survival and livelihood of the people who depend on them in jeopardy.

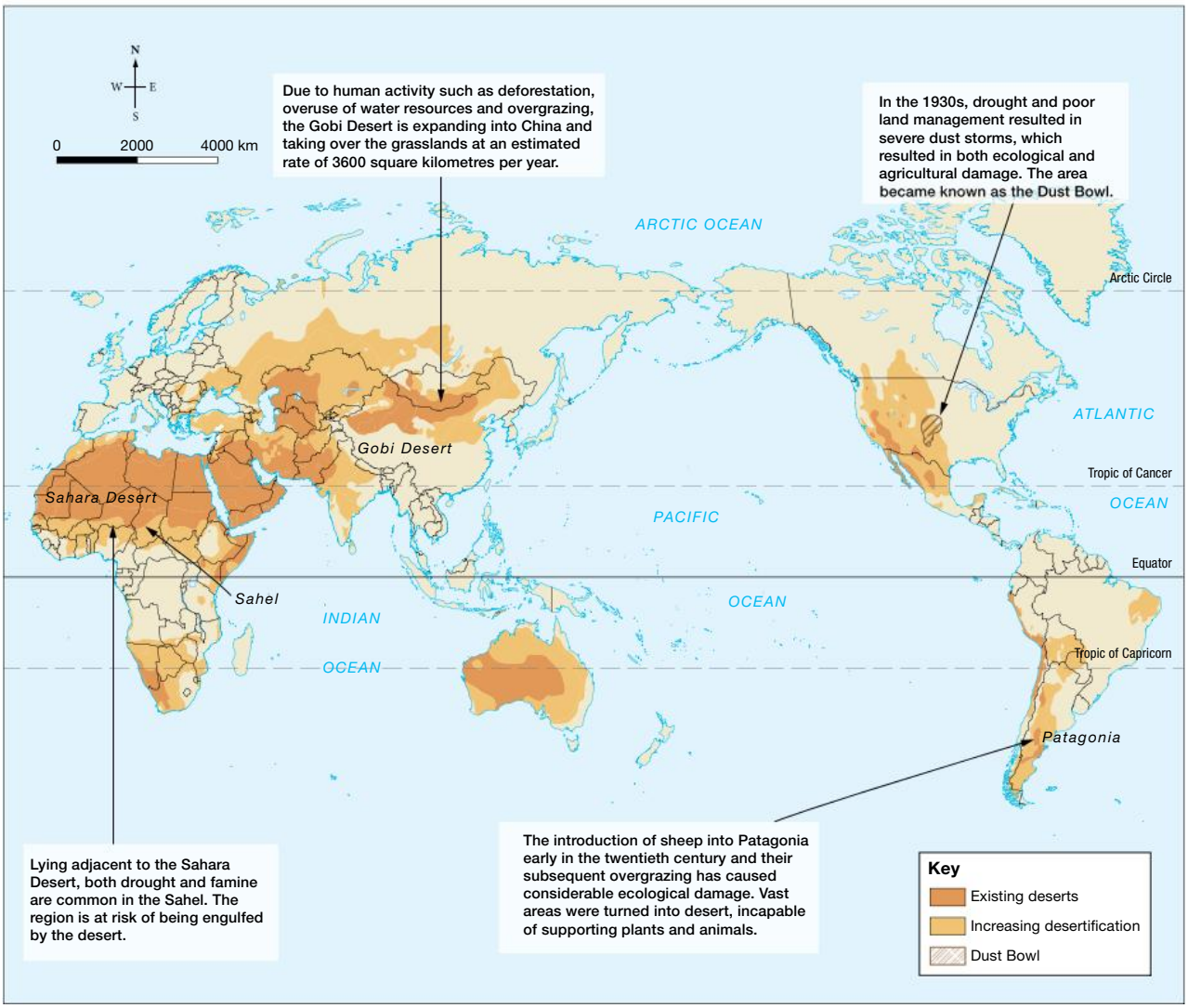
The United Nations estimates that approximately 41 per cent of the Earth's land surface is at risk of turning into desert. This is a process known as **desertification**, an extreme form of land degradation that affects arid, semi-arid and dry sub-humid areas of the Earth. These dryland regions often border existing deserts, but unlike deserts, they support population and agriculture. Drylands are fragile environments that degrade rapidly when the land is not carefully managed.

The areas affected are home to more than 2 billion people in 168 countries. Figure 1 shows the Earth's desert areas and those places most at risk from desertification. Estimates predict that by 2025, without intervention, two-thirds of the arable lands in Africa will be lost, along with one-third in Asia and one-fifth in China. Based on current trends, Bangladesh will have no fertile soil available in 50 years. Desertification is a global issue as it is present on all continents in both developed and developing economies.

drylands ecosystems characterised by a lack of water. They include cultivated lands, scrublands, shrublands, grasslands, savannas and semideserts. The lack of water constrains the production of crops, wood and other ecosystem services.

desertification the process by which useful agricultural areas on desert fringes become degraded and change into desert

FIGURE 1 The drylands of the Earth are spreading. It is estimated that 12 million hectares of productive land (an area three times larger than Switzerland) is lost annually due to desertification.

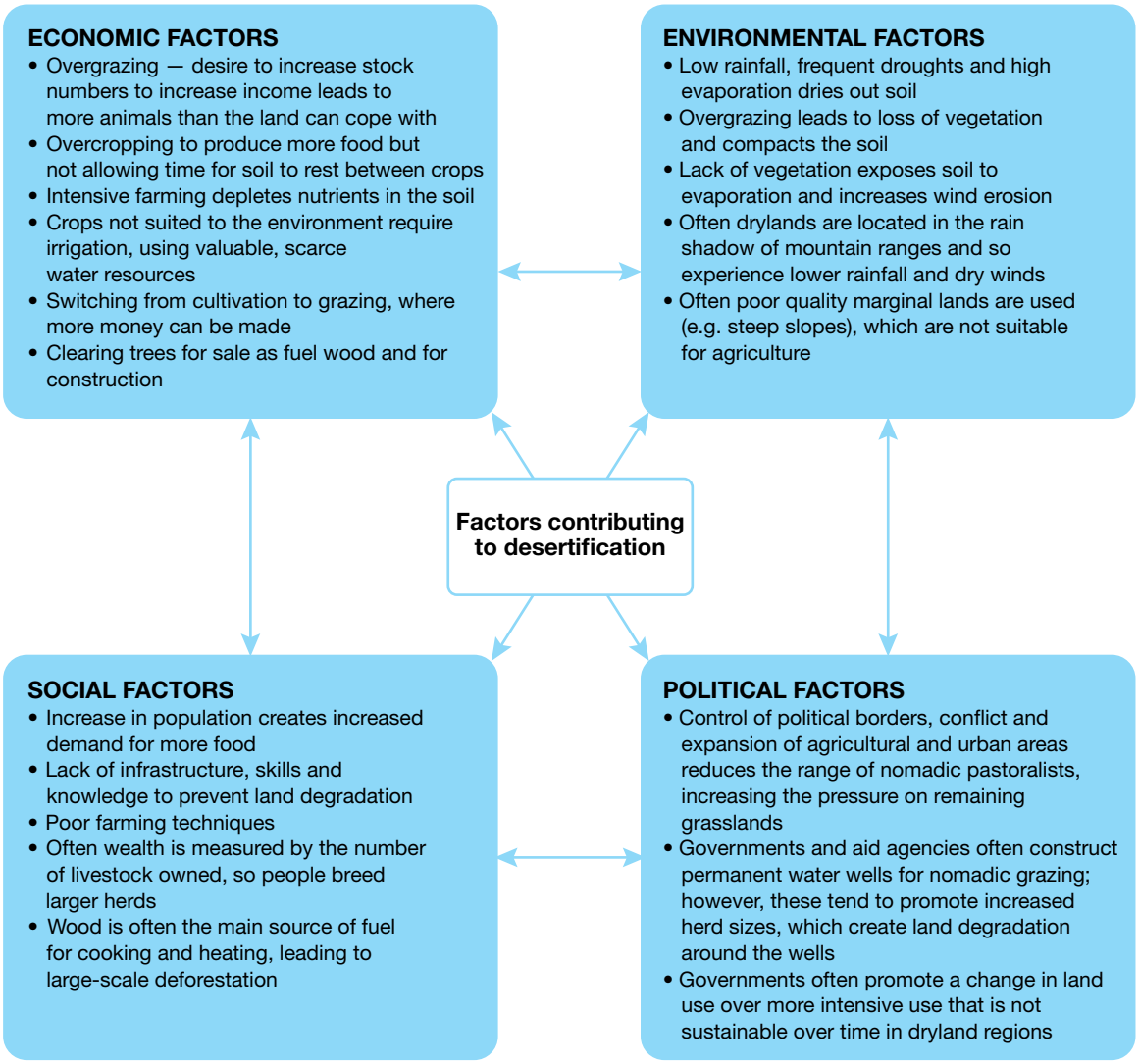


Source: UNEP World Conservation Monitoring Centre

13.6.2 What causes drylands to dry up?

Desertification is largely a result of human-induced environmental change, caused by the complex interconnection of environmental, political, cultural and economic factors. It generally arises from the poor management of dryland environments. Increasing populations, the demand for more agricultural production and overuse of the soil degrades the land to the extent that once productive places turn into wastelands (see figure 2).

FIGURE 2 Factors contributing to desertification



13.6.3 What are the impacts of desertification?

Currently, approximately 12 million hectares of land, an area almost three times the size of Switzerland, is lost annually, enough to have grown 20 million tonnes of grain. The cost to global economies is estimated to be $490 billion per annum.

Desertification brings about environmental change as the loss of topsoil and protective vegetation enables desert sand dunes to migrate and smother former farmland (see figure 3).

FIGURE 3 Fence drowned by a huge sand dune in the United Arab Emirates

Desertification also affects the wellbeing of over 1 billion people in the world. While poverty can contribute to desertification, it is also a consequence of it, as poverty forces people to over-exploit the land, which can then accelerate land degradation. It can also increase the risk of food insecurity as food production decreases. As the land fails, social and cultural networks can become lost as whole villages can effectively be abandoned as people leave farming in search of employment in urban areas.

13.6.4 How can desertification be tackled?

Desertification, climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. As a result of this, the United Nations developed the United Nations Convention to Combat Desertification (UNCCD), an agreement supported by 193 countries with the aims of:

- improving living conditions for people living in drylands
- maintaining and restoring land and soil productivity
- reducing the impacts of drought.

This worldview encourages cooperation in exchanging knowledge and technology between developed and developing countries and promotes the idea of a 'bottom up' approach to a problem. This means encouraging and supporting people to develop their own solutions rather than a government-led 'top down' approach.

13.6.5 How is China combating desertification?

China is one of the countries most severely impacted by desertification, which affects about 25 per cent of the total land area (approximately 3327 million km^2) and negatively affects 400 million people (see figure 4).

FIGURE 4 The predicted scale of desertification in China

Source: United States Department of Agriculture, Natural Resources Conservation Service, Soil Survey Division, World Soil Resources; Paul Reich, Geographer. 1998. Global Desertification Vulnerability Map. Washington, D.C.

In the wake of rapid population growth (from 550 million in 1950 to 1.354 billion in 2013), the demand for food, fuel, construction timber and livestock feed surged. With a viewpoint of 'growth at all costs', more farmland was opened up on desert fringes and the number of livestock doubled in just 10 years. This expansion was done without any environmental consideration. Thus, human activities in the form of inappropriate land use have magnified the problem of desertification (see figure 5).

Each year, the Gobi Desert in Mongolia swallows 360 000 hectares of grasslands, and dust storms remove 2000 square kilometres of topsoil. Sand and dust from the desert regions of China is carried eastwards by the prevailing winds, choking the city of Beijing: destroying crops, closing airports and creating a surge in respiratory ailments. The sand storms, or 'Yellow Dragon' as they were traditionally called, continue their journey and impact on international communities in South Korea, Japan, Russia and even the United States (see figure 6).

The Chinese Government has been working relentlessly on the problem, implementing a range of schemes, two of which are described in section 13.6.6.

China currently spends $5 billion each year on combating desertification. The aim is to reclaim half the treatable land area by 2020 and the remainder by 2050. Already China has slowed the rate of desertification by about one-third of 1999 levels, making it a world leader in this field.

FIGURE 5 Causes of desertification in China

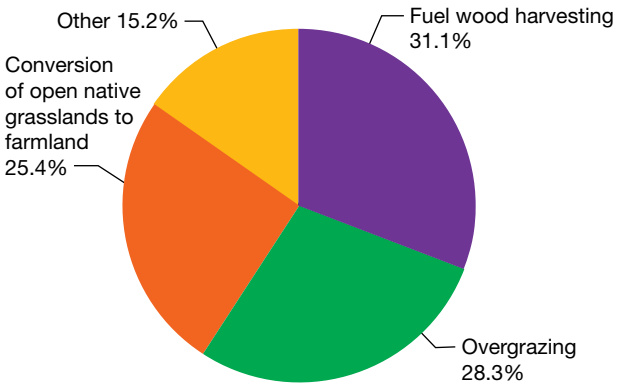
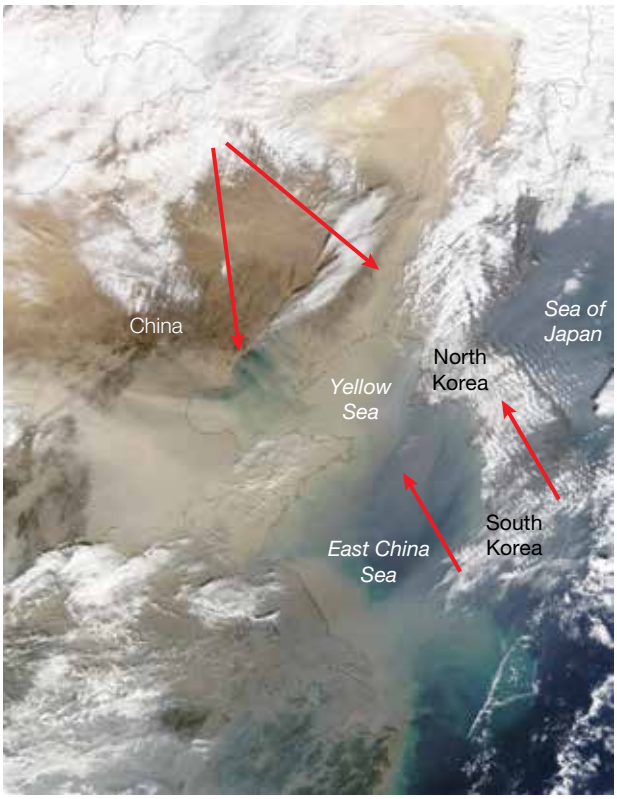


FIGURE 6 A dust storm from China affecting neighbouring countries



Source: Image courtesy Jacques Descloitres, MODIS Rapid Response Team at NASA GSFC.

13.6.6 The Great Green Wall of China

To halt the spread of deserts and reduce the impacts of climate change, the Chinese Government embarked on a plan to create the Great Green Wall of China. Green walls are ambitious initiatives designed to act as a barrier against desert winds and prevent desertification. Both the **Sahel** region in Africa and China have embarked on massive replanting projects that are expected to reduce erosion, enhance biodiversity, provide new grazing lands, boost agriculture and provide employment (see figure 7). Use the **Great Green Wall of China** weblinks in the Resources tab to find out more about the Great Green Wall of China.

Sahel a semiarid region in sub-Saharan Africa. It is a transition zone between the Sahara Desert to the north and the wetter tropical regions to the south. It stretches across the continent, west from Senegal to Ethiopia in the east, crossing 11 borders.

The Chinese Government envisaged a 4480-kilometre series of forest strips spanning the country from east to west to protect valuable farmland and waterways against wind erosion. To make this target a reality, every citizen over the age of 11 was expected to plant at least three saplings each year. Since the start of the millennium, Chinese citizens have planted over 56 billion trees. By 2012, the Chinese State Forestry Administration had succeeded in increasing forest cover from 12 per cent to 18 per cent, with the goal of reaching a national forest cover of 42 per cent by 2050. However, a study done by geographers at the University of Alabama noted that 'the reforestation efforts have done little to abate China's great yellow dust storms' (see table 1).

FIGURE 7 The Great Green Wall of China: an ambitious attempt to stop the advance of desert sands from the Gobi Desert

TABLE 1 Impacts of planting green walls

Environmental benefits	Environmental drawbacks
• Mass planting of fast-growing species (known as **monoculture**) • Trees act as windbreak and reduce erosion • Long-term possibility of harvesting trees as a commercial wood crop or for pulp and paper • Growth of trees acted as a carbon store, reducing greenhouse gases	• Monoculture reduces biodiversity and provides poor habitat for endangered native animal and bird species. • Monoculture is highly susceptible to disease. A pest can wipe out an entire plantation, ruining decades of work. • Many tree species chosen were not native and after initial growth soon died. In some places up to 85 per cent of the plantings failed. • Initial rapid growth of trees used a lot of soil moisture and lowered watertables. • Trees out-competed native grasses, which have a more extensive root system for holding soil. • Plantations generate less leaf litter than native forests, so fewer nutrients are entering the soil.

monoculture cultivating a single crop or plant species over a wide area over a prolonged period of time

While China reports an overall increase in forested areas, from 5 per cent to 12 per cent, Greenpeace reports that only 2 per cent of China's original vegetation remains. Many of the trees planted have a lifespan of only forty years.

As one Chinese ecologist, Jian Gaoming, has stated, there is a need for 'nurturing the land by the land itself'. This is an earth-centred approach to the problem of desertification. His research in Inner Mongolia noted that native grasslands will restore themselves in as little as two years, if protected from grazing animals by fences and human activities are eliminated.

eBook*plus*

Weblink
Great Green Wall of China

Restoring grasslands

It is estimated that 80 per cent of China's natural grasslands (42 per cent of its land area) are degraded as a result of overgrazing. A wide range of rehabilitation programs are being introduced. These include:

- *Moving people:* In places especially at risk of desertification, people are being resettled in order to prevent further damage. However, this has affected the lifestyles and traditional farming practices of the nomads in Tibet and Mongolia who are being forced off their land and into new settlements (see figure 8).
- *Changing land use:* Land use is converted from grazing to tree crops and forests, with farmers receiving compensation for the loss of stock and income.
- *Total grazing bans:* Over the years 2005 to 2010, a total ban was placed on animal grazing on 7 million hectares of land (an area twice the size of Germany). This was part of a larger plan to restore more than 660 million hectares of grasslands at an estimated cost of approximately AU$4 billion. This has meant that more than 20 million animals had to be farmed indoors and hand fed. In test projects, after three years of grazing bans the vegetation rate increased from 20 per cent to over 60 per cent, and local sand storms have reduced.

FIGURE 8 Nomadic grazing on grasslands in Mongolia. Why would this area be prone to desertification?

ACTIVITIES

IDENTIFY

1 What is the difference between deserts and drylands?
2 Why are drylands especially vulnerable to desertification?
3 Refer to figure 1. Describe the distribution of those ***places*** in the world most at risk of desertification.
4 Identify an economic, social and ***environmental*** impact of desertification in China.

EXPLAIN

5 In your own words, explain what is meant by desertification and why it is a global issue.
6 a Explain the difference between a 'top down' and a 'bottom up' approach to resolving a problem.
  b How effective do you think each approach can be in combating desertification in China?
7 Evaluate, according to ***environmental***, social and economic impacts, the effectiveness of the following for combating desertification in China:
  a 'green walls'
  b grazing bans

INVESTIGATE

8 Investigate one of the causes of desertification shown in figure 2 and write a news report that explains the ***interconnection*** between this factor and ***environmental change***. In your report include the following:
  a a description of the impact of this factor over ***space***
  b an example of a ***place*** that has been ***changed*** as a result of this factor
  c the ***scale*** of this ***change***
  d a strategy for the ***sustainable*** management of the ***environment*** to combat this factor.

PREDICT

9 How would you envisage the issue of desertification in China in the year 2050? Give reasons for your answer.

APPLY

10 The Chinese ecologist Jian Gaoming's viewpoint on managing desertification is 'nurturing the land by the land itself'. How does this Earth-centred viewpoint compare to the green wall scheme, which is a human-centred viewpoint? Which do you think is the more ***sustainable*** approach? Discuss.

13.11 How do we deal with salinity?

13.11.1 Is salinity an issue in Australia?

One-third of the world's food is produced on irrigated land. It is estimated that 20 per cent of this land is affected by salt. Rather than simply implement strategies to reduce salinity, should we also place more emphasis on developing plants that can tolerate higher levels of salt in the soil?

The Murray–Darling Basin

The Murray–Darling Basin (see figure 2) is Australia's largest **drainage area**. Extending across parts of four states and the entire Australian Capital Territory, it contains the country's three longest rivers: the Murray (2530 kilometres), the Darling (2740 kilometres) and the Murrumbidgee (1690 kilometres). It is also one of the country's most significant agricultural regions, producing close to 45 per cent of the nation's food. Because it receives very little rainfall, the area depends heavily on irrigation. In fact, 70 per cent of Australia's irrigation occurs here.

drainage area (or basin) an area drained by a river and its tributaries

Over time, human activities in the Murray–Darling Basin have increasingly threatened the basin's **ecology** (see figure 1). These activities have included introducing non-native plant and animal species, changing the natural flow of the river for irrigation purposes, clearing the land and over-watering crops. It is the last two activities that have particularly contributed to the region's salinity. (Although, in 1829 when explorer Charles Sturt discovered the Darling River during the dry season, he observed that the water was too salty to drink.) It has been estimated that by 2050, 1.3 million hectares (or 93 per cent) of land in the region could be salt-affected.

ecology the environment as it relates to living organisms

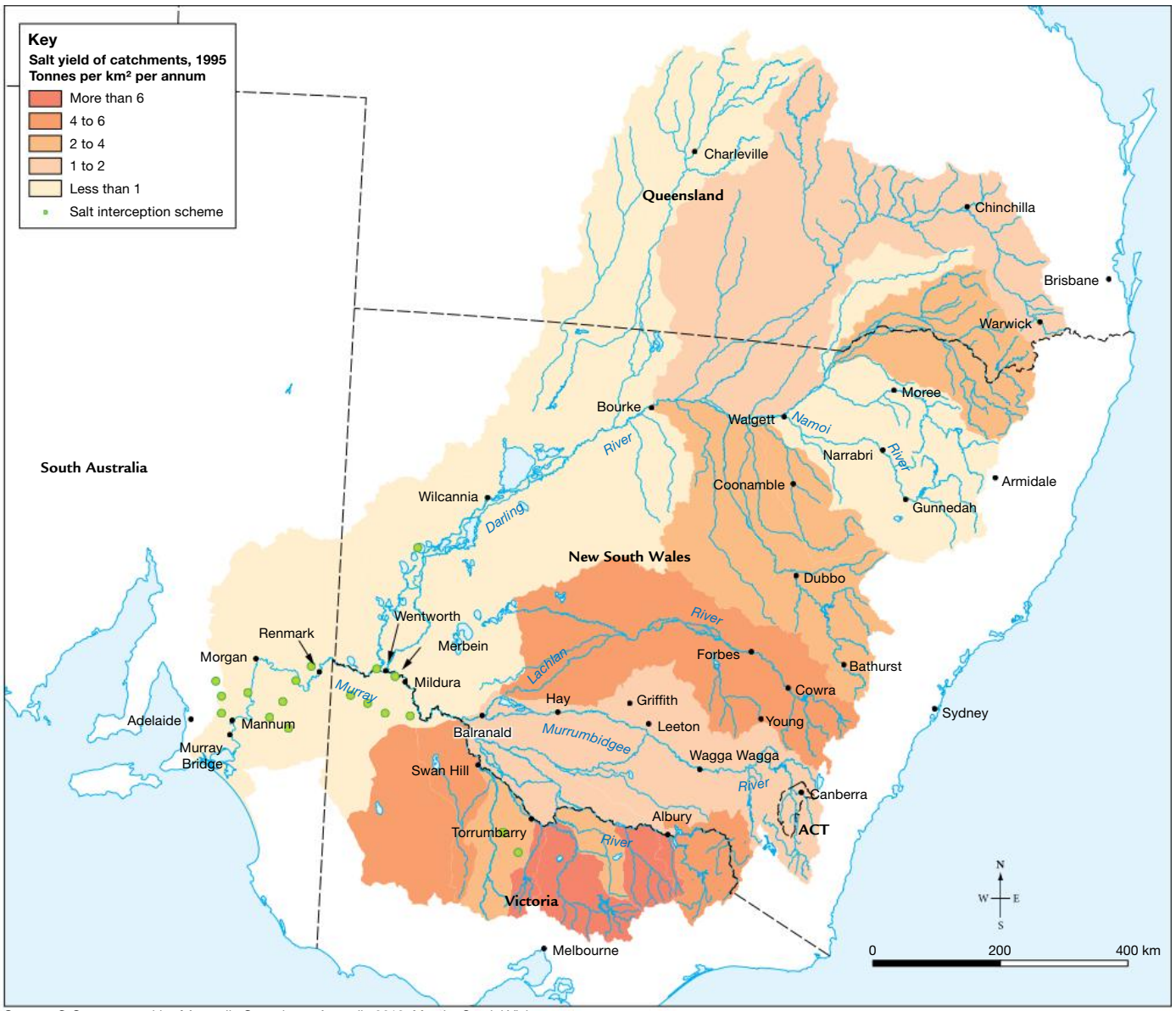
FIGURE 1 The earliest signs of salinity: the watertable has risen, bringing salt to the root zone. Look carefully at the trees in the background. What do you observe?

Tackling the problems

Over the years, a range of strategies have been investigated to better manage the Murray–Darling Basin and reduce salinity problems. Strategies have included the development of action plans such as revegetation programs and educational programs. In 2008, the Commonwealth Government took control of the region to allow for the implementation of a comprehensive management strategy that would provide for the needs of all states and also be environmentally sustainable.

As part of the measures to control salinity, salt-interception schemes (see figure 2) have been established along the Murray River. Collectively, they remove 500 000 tonnes of salt annually from groundwater and drainage basins (see figure 3). Prior to the Woolpunda and Waikerie schemes, the Murray River carried 250 tonnes of salt per day past Woolpunda and 100 tonnes a day past Waikerie. Recent surveys show that salinity levels have decreased to less than 10 tonnes a day in each area.

FIGURE 2 Salt interception in the Murray–Darling Basin



Source: © Commonwealth of Australia Geoscience Australia 2013. Map by Spatial Vision.

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Weblink
Interception

Use the **Interception** weblink in the Resources tab to read more about one way to tackle the salinity problem: intercepting the salty water before it reaches rivers.

FIGURE 3 Salt harvested from evaporation ponds is exported all around the world.

13.11.2 What is happening overseas?

While rice is a water-thirsty crop, it does not like to be completely submerged for its entire growing season. Rice grows best in fertile soils where there is an abundant supply of water that can be controlled throughout the growing season, but it can adapt to a variety of growing conditions.

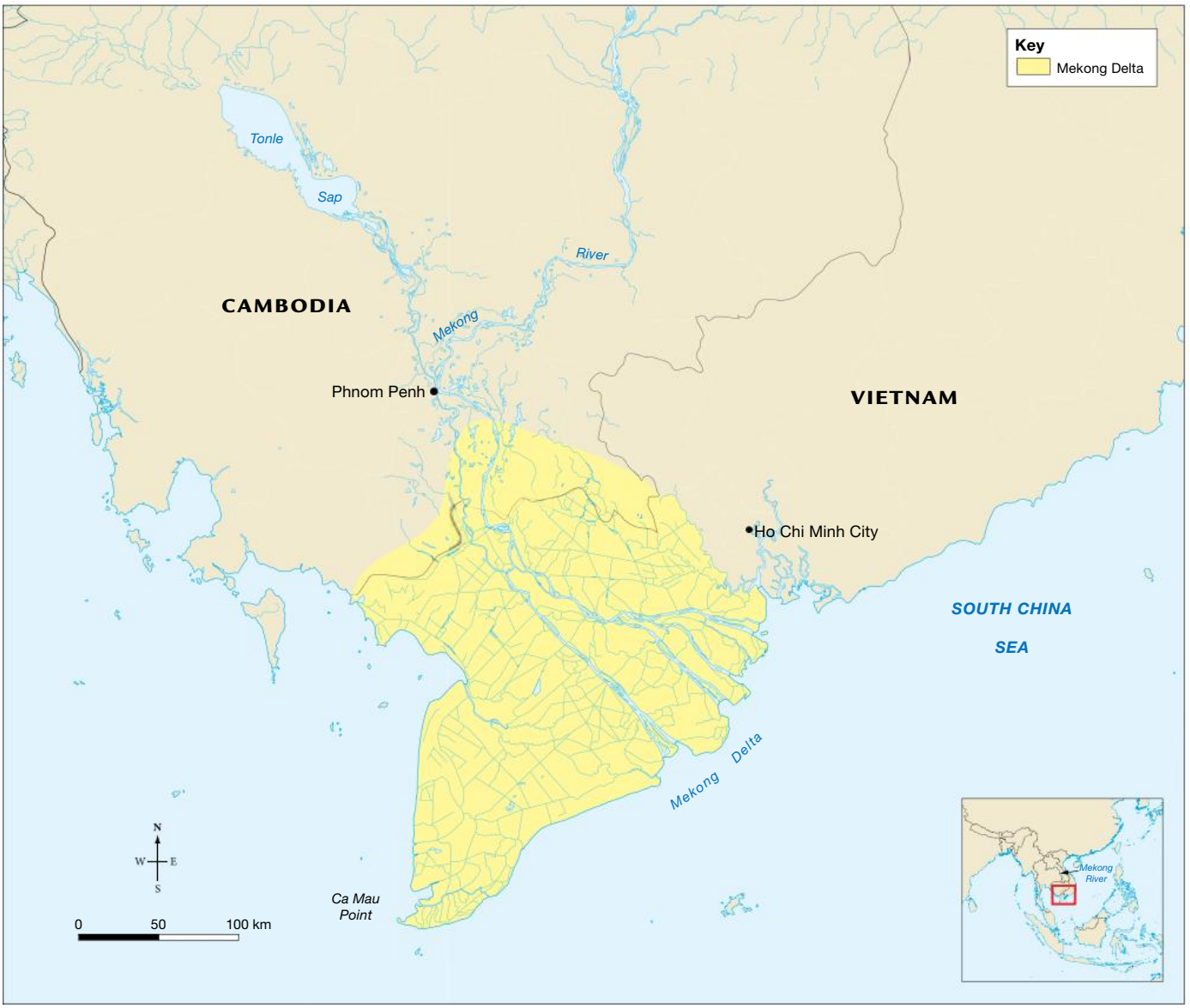
Vietnam's Mekong Delta region (see figure 4) is a major exporter of both rice and shrimp. Drought and the early arrival of the dry season, which is being attributed to climate change, is allowing sea water to encroach on valuable farming land.

Scientists are now developing strains of rice that are not only salt-resistant but can also withstand being submerged in water for almost three weeks, whereas traditional strains die within a week of being flooded and fully submerged.

Additionally, in some regions, farmers are making use of the **brackish** water that results from periods of saltwater intrusion. While brackish water is not suited to rice farming, it is ideal for cultivating shrimp. With the onset of the monsoon season, the farmers rely on the heavy rains to flush out the salt water and allow them to plant their rice crops.

brackish (water) water that contains more salt than fresh water but not as much as sea water

FIGURE 4 The Mekong Delta



Source: Vector Map Level 0 Digital Chart of the World. Map by Spatial Vision

FIGURE 5 Dry rice husks suitable only for poultry are the result of brackish water from the sea flowing inland

ACTIVITIES

EXPLAIN

1 Why is the Murray–Darling Basin a significant part of the Australian ***environment***?
2 What factors have contributed to the degradation of the Basin's land and water resources since the arrival of Europeans?
3 With the aid of a Venn diagram, compare salinity issues that exist in the Murray–Darling Basin and Vietnam's Mekong Delta. Include references to the ***scale*** of the issue and the rate of ***change***.

INVESTIGATE

4 Which general area of the Murray–Darling Basin is most affected by salinity: the north-east, the western region or the south-east? Describe the ***scale*** of the problem. Investigate the land use of this area and explain the ***interconnection*** between land use and salinity in the Murray–Darling Basin.
5 With the aid of a diagram, explain what a delta is and why it is important.
6 In groups, investigate the Mekong River, its delta and its importance to Vietnam.
   a Prepare a report on how the river is used and the issue of land degradation. In your report make reference to the ***scale*** of the problem and the rate at which ***change*** is occurring.
   b What strategies have been suggested or used to deal with this issue? Are these strategies a ***sustainable*** option for caring for the ***environment***? Why/why not?

THINK

7 Refer to figure 2.
   a What is the aim of such salt-interception schemes? Explain.
   b Do you think this is a ***sustainable*** management strategy? Explain.
   c Discuss the impact of this scheme on river ecosystems.
   d What do you think happens to the salt that is extracted?
   e Do you think a similar scheme could be developed for the Mekong Delta? Justify your point of view.

13.12 SkillBuilder: Writing a fieldwork report as an annotated visual display (AVD)

13.12.1 Tell me

What is a fieldwork report?

A fieldwork report helps you process all the information that you have gathered during fieldwork. You sort your data, create tables and graphs, and select images. You interpret the data as text or annotated images to convey your ideas. To convey your ideas, you synthesise, or pull together, all the data in a logical presentation. Finally, you summarise all you have learned and collected in your fieldwork-based research in a statement or recommendations on the topic. A fieldwork report may be presented as a word-processed report; a wall-mounted, annotated visual display; an oral presentation, using PowerPoint as support; a podcast; a website publication; or another form of media.

Why is a fieldwork report useful?

A fieldwork report is used to summarise the findings from your time in the field. Your fieldwork report will highlight a particular environment, social issue or key inquiry question that you are investigating. You may be presenting this information in order to inform your classmates, to raise community awareness, or to encourage a relevant authority to take action. Many organisations undertake fieldwork investigations to determine future plans.

Fieldwork reports are also useful for:

- synthesising and summarising all the information collected in the field
- displaying your ideas for classmates to see
- resolving land use issues, such as transport infrastructure expansions
- providing input to local and national government planning and strategies
- determining the route of a new bicycle path
- testing for mineral resources.

FIGURE 1 An annotated visual display (AVD) completed from secondary sources

EARTHQUAKES IN AUSTRALIA

Fault lines in Australia

'We're due for a big one'

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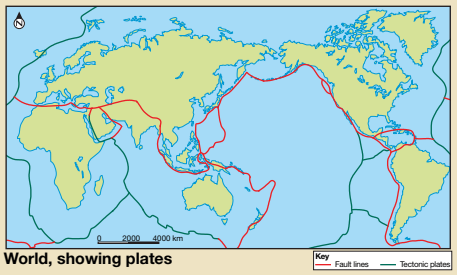

World, showing plates

Don't forget your list of references. If there are lots of references, you can put them on the back.

Remember for every map: **B**order, **O**rientation, **L**egend, **T**itle, **S**cale and **S**ource.

'Safest country in the world'

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Newcastle

Conclusion

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References

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Use a large, coloured piece of card from the newsagent for your backing.

You can write directly onto the card or stick paper onto it.

Break your information down into several sections rather than having lots of writing.

Spread your maps and photos out to make the presentation interesting.

Model

A good fieldwork report presented as an AVD:

- is clearly structured and has a title
- includes an introduction
- contains statements of findings, which provide a range of data sources, such as graphs (of various types), tables and photographs
- includes evidence that you have identified patterns in the data, been able to describe the current situation, and synthesised data to come up with a clear understanding of the topic
- clearly states limitations and successes
- has a conclusion.

13.12.2 Show me

How to create an AVD

You will need:

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eLesson
Writing a fieldwork report as an annotated visual display (AVD)
Searchlight ID: eles-1747

- to revisit the aims of your fieldwork
- a large piece of chart paper on which to present your material
- a piece of A4 paper for planning the layout
- maps of the location
- data collected in the field that has been selected and processed to produce tables and a range of graphs
- photographs that have been selected for relevance and referred to in the text
- relevant secondary data.

Procedure:

To complete an AVD you need to have all your information readily available.

STEP 1

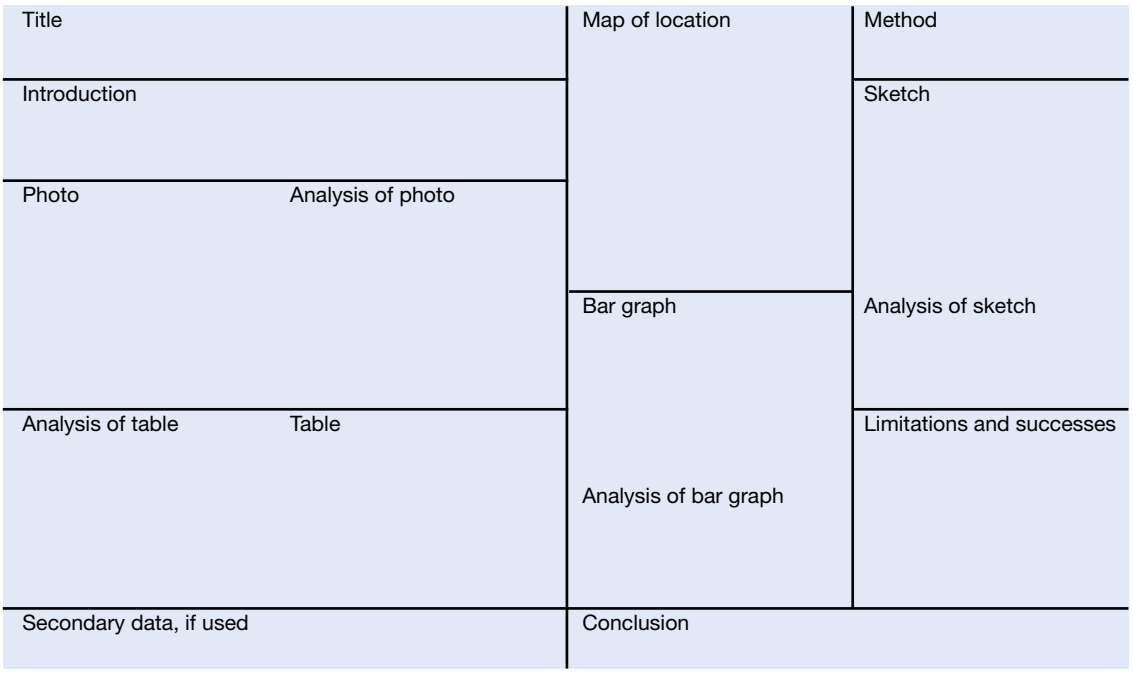
Determine a simple, short and concise title for your fieldwork study.

STEP 2

On a separate sheet of paper, sketch a layout for your work. There are a number of things to consider when positioning material.

- A short and precise introduction should appear in the top left corner (see step 3).
- A map showing location should be close to the introduction.
- You need to describe your method (see step 4).

FIGURE 2 Sample layout of an AVD



- Findings — the primary data collected — should be presented in tables, graphs and photographs (see step 5).
- If you include secondary data, decide where it fits into the 'story' that is being told (see step 6).
- State the limitations and successes of the fieldwork (step 7).
- Incorporate a conclusion (step 8).

STEP 3

Begin with an introduction. This should be short, and should state clearly the aims of the fieldwork and the location of the investigation, shown as a map. For example, 'This fieldwork aims to investigate [topic] and was undertaken at [place] on [dates]'.

STEP 4

The next section is the method. State where you went within the broader location; what information you gathered; the methods you used to gather information; and why you collected that information. This should be a concise paragraph. For example: 'We visited three places along the coastline. One was a bayside beach [name], the second a rocky headland [name] and the third an ocean beach [name]. We observed the waves, counted the tourists and photographed sand build-up at each site. We hoped this data would show…'

FIGURE 3 Sample section showing text and photograph closely connected

When storms occur and waves are larger, more material is carried away in the backwash to deep water.

Backwash — the movement of water back to the sea is shifting sand, shells, seaweed and other materials down the beach and out to sea.

STEP 5

The findings are the main focus of the report. This is where you present the information that you gathered in the field. It is important that your work has a clear structure in order to guide the reader through the development of the ideas. Look for interconnections between the data, and set out the information in an organised manner. Figure 3 shows a section taken from an AVD.

The various maps, graphs, diagrams and photographs are presented in this section with a discussion of the important findings that each item of data reveals. Place the analysis close to each item of data. It is a good idea to number the items and refer to the numbering system in the text; this ensures the reader is connecting with the appropriate data. For example, 'Figure 2 shows …' or 'The photograph in figure 5 displays …'

All data should incorporate the geographic conventions: BOLTSS. Annotations to photographs and diagrams are recommended, because these save space and connect the reader with the data.

STEP 6

Consider whether you need to include any information from a secondary source. This is information that is reported by someone else and appears in a magazine, newspaper, journal, government report or the internet, or is spoken (in a talk, speech or interview, for example). This information is not the focus of your work and must only supplement your fieldwork findings. Therefore, it must be very brief. Figure 4 shows how secondary data might be done as a précis in an AVD.

FIGURE 4 A secondary source and a précis of it for the AVD

Residents and beach visitors were treated to a spectacular sight when a large sand dredge began restoring the eroded beach to its former splendour. The beach had gradually been washed away with every winter storm that arrived.

Under a master plan for the area, a total revamp is planned, including recreating the beach. A partnership between council, the community and the state government, will contribute $5.4 million to the project, including adding 180 000 cubic metres of sand reclaimed from the sea. A new 50-metre-wide stretch of sand over a length of 900 metres will appear.

As the area had been neglected for some time, the master plan is extensive with plantings of native trees, enhancement of wetlands, plantings for shade, a foreshore bicycle trail, sealed parking bays and redevelopment of the Life Saving Club building, including a cafe. An up and rising local sculptor has kindly offered to donate a sculpture 'The Wave' to be placed along the foreshore. Council will support this installation.

The renourished beach is a reflection of Council's commitment to continually improving foreshore amenity for residents of the beach-going population.

The Inquirer, August 10, 2012

Précis of article

The recreated beach is 50 metres wide by 900 metres long. A sand dredge took 180 000 cubic metres of sand from the sea. Trees have been planted to hold soil and provide shade, the wetlands have been developed, and community wellbeing has been enhanced by a bicycle path, car parking and a cafe at the revamped surf lifesaving club.

STEP 7

Include a statement about the limitations and successes of the fieldwork. The limitations should cover anything that went wrong or ways in which the fieldwork could be improved. The successes should include new things learned and any interest that you may have gained from the investigation, particularly if you want to recommend active citizenship.

STEP 8

End your report with a conclusion. This should relate to the aims of the fieldwork. For example, 'From the fieldwork investigation, it is possible to conclude that…' Go back to your aims and check you have answered what you set out to discover.

13.12.3 Let me do it

Developing my skills

During Year 10 Geography, your class should undertake fieldwork. This SkillBuilder can only be completed after that has taken place. The Focus on Fieldwork feature in section 13.2.2 suggests fieldwork in the school grounds or at a local environment. Practise an AVD layout for only one of these environments.

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Interactivity
Writing a fieldwork report as an annotated visual display (AVD)
Searchlight ID: int-3365

Questions

1. What forms of land degradation might you find in this environment?
2. How would you rate your local environment in terms of degradation?
3. Can you suggest some activities that could help to improve the environment?
4. Which local authorities ought to be concerned about this environment?
5. How might you alert the local community to the degradation taking place?

Checklist

Use this checklist after you have been out in the field.

I have:

- clearly structured the layout
- included a title and introduction
- provided statements of findings from a range of data sources — various graph types, tables and photographs
- provided evidence that I have identified patterns in the data, been able to describe the current situation, and synthesised data to show a clear understanding of the topic
- clearly stated limitations and successes
- added a conclusion.

Skills questions

1. Fieldwork reports are used to show:
   a. information gathered from textbooks
   b. an investigation of an environment or an issue
   c. the contours of an area
   d. land use.
2. A fieldwork report does not include:
   a. photographs
   b. measurements
   c. internet addresses
   d. graphs.
3. Why does a fieldwork report need to be well structured?
4. Why do you need to be well organised before you undertake fieldwork?

13.14 Review

13.14.1 Review

1. Briefly explain some of the processes that can cause the land to degrade.
2. Use figure 1 to explain the link between soil erosion and the removal of vegetation.
3. With the aid of a diagram, explain why Australia's soil:
   a. has a level of naturally occurring salt
   b. is getting saltier, particularly in settled areas.
4. a. What is salinity?
   b. With the aid of a diagram, explain the difference between dryland and irrigation salinity.
   c. Which type of salinity do you think is of most concern in Australia? Give reasons for your answer.
5. Draw a mind map that shows the consequences of land degradation for both the ***environment*** and the people who depend on its resources.
6. Investigate the Green Wall project in the Sahel region in Africa and then compare it with the Chinese example.
   a. In what ways are these projects similar, and how do they differ?
   b. Which project do you think is having the greatest success? Give reasons for your answer.
   c. Evaluate the approach taken by both Africa and China. In your evaluation consider the following:
      i. Is this the best approach to managing desertification? Explain.
      ii. Do you think this is an example of ***sustainable*** management of an ***environment***? Justify your point of view.
7. a. Explain how introduced species can cause land degradation.
   b. Do you think we can eradicate invasive species? Give reasons for your answer.
8. Make your own sketch of figure 2 in your notebook.Annotate your diagram to explain the following:
   a. the different land management techniques shown
   b. how each technique helps prevent soil erosion
   c. what will happen in the section where the farmer has ploughed his lines vertically (up and down the slope) instead of horizontally. Show this as a series of additional sketches with annotations that explain the transition from one type of erosion to the next.

FIGURE 1 Link between soil erosion and removal of vegetation

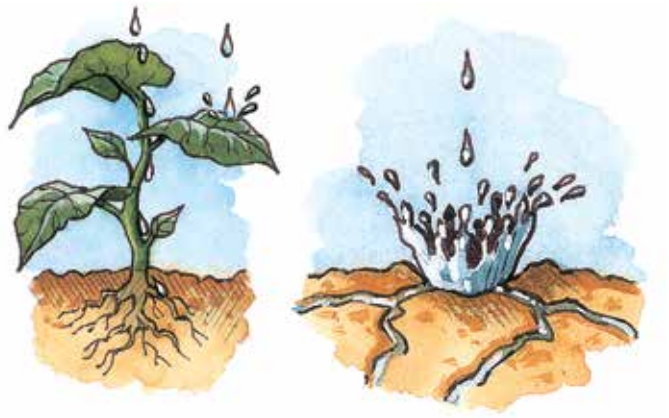
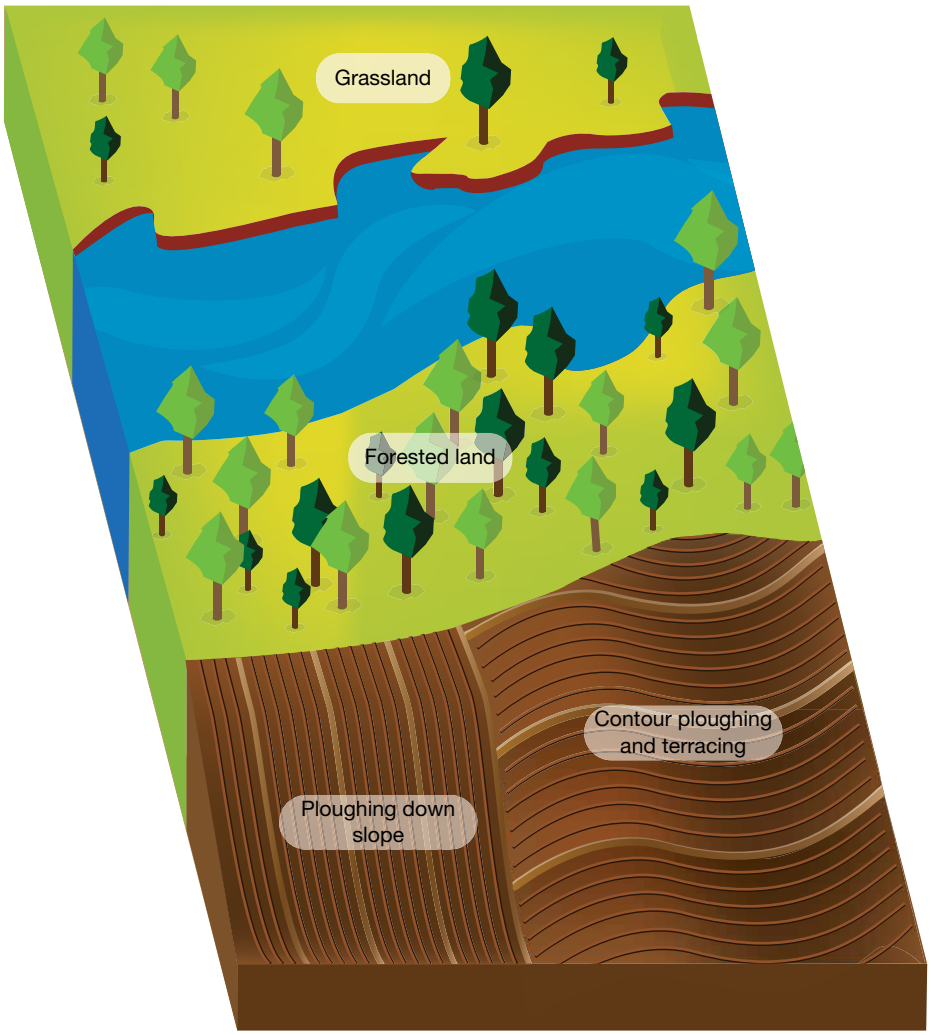


FIGURE 2 Land management techniques



9. Study table 1 showing rainfall data and soil erosion based on land use for a number of hypothetical locations.

TABLE 1 Rainfall data and soil erosion based on land use for four locations

Place	Average rainfall (mm)	Soil erosion (tonnes per hectare per year)		
		Forest	Agriculture (crops)	Cleared land (bare soil)
Place A	2150	0	47	142
Place B	1250	0.2	13.5	27
Place C	875	0.2	1.2	17
Place D	1350	0.30	7.8	21.6

FIGURE 3 Axes and legend for scattergraph showing the amount of soil lost through erosion with different vegetation covers

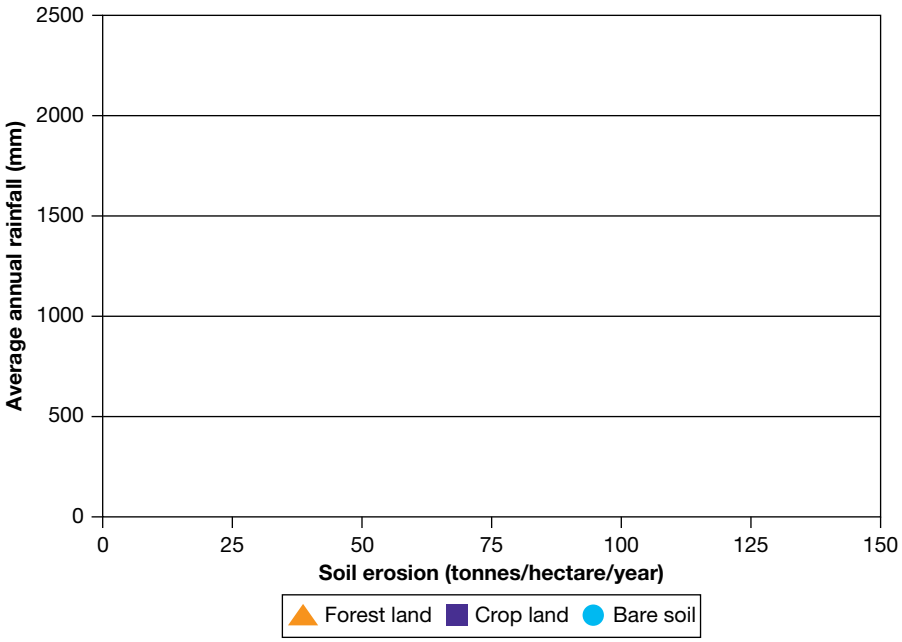


FIGURE 4 Indigenous land management technique

a. Use the information shown in the table to construct a scattergraph illustrating the amount of soil lost through erosion with different vegetation covers. (A scattergraph shows a series of separate points that are not joined with lines.) Use symbols to help you distinguish the different types of vegetation cover. Use figure 3 as a guide for constructing your scattergraph.
b. Describe the relationship between land use and soil erosion. Use examples to illustrate your answer.
c. Describe the relationship between soil erosion and annual rainfall. Do you think that the slope or gradient of the land would have an impact on the rate of soil erosion? Explain.
d. If you were to buy a large area of forested land in place A with the intention of establishing a wheat farm, what steps would you take to reduce the risk of soil erosion? How would the slope or gradient of the land affect your planning?

10. Study figure 4.
a. What land management technique is being used and what is its purpose?
b. How would an Indigenous person know when to use this strategy?
c. Identify at least two other methods used by Indigenous communities to live in harmony with the ***environment***.

13.14.2 Reflect

It is not just the land that is degraded

Invasive species are a major problem around the world. But it is not just the land that they invade. Exotic plants and animals also invade our waterways. Once a species takes hold it can be very difficult to control.

FIGURE 5 (a) Water hyacinth, a serious problem in many parts of the world, (b) is being used in other areas to make furniture.

Water hyacinth

Found on most continents, the water hyacinth spreads quickly. When not controlled, it prevents sunlight from reaching native aquatic plants; starves the water of oxygen, killing fish; and provides an ideal breeding ground for mosquitoes. However, when controlled it has been useful, and humans have found a number of uses for it, including cleaning industrial wastewater, as a source of biofuel and to make furniture.

11. Do you think other invasive plant species could be used commercially? Give reasons for your answer.
12. Design an advertising campaign to convince people to purchase furniture made from water hyacinth.

Charlie Carp

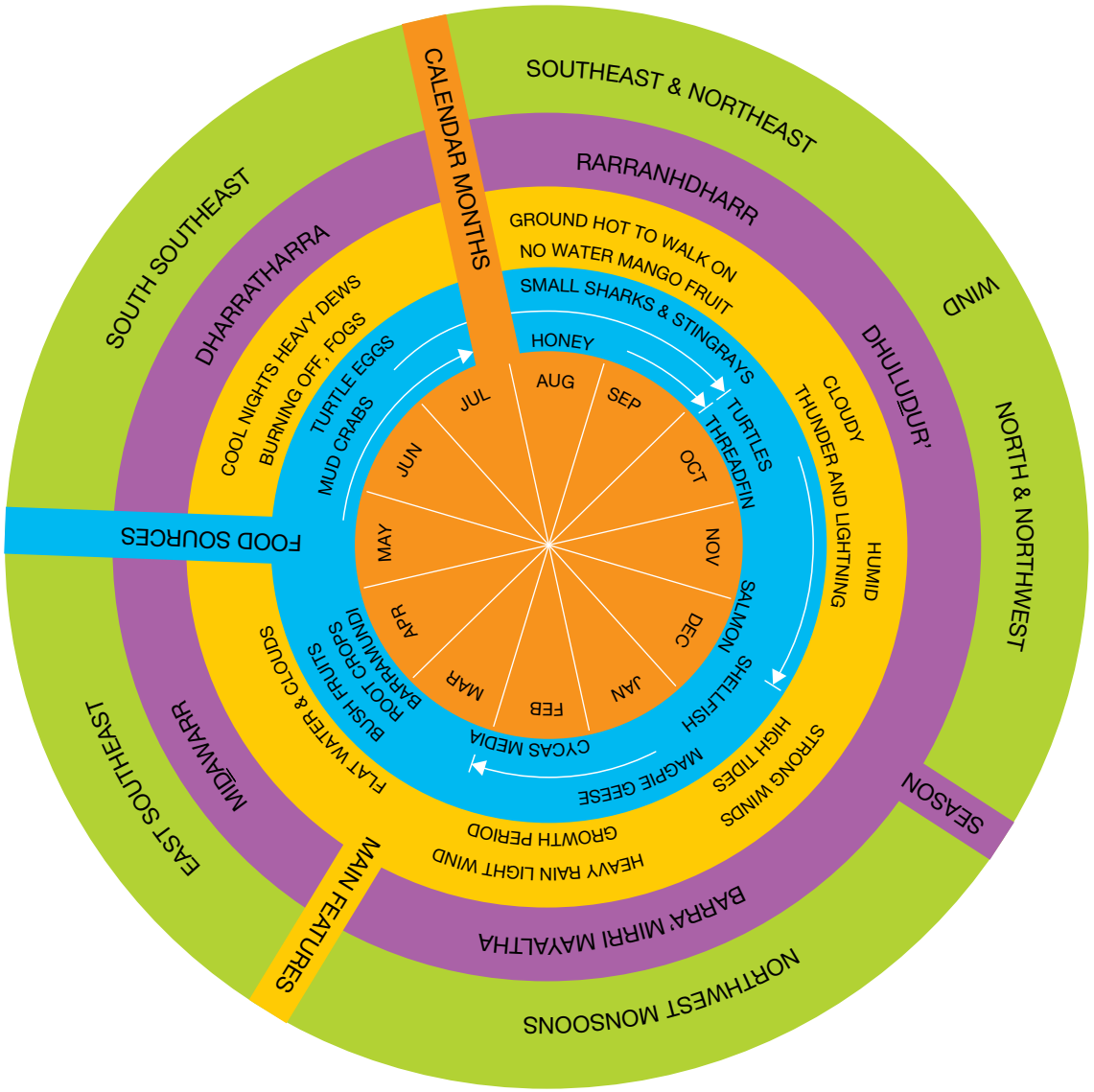
Carp (see figure 6) have long been a major problem in the waters of the Murray–Darling Basin. They have no natural predators and prey upon the young of native Australian fish species, muddy the water and cause the erosion of riverbanks. Carp have provided the foundation upon which a small business, Charlie Carp, was launched — this business harvests over 150 tonnes of carp annually and turns them into an environmentally friendly fertiliser.

FIGURE 6 Carp

13. Why do you think carp make such an effective fertiliser?
14. What advantages might a product such as Charlie Carp have over chemical-based fertilisers?
15. Could a product such as this eliminate the need for chemical fertilisers? Why/why not?
16. 'Culling our native animals is cruel, unethical and unnecessary.'
    a. What would be the different positions that the following groups of people would have on this issue?
       - Vegetarians
       - Environmentalists
       - Farmers
    b. What cultural values and beliefs may influence their different perspectives?

17. There is much to learn from Indigenous Australians' traditional land management practices. Identify and analyse the challenges as well as the benefits of doing this.

FIGURE 7 Indigenous communities are defined by observable changes in the seasons.



CHAPTER 14

Inland water — dammed, diverted and drained

Inland waters are important sources of water for both environments and people.

14.1 Overview

14.1.1 Introduction

Water makes life on Earth possible, and rivers are like blood running through the veins of a body. Over time we have dammed, diverted and drained water, and this has brought about significant environmental change. Careful stewardship of these resources will provide a health insurance policy for a sustainable future.

Starter questions

1. How many different types of freshwater bodies can you think of within 100 kilometres of where you live?
2. Where does your fresh water come from? Name and describe the location of the freshwater bodies that supply your house. You may need to refer to an atlas.
3. If you didn't have shops, supermarkets, water taps and pipes where you live, what water sources would you get your daily fresh water from?

Inquiry sequence

		Syllabus outcomes
14.1 Overview		
14.2 What is inland water?		GE5-2, GE5-3, GE5-8
14.3 Dam it?		GE5-3, GE5-4, GE5-7, GE5-8
14.4 Do we have to dam?		GE5-3, GE5-4, GE5-8
14.5 SkillBuilder: Creating a fishbone diagram	eBook plus ONLINE ONLY	GE5-7, GE5-8
14.6 Is fighting worth a dam?		GE5-3, GE5-4, GE5-7, GE5-8
14.7 What happens when we divert water?		GE5-3, GE5-4, GE5-5, GE5-8
14.8 Why is groundwater shrinking?		GE5-3, GE5-4, GE5-5, GE5-8
14.9 Why is China drying up?		GE5-3, GE5-4, GE5-5, GE5-8
14.10 Investigating topographic maps: Why do we drain wetlands?		GE5-5, GE5-8
14.11 SkillBuilder: Reading topographic maps at an advanced level	eBook plus ONLINE ONLY	GE5-7, GE5-8
14.12 How can we put water back?		GE5-5, GE5-7, GE5-8
14.13 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Draining away
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14.2 What is inland water?

14.2.1 Inland water

Have you ever stopped to think that the water flowing down a river or rippling across a lake is providing us with a life support system? The rivers, lakes and wetlands that make up our inland water are important for supplying water for our domestic, agricultural, industrial and recreational use. They provide important habitats for a wide range of terrestial and aquatic life.

perennial describes a stream or river that flows permanently

ephemeral describes a stream or river that flows only occasionally, usually after heavy rain (e.g. Todd River, Alice Springs)

Inland water systems cover a wide range of landforms and environments, such as lakes, rivers, floodplains and wetlands. The water systems may be **perennial** or **ephemeral**, flowing (such as rivers), or standing water (such as lakes) (see figure 1). There are interconnections between surface water and groundwater, and between inland and coastal waters. Inland water is an important link in the water cycle, as water evaporates from its surface into the atmosphere. In return, rainfall can be stored in rivers and lakes, or soak through the soil layers to become groundwater.

Why is inland water important?

Inland water provides both the environment and people with fresh water, food and habitats. It provides environmental services; for example, it can filter pollutants, store floodwater and even reduce the impacts of climate change. The economic value of these services cannot easily be measured. Their importance, however, can be taken for granted and not appreciated until the services are lost or degraded.

What are the threats to inland water?

Inland water is extremely vulnerable to change. It has been estimated that in the last century over 50 per cent of inland water (excluding lakes and rivers) has been lost in North America, Europe and Australia. Those systems remaining are often polluted and reduced in size. The loss is largely a result of human activity. Table 1 illustrates some of the reasons for changes to inland water systems, and their possible impacts on the environment and people. As water is such a valuable resource, much of our inland waterways have been dammed, diverted or drained to meet the needs of people.

FIGURE 1 The Parana River floodplain in northern Argentina shows a variety of different types of inland water.

FOCUS ON FIELDWORK

Identifying features of your local catchment

Use Google Maps or Google Earth to view your local catchment area. Draw a sketch map of the river and the tributaries. Annotate your map with any human-made features such as levees, dams or weirs.

Visit the river or one of its tributaries near your school. Annotate your map showing the location of your site visit. Observe the human-made features. Draw a fieldsketch of your fieldsite. As a class, discuss how the area might have looked before any human-made changes were present. When you return to class, create an overlay for your sketch map to show the land use around the river and tributaries.

1. Describe the relationship that exists between land use and human-made features of the catchment.
2. Examine your sketch map and describe how extensive the changes to the river system been. How does your fieldwork support your answer?
3. Predict the impact of the human-made changes on the rest of the catchment.

FIGURE 2 Wetlands are an example of inland water systems that are vulnerable to human-induced damage.

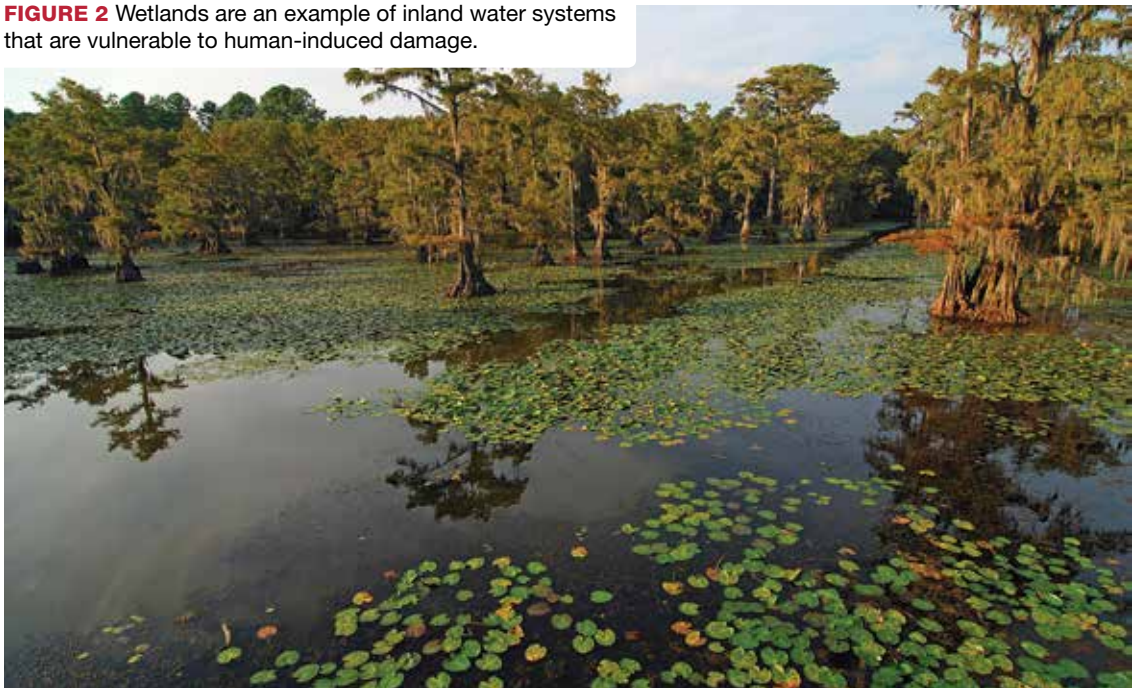


TABLE 1 Threats to inland water

Cause of change to inland water systems	Environmental functions threatened	Impacts of change
Increasing population and increasing demand for water across space	Most services (e.g. fresh water, food and biodiversity) Regulatory features such as recharging groundwater and filtering pollutants	Increased withdrawal of water for human and agricultural use Large-scale draining of wetlands to create farmland
Construction of infrastructure including dams, weirs and levee banks, diverting water to other drainage basins	Services supporting the quality and quantity of water Biodiversity, habitat, river flow and river landforms	Changes to the amount and timing of river flow. The transportation of sediment can be blocked and dams can restrict fish movements.
Changing land use (e.g. draining of wetlands, urban development on floodplains)	Holding back floodwaters and filtering pollutants Habitats and biodiversity	Alters run-off and infiltration patterns Increased risk of erosion and flood
Excessive water removal for irrigation	Reduced water quantity and quality Less water available for groundwater supply	Reduced water and food security Loss of habitat and biodiversity in water bodies
Discharge of pollutants into water or on to land	Change in water quality, habitat Pollution of groundwater	Decline in water quality for domestic and agricultural use Changes ecology of water systems

ACTIVITIES

IDENTIFY

1 Match the following terms with their correct definition in the following table.
main channel, *tributary*, *anabranch*, *meander*, *oxbow lake (or billabong)*, *floodplain*
You may need to use a dictionary to help.

Term	Definition
	a smaller stream that flows into a larger stream
	bend in the river
	area of relatively flat, fertile land on either side of a river
	main river
	a cut-off meander bend
	where a river branches off and joins back into itself

EXPLAIN

2 Make a simplified sketch of figure 1 and clearly label an example of each of the features listed in question 1 on your sketch.

3 The Parana River is 4880 kilometres long, making it the second longest river in South

America. The river flows from the south-east central plateau of Brazil south to Argentina. Figure 1 is a small section of this river. Locate the river in your atlas. What evidence is there to suggest that this river frequently floods?

4 Refer to figure 1. The brown shading visible in the water and on the land represents the river's muddy sediment. This is material such as sand and silt carried and deposited by a river.
   a Where has this sediment come from?
   b How does the sediment get onto the floodplain?
   c If the river is dammed upstream, what ***changes*** are likely to happen to the sediment carried and to the floodplain?

5 Suggest two short-term and two long-term examples of human-induced ***changes*** that could have an impact on the wetland in figure 2.

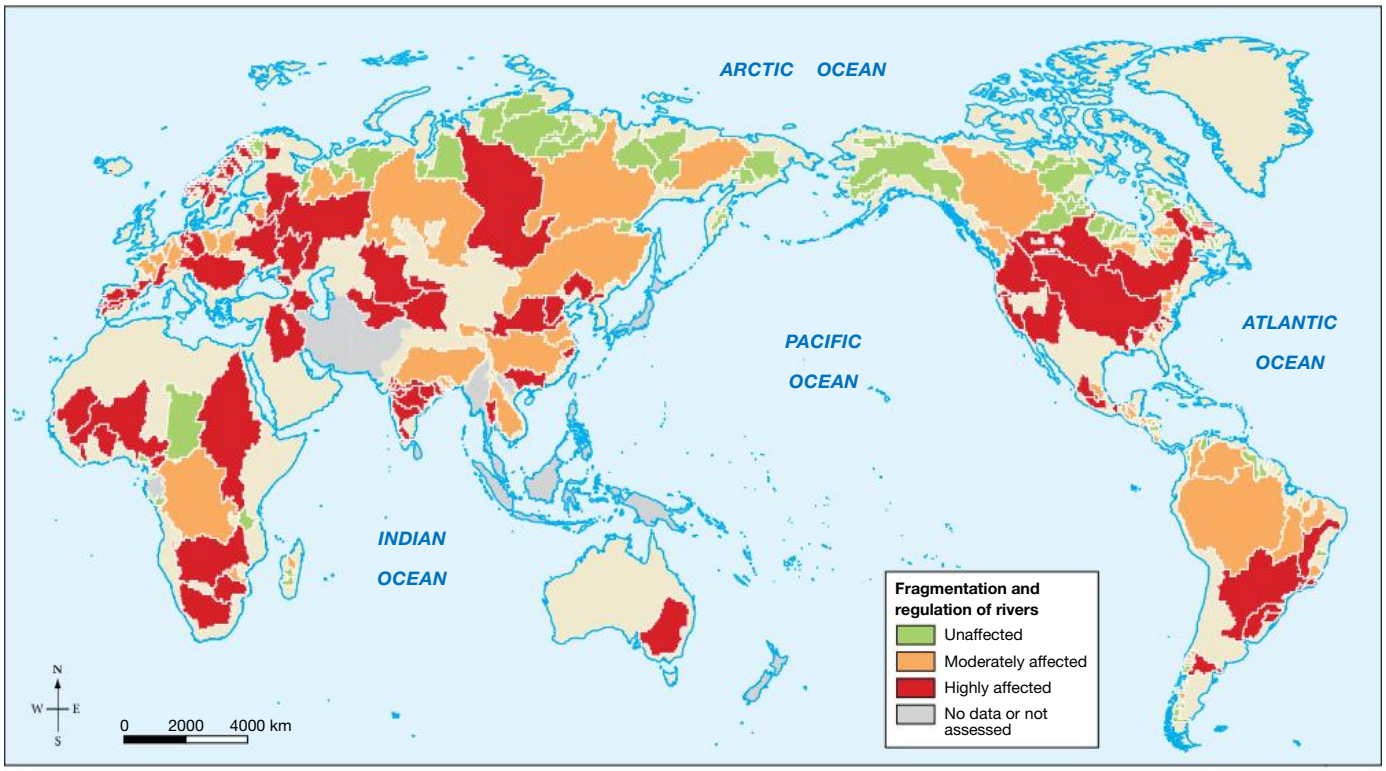
14.3 Dam it?

14.3.1 Why dam rivers?

Are dams marvellous feats of modern engineering or environmental nightmares? Without them we would not have a dependable supply of water or electricity, nor would we feel relatively safe from floods. For many decades, dams have been seen as symbols of a country's progress and economic development. But more and more the true costs, socially, economically and environmentally, are emerging.

A reliable water supply has always been critical for human survival and settlement; however, water is not evenly distributed over the world by either time or space. Some places suffer from regular droughts, while others experience massive flooding. As a result, people have learned to store, release and transfer water to meet their water, energy and transport needs. This could be in the form of a small-scale farm dam or a large-scale multi-purpose project such as the Snowy River Scheme. Constructing dams is one of the most important contributors to environmental change in river basins. Globally, over 60 per cent of the world's major rivers are controlled by dams.

FIGURE 1 Degree of river fragmentation in the world's major drainage basins



Source: University of New Hampshire UNH/Global Runoff Data Centre GRDC http://www.grdc.sr.unh.edu/

Figure 1 shows the degree of **river fragmentation**, or interruption, in the world's major drainage basins. River fragmentation is an indicator of the degree to which rivers have been modified by humans. Highly affected rivers have less than 25 per cent of their main channel remaining without dams, and/or the annual flow pattern has changed substantially. Unaffected rivers may have dams only on tributaries but not the main channel, and their discharge has changed by less than 2 per cent.

Dams, **reservoirs** and **weirs** have been constructed to improve human wellbeing by providing reliable water for agricultural, domestic and industrial use. Dams can also provide flood protection and generate electricity.

river fragmentation the interruption of a river's natural flow by dams, withdrawals or transfers

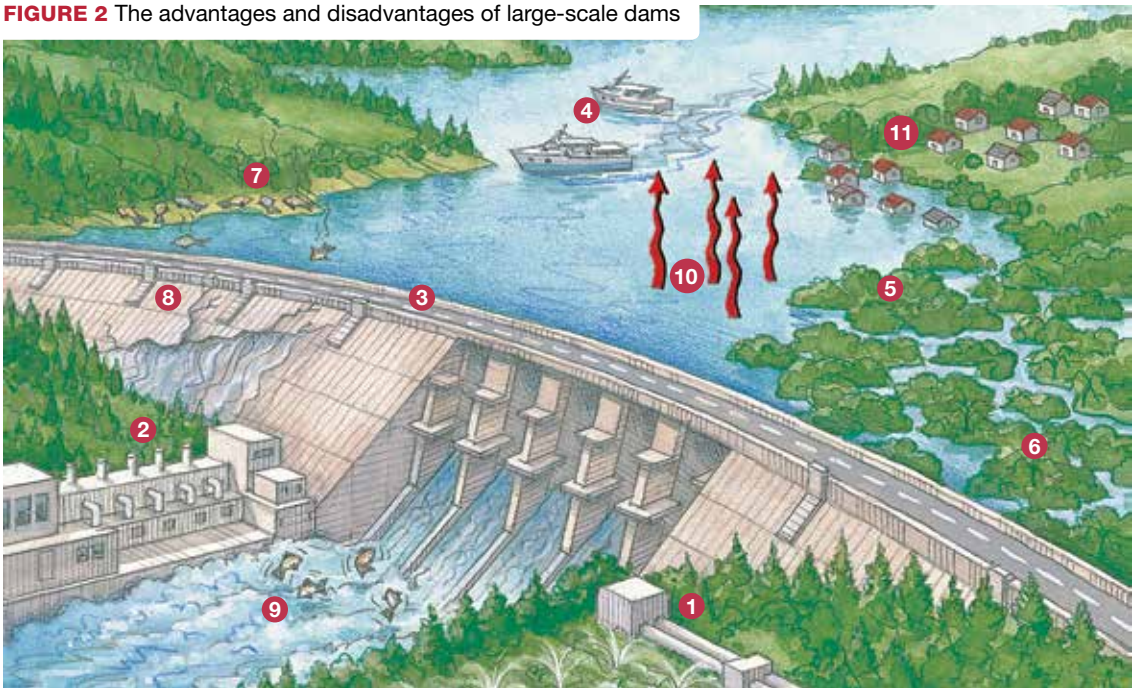
reservoir large natural or artificial lake used to store water, created behind a barrier or dam wall

weir wall or dam built across a river channel to raise the level of water behind. This can then be used for gravity-fed irrigation.

14.3.2 What changes do dams bring?

Rivers and the native flora and fauna that surround them have adapted to the natural fluctuations of water levels for thousands of years. These periods of high and low water flow have created rich and diverse ecosystems. While there are many benefits, large-scale or mega dams bring significant changes to the environment and surrounding communities (see figure 2).

FIGURE 2 The advantages and disadvantages of large-scale dams



Positive changes

1. A regular water supply allows for irrigation farming. Only 18 per cent of the world's arable land is irrigated, but it produces over 40 per cent of crop output.
2. Released water can generate hydro-electricity, which accounts for 24 per cent of global energy and 90 per cent of renewable energy.
3. Dams can hold back water to reduce flooding and even out seasonal changes in river flow.
4. Income can be generated from tourism, recreation and the sale of electricity, water and agricultural products.

Negative changes

5. Large areas of fertile land upstream become flooded or inundated as water backs up behind the dam wall. Alluvium or silt is deposited in the calm water that previously would have enriched floodplains.
6. Initially, flooded vegetation rots and releases greenhouse gases.
7. The release of cold water from dams creates thermal pollution. Originally the Colorado River had a seasonal fluctuation in temperature of 27 °C. Today, temperatures average 8 °C all year. The water is too cold for native fish reproduction, but is ideal for some introduced species.
8. Some dams are constructed in tectonically unstable areas, which are prone to earthquakes.
9. Dams block the natural migration of fish upstream.
10. Over 7 per cent of the world's fresh water is lost through evaporation from water storages.
11. More than 30 million people worldwide have been forced from their homes and land due to dams. Often these people are poor or indigenous and receive little compensation.

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Interactivity
Dam it
Use this interactivity to classify the impacts of damming rivers.
Searchlight ID: int-3292

CASE STUDY 1

Dammed disasters: the Samarco mine dam

Samarco is a Brazilian mining company jointly owned by Vale and BHP Billiton. On 5 November 2015 a dam owned by Samarco, containing by-products of iron mining, collapsed.

The dam, located in the Bento Rodrigues subdistrict of Mariana, Brazil (see figure 3), sent up to 60 million cubic metres of water, mud and iron-ore by-products down the mountainside, causing significant flooding and killing 16 people (see figure 4).

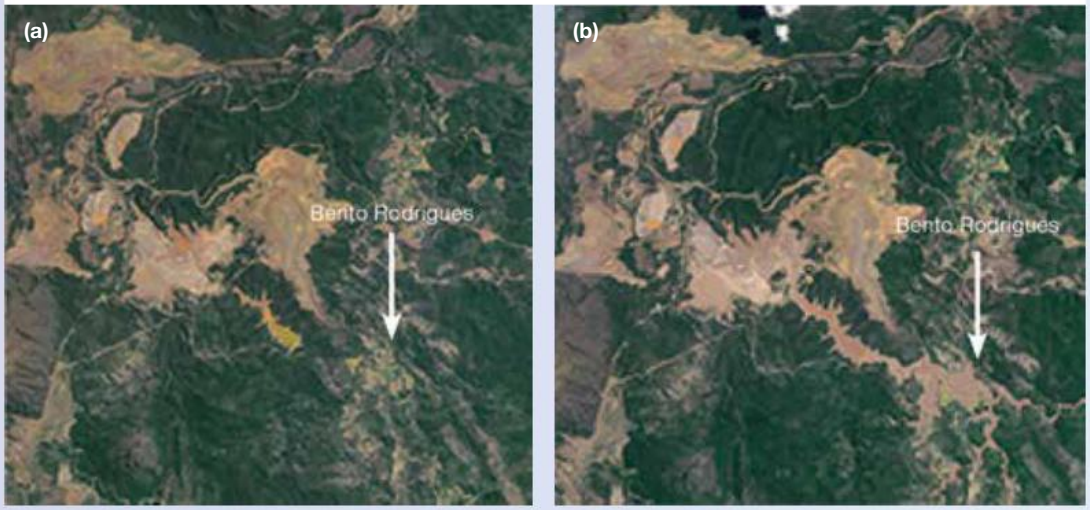
The toxic sludge, containing substances such as mercury and arsenic, flowed into the Rio Doce (the Doce River) and travelled more than 500 kilometres to the Atlantic Ocean (see figure 5). The pollution has killed thousands of fish, cut off drinking water to a quarter of a million people and significantly altered marine food chains along the coast of Brazil and into the Southern Atlantic Ocean.

FIGURE 3 Map of Bento Rodrigues

Source: www.theguardian.com

FIGURE 4 Bento Rodrigues after the dam burst

FIGURE 5 Satellite images showing Bento Rodrigues; (a) shows the landscape before the dam burst and (b) shows the toxic sludge spreading across the landscape.

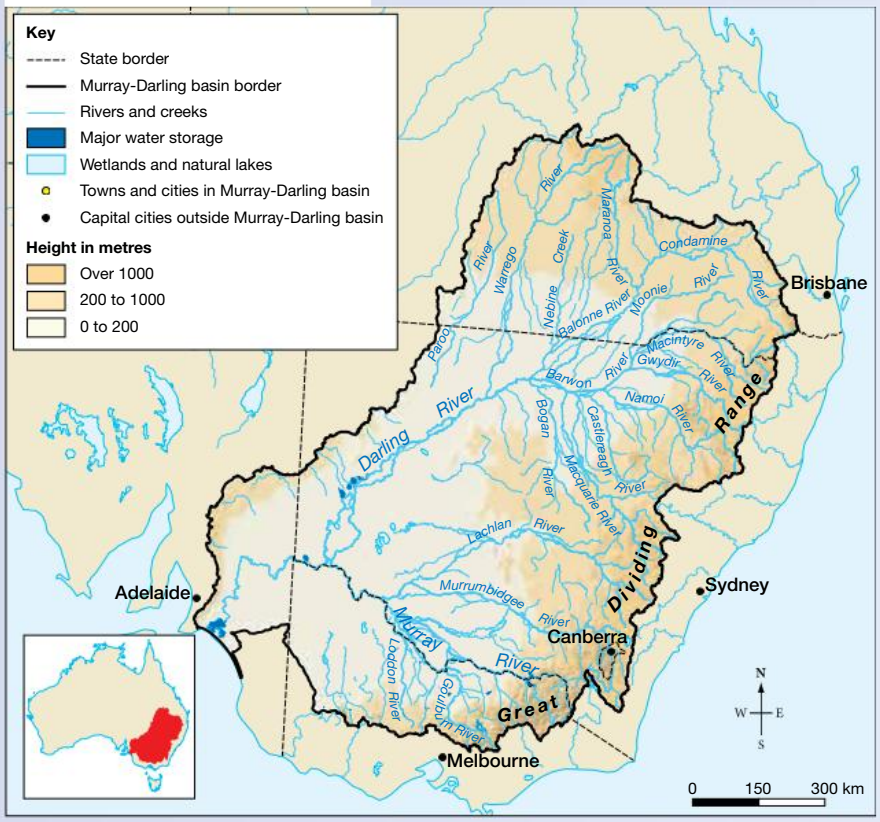


CASE STUDY 2

Murray–Darling Basin

Damming or building weirs in rivers significantly alters the natural migration of fish which has an impact on the fish population and the river ecosystem. In the Murray–Darling basin there are over 3600 physical barriers to the movement of native fish in the form of dams, weirs, levees, causeways, culverts and road crossings, with only a small number of these having passageways for fish. This is particularly detrimental to the Murray Cod, a native Australian fish whose migration and breeding areas have been significantly altered because of river regulation.

FIGURE 6 Murray–Darling Basin



Source: Spatial Vision

CASE STUDY 3

Yangtze River

The Three Gorges Dam, located on the Yangtze River in China, has had a huge impact on the spawning of several fish species in the river. Since the dam's construction the annual harvest of four species of carp, as well as their larvae and eggs, was 50–70 per cent below pre-dam levels. Other dams along the Yangtze River have further fragmented the fish habitats and led to the decline in the populations of three of China's famous ancient fish species; the Chinese sturgeon, River sturgeon and Chinese paddlefish.

FIGURE 7 Yangtze River

Source: Spatial Vision

FOCUS ON FIELDWORK

Investigating the impacts of weirs and walls on water quality

Visit a weir, floodgate or dam wall in your local catchment to investigate the effects it has on the water quality. Take measurements of the water temperature, turbidity and pH, as well as observations, at different points along the waterway, including inside the barrier and in the main water channel. Tabulate these results and the time of day at which they were taken. You may wish to collect the data over a long period of time.

Compare the results at each location and make suggestions as to how the water quality is being affected at each location. Consider the following questions:

1. How did the barrier affect the water temperature and pH?
2. Was any water hyacinth evident?
3. Did you observe any evidence of blue green algae in the still water?
4. What impacts has the barrier had on the water quality?
5. Why was the barrier built?

FIGURE 8 The water hyacinth is an aquatic weed, native to the Amazon Basin. Imported into Australia in the 1890s, it has infested rivers, lakes and dams, covering the surface and altering the natural habitat.

ACTIVITIES

IDENTIFY

1 What human activities are responsible for ***changing*** or fragmenting rivers?
2 Using figure 1, describe the location of ***places*** with rivers that are largely unaffected by river fragmentation.
3 Using your atlas, compare a map of world population distribution with figure 1. What do you notice about the ***interconnection*** between population concentration and moderately to highly fragmented rivers?
4 Suggest the ways that native fish can be affected by large dams.

EXPLAIN

5 Construct a table with the following headings to classify the impacts of dam building. Use information from figure 2 and include impacts from your own region.

Positive impacts on people	Negative impacts on people

Positive impacts on environment	Negative impacts on environment

6 Use the **Controversial dams** weblink in your eBookPLUS to view slides of 10 of the world's most controversial dams. Construct a table to (a) name each scheme and its location, (b) list the purposes for each of the dams and (c) list reasons why the schemes are controversial.
7 'The positive impacts of large dam building projects on people outweigh the negative impacts on the environment.' Do you agree or disagree with this statement? Give reasons for your point of view.
8 Use the **IRO** weblink in your eBookPLUS to watch a video called 'We all live downstream' by the International Rivers organisation.
  a Explain what is meant by the phrase 'Rivers connect landscapes, cultures and livelihoods.'
  b What would you consider are the two main messages coming from this video?
  c What do you think people can do to reduce the impacts of proposed new dams?

INVESTIGATE

9 Research the strategies that have been implemented to aid fish migration in both the Murray–Darling and Yangtze Rivers. Use data to compare the success of the strategies and make recommendations to further mitigate species decline in both rivers.

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Weblinks
- Controversial dams
- IRO

14.4 Do we have to dam?

14.4.1 Why should a river flow?

Traditionally, water flowing out to sea was seen as a waste. If it could be stored, then it could be used. Little thought was given to the health of the river and the importance of keeping water in a stream. The benefits of damming rivers for multi-purpose use have always been given priority by governments around the world. But is this the only solution to our growing water needs?

Large-scale or mega dams have always been linked to economic development and improvement in living standards. It has only been in recent times that the real costs of these schemes, environmentally, economically and socially, have been questioned. Figure 1 shows the number of downstream communities in each country that have the potential to be affected by the construction of mega dams.

There is also the concern that multi-purpose dams have conflicting aims. To generate hydroelectricity you need to release a large volume of stored water. To provide **flood mitigation** you need to keep water levels low in a dam, but then you need a large store if you wish to use the water for irrigation. So what do you do?

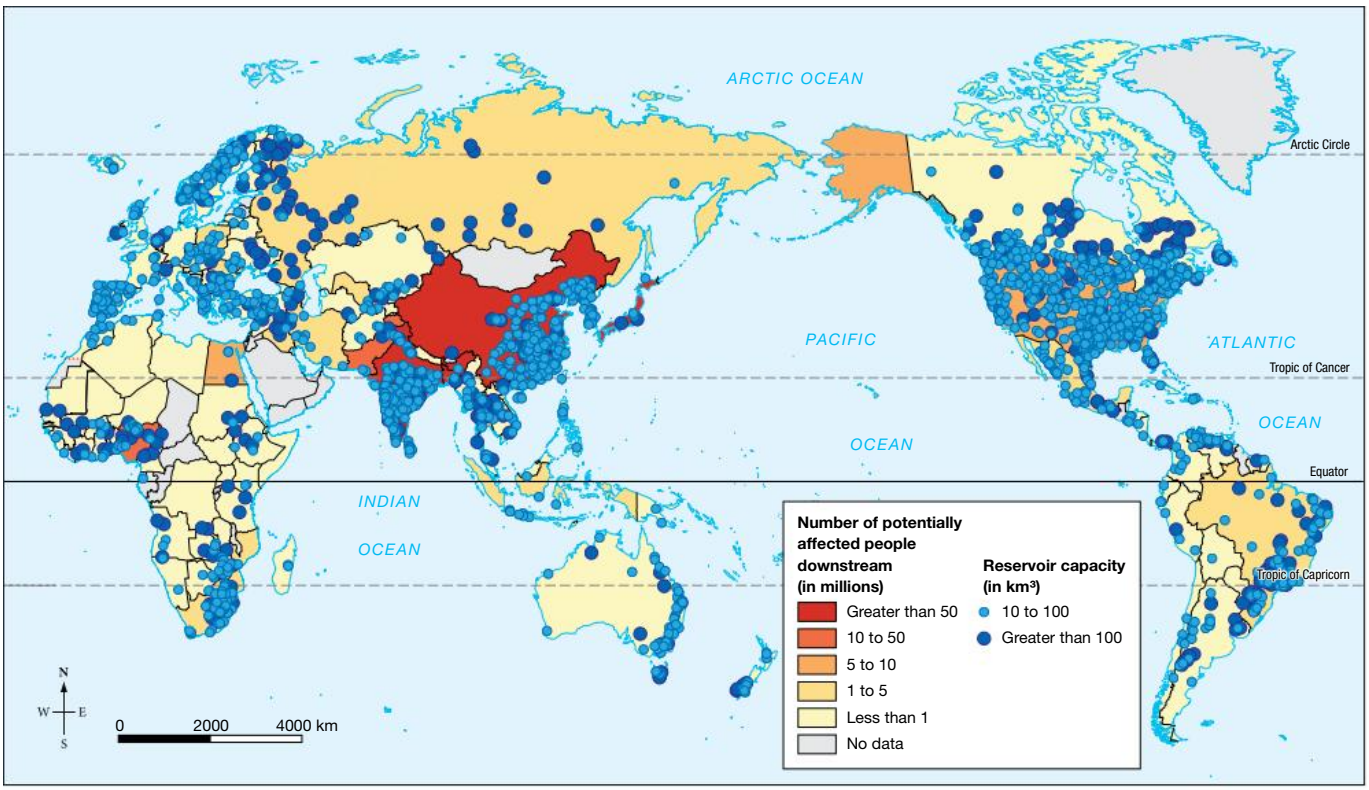
flood mitigation managing the effects of floods rather than trying to prevent them altogether

More than one billion people worldwide lack access to a decent water supply, yet it has been estimated that only 1 per cent of current water use could supply 40 litres of water per person per day, if the water was properly managed. The problem is not so much the quantity or distribution of water resources but the mismanagement of it. During the twentieth century, over $2 trillion has been spent on the construction of more than 50 000 dams. The emphasis now is to switch from *controlling* river flow to *adapting* to river flow. In other words, building small-scale projects that promote social and environmental sustainability. In many regions of the world, whole communities are protesting against the need for mega dams in preference to smaller schemes that benefit local people directly (see subtopic 14.6).

14.4.2 What are the alternatives to dams?

There are viable alternatives to dams that are often cheaper and have fewer social and environmental impacts. The focus has to be, firstly, the reduction in demand for water and, secondly, on being more efficient with the existing water.

FIGURE 1 Distribution of downstream communities affected by large dams



Source: Lehner *et al.:* High resolution mapping of the world's reservoirs and dams for sustainable river flow management. Frontiers in Ecology and the Environment. GWSP Digital Water Atlas (2008). Map 81: GRanD Database (V1.0). Available online at http://atlas.gwsp.org.

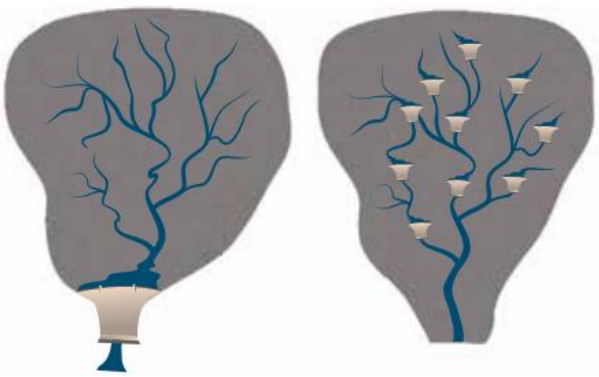
How can water savings be made?

Agriculture

Globally, more than 70 per cent of fresh water is used for agriculture. Irrigation is often very inefficient, with over half of the water applied not actually reaching the plants. High rates of evaporation and leaking **infrastructure** waste water. Often governments subsidise and encourage farmers to grow water-thirsty crops, such as cotton, in semi-arid regions. Poorly designed and managed irrigation schemes can become unsustainable if they develop waterlogging and salinity problems.

infrastructure the facilities, services and installations needed for a society to function, such as transportation and communications systems, water and power lines

FIGURE 2 Research in India has shown that 10 micro dams with one-hectare catchments will store more water than one dam of 10 hectares.



Vast water savings could be made by improving irrigation methods, switching to less water-consuming crops and taking poor quality land out of production. If the amount of water consumed by irrigation was reduced by 10 per cent, water available for domestic use could double across the globe.

Urban use

It is estimated that as much as 40 per cent of water is wasted in urban areas just through leaking pipes and taps. Savings can be made by:

- reducing leaking pipes and improving water delivery infrastructure
- encouraging the use of water- and energy-efficient appliances and fixtures

- changing the pricing of water to a 'the more you use, the more you pay' system
- offering incentives to industry to reduce water waste and recycle
- harvesting rainwater, collecting rainwater off roofs, recycling domestic wastewater and other efficiency schemes.

Small-scale solutions

It has been estimated that it would cost $9 billion a year between now and 2025 to provide all of the world's people with adequate water and sanitation using small-scale technologies. This amount is only one-third of current spending in developed nations on water and sanitation. It is the equivalent of nine day's defence spending by the United States of America. Rather than one large, expensive dam, smaller projects that benefit local communities can be more desirable. These are often constructed and maintained by people who benefit directly from control over their own resources, at a minimal cost (see figure 2).

How can we reduce the need for dams?

As many countries are actually running out of suitable places to locate large dams, alternatives need to be found. **Rainwater harvesting** schemes such as illustrated in figure 3 (a) and (b) can be used for storing water. **Micro hydro-dams** (see figure 4) can be used for generating electricity. Both of these schemes are easier and cheaper to build than large dams, and have lower environmental impacts.

rainwater harvesting the accumulating and storing of rainwater for re-use before it soaks into underground aquifers

micro hydro-dam dam that produces hydro-electric power on a scale serving a small community (less than 10 MW). They usually require minimal construction and have very little environmental impact.

FIGURE 3 Two methods for water harvesting: (a) rainwater tank and (b) groundwater recharging

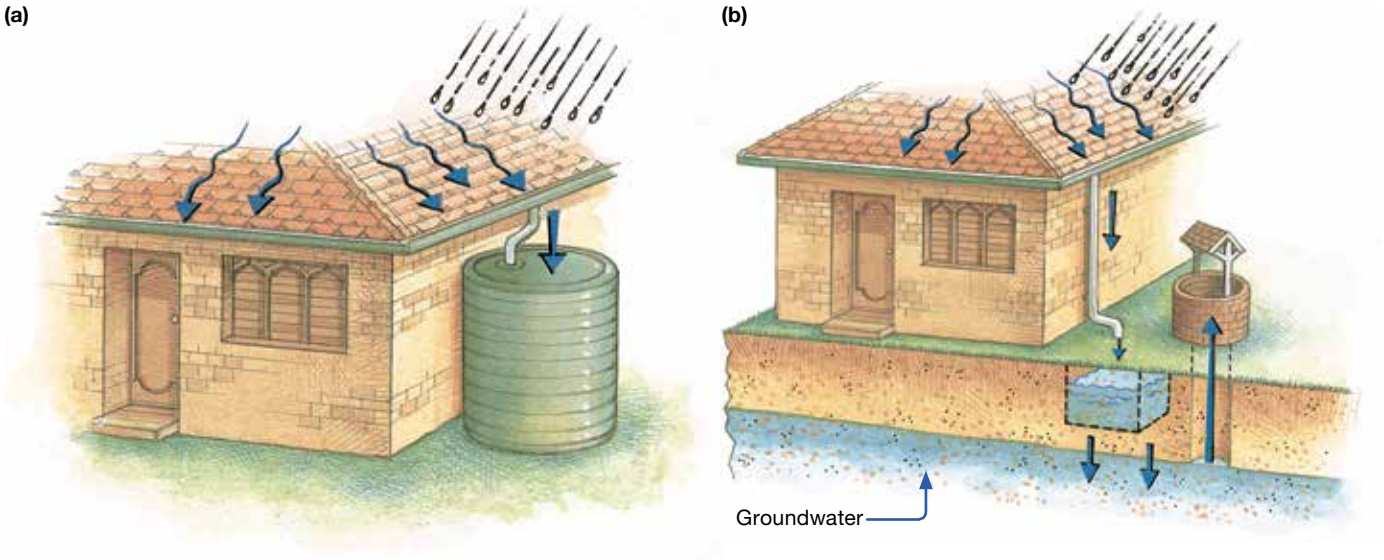


FIGURE 4 Water collected from a stream uphill rushes down the pipe and drives a small turbine in the hut to generate electricity for a local community in the Philippines.

CASE STUDY

Rajasthan, India

The state of Rajasthan is located in the arid north-west of India (see figure 5). The region has only 1 per cent of the country's surface water and a population growth rate of 21 per cent (compared to Australia's 1.5 per cent). The largest state in India faces both water scarcity and frequent droughts. Continual pumping of groundwater has seen underground water supplies dropping.

Traditionally, forests, grasslands and animals were considered property to be shared by all, and were carefully managed by a strict set of rules by local communities. These resources were used sustainably to ensure continual regeneration of plants and trees to enable farming to continue each year. By the mid twentieth century, government initiatives had taken control of local resources and promoted excessive mining and logging in the area. Large-scale deforestation resulted in severe land degradation, which increased the frequency of flash floods and droughts. There was little motivation for villages to maintain traditional water systems, or johads, and so there was a gradual decline in people's economic and social wellbeing.

Tarun Bharat Sangh (TBS) is an aid agency that was established in the mid-1980s. It set about trying to re-establish traditional water management practices. It focused its attention on the construction and repair of nearly 10 000 johads in over 1000 villages. Johads are often small, dirt embankments that collect rainwater and allow it to soak into the soil and recharge groundwater aquifers (see figure 6).

Another johad design features small concrete dams across gullies that would seasonally flood, trapping the water and allowing it to infiltrate. Water, stored in aquifers, can later be withdrawn when needed via wells. The benefits have been remarkable and the estimated cost calculated to be an average of US$2 or 100 rupees per person. This is compared to over 10 000 rupees per head for water supplied from the Narmada River Dam Project.

What have been the benefits?

Environmental benefits

- Groundwater has risen by six metres.
- Five rivers which flowed only after the monsoon season now flow all year (fed by **base flow**).
- Revegetation schemes have increased forest cover by 38 per cent, which helps improve the soil's ability to hold water and reduce evaporation and erosion.

Social benefits

- More than 700 000 people across Rajasthan have benefited from improved access to water for household and farming use.
- There has been a revival of traditional cultural practices in constructing and maintaining johads.
- The role of the village council (Gram Sabha) is promoted for encouraging community participation and social justice.
- With a more reliable water supply communities became more economically viable.

FIGURE 5 Distribution of rainfall in India. The state of Rajasthan is highlighted.

Source: World Climate - http://www.worldclim.org/

FIGURE 6 A johad or traditional small water harvesting dam in India

ACTIVITIES

IDENTIFY

1 Why has water flowing out to sea been considered a waste?

2 a Refer to figure 1. Which countries in the world have the most number of people affected by large dams? Suggest a reason why.
  b In what ways would they be affected?
  c Would people and ***environments*** upstream of large dams be affected by the dams? Give reasons for your answer.

3 Where are the world's largest (over 100 km^3) dams?

EXPLAIN

4 Suggest reasons why large-***scale*** dam projects were seen as indicators of development and progress in countries.

5 Suggest reasons that make a ***place*** suitable for a large dam. Consider landforms, climate, soil and rock type.

6 Study the information in figure 5. Explain why Rajasthan has water issues. Use data in your answer.

7 Some ***places*** in India can receive up to 2500 mm of rainfall per year, but this can all fall in 100 hours. Suggest possible repercussions of this for local communities.

8 Have small-***scale*** water management schemes in Rajasthan been successful? Why or why not?

INVESTIGATE

9 a Investigate the different methods of irrigating crops, such as flood, furrow and drip irrigation. What are the advantages and disadvantages of each in terms of water use and waste?
  b Which irrigation method would:
    i be the most economically viable
    ii have the most ***environmental*** benefit?

10 Use the **Water harvest** weblink in your eBookPLUS.
  a Select two locations and describe the different traditional water harvesting schemes in use.
  b Compare your two locations and schemes with the johad scheme in Rajasthan, and evaluate how effective they are in terms of economic viability (how affordable they are to construct and manage), ***environmental*** benefit (if they are using the water resources ***sustainably***) and social justice (if the schemes are fair for all people, and if the community benefits).

base flow water entering a stream from groundwater seepage, usually through the banks and bed of the stream

eBookplus

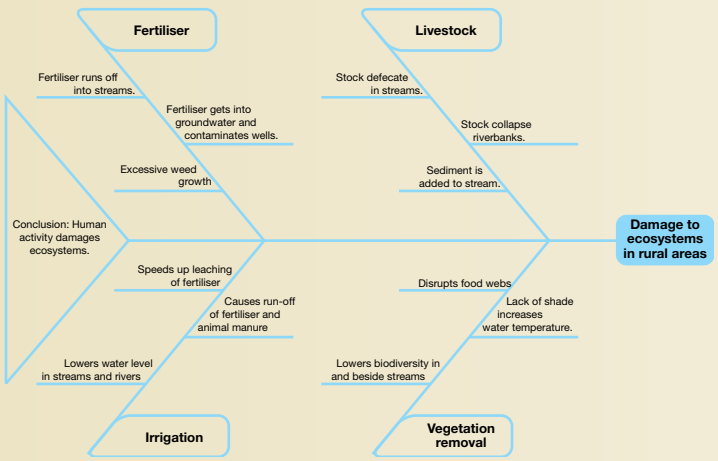
Weblink
Water harvest

eBookplus ONLINE ONLY

14.5 SkillBuilder: Creating a fishbone diagram

What is a fishbone diagram?

A fishbone diagram is a graphic representation of the causes of a particular effect. Fishbone diagrams can also detail the positive and negative impacts of an action or event.



eLesson
Watch this video to learn how to create a fishbone diagram.

Searchlight ID: eles-1748

Interactivity
Try this interactivity to learn how to create a fishbone diagram.

Searchlight ID: int-3366

14.6 Is fighting worth a dam?

14.6.1 People versus power?

Around the world, from Africa to Asia to South America, there has been a growing movement of community and environmental groups challenging the construction of mega dams in terms of location and potential impacts. Organisations such as International Rivers work with local groups to help restore justice to dam-affected communities, find better alternatives and promote the restoration of the river through better dam management.

CASE STUDY

Belo Monte Dam, Brazil

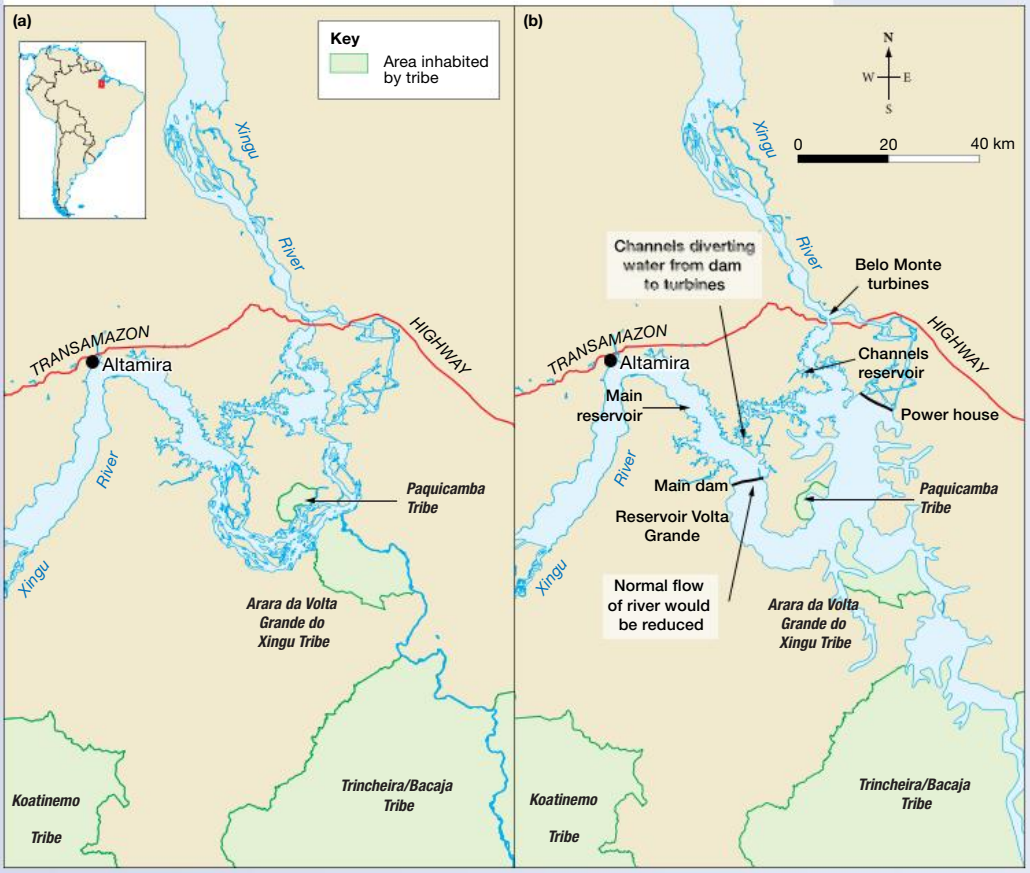
For over 20 years, there has been an ongoing protest (see figure 3) over the planned construction of five huge dams on the Xingu River in Brazil. The project was eventually cancelled and replaced with the single Belo Monte Dam (see figure 1).

Work commenced in 2012 on what is to be the world's third largest dam (see figure 2). The dam is designed to divert more than 80 per cent of the flow of the Xingu River, drying out over 100 kilometres of river, known as the Big Bend. It will flood over 516 km^2 of rainforest and displace more than 20 000 Indigenous people, although environmental groups put the figure closer to 40 000. The estimated cost is $18 billion and the government plans to invest $1.2 billion to reduce the negative impacts of the dam.

Construction has been delayed and battles fought in court over the legality of the **environmental impact assessment**, which was done after work had already started on the project. For the indigenous people, diverting water from the river channel will reduce fish populations. There are very few roads in the region so river trading will be reduced. The

environmental impact assessment a tool used to identify the environmental, social and economic impacts, both positive and negative, of a project prior to decision-making and construction

FIGURE 1 (a) Location of the Belo Monte Dam and (b) the changes it will bring



Source: Spatial Vision

FIGURE 2 First stages of the constuction of the Belo Monte Dam

FIGURE 3 Protesters at the dam site cut a channel through earthworks to restore flow in the Xingu River. The wording translates as 'Stop Belo Monte'.

loss of rainforest, lowering of watertables and drying out of soils are further predicted impacts. Traditional livelihoods and cultures based on small-scale fishing, floodplain farming and forest management will disappear.

While the government is claiming the dam will provide **green energy**, the amount of greenhouse gas released from drowned and rotting vegetation, behind the dam wall, will actually contribute to global warming for some years. River flow in the region is seasonal, so hydro-electricity can be generated at peak flow for only a few months of the year. During the dry months, only 1000 MW of a potential 11 000 MW will be generated. There is a distinct possibility that another dam will need to be built upstream to supply a more even and continual flow of water for power generation. Run-off from the construction site is already affecting water quality for people using the river for drinking and fishing. Upstream, the small town of Altamira (see figure 1) is rapidly expanding, with an estimated population of 20 000 labourers flooding in looking for construction work. Land prices are skyrocketing, the cost of living is increasing and crime rates are soaring.

green energy
sustainable or alternative energy (e.g. wind, solar and tidal)

ACTIVITIES

IDENTIFY

1 What is the primary aim of an ***environmental*** impact assessment?
2 Why won't the Belo Monte Dam be able to generate maximum electricity all year round?
3 Refer to figure 2. What do you notice about the landscape in this image?

EXPLAIN

4 Refer to figure 1(a) and (b) to describe the ***environmental changes*** the dam will bring to the Xingu River.

INVESTIGATE

5 Research one other controversial dam site around the world and compare it with the Belo Monte dam in terms of (a) size, (b) purpose and (c) impacts.

Some suggestions are dams planned or under construction on the Omo and Zambezi Rivers (Africa), Mekong River (Southeast Asia) or Ganges River (southern Asia).

6 Find out more about the Belo Monte Dam using the **Belo Monte tour** weblink in your eBookPLUS. What is the purpose of a protest group? How effective do you think they are? Also refer to figure 3.
7 Will the Belo Monte Dam bring economic, social and ***environmental*** benefits? Discuss your viewpoint, using these criteria as subheadings.

PREDICT

8 Is there a ***sustainable*** future for mega dam projects such as the Belo Monte Dam? Justify your answer.

eBook*plus*

Weblink
Belo Monte tour

14.7 What happens when we divert water?

14.7.1 Why is water diverted?

Many of the world's greatest lakes are shrinking, and large rivers such as the Colorado, Rio Grande, Indus, Ganges, Nile and Murray discharge very little water into the sea for months and even years at a time. Up to one-third of the world's major rivers and lakes are drying up, and the groundwater wells for 3 billion people are being affected. The overuse and diversion of water is largely to blame.

diversion man-made project to divert the water from a river

Due to the uneven distribution of water and population there is often the need to transfer water, and large-scale **diversions** often require piping or pumping water from one drainage basin to another. For example, water from the Snowy River is diverted into the Murray and Murrumbidgee rivers. Diverting water can alleviate water shortages and allows for the development of irrigation and the production of hydro-electricity. Diversions, however, are not always the most sustainable use of water resources.

14.7.2 A dying Lake Urmia in Iran

terminal lake a lake from which the water does not drain into a river or sea. Water can leave only through evaporation, which can increase salt levels in arid regions. Also known as an endorheic lake.

The largest lake in the Middle East and one of the largest salt lakes in the world is drying up. Since 2005, Lake Urmia in northern Iran has lost more than 65 per cent of its surface area, exposing extensive areas of salt flats (see figure 1 (a) and (b)).

The lake was declared a Wetland of International Importance by the Ramsar Convention in 1971, and a UNESCO Biosphere Reserve in 1976. The lake and its surrounding wetlands serve as a seasonal habitat and feeding ground for migratory birds that feed on the lake's shrimp. This shrimp is the only thing, other than plankton, that can live in the salty water. Lake Urmia is a **terminal lake**: the rivers, some permanent and some ephemeral, that flow into the lake bring naturally occurring salts. Because of the arid climate, high evaporation causes salt crystals to build up around the shoreline. Figure 2 shows the declining surface area of Lake Urmia.

FIGURE 1 Lake Urmia (a) in 1998 and (b) in 2011

FIGURE 2 Declining surface area of Lake Urmia

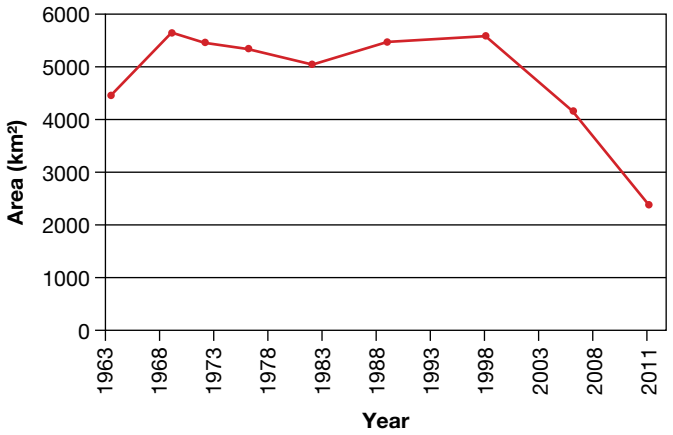
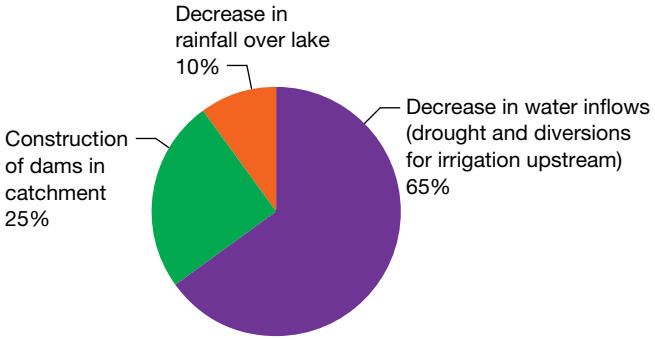


FIGURE 3 Reasons for Lake Urmia's decline



Note: Average rainfall is 235 mm. The last decade has seen this decrease by 40 mm.

Why is the lake drying up?

Reasons for the decline in the lake's level are a combination of prolonged drought and increased diversions for irrigation (see figure 3). Often people withdraw water illegally, without paying for it, or take more than they are allocated.

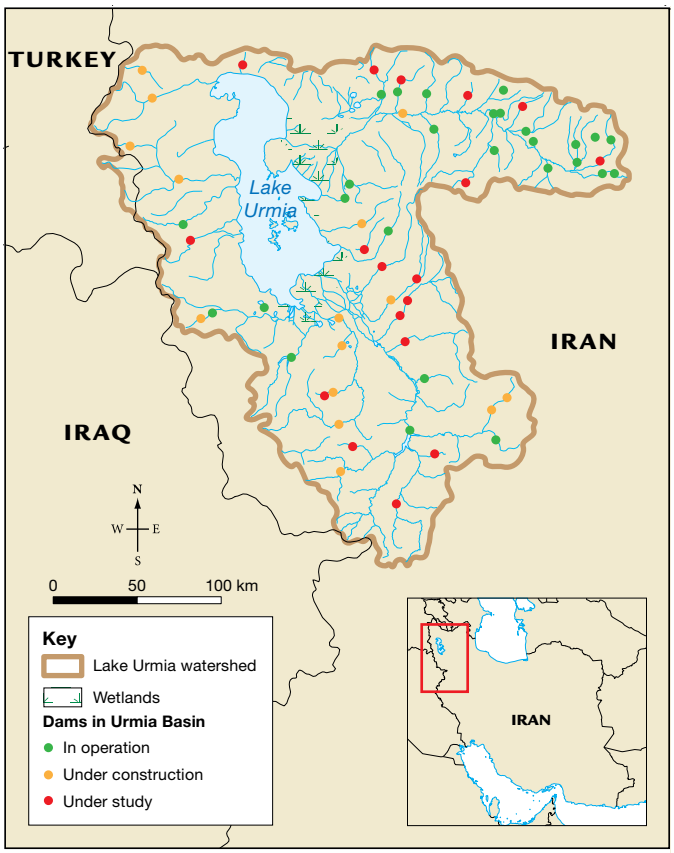
Impacts include:

- increased salinity of the lake due to high evaporation and reduced fresh water flowing in via rivers (salt levels have increased from 160 g/litre to 330 g/litre)
- collapse of the lake's ecosystem and food chain. Salt levels of over 320 g/litre are fatal to the lake's brine shrimp which are the only link in the food chain between algae and the migratory bird population.
- loss of habitat as surrounding wetlands dry up, which then reduces tourism to view wetland wildlife
- over 400 square kilometres of exposed lakebed around its shores is nothing but salty deserts, unable to support native vegetation or food crops
- salt storms occur as wind blows salt and dust from the exposed, dry lakebed, which is a potential health hazard for people
- less water is available for food production.

Possible actions

Essentially, more water is required to flow into the lake to increase the water level and dilute the salt. This water must come from either reducing water allocated to irrigation and/or transferring water into the basin from the Zab or Aras rivers or even the Caspian Sea, over 300 kilometres away. This would require the cooperation of other countries and the scale of the project would be very expensive. Would it be enough to save the lake?

FIGURE 4 Distribution of dams, existing and under construction, in the lake's catchment area. This level of diversions is unsustainable.



Source: Spatial Vision

ACTIVITIES

INVESTIGATE

Conduct some online research and investigate the decline of either Lake Chad in Africa, Owens Lake in the United States or the Aral Sea in Kazakhstan. Use the following points as a guide to writing an investigative report:

- location
- original size and appearance of the lake/sea
- original uses of the lake/sea and surrounding area
- causes and rate of decline
- ***changes*** that have taken place
- impacts on people and the ***environment***
- possible solutions.

Include annotated images, maps and data where possible.

14.8 Why is groundwater shrinking?

14.8.1 What is groundwater?

Of all the fresh water in the world not locked up in ice sheets and glaciers, less than 1 per cent is available for human use and most of that is groundwater. Groundwater is used by more than two billion people, making it the single most used natural resource in the world. It is also the most reliable of all water sources. Fresh water stored deep underground is essential for life on Earth.

Groundwater is one of the invisible parts of the water cycle as it lies beneath our feet. Rainfall that does not run off the surface or fill rivers, lakes and oceans will gradually seep into the ground. Figure 1 shows where groundwater is stored in porous rock layers called aquifers. Water is able to move through these aquifers and can be stored for thousands of years. Unlike most other natural resources, groundwater is found everywhere throughout the world.

14.8.2 What are the advantages of using groundwater?

watertable upper level of groundwater, below which all pores in the soils and rock layers are saturated with water

recharge the process by which groundwater is replenished by the slow movement of water down through soil and rock layers

subsidence the gradual sinking of landforms to a lower level as a result of earth movements, mining operations or over-withdrawal of water

Since the mid-twentieth century, advances in drilling and pumping technology have provided people with an alternative to surface water for meeting increasing water demands. Groundwater (see figure 1) has many advantages:

- It can be cleaner than surface water.
- It is less subject to seasonal variation and there is less waste through evaporation.
- It requires less and cheaper infrastructure for pumping as opposed to dam construction.
- It has enabled large-scale irrigated farming to take place.
- In arid and semi-arid places groundwater has become a more reliable water supply, which has led to improved water and food security.

If groundwater is removed unsustainably, that is, at a rate that is greater than is being replenished naturally by rainfall, run-off or underground flow, then **watertables** drop and it becomes harder and more expensive to pump. In areas of low rainfall there is very little **recharge** of groundwater so it may take thousands of years to replace. Over-extraction of groundwater can result in wells running dry, less water seeping into rivers and even land **subsidence** or sinking. Figure 2 identifies those places in the world most at risk of groundwater depletion. Many of these are important food bowls for the world.

14.8.3 Can we improve our use of groundwater?

In the past we had limited knowledge of the interconnection between groundwater and surface water. As agriculture is the biggest user of groundwater, any improved efficiencies in water use can reduce the demand for pumping more water. Improved irrigation methods and the re-use of treated effluent water are all methods that could reduce our unsustainable use of groundwater. Many countries share aquifers so pumping in one place can affect water supplies in another. There is a need for more international cooperation and management of the aquifer as a single shared resource.

FIGURE 1 Diagram showing groundwater

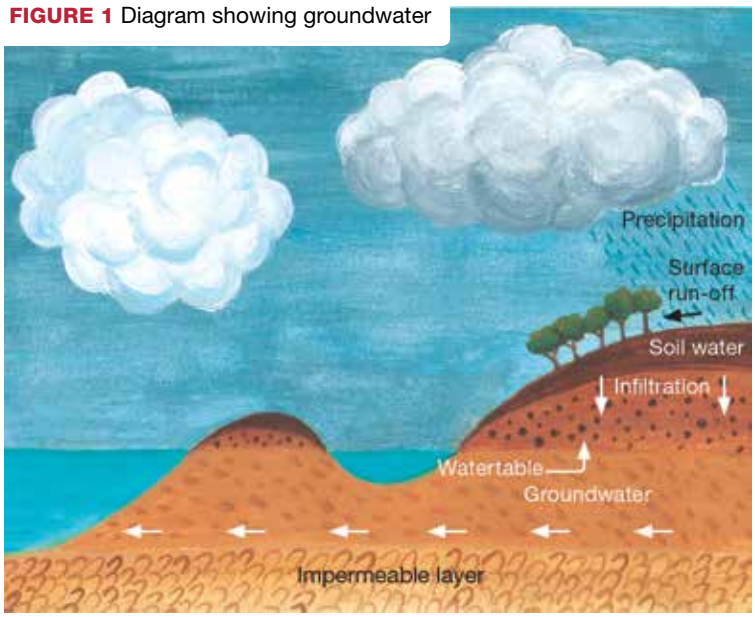
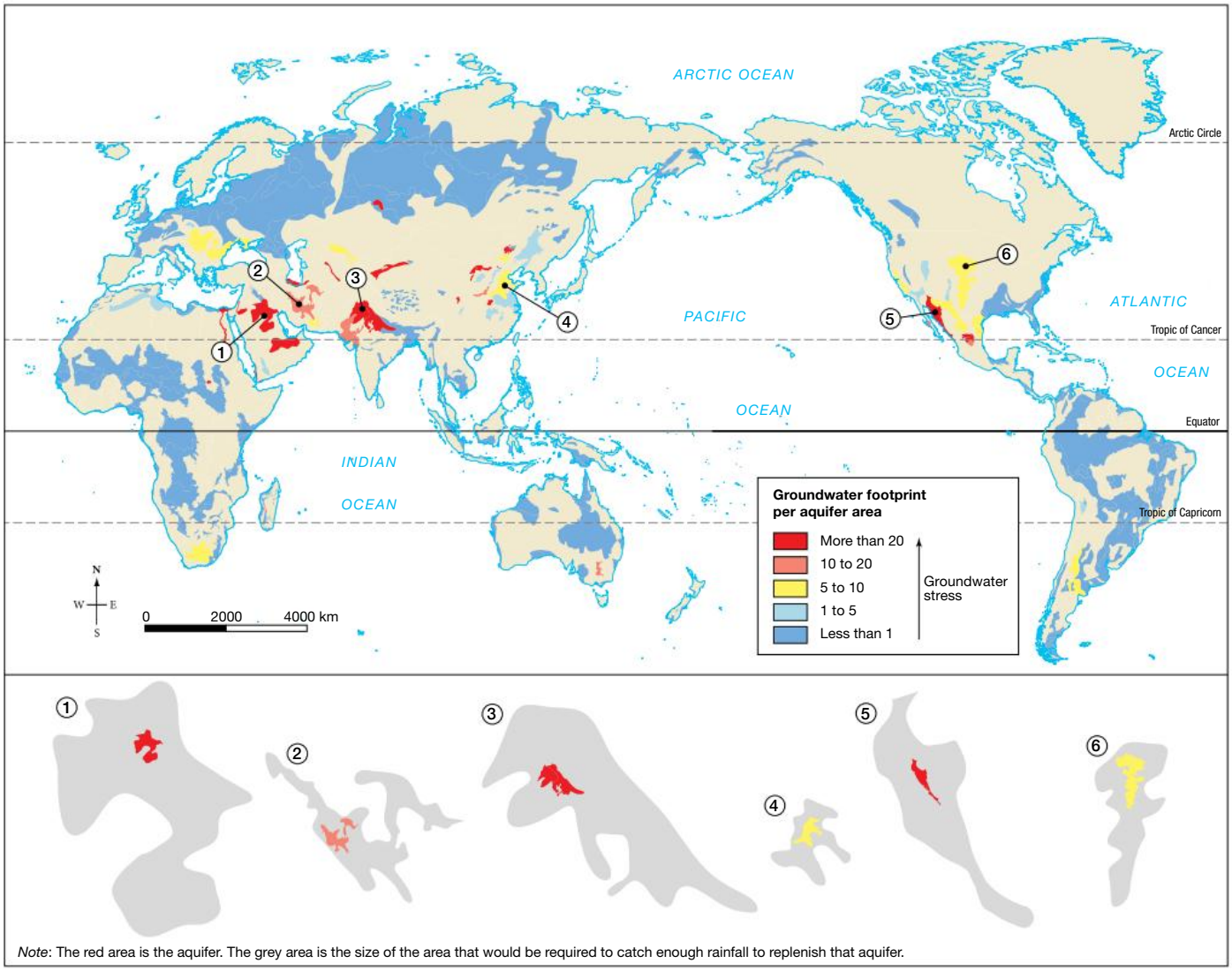


FIGURE 2 The world's use of groundwater



Note: The red area is the aquifer. The grey area is the size of the area that would be required to catch enough rainfall to replenish that aquifer.

Source: BGR & UNESCO 2008: Groundwater Resources of the World 1 : 25 000 000. Hannover, Paris.

ACTIVITIES

IDENTIFY

1 Refer to the interactivity 'That sinking feeling' (int-3293) in the Resources tab and figure 1.
   - **a** What is the difference between groundwater and the watertable?
   - **b** Describe how water can move vertically and horizontally through the ground.
   - **c** What is the ***interconnection*** between atmospheric, surface and groundwater?

2 Refer to figure 2. Describe, with the use of an atlas, the location of ***places*** in the world that have the highest groundwater stress.

EXPLAIN

3 What are the advantages and disadvantages of using groundwater for domestic and agricultural purposes?

4 Looking at figure 2, explain the ***scale*** of the area needed to replenish the most stressed aquifers.

PREDICT

5 Using an atlas, find a map of world food production and compare this with any three ***places*** from figure 2.
   - **a** What types of food are produced in those regions of the world where watertables are severely depleted?
   - **b** What are the future implications for ***sustainable*** food production in these regions?

APPLY

6 Who owns groundwater? How can we manage the resource ***sustainably***? Write a paragraph expressing your viewpoint.

eBook*plus*

Interactivity
That sinking feeling
Use this interactivity to learn more about how people change groundwater resources.
Searchlight ID: int-3293

14.9 Why is China drying up?

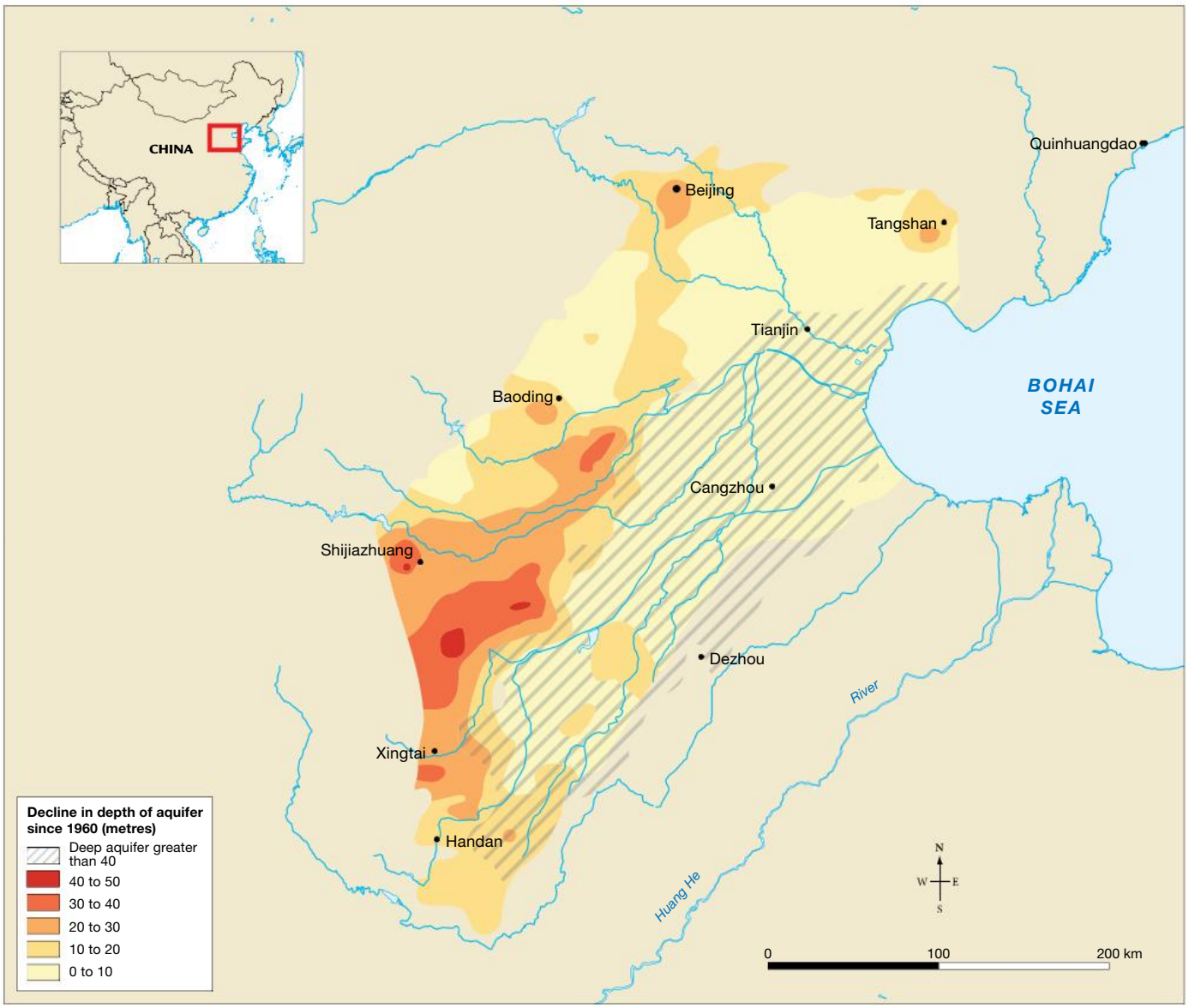
14.9.1 What is happening to groundwater in China?

What do you do if you don't have access to a reliable water source? You do what hundreds of millions of people do around the world on a daily basis. You dig for it. Beneath our feet lie vast quantities of fresh water that may have taken thousands of years to slowly work its way deep into rock layers. Since ancient times, people have used groundwater to provide for their water needs.

The groundwater under the North China Plain, which produces half of China's wheat and a third of the corn, is falling at an alarming rate. Rapid growth in both population and irrigated agriculture, combined with increasing demand for water, has seen the increased pumping of groundwater in northern China. Groundwater under the North China Plain supports more than 200 million people and supplies over 70 per cent of the water needs (see figure 1). Limited rainfall and increasing need in this region has led to the watertable around Beijing dropping by 5 metres per year. As a consequence of this, existing wells are drying up and new, deeper wells are being drilled.

After extensive flooding in the 1960s, the government set about building dams and canals to reduce flood impacts and provide water to rapidly growing cities. Farmers were encouraged to increase grain

FIGURE 1 Decline in the aquifer under the North China Plain



Source: UNEP Global Environmental Alert Service GEAS.

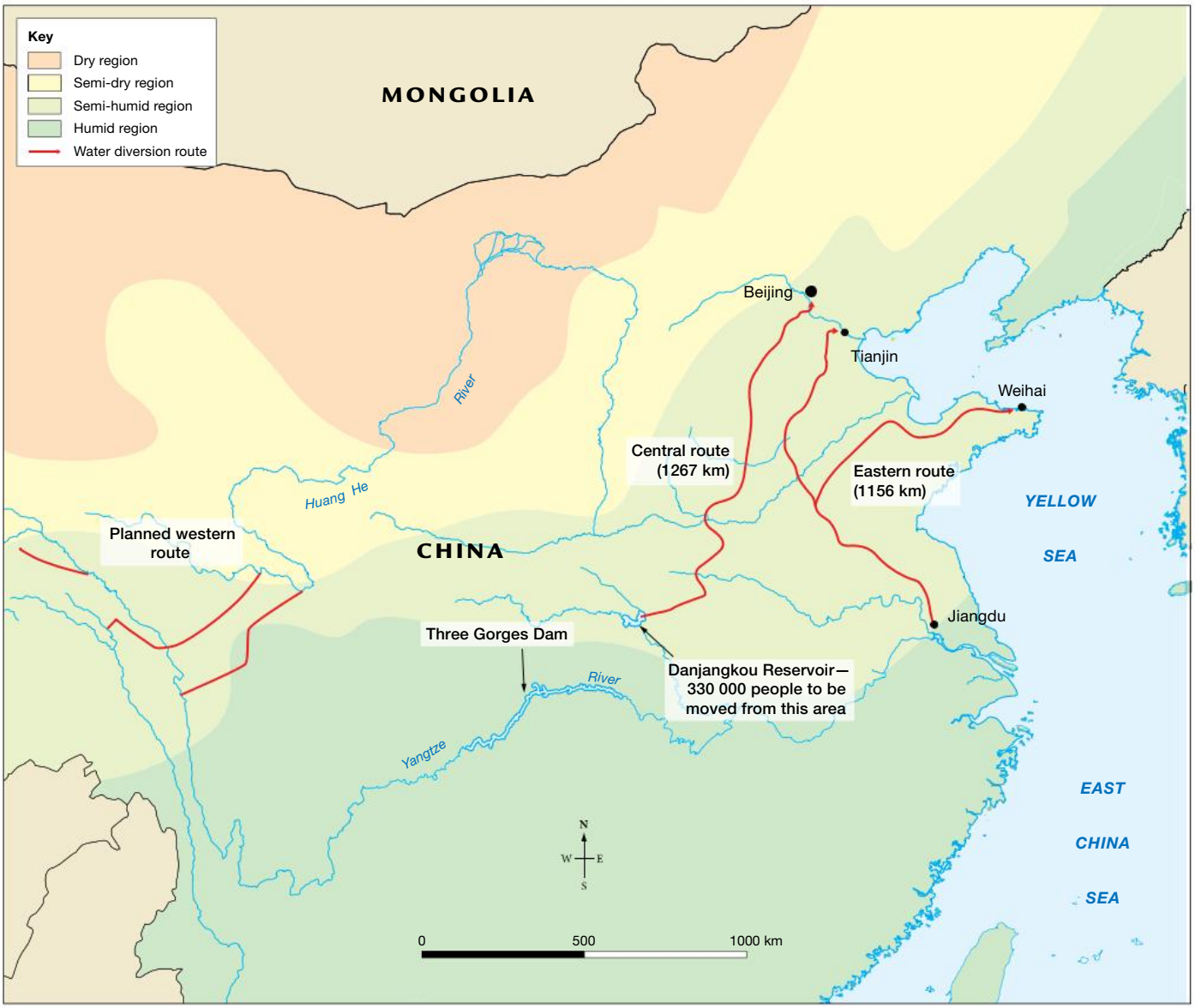
production by drawing on groundwater to irrigate a second crop each year. As cities continued to expand, they too began to pump unsustainable amounts of groundwater for domestic and industrial use. Scientists now also believe that climate change has reduced rainfall in the region, which will only make the situation worse.

An ambitious project has been started to effectively 're-plumb' the country: the South–North Water Transfer Project. The project, connecting four major river basins, three megacities and six provinces, began in December 2002 and aims to be completed by 2050. Construction began with an estimated cost of US$62 billion, however by 2014 more than US$79 billion had already been spent. The project will transfer over 44.8 billion cubic metres of water per year north from the Yangtze River via three canals into the Huang He River Basin in the north of the country (see figure 2). The Yangtze River, on average, releases 960 billion cubic litres of water into the sea each year.

The central and eastern routes of the project have already been completed and the western route still remains in the planning phase. In this process, over 340 000 villagers have been displaced, with many farmers relocated to areas with infertile soils. The project's water will largely go to expanding industries and cities such as Beijing and Tianjin. Little of the water will be directed towards food production. Irrespective of the cost and relocation of hundreds of thousands of people, the biggest concerns of the scheme will be over water quality. The Huang He River collects over 4.29 billion tonnes of waste and sewage each year (see figure 3), and over 40 per cent of China's total waste water

basin the land area drained by a river and its tributaries; another name for a river catchment

FIGURE 2 Planned South–North inter-**basin** transfer of water from the Yangtze River in the south to the Huang He River in the north

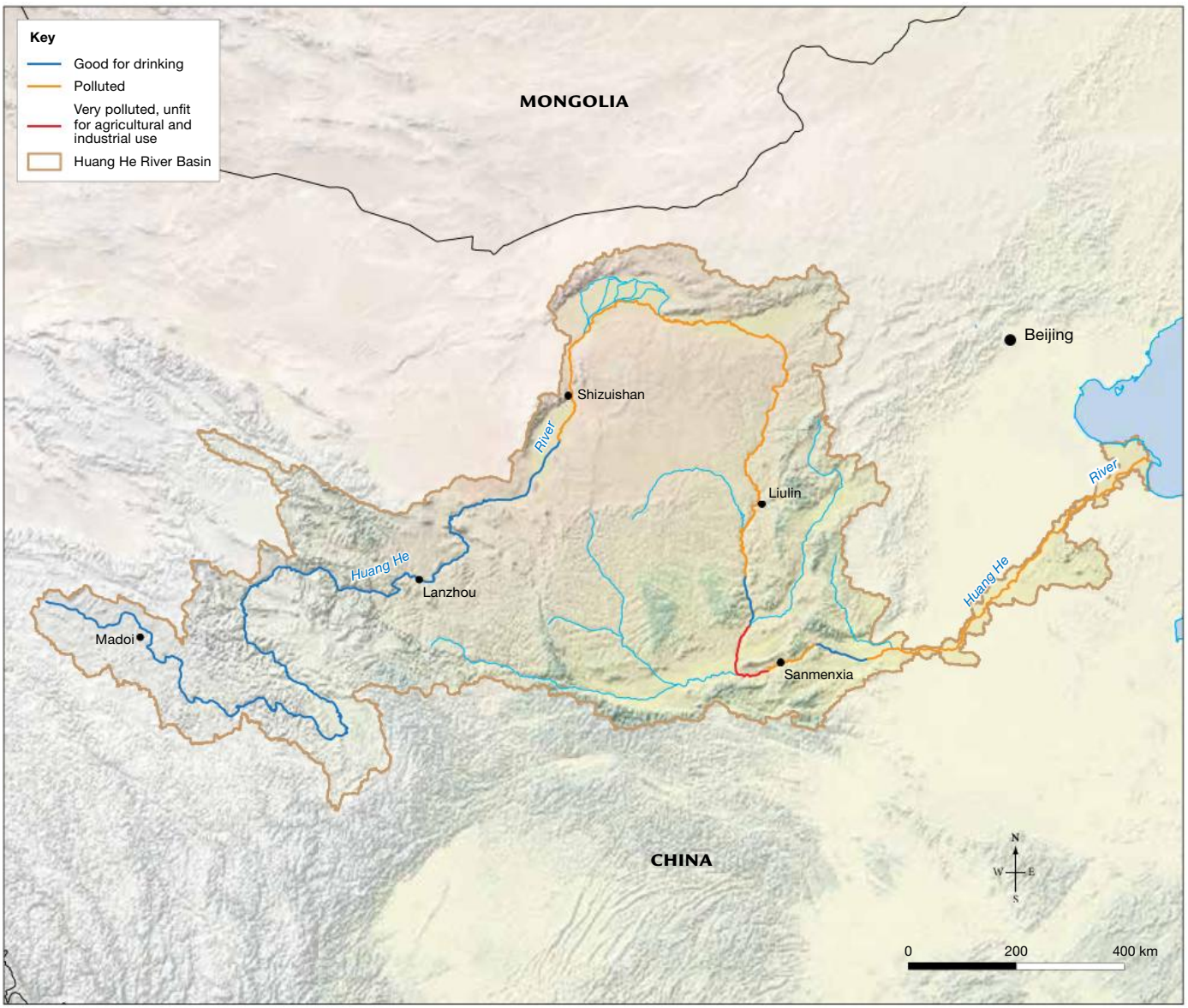


Source: BBC News

is dumped in the Yangtze River (see figure 4). This figure is likely to increase as more and more industry locates in places close to new water sources.

With less water to flow downstream there will be less water available for the dilution of polluted water. This will impact on river environments and there is a possibility that the water reaching the north will be too polluted for human or even agricultural use. To address this, over 250 projects have been planned to reduce pollution and ensure that the water meets minimum drinking standards, however significant concerns still exist.

FIGURE 3 Levels of pollution distributed along the Huang He River



Source: Spatial Vision.

GEOskills TOOLBOX

Using relief maps

Relief maps show the terrain of a region through the use of colour or shading. These maps can easily communicate specific shapes of the terrain without the need for contour lines. Figure 3 shows the terrain in China through darker shading, allowing the catchment areas to be easier to identify.

1 Examine figure 3. Use the information about relief to help you explain the location of water that is good for drinking, polluted or very polluted.
2 Predict other factors that would also impact on the location of water quality.

FIGURE 4 Polluted water flows into the Yangtze River. Suggest possible sources for the pollution you can see entering the river here.

ACTIVITIES

IDENTIFY

1 Using figure 1, describe the location of the North China Plain. Use distance, direction and place names in your answer.

2 Refer to figure 2. Suggest a reason why northern China uses groundwater to supply over 70 per cent of its water needs.

EXPLAIN

3 Use the **South–North Water Transfer Project** weblink in your eBookPLUS to find out the reasoning behind the South–North Water Transfer Project.

a Identify one political, ***environmental*** and social factor that led to the need for such a massive water transfer project.

b Identify one political, ***environmental*** and social impact of the project.

APPLY

4 a Is the South–North Water Transfer Project nothing but a 'pipe dream'?

b Is a human-centred rather than earth-centred viewpoint the best option for water management in northern China?

5 There is often talk about transferring water from the wetter regions of northern Australia to the water-hungry regions further south. What would you need to know before planning a project similar to the one in China? Thinking geographically, write a list of 10 questions you would like to ask before designing such a project.

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Weblink
South–North Water Transfer Project

14.10 Why do we drain wetlands?

14.10.1 What are the threats to wetlands?

Often referred to as the area where 'earth and water meet', **wetlands** are one of the most important and valuable biomes in the world.

wetland an area covered by water permanently, seasonally or ephemerally; includes fresh, salt and brackish waters such as rivers, lakes, rice paddies and areas of marine water, the depth of which at low tide does not exceed 6 metres

impervious describes a rock layer that does not allow water to move through it due to a lack of cracks and fissures

eutrophication a process in which water bodies receive excess nutrients that stimulate excessive plant growth

- Dams alter seasonal floods and block supply of sediment and nutrients onto the floodplain and deltas. Three to six times more water is held in dams than in rivers. Often little water and sediment reaches the mouths and deltas of large rivers. For example, dams have cut the sediment supply to Pakistan's Indus River Delta by 75 per cent, resulting in erosion and loss of wetlands.
- Agricultural expansion is the largest contributor to wetland loss and degradation globally. Farming often requires the draining of wetlands to create more land. Biodiversity is reduced and water run-off from agriculture is often polluted with fertilisers and pesticides. Increased pumping from aquifers depletes groundwater resources.
- Loss of wetlands affects populations and the migratory patterns of birds and fish. The introduction of invasive species results in changed ecosystems and loss of biodiversity. Seventy per cent of amphibian species are affected by habitat loss.
- Clearing for urban growth, industry, roads and other land uses replaces wetlands with hard **impervious** surfaces, which reduces infiltration and leads to polluted run-off and increased impacts of flooding.
- While wetlands can naturally filter many pollutants, excessive amounts of fertilisers and sewage causes algal blooms and **eutrophication**, depriving aquatic plants and animals of light and oxygen.
- Climate change is expected to increase the rate of wetland degradation and loss.

FIGURE 1 A wetland in Queensland. What features in this image would be typical for a wetland?

ACTIVITIES

IDENTIFY

1 Identify and give the grid references for two different types of wetlands in figure 2.
2 What is the average elevation (height) of this region?
3 Suggest two reasons why this ***place*** is subject to inundation (flooding).
4 This area is part of the River Murray Reserve, and the southern area is part of a State Forest. Why would these be suitable land uses for this area?

APPLY

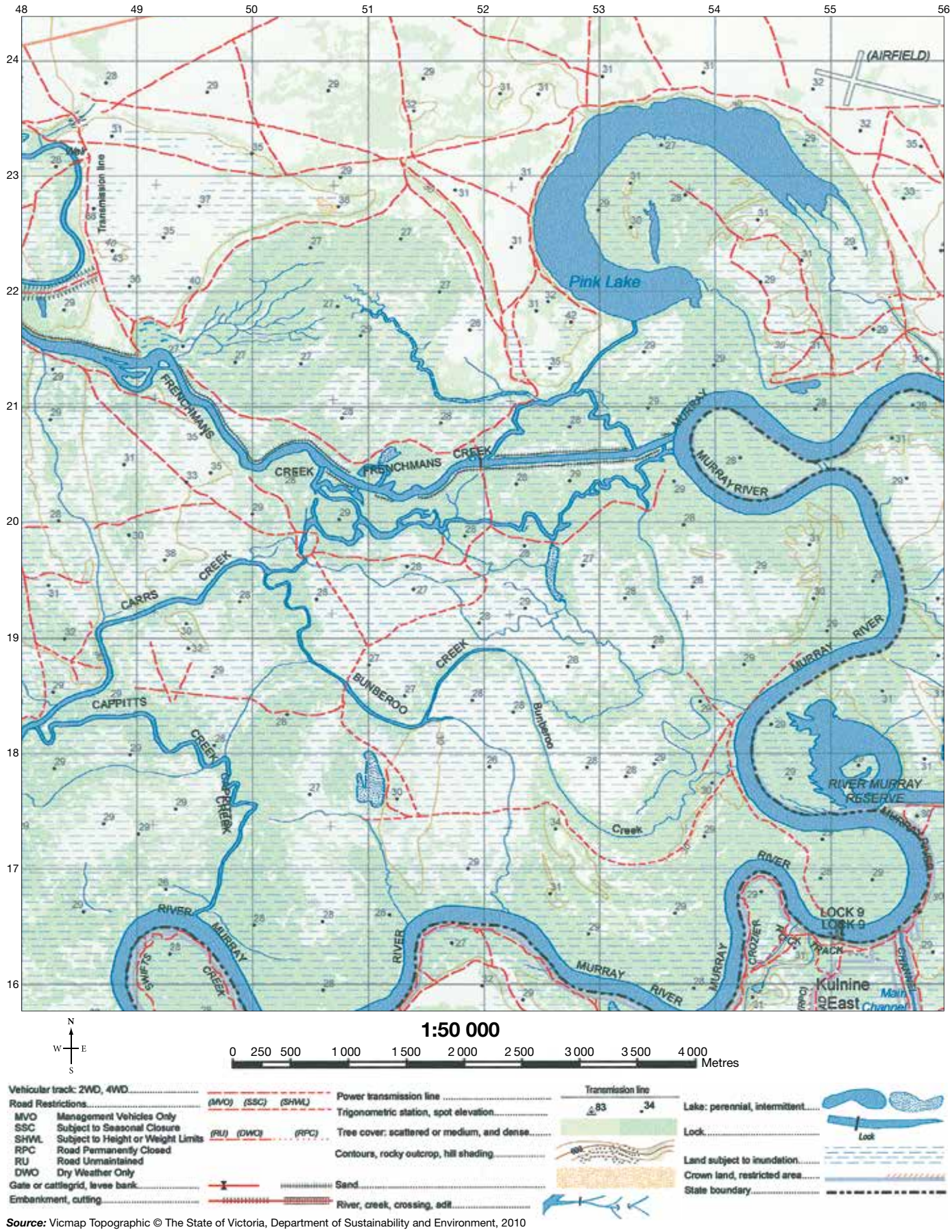
5 Use evidence from the map to make a list of the ***changes*** that people have brought to this region.
6 If a dam was to be built several kilometres upstream, suggest possible ***changes*** that might occur to the wetlands in the map area.
7 Name the features at the following locations and suggest how they are used to manage water.
  a GR551165
  b GR555159
8 a Locate the state border between NSW and Victoria. Who 'owns' the Murray River?
  b What problems would exist for managing a river resource that is also used for a political border?
9 Use the **Wetlands** weblink in your eBookPLUS to describe the importance of, and threats to, wetlands.

eBookplus

Interactivity
Wetland wonderlands
Use this interactivity to learn more about the functions of wetlands.
Searchlight ID: int-3294

Weblink
Wetlands

FIGURE 2 Topographic map of Wentworth, New South Wales



Source: Vicmap Topographic © The State of Victoria, Department of Sustainability and Environment, 2010

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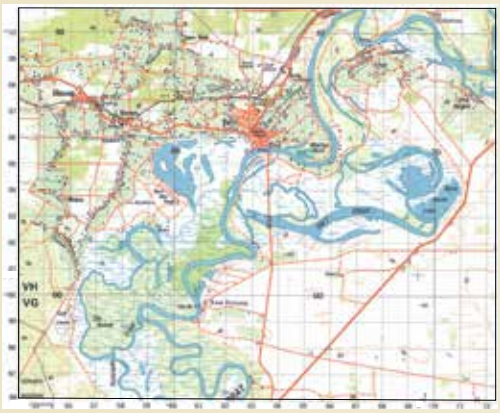
14.11 SkillBuilder: Reading topographic maps at an advanced level

What is reading a topographic map at an advanced level?

Topographic maps are more than just contour maps showing the height and shape of the land. Identifying the additional information requires more advanced skills such as calculating local relief, gradients and the size of various areas.



eLesson

Watch this video to learn how to read topographic maps at an advanced level.

Searchlight ID: eles-1749

Interactivity

Try this interactivity to learn how to read topographic maps at an advanced level.

Searchlight ID: int-3367

14.12 How can we put water back?

14.12.1 Where has the water gone?

Without doubt, the biggest environmental challenge facing the Murray–Darling Basin is the over-extraction and diversion of water for farming, towns and industry. The amount of water taken out of the river system has increased five-fold over the past century. Current levels of water use are unsustainable, and there just isn't enough water to go around.

The rivers, lakes and wetlands of the Murray–Darling Basin (see figure 1) make it Australia's most important inland water body. Decades of continually diverting water from its rivers and prolonged periods of drought have brought significant changes to the rivers, surrounding floodplains and surrounding wetlands. In addition, 90 per cent of floodplain wetlands in the Murray–Darling Basin have been lost due to human-induced changes to **river regimes**. The floodplains of the Murray River are now flooded once every 10–12 years compared to 3–4 years out of 5 a century ago. Reduced flow has also meant that the mouth of the river blocks regularly, preventing the flushing out of pollutants and impacting on the Lower Lakes wetlands.

river regime the pattern of seasonal variation in the volume of a river

14.12.2 Why has river health declined?

One of the difficulties in managing the water resources of the Murray–Darling Basin has been the fact that there are four states and one territory that all use and manage the water in their own way. The twentieth century saw the management of the river switch focus from using the river for transport to the expansion of agriculture. This period saw a rapid rise in the amount of water withdrawn and a decline in the health of river ecosystems. Today, 20 out of 23 catchments within the Basin have 'poor' to 'very poor' ecosystem health.

Contributing factors include:

- extensive clearing of native vegetation in the catchments
- introduction of exotic weeds and animals
- run-off of pollutants
- draining of wetlands.

FIGURE 1 Key features of the Murray–Darling Basin

Source: Murray Darling Basin Commission.

In the twenty-first century we are now working towards a more sustainable approach to managing water, with a greater emphasis on balancing the competing needs of the community and river environments. In essence, it means improving the health of the rivers and wetlands and keeping more water in the system.

14.12.3 How do you put water back into the rivers?

There have been a number of government initiatives put in place over the years to reduce the amount of water being harvested from the river:

- *The Cap Policy*. This policy put a stop to increasing water withdrawals. All rivers in the Basin are capped at the 1993–1994 level, so that is the maximum amount of water that can be taken out in any year. The amount withdrawn cannot be increased. Therefore, water had to be used more efficiently.

FIGURE 2 Wanganella Swamp (Deniliquin, New South Wales) (a) before, (b) during and (c) after an environmental flow

(a)

(b)

(c)

Source: Murray Darling Wetlands Working Group

icon sites six sites located in the Murray–Darling Basin that are earmarked for environmental flows; they were chosen for their environmental, cultural and international significance

environmental flow the quantity, quality and timing of water flow required to sustain freshwater ecosystems

- *The Living Murray Program*. In an effort to try and improve the health of rivers, the Murray–Darling Basin Authority (MDBA) concentrates on maintaining the health of six **icon sites** (see figure 1) by providing them with additional water in the form of **environmental flows**. Water 'savings' have to be made elsewhere through improvements in water storage, distribution and irrigation methods. Figure 2 (a), (b) and (c) shows the effects of an environmental flow on a stressed wetland.
- *The Murray–Darling Basin Plan*. In 2008, the states with a stakehold in the Murray–Darling Basin signed over control of their share of water to the Federal Government. This meant that, for the first time, the Commonwealth could make decisons and policies for the entire Basin. The Federal Government then committed over $8 billion for buying back water entitlements and improving water efficiency and irrigation infrastructure. Water allocations will be reduced in different regions of the Basin by between 27 per cent and 45 per cent. Central to the plan is providing sufficient water for the rivers first and then allocating water for diversions for all other purposes. The goal is to be able to allow sufficient movement of water, salts and materials through the river to keep the mouth open 90 per cent of the time.

ACTIVITIES

IDENTIFY

1 Describe how the management of water resources has ***changed*** over time.

2 **a** What is an icon site?
b Refer to figure 1. Where are they located?
c Why are they important?

EXPLAIN

3 Why is there a need for ***environmental*** flows in the Murray–Darling Basin?

4 Suggest why both the amount and timing of ***environmental*** flows is important for a healthy river.

5 Compare the three photographs in figure 2. Describe the ***changes*** in the appearance of the wetland before, during and after an ***environmental*** flow.

6 Construct a table to identify one advantage and one disadvantage of each of the three water policies listed in this section.

7 What steps could an irrigation farmer take to adapt to a reduced allocation and more ***sustainable*** use of water?

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14.13 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au.**

14.5 SkillBuilder: Creating a fishbone diagram

14.5.1 Tell me

What is a fishbone diagram?

A fishbone diagram is a graphic representation of the causes of a particular effect.

Why are fishbone diagrams useful?

Fishbone diagrams are useful for visualising a problem (or effect), and showing the causes of that problem. Bones above and below the central line are used to identify causes, while the 'head' of the diagram gives the problem, or effect. Each major category of cause then has a number of causes and even sub-causes. These are all linked to convey the interconnection of ideas.

Fishbone diagrams can also be adapted and used to list the positive and negative impacts of an action or event. They are useful when you are:

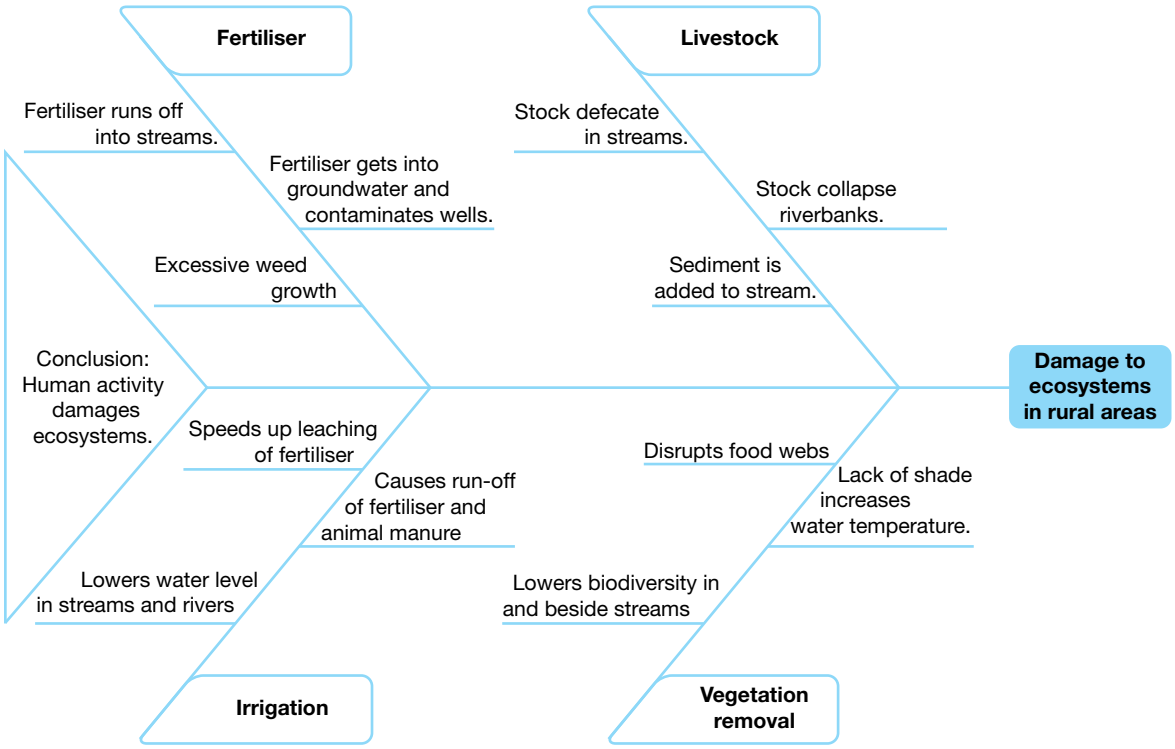
- brainstorming
- clarifying interconnections
- expanding ideas
- structuring an extended response.

Model

A good fishbone diagram:

- is drawn in pencil
- has ruled lines
- identifies and labels causes and sub-causes
- identifies and labels the effect
- includes a clear title.

FIGURE 1 Fishbone diagram that examines the causes of damage to ecosystems in rural areas



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eLesson
Creating a fishbone diagram
Searchlight ID: eles-1748

14.5.2 Show me

How to develop a fishbone diagram

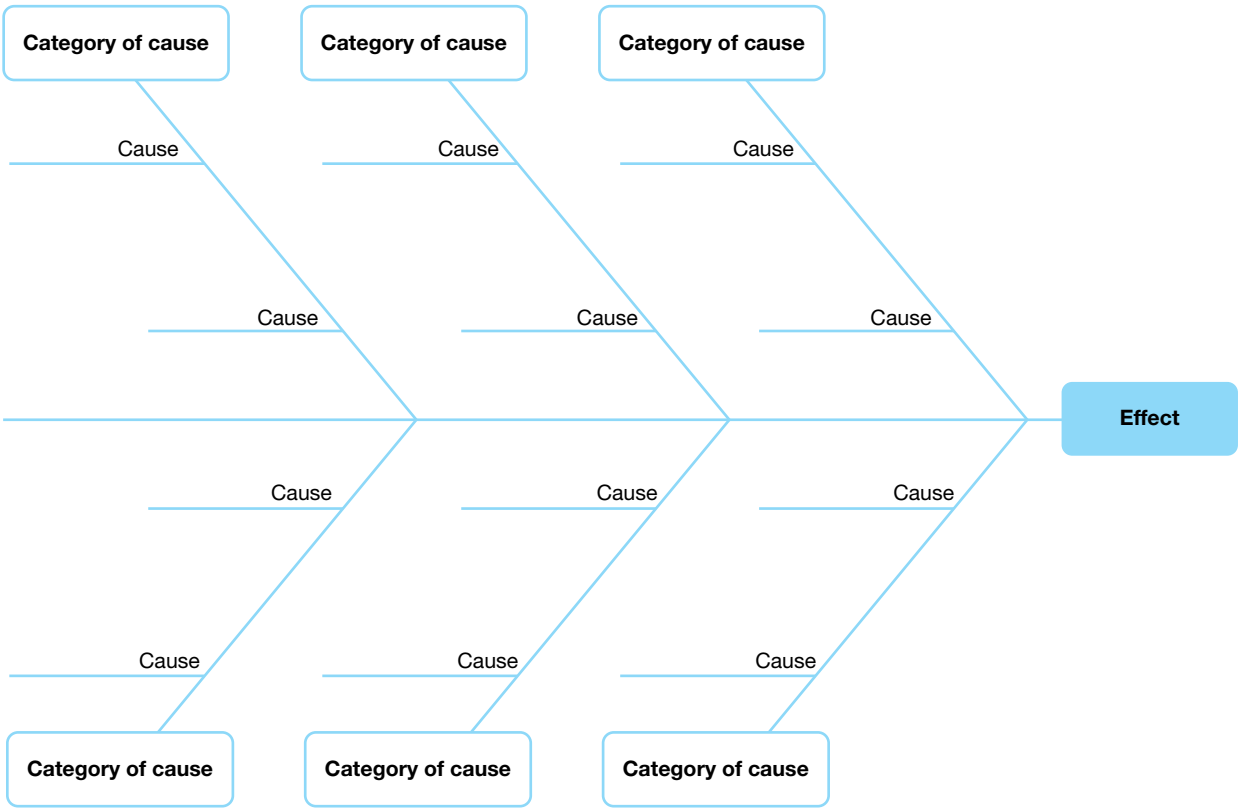
You will need:

- a template of a fishbone diagram (see figure 2)
- a piece of paper
- a ruler
- a light-grey lead pencil.

Procedure:

To complete a fishbone diagram, obtain a template to work on.

FIGURE 2 Fishbone diagram template



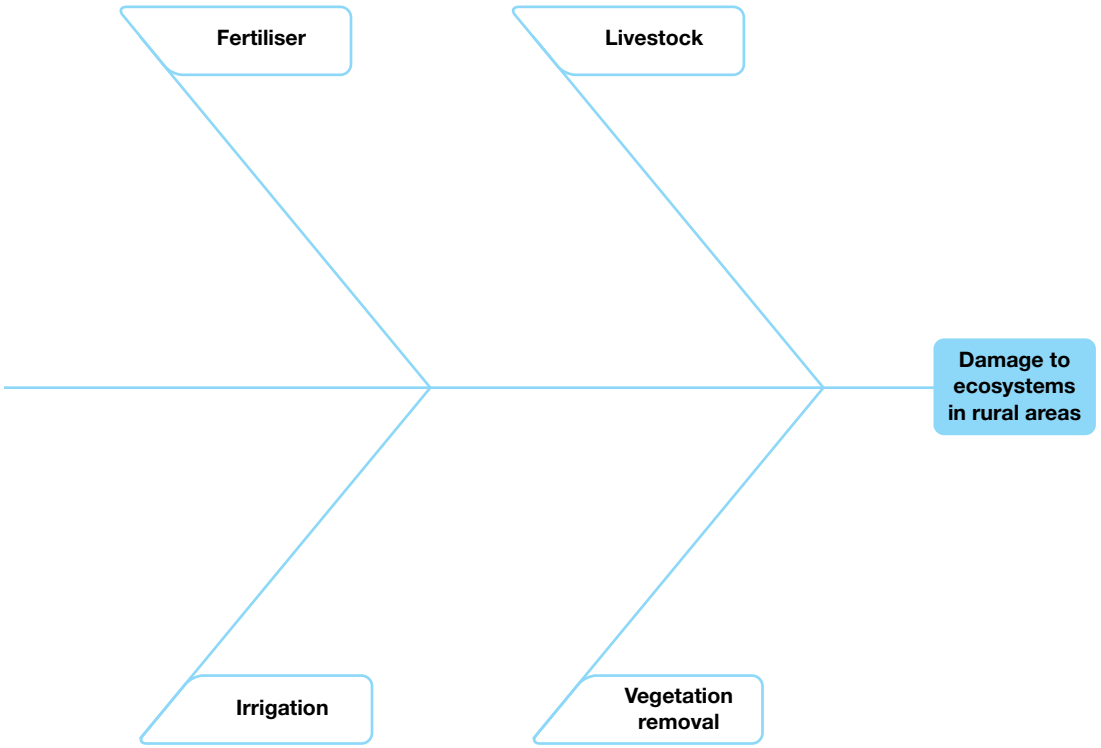
STEP 1

Determine the problem to be considered — this becomes your 'effect'. Place the effect in the head of the fishbone diagram; for example, 'Damage to ecosystems in rural areas'.

STEP 2

Consider all the possible causes of the problem and decide what major categories these fall into. Then decide which of these categories is the most significant, and place them in the category of causes boxes closest to the fish head; place the least important categories of causes close to the fish tail. For example, 'Vegetation removal' and 'Livestock' go closest to the fish head (see figure 3).

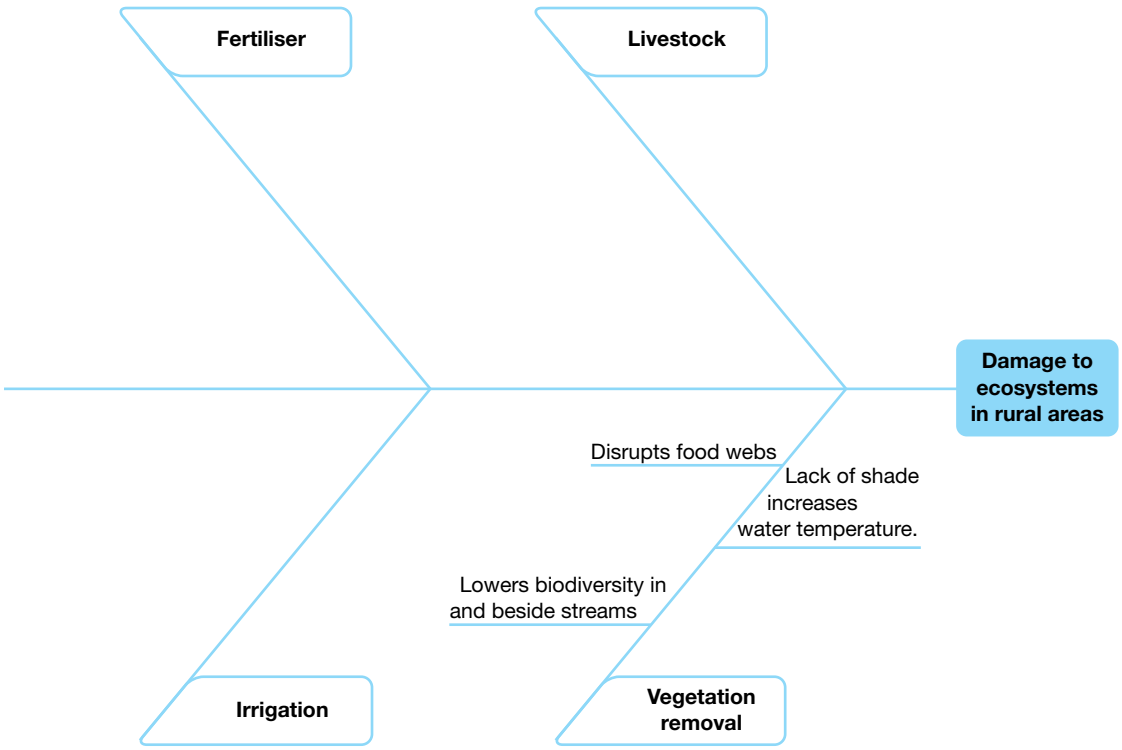
FIGURE 3 A fishbone diagram showing categories of causes



STEP 3

For each category of causes, now brainstorm a number of causes within that category. Keep asking 'Why is this a problem?' or 'Why does this happen?' For example, if we ask why vegetation removal damages ecosystems in rural areas, we come up with 'Lowers biodiversity' and 'Increases water temperature' (see figure 4).

FIGURE 4 A fishbone diagram and some causes within a category



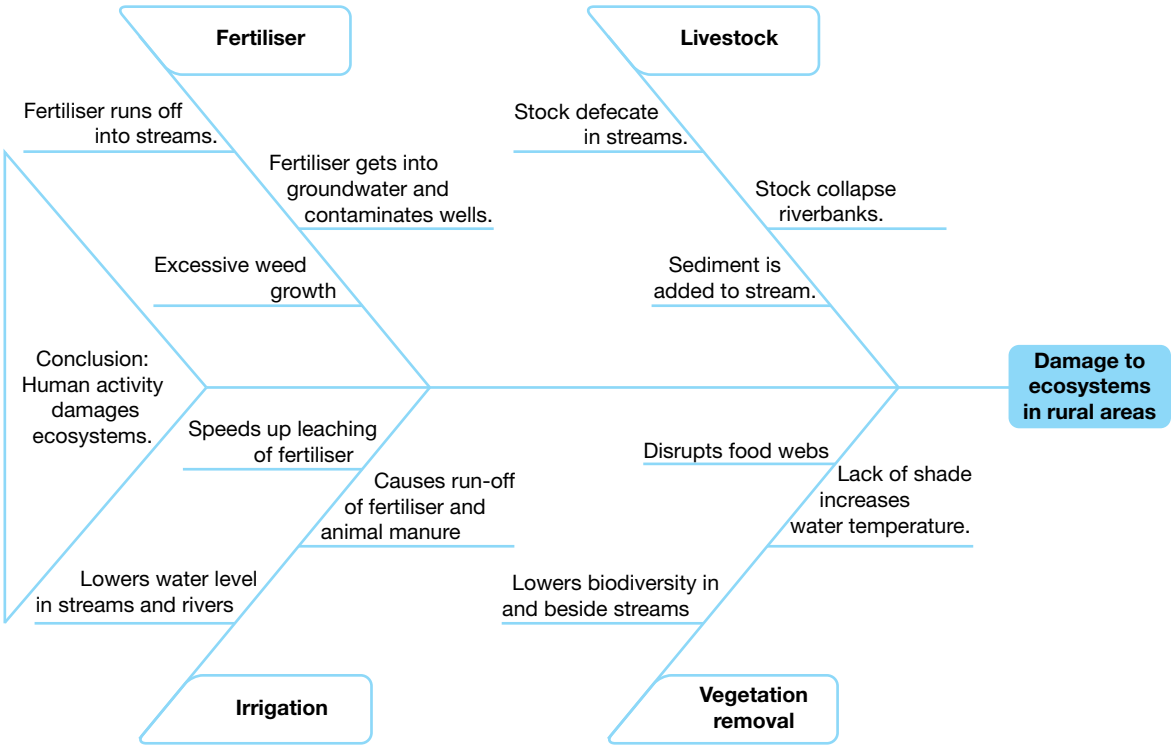
STEP 4

Consider another category and its related causes. Complete the bones of the fish with all your ideas.

STEP 5

Now in the tail of the fish you can draw your conclusion (see figure 5). How do you assess the causes of damage to rural ecosystems, given the four categories you considered?

FIGURE 5 Conclusion shown on fishbone diagram



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Interactivity
Creating a fishbone diagram
Searchlight ID: int-3366

14.5.3 Let me do it

Developing my skills

Referring to topic 14, complete a fishbone diagram on the causes of damage to inland water resources.

Questions

1. What were the four main categories you used? Were your categories the same as those used by others in the class?
2. Could you think of more causes than the lines provided?
3. Did you share your ideas about possible causes with other class members to build up your responses?
4. What did you conclude about the damage to inland water resources?
5. Did the fishbone diagram help you to find the causes of the problem? Explain your answer.

Checklist

I have:

- drawn in pencil
- ruled all lines
- identified and labelled causes
- identified and labelled the effect
- provided a clear title.

Skills questions

1. Fishbone diagrams are used to show:
   a. fish and water
   b. cause and effect
   c. land and rainfall
   d. fins and bones.
2. A fishbone diagram includes information about:
   a. examples
   b. places
   c. causes
   d. photographs.
3. Why would you use a template as the basis of your diagram?
4. Why might fishbone diagrams be a great way to organise ideas for an extended response on a topic?

14.11 SkillBuilder: Reading topographic maps at an advanced level

14.11.1 Tell me

What is reading a topographic map at an advanced level?

Topographic maps are more than just contour maps showing the height and shape of the land. They also include local relief and gradients and allow us to calculate the size of various areas. Reading this information requires more advanced skills.

Why is reading a topographic map at an advanced level useful?

All topographic maps use similar symbols to show the main features in the landscape. These conventional symbols make it easy for map readers to quickly identify the features shown in the legend. With advanced skills in map reading, inferences can be made about the interconnection of environments, landforms, climate and human activity. You can learn a great deal about an environment with advanced topographic map-reading skills.

Topographic maps are also useful for:

- showing the changing shape of the land
- determining water flows across a region
- considering infrastructure, such as roads and railways
- revealing land use, such as farming.

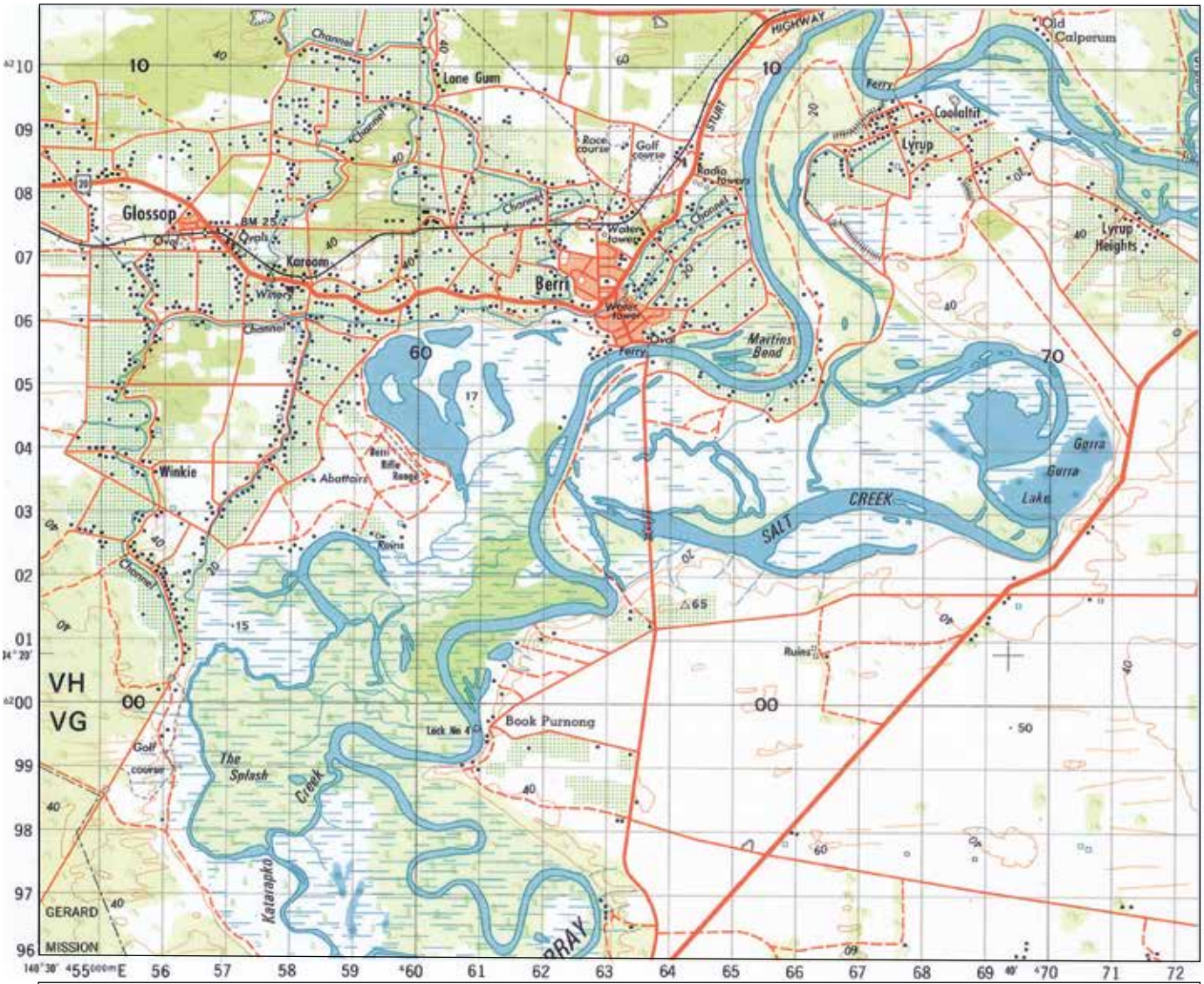
Model

The local relief between Berri township and the village of Lone Gum (602098) is 20 metres (see figure 1). You will notice there is a 20-metre contour in Berri and a 40-metre contour in Lone Gum, so the local relief is 20 metres. The gradient of the area is 1:200. The area of Gurra Gurra Lake is 1.5 square kilometres, and the township of Berri covers an area of three square kilometres. It is surrounded by an irrigation area to the west and south-west of about 34 square kilometres.

A good reading of a topographic map at an advanced level uses:

- the key, or legend, to locate features
- grid references to locate places
- spot heights to calculate local relief
- contours to calculate distances, contour interval and gradient
- scale to calculate area.

FIGURE 1 Topographic map of Berri, South Australia



LEGEND

- Built-up area; National route marker
- Principal road and highway; Cutting
- Secondary road; Embankment
- Minor road; Road bridge
- Vehicular track
- Gate; Cattle grid
- Light railway or tramway
- Power transmission line
- Fence; Levee or bank
- Mine; Windmill; Yard; Quarry
- Building/s; Church; Ruin; Drive-in theatre
- Trig station; Bench mark with height; Spot height
- Cliff; Contour with value; Depression contour
- Sandridges
- Forest, dense; medium; scattered

GN
MN
TN
GRID CONVERGENCE 0.1°
GRID/MAGNETIC ANGLE 8.2°

True north, grid north and magnetic north are shown diagrammatically for the centre of the map. Magnetic north is correct for 1981 and moves easterly by 0.1° in about five years

- Scrub, dense; medium; scattered
- Tropical rainforest; Pine plantation
- Orchard, plantation or vineyard; Mangrove
- Lake, perennial; Stream, perennial
- Swamp, perennial; intermittent
- Land subject to inundation; Rice field
- Bore or well; Spring; Tank or small dam

SCALE 1:100 000

kilometres 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 kilometres

HEIGHTS IN METRES. CONTOUR INTERVAL 20 METRES

Source: Map supplied by MAPLAND, Environmental and Geographic Information, Department for Environment and Heritage, South Australia

14.11.2 Show me

How to read a topographic map at an advanced level

You will need:

- a topographic map of the region being considered
- a piece of tracing paper
- a pencil
- a ruler.

Procedure:

To calculate local relief, gradient and area, you must have a topographic map and identify an area to study.

STEP 1

Revise your skills: check the legend symbols, determine the map scale, and check your grid reference skills. These skills should have been covered in your previous Geography studies.

STEP 2

Cast your eye over the map, and make interpretations of the area. What are the obvious features of this map? In figure 1, the land is not high and much of the land use is irrigated land. Are there any unusual features as well? In figure 1 there is a large area that is covered by water with unusual water features. Can the road system tell you anything about the importance of Berri in the region?

STEP 3

Look very closely at the map. Discovering the local relief of the area is best done using spot heights. A symbol for spot heights should be included in the key/legend. These are small dots on the map with a number written beside them. Spot heights are used to indicate the highest or lowest point, but can also be given across a map when the land is flat and few contours appear. Find a spot height of 17 metres (grid reference 608047) south-west of Berri township.

STEP 4

Calculate the local relief within the region. Local relief is the measure of the difference in height between the highest and lowest points within a relatively small area. In figure 1, in the Berri township area, the highest point is 60 metres and the lowest point is 20 metres or less, so the local relief is 40+ metres. Because this is a low number, the change in height across the area is minimal.

STEP 5

Gradient is the measurement of the steepness of the land between two places. To calculate the gradient you need (a) the difference in height between two places — the vertical interval or 'rise'; and (b) the horizontal distance between two places — called the 'run'. The gradient is expressed as a ratio, so both the rise and the run must be expressed in the same units of measurement, generally metres. The example below calculates the gradient between the township of Winkie (40 metres) and the abattoirs at 582035 (20 metres) with a distance of two kilometres (2000 metres) between the places.

$$\frac{\text{Vertical interval (rise)}}{\text{Horizontal distance (run)}}$$

$$= \frac{20}{2000}$$

$$= \frac{1}{500}$$

= The land rises one metre in height for every 100 metres in distance.

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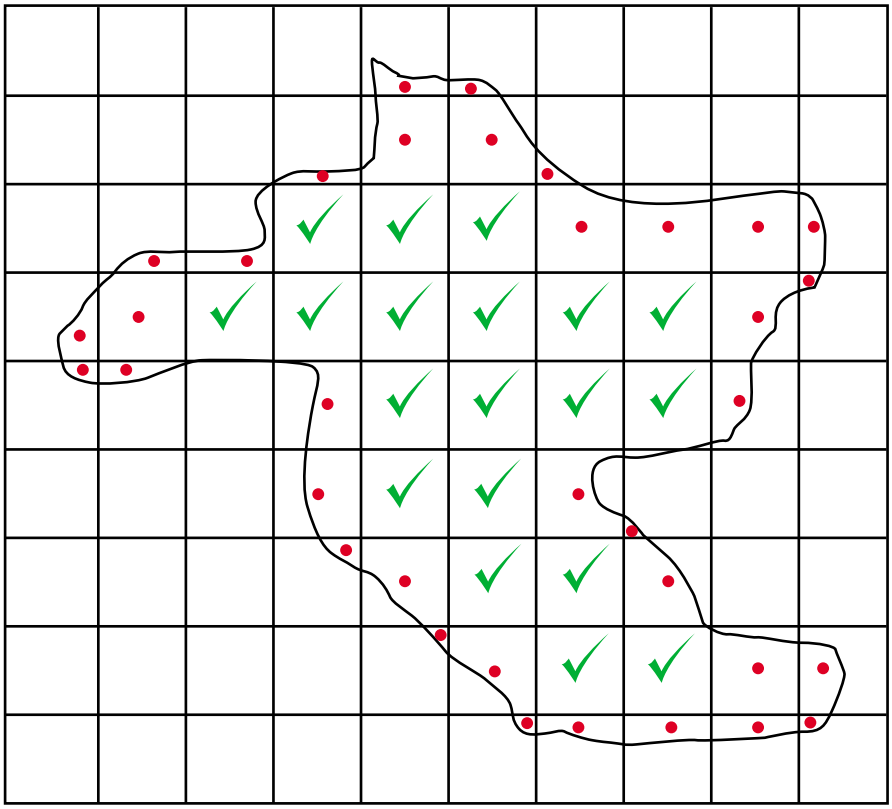
eLesson
Reading topographic maps at an advanced level
Searchlight ID: eles-1749

FIGURE 2 In this example, there are 19 complete grid squares and 35 incomplete grid squares. Halving the number of incomplete grid squares and adding this number (17.5) to 19 gives a total of 36.5 complete squares.



STEP 6

To calculate the area of an unusual shape on the map, a scaled grid can be placed over the map and the parts can be added up to give a squared area. On a piece of tracing paper, use a pencil and ruler to draw a grid in accordance with the scale of the map. Maps of 1:100 000 mean that each grid square is one square kilometre. That is, each side of the grid square is one kilometre. If the scale is 1:50 000, then you need to draw a grid with each line two centimetres apart. Each complete square then represents one square kilometre.

STEP 7

Lay the tracing paper over the mapped area and mark the squares that are complete in the mapped area. Add up this number. In the example shown in figure 2, there are 19 complete squares — these are shown with a green tick. In the case of Berri township, there is one complete square.

STEP 8

Now mark the incomplete squares and count them as half squares. That is, halve the number of incomplete squares. In figure 2, there are 35 incomplete squares. When halved, this comes to 17.5. Berri township has two incomplete squares, so when halved, you get one. Add up the number of markings from steps 7 and 8 to obtain the total size of the area identified. For example, Berri township has an area of two square kilometres.

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Interactivity
Reading topographic maps at an advanced level
Searchlight ID: int-3367

14.11.3 Let me do it

Developing my skills

Use the topographic map for the region west of Wentworth in subtopic 14.10 to complete the following calculations.

a. Calculate the local relief between Cappits Creek and the Murray River.
b. Calculate the local relief between Frenchmans Creek, Bunberoo Creek and the Murray River.
c. Calculate the gradient from the top of the map to the bottom of the map.
d. Calculate the size of the area of land between Frenchmans Creek and the Murray River.
e. Calculate the area of Pink Lake.

Questions

1. How would you describe the topography of the mapped area? Refer to local relief.
2. Using your understanding of gradient, why is it necessary to control Frenchmans Creek with levees?
3. Calculate the area that is prone to inundation and shown as wetland.
4. What time of year would be the best time to drive on the road network of this region? Explain your answer.
5. Use grid references to suggest where an oxbow lake might form. Explain what will happen.

Checklist

I have used:

- the key/legend to locate features
- grid references to locate places
- spot heights to calculate local relief
- contours to calculate distances, contour interval and gradient
- scale to calculate area.

Skills questions

1. A gradient is useful for working out:
   a. how the river level changes in high and low flow
   b. the steepness of the land
   c. the landforms
   d. irrigated areas.
2. An area calculation includes information about:
   a. space
   b. place
   c. vegetation
   d. water.
3. What important information do calculations of local relief provide?
4. What are the benefits of developing topographic map skills?

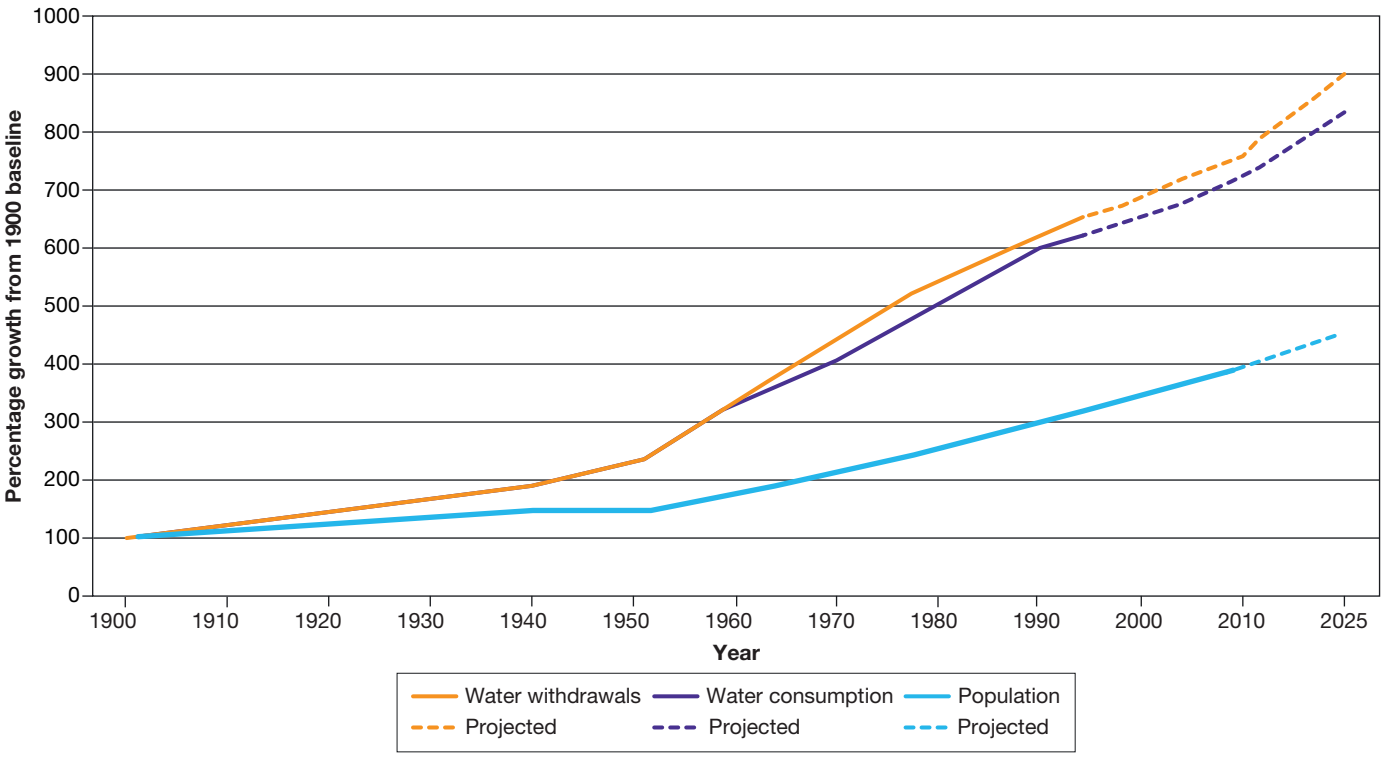
14.13 Review

14.13.1 Review

Dammed

1. Refer to the graph in figure 1.
   a. How has the growth in water consumption compared to the growth in world population over time?
   b. Which of the three features on the graph show the greatest rate of increase?
   c. How can you explain the fact that water withdrawal is greater than water consumption?
   d. What is the projected trend in water use and consumption?
   e. What are the likely implications of this for water managers?

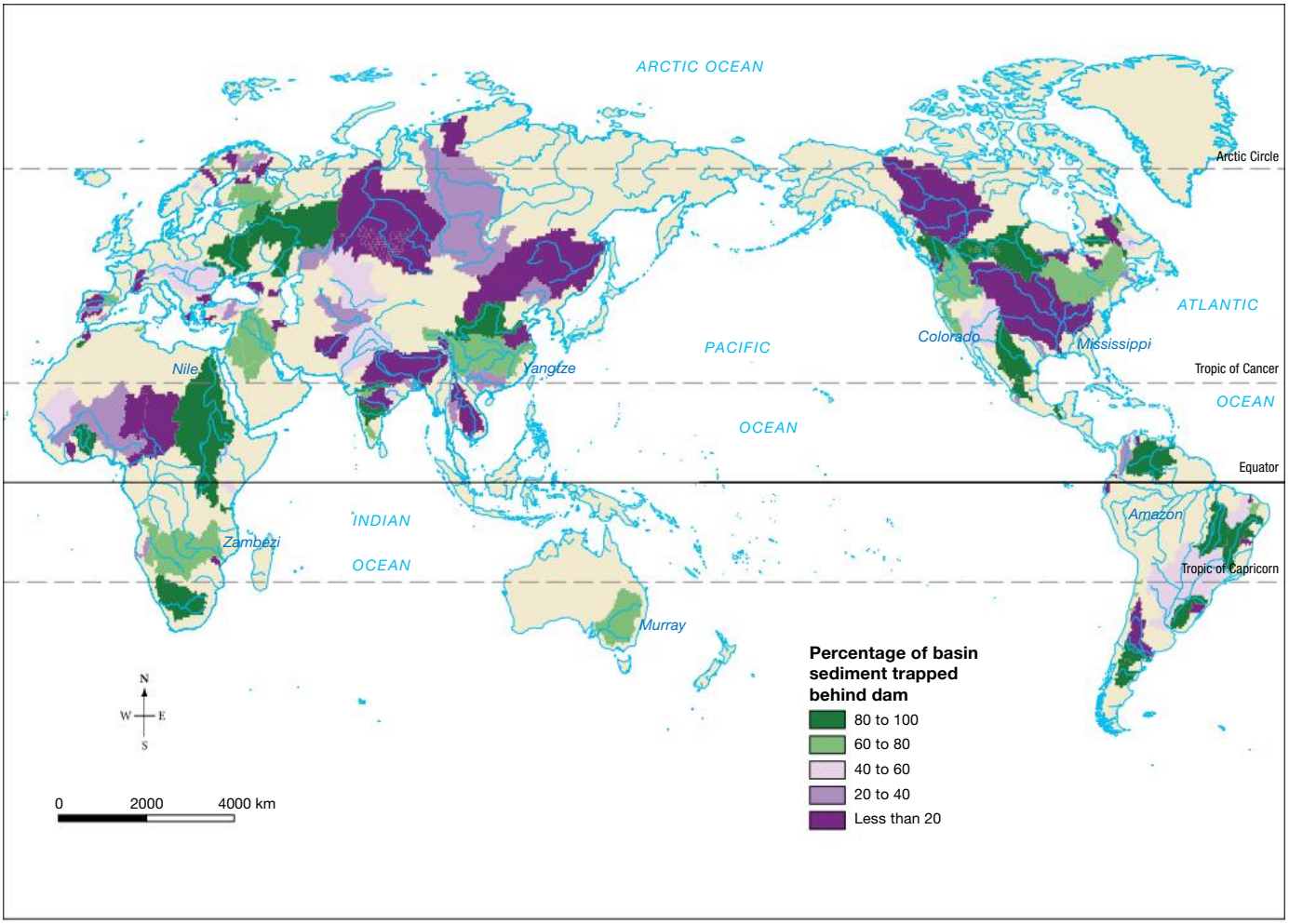
FIGURE 1 A comparison of the rate of population growth, water consumption and water withdrawals



Source: UNEP, 2012. *A glass half empty: regions at risk due to groundwater depletion*. Global Environmental Alert Service (GEAS).

2. Draw a mind map to show the ***environmental***, social and economic impacts, both positive and negative, of large-scale dam construction.
3. Refer to figure 2.
   a. Where does the sediment trapped in reservoirs come from?
   b. Without the dams, where would the sediment normally end up?
   c. 'What happens upstream, impacts downstream.' Research what is happening to either the Nile, Pearl or Mississippi Deltas to show the ***interconnection*** between upstream and downstream uses and processes.

FIGURE 2 Reservoirs around the world trap more than 2.3 gigatons (1 billion metric tons) of sediment each year. This sediment would normally be washed downstream, some to be deposited on floodplains, some to build up river deltas and the rest washed into the sea.



Source: University of New Hampshire UNH/Global Runoff Data Centre GRDC. Map by Spatial Vision.

4. Refer to figure 1 (a) and (b) in subtopic 14.7 'What happens when we divert water?'. Describe the changes that you can see to the coastline of Lake Urmia over time.
5. Refer to figure 4 in subtopic 14.7 'What happens when we divert water?'.
   a. How many dams are planned or under study for the Lake Urmia catchment area? How does this compare to the number of existing dams?
   b. What ***changes*** might you expect to see in and around Lake Urmia if these dams are constructed?

Diverted

6. Why do we divert waters from rivers and other inland water sources?
7. Using the data provided in table 1, construct a line graph to show the average natural river flow for the Murray River before the river was regulated. Using a different colour, create a second line graph to show the ***change*** in average flow after regulation/control of the river. Complete your graph with full BALTSS (Border, Axis, Legend, Title, Scale and Source).

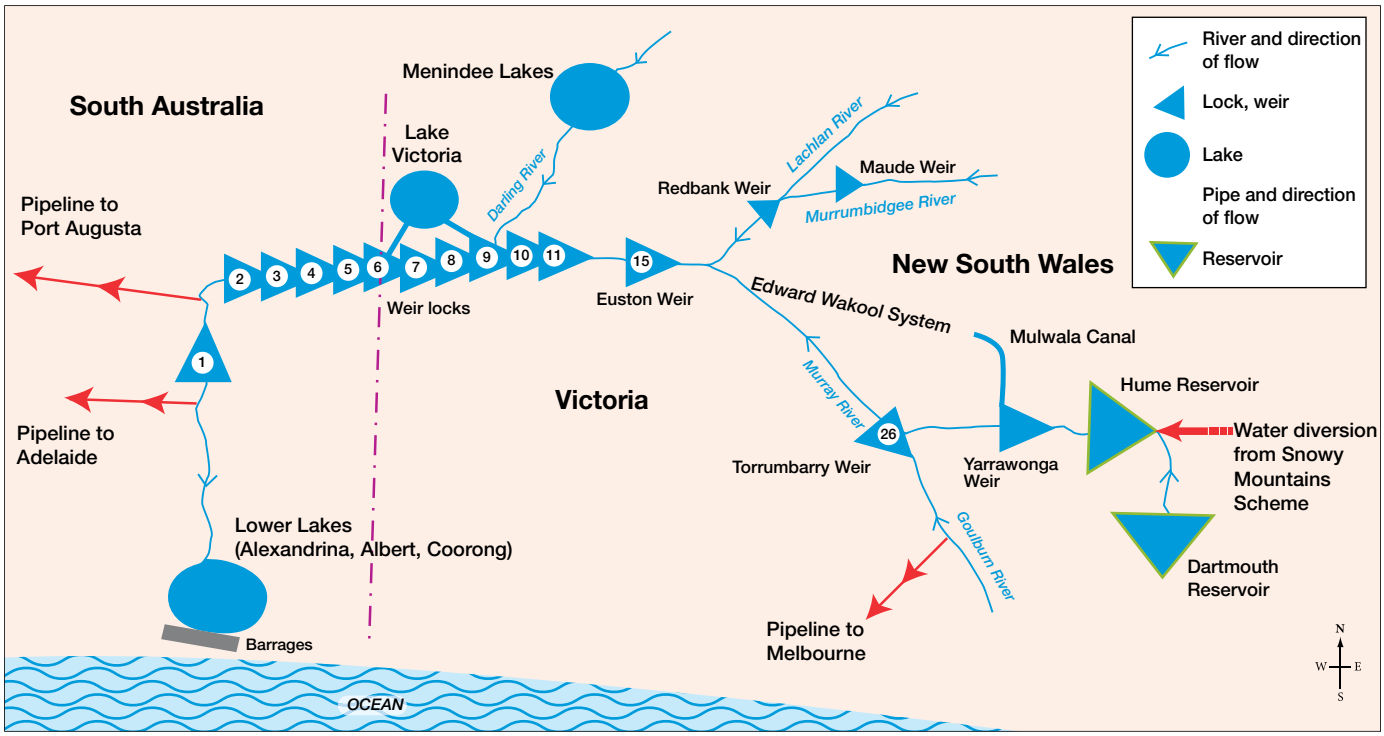
TABLE 1 Regulated and unregulated river flows for the Murray River over 12 months

	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Natural (unregulated) river flow (GL)	60	550	700	700	430	220	140	100	100	100	170	290
Regulated river flow (GL)	80	190	200	450	480	540	660	600	700	400	120	90

Note: One gigalitre (GL) = 1×10^9 litres; 1 GL = 1000 Olympic-size swimming pools
Source: © Murray–Darling Basin Authority.

8. a. Describe the average pattern of flow for the river, using seasons and amounts in your answer. Which season has the highest flows? Which season has the lowest flows?
   b. Compare the natural flow with the regulated flow by identifying any similarities and/or differences.
   c. What reasons can you give for your observations in part (b)? Why would water managers require higher flows in summer?
   d. Suggest some possible impacts on aquatic ***environments*** if a river's peak flows are seasonally ***changed***.
   e. How might controlling the flow of rivers impact on floodplain wetlands that require regular flooding?
9. Study figure 3.
   a. Where is water diverted from another river basin into the Murray–Darling Basin?
   b. List three ***places*** outside the Murray–Darling Basin that receive water from the Murray River.
   c. Follow a drop of water from the Dartmouth Reservoir to the river mouth. How many water storages does the drop of water pass through?
   d. Look back at figure 2. What do you notice about the level of sediment trapped behind dams in the Murray–Darling Basin?

FIGURE 3 How the Murray River water is managed



Source: Spatial Vision

10. 'The Murray River is nothing but a series of lakes and ponds. It is not a natural river.' Discuss.

Drained

11. How has our perception and use of wetlands ***changed*** over time?
12. Why are wetlands important to migrating birds?
13. Select one of the migratory birds listed below and conduct research to complete:
    - a description of the habitat in which they live
    - a map to show their migration route
    - a description of their migration path (using place names, distances and directions)
    - a description of any human-induced threats to either their habitat or ***places*** along their migration route.

    Short-tailed shearwater, wandering albatross, Wilson's storm-petrel, eastern golden plover, Japanese snipe, oriental cuckoo, white egret, masked booby.
14. What can you do? Get involved in the restoration of a local wetland. They often have 'Friends of …' volunteer organisations that have regular weeding and tree planting events.

14.13.2 Reflect

15. The Three Gorges Dam in China is the world's biggest dam complex, but it has been built at great social, economic and ***environmental*** cost.
    a. Study figures 4 and 6. List as many points as you can think of to describe the ***changes*** dam construction has brought to the natural ***environment***.
    b. Refer to figure 5. Why is there a need to relocate so many people when constructing a dam? Which province had the most number of people relocated? How many?
    c. Study the information in figures 4, 5 and 6. Construct a table to highlight the benefits and drawbacks of the dam project.

FIGURE 4 Features and benefits of the Three Gorges Dam

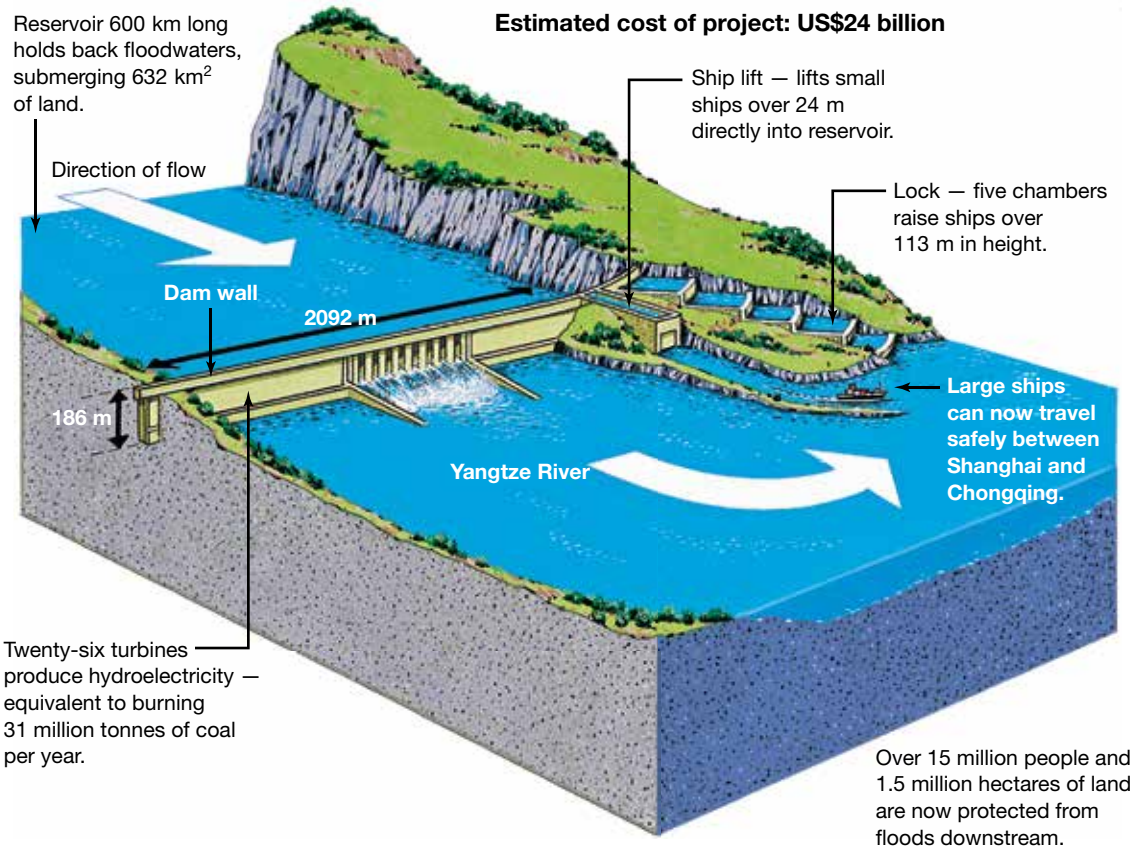
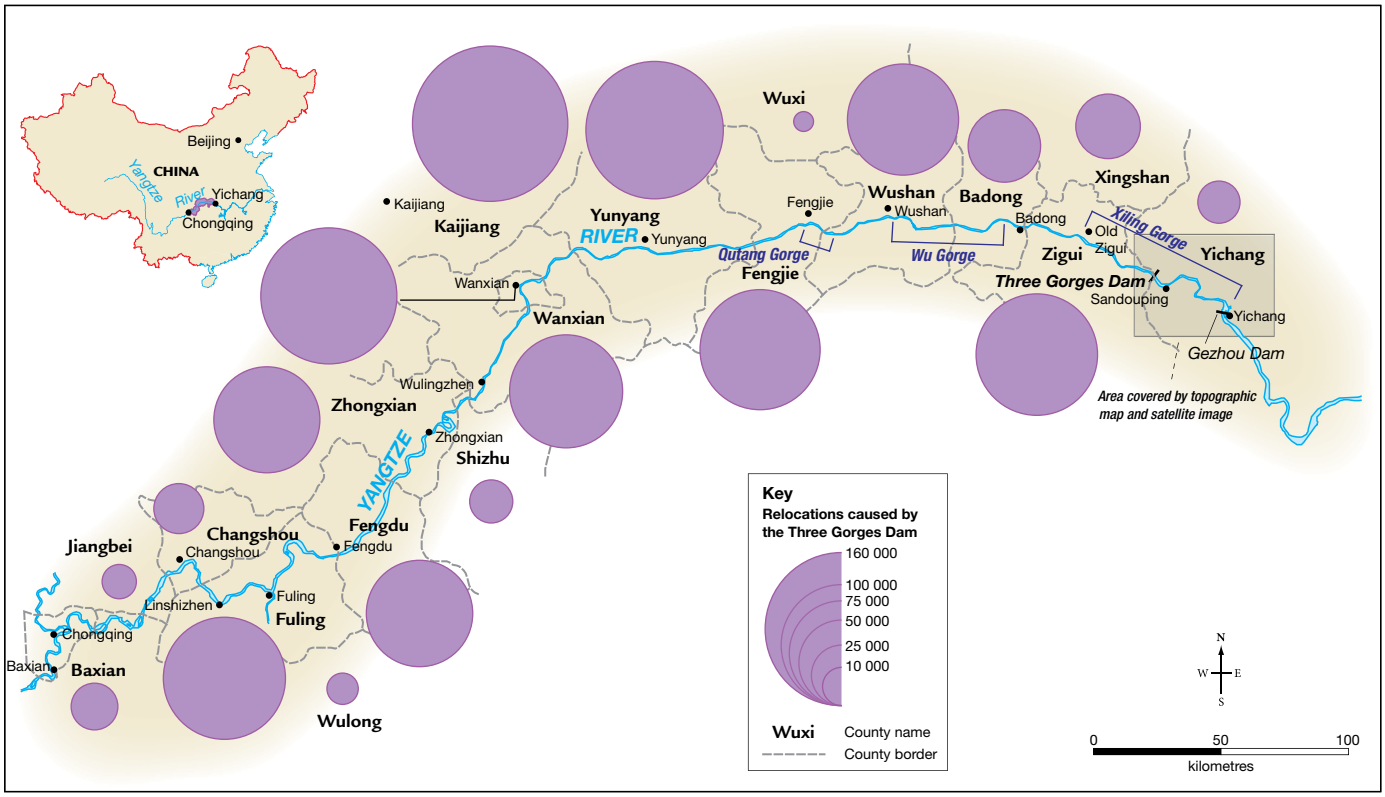


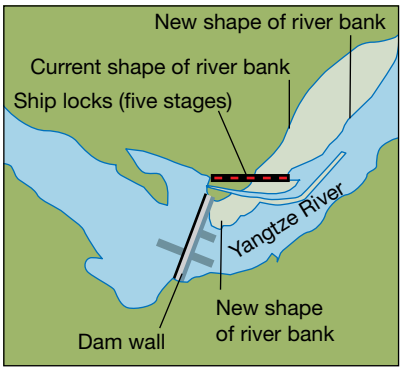
FIGURE 5 Number of people relocated by the Three Gorges Dam



Source: MAPgraphics Pty Ltd, Brisbane

16. Are large dams now a thing of the past? Could large-scale dam projects, such as the Three Gorges Dam, be initiated in Australia? Give reasons for your answer.
17. The construction of the Belo Monte Dam in Brazil will dislocate thousands of Indigenous people. A local federal prosecutor is bringing Norte Energia (the company building the dam) to court on charges of 'ethnocide against the Indigenous people'. (Ethnocide is the deliberate and systematic destruction of the culture of an ethnic group.)
    a. Suggest an argument to support this case and then a counter-argument to represent an opposing viewpoint.
    b. Which viewpoint do you support? Give reasons.
18. Does a large company such as Norte Energia have obligations to the people dislocated by such a large-scale scheme? Before deciding, carefully consider the consequences of the company being deemed responsible or not responsible.

FIGURE 6 Changes to the natural landscape due to the Three Gorges Dam



CHAPTER 15

Managing change in coastal environments

Houses along Malibu Beach in California are regularly threatened by severe storms. Is housing the most suitable land use for this area?

15.1 Overview

15.1.1 Introduction

The coast is home to 80 per cent of the world's population, and it is a popular place to settle for reasons of climate, water resources, land for agriculture and industry, access to transportation systems, and recreation. Hence, it is essential to understand the changes that are occurring to coastal environments, and how they will affect human settlements. The changes are both natural and human-induced. They are sometimes short term (as a result of storms and tsunamis) and sometimes long term (climate change leading to rising sea levels). To cope with these changes, careful planning and management is needed to ensure a sustainable future for human activity at the coast.

Starter questions

1 How do people use coastal ***places***?
2 What ***changes*** have people brought to the coastal area in the image on these pages?
3 What could you do here to help reduce this problem of man versus nature?
4 What ***changes*** to coastal areas have you observed when visiting a beach?

Inquiry sequence

		Syllabus outcomes
15.1 Overview		
15.2 How are coastal landforms created?		GE5-2, GE5-7, GE5-8
15.3 How do deposition and erosion change coasts?		GE5-2, GE5-7, GE5-8
15.4 What are the human causes of coastal change?		GE5-3, GE5-7, GE5-8
15.5 Why did environmental change in the Tweed impact the Gold Coast?		GE5-3, GE5-7, GE5-8
15.6 How do inland activities affect coasts?		GE5-3, GE5-7, GE5-8
15.7 SkillBuilder: Comparing aerial photographs to investigate spatial change over time	eBook plus ONLINE ONLY	GE5-7
15.8 Investigating topographic maps: What are the consequences of coastal change in Merimbula?		GE5-3, GE5-7, GE5-8
15.9 Why are low-lying islands disappearing?		GE5-3, GE5-7, GE5-8
15.10 How do we manage coastal change?		GE5-4, GE5-5, GE5-8
15.11 SkillBuilder: Comparing an aerial photograph and a topographic map	eBook plus ONLINE ONLY	GE5-7
15.12 How do coastal areas change?		GE5-4, GE5-5, GE5-8
15.13 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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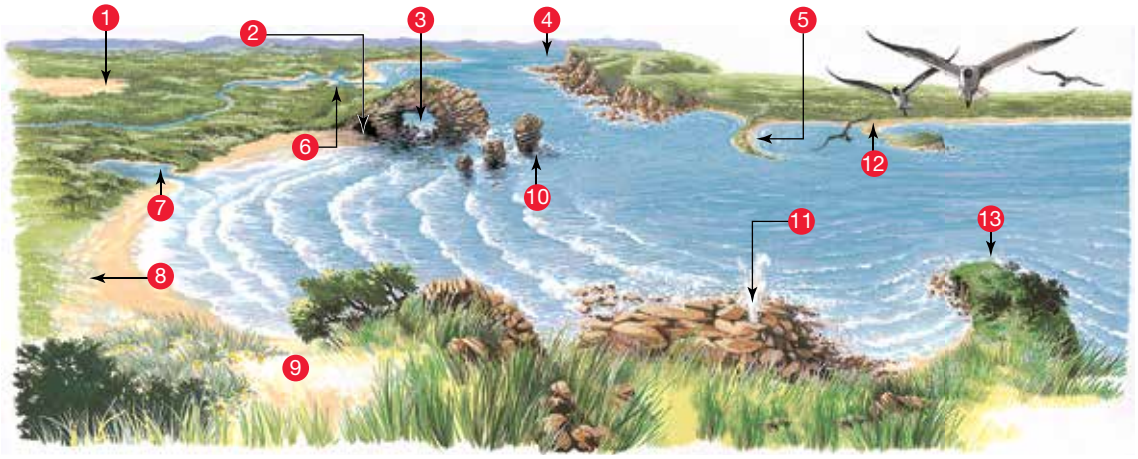
15.2 How are coastal landforms created?

15.2.1 What are types of coastal landforms?

Marine and terrestrial structures found at the coast include beaches, bays, dunes and cliffs (see figure 1). Others such as fiords are unique to Polar Regions. Structures found under the sea can include the continental shelf, canyons and trenches.

FIGURE 1 The range of coastal landforms



1. **Dune blowouts** — loose sand is blown from the dune because vegetation has been removed.
2. **Caves** — formed where weak rocks are eroded on each side of a headland as a result of wave refraction.
3. **Arch** — caves will erode on either side of a headland and join to form an arch.
4. **Cliff** — created when erosion undercuts a rock platform and the weakened rock collapses.
5. **Longshore drift** — moves sand and other material along a beach.
6. **Estuaries** — of a river that are tidal and occur at the mouth of the river where it meets the sea.
7. **Lagoon** — formed when a sandbar begins to develop, eventually closing an estuary.
8. **Beaches** — formed when material is brought to the shore by waves. Spits can develop when deposited sand accumulates perpendicular to the beach.
9. **Dunes** — formed when sand on a beach is stabilised by vegetation.
10. **Stack** — created by ongoing erosion of an arch, where one section of the arch collapses.
11. **Blowhole** — formed when the roof of a cave collapses as a result of the action of waves.
12. **Tombolo** — a spit joining two land areas.
13. **Headlands** — when coastal rocks are very hard and resist erosion from the waves.

15.2.2 Ocean processes

Waves, tides, currents, rips, storm surges and tsunamis form and transform coastal landscapes.

Winds generate waves and create swell. Destructive waves cause erosion of coastal landforms and are often associated with storm conditions (see figure 2).

Constructive waves deposit sediments to form beaches and sand dunes and are associated with calm weather (see figure 3).

Swash is the water that is washed onto the beach when a wave breaks. Backwash is the water that runs back down the beach. Destructive waves have more powerful backwash than swash. Constructive waves have more powerful swash than backwash.

Longshore drift occurs when the ongoing swash and backwash moves in a sideways direction and moves material in a zig zag pattern along the coastline (see figure 4).

Erosion and deposition are the main natural processes that create coastal change. These processes are examined in more detail in subtopic 15.3.

longshore drift
a current that moves sediment parallel to the shoreline, created by the backward and forward motion of waves

FIGURE 2 Destructive waves: the backwash is more powerful than the swash.

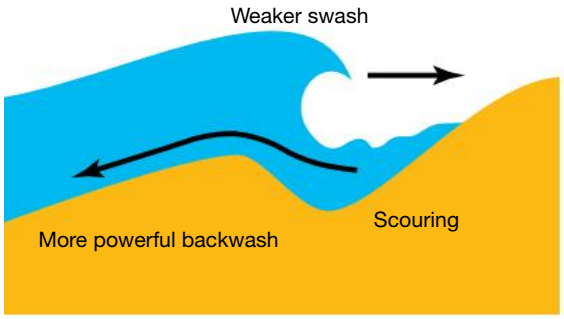


FIGURE 3 Constructive waves: the swash is more powerful than the backwash.

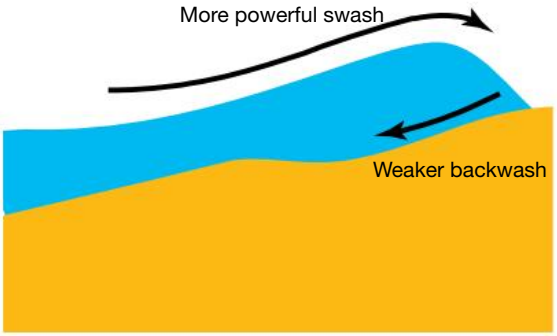
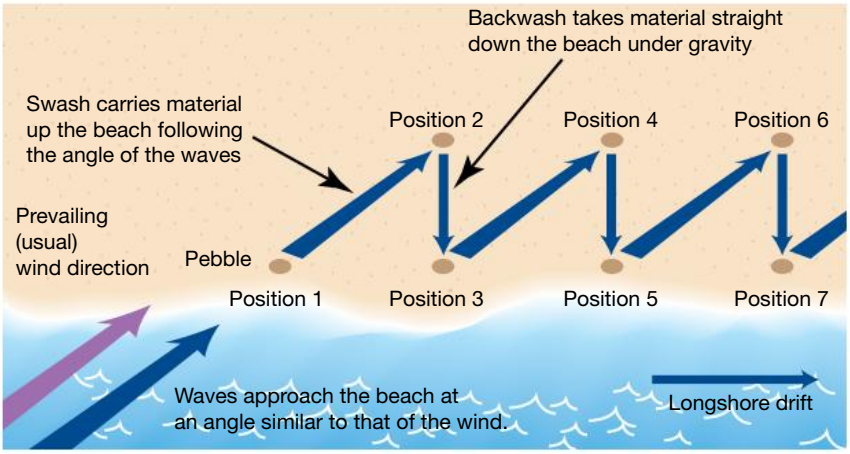


FIGURE 4 Longshore drift



GEOskills TOOLBOX

Exploring Google Earth

In the same way that topographic maps can show the shape of the land using contour lines, Google Earth can be used to examine change in elevation, and can show a cross-section of the land between two points. To show the changes in elevation between two points, open Google Earth on a desktop or notebook computer and select *Add Path* from the *Toolbar* and name the path, which will become our cross-section. Using the mouse or trackpad, draw a line between two points on the globe. Left-Click *OK*. Select the path from the Places panel. Under Edit, select *Show Elevation Profile* OR right-click the path and left-click *Show Elevation Profile*.

1 Using Google Earth, locate a coastal area with predominantly natural features.

a Identify three coastal landforms in or around this coastal area. Create a table like the one below. State the name of the landforms and describe them.

Coastal landform	Description

b Create a cross-section of one landform using Google Earth.

c Describe the advantages and disadvantages of creating a cross-section using Google Earth compared to creating one by hand using a topographic map.

ACTIVITIES

IDENTIFY

1 Outline the two main coastal processes that form coastal landforms.

2 Describe the differences between constructive and destructive waves.

EXPLAIN

3 Explain how longshore drift moves sand along a coastline.

PREDICT

4 Predict what would happen on a beach if a council constructed a rock barrier at a right angle to the beach.

15.3 How do deposition and erosion change coasts?

15.3.1 How does deposition create coastal landforms?

Coasts are a dynamic natural system. The forces of nature are constantly at work, either creating new land or wearing it away.

Beaches

Sediments transported down rivers and eroded from cliffs provide the material for beaches to develop. Constructive waves move sand and sediment onto the shore to create beaches.

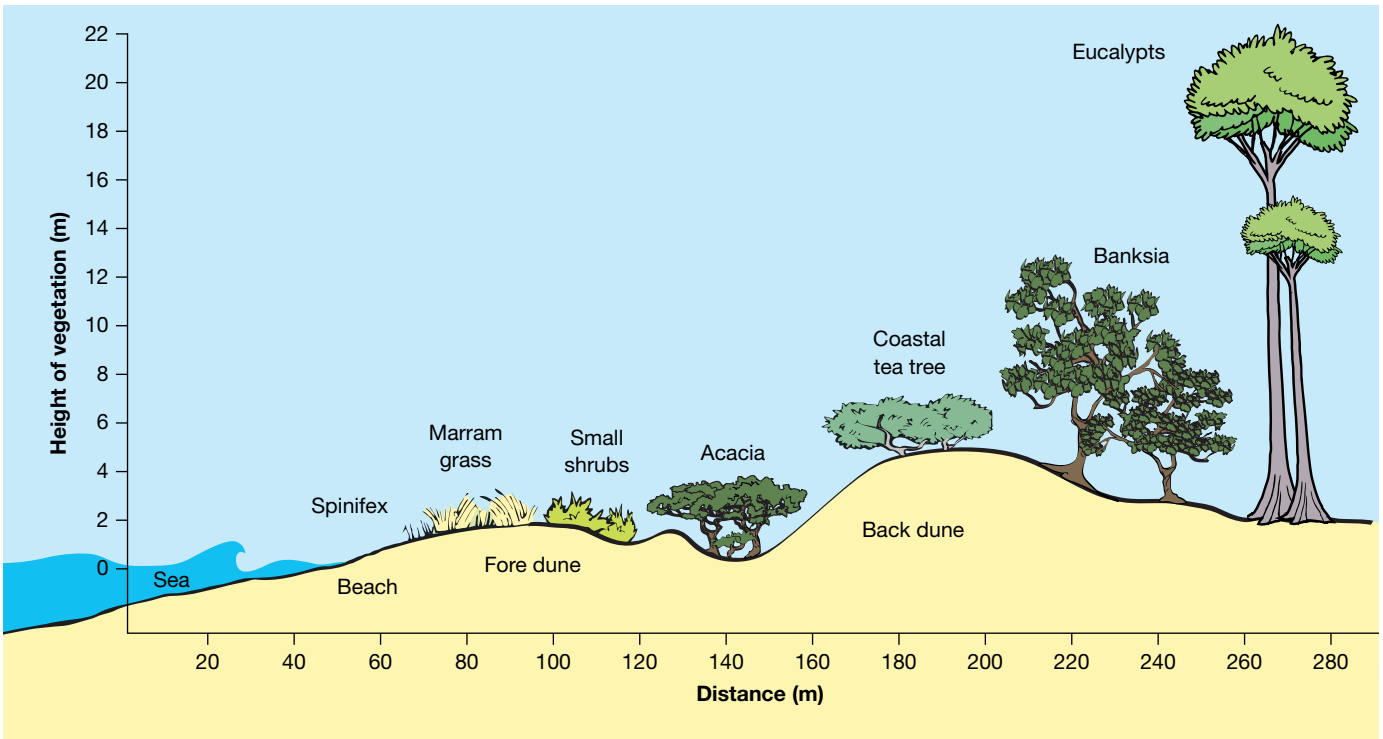
coastal dune vegetation succession the process of change in the plant types of a vegetation community over time — moving from pioneering plants in the high tide zone to fully developed inland area vegetation

Dunes

Wind moves dried out sediments onshore and inland. A fore dune will form close to the beach. Further from the shore a back dune will develop. Between the fore dune and back dune a depression will form called a swale. Dune vegetation helps to stabilise the sand and the landforms themselves. Vegetation becomes larger and more varied as freshwater and soil conditions improve further away from the beach (See figure 1). This progression of plants is known as the **coastal dune vegetation succession**.

Other coastal landforms created by deposition include spits, bars and barriers.

FIGURE 1 Transect showing the beach and stable and well-vegetated dunes



FOCUS ON FIELDWORK

Measuring the length and angle of dunes

A measurement of the size and angles of coastal dunes can contribute to understanding how deposition and erosion have impacted on the dunes. To do this you need to identify the berm, fore dune and back dune. Use a tape measure to determine the length of each landform. A clinometer can be used to determine the steepness of the dunes. Use the clinometer to determine the angle of the slopes for each landform. To do this, look through the clinometer and take the reading from within the eyeglass.

Visit a coastal area and complete the following activities.

1 Determine the length of the berm, fore dune and back dune.
2 Determine the angle of the slope for each of the berm, fore dune and back dune.
3 Repeat the exercise at various locations along the beach.
4 Compare your results to determine the parts of the beach most affected by erosion and deposition.

15.3.2 How does erosion create coastal landforms?

The weight and pressure of sea water hitting coastal rocks can lead to weathering. When loose sediments or pebbles are carried by the water this can exacerbate weathering. Erosional landforms include headlands, bays, cliffs, platforms, caves, arches, blowholes and stacks.

Headlands and bays

Harder rocks or rocks with fewer fractures form headlands that tend to resist erosion. Bays are composed of softer rocks or rocks with more fractures that are more easily eroded. This leads to the retreat of the coastline (see figure 2).

Cliffs and platforms

Platforms are flat, rocky, horizontal structures that have been worn down by the action of waves. Cliffs are raised, rocky structures. Waves wearing away the base of a cliff will create a notch, which will result in collapse and the coastline moving further inland (see figure 3).

Caves, arches, blowholes and stacks

Caves are parts of the coast that have been more actively eroded from the surrounding rocky area, leaving a hollow in the cliff section. If part of the roof section of the cave collapses, in-rushing waves may be channeled up this chimney structure, forcing water and air out at the horizontal land surface above. Stacks are simply remnants of cliff areas that have resisted erosion and been left stranded out to sea.

FIGURE 2 Wave refraction results in the concentration of waves on a headland.

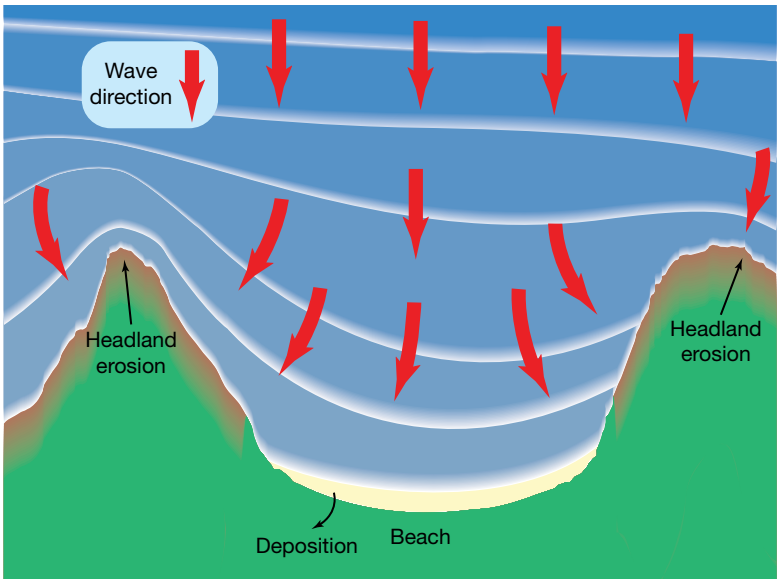
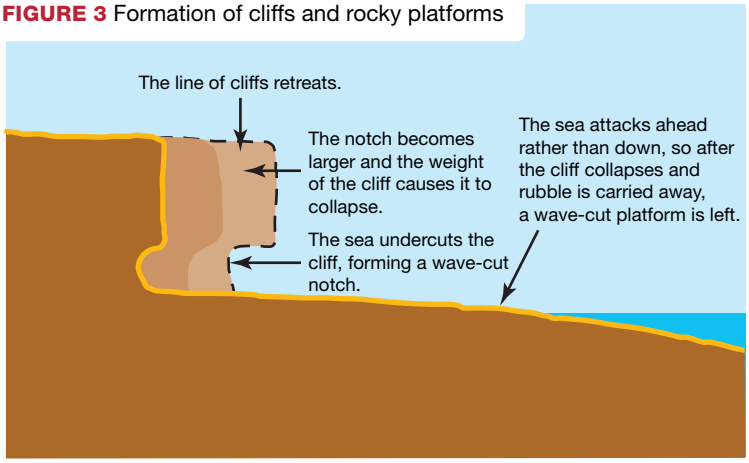


FIGURE 3 Formation of cliffs and rocky platforms



ACTIVITIES

EXPLAIN

1 Explain why vegetation ***changes*** from the front of the fore dune to the back of the back dune.

APPLY

2 Using the internet, find examples of well-known coastal landforms that have been created by erosion and deposition. Present your findings as a digital poster or presentation.

INVESTIGATE

3 Fraser Island is located off the coast of Queensland. It has been recognised as the largest sand island in the world and contains many specialised landforms, such as perched lakes, and unique coastal ecosystems. Once mined for sand and logged for timber, it has become a popular eco-tourism destination. An issue for today is how to sustainably manage the impacts of eco-tourism and protect the ***environment*** of this World Heritage listed island.

a Research the past and present uses of Fraser Island.
b When did it become a World Heritage site?
c What are some of its unique features?
d What does the future hold for Fraser Island?

GEOskills TOOLBOX

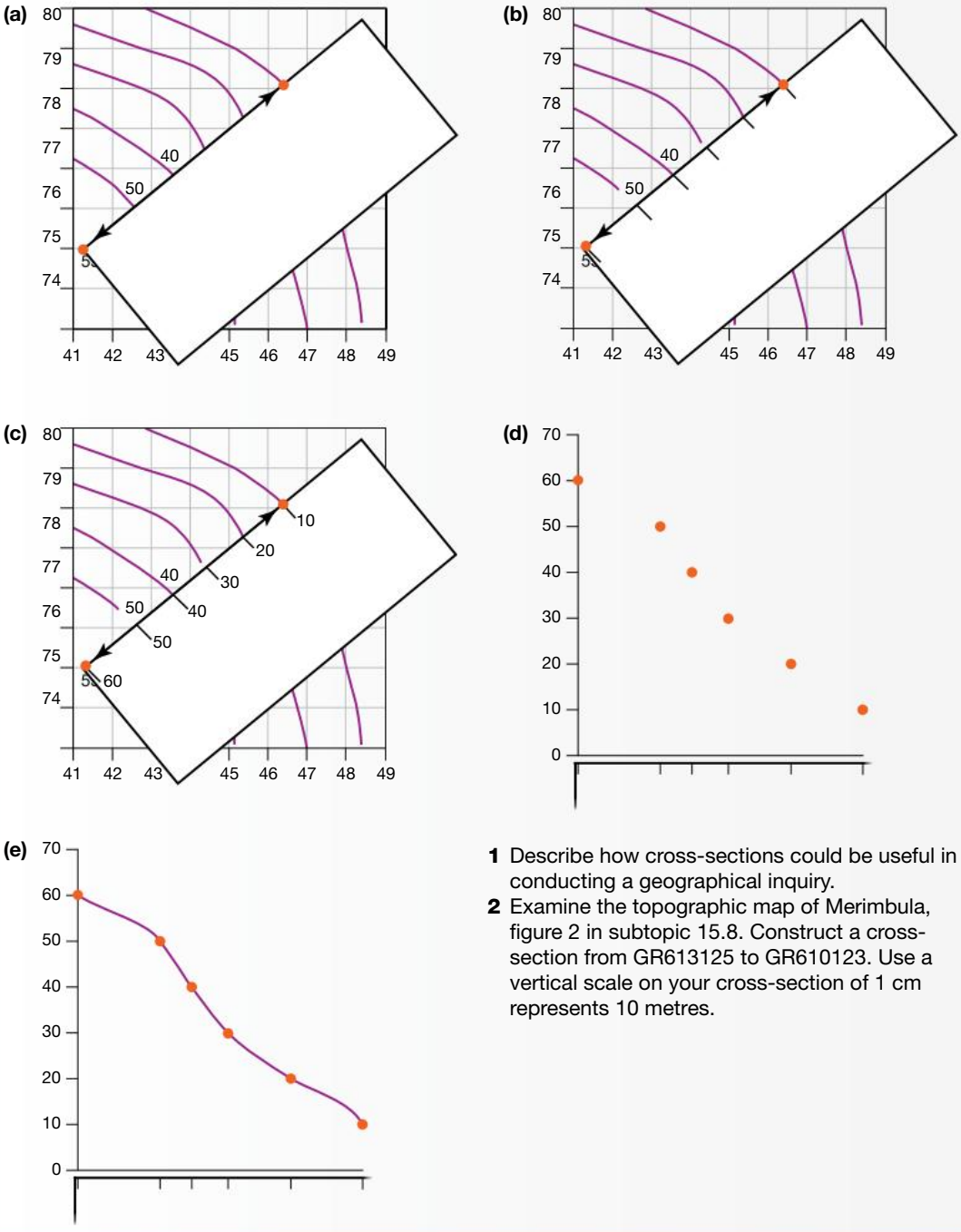
Cross-section

A cross-section is a diagram that shows the shape of a landform represented on a map. Steps to follow to complete a cross-section are:

a Take a piece of paper and place it on top of the map between the two points that will be the ends of your cross-section.
b Put a mark on the paper each time a contour line meets the edge of the paper.
c Make sure you record the value of the contour line (the height above sea level) for each mark.
d Plot the lines from your piece of paper on a graph. You will be given a scale on the vertical axis. It is usually the same as the contour interval on the map.
e Join the dots with a smooth curved line.

You should label the grid references or places that are your beginning and end points.

FIGURE 4a–e Steps to complete a cross-section



1 Describe how cross-sections could be useful in conducting a geographical inquiry.
2 Examine the topographic map of Merimbula, figure 2 in subtopic 15.8. Construct a cross-section from GR613125 to GR610123. Use a vertical scale on your cross-section of 1 cm represents 10 metres.

15.4 What are the human causes of coastal change?

15.4.1 What types of human activities affect coasts?

Human activities along the coast can interfere with natural coastal processes, resulting in significant changes to coastal environments. Human impacts on coastlines include the construction of ports, boat marinas and sea walls; changes in land use (for example, from natural to agricultural or urban environments); and the disposal of waste from coastal and other settlements.

Our day-to-day lives across the globe contribute to global warming and sea level rise, which in turn also affect our coastlines. The greatest threat to coasts today is rising sea levels. It is recognised that global warming is a result of enhanced greenhouse gas emissions, which is human-induced. This is leading to the melting of polar ice caps and glaciers. Some of the predicted changes to coastal environments due to global warming include:

- increases in intensity and frequency of storm surges and coastal flooding
- increased salinity of rivers and ground waters resulting from salt intrusion
- increased coastal erosion
- inundation of low-lying coastal communities and critical infrastructure
- loss of important mangroves and other wetlands
- impacts on marine ecosystems such as coral reefs.

(***Source:*** *World Ocean Review 2010*, published by Maribus.)

GEOskills TOOLBOX

Drawing a précis map from a satellite image

A précis map is a simple sketch map that can be drawn from either a photograph, satellite image or a topographic map. It shows patterns of an area, rather than all the specific detail as shown on a topographic map or photograph.

To draw a précis map, begin by drawing a frame or border for your map. You may like to lightly sketch in the lines that make up the grid squares from the topographic map if you are using one. Draw the basic outline of your map by following coastlines, drawing in waterways and any major roads. Often a précis map will be drawn based on a particular theme that you are studying. Examples of themes are vegetation types or land uses. Create a key that shows the categories of information that will be shown on your map and how each category will be represented (shading, colour, etc.). Examine the topographic map, photograph or satellite image and shade your map based on the patterns of features you can see. Include an appropriate scale, north point and title on your précis map.

1 Examine a satellite image of Clovelly and Gordon's Bay from Google Maps. Create a précis map of the area showing the area's patterns of settlement in relation to the coastline.

ACTIVITIES

INVESTIGATE

1 The Gold Coast is a popular tourist destination in Queensland.
- **a** Research past and ongoing developments along its coastal zone and display these in the form of a photographic essay.
- **b** Explore why these ***changes*** have taken place. Describe whether they have been mostly natural ***changes*** or human-induced ***changes***.
- **c** Different people and groups can have opposing opinions about ***change***. List the various groups of people affected by coastal ***change*** in the Gold Coast. Describe how their opinions may differ.

2 Using the internet, investigate how human activities have caused coastal ***change*** at one location outside of Australia. Describe these human activities and analyse the consequences of these human activities on the selected coastal zone.

CASE STUDY

Coastal change at Clovelly and Gordon's Bay, Sydney

Nine out of every 10 Australians live within 50 kilometres of the coast, and many areas along Australia's eastern coastline demonstrate the environmental change that results from human impact.

Clovelly Beach is a small beach located at the end of a narrow bay. Concrete platforms and walkways have been built either side of the bay, with steps providing access to the water. The concrete foreshore at Clovelly was constructed in the 1920s to provide easy access to the bay for swimmers. Some human impacts attempt to protect the Clovelly coast. The April 2015 Sydney storms resulted in significant erosion of Clovelly Headland near Shark Point, and as a result rock stabilisation works were required. Randwick City Council undertook this stabilisation work including excavation, installation of sandstone boulders and some landscaping.

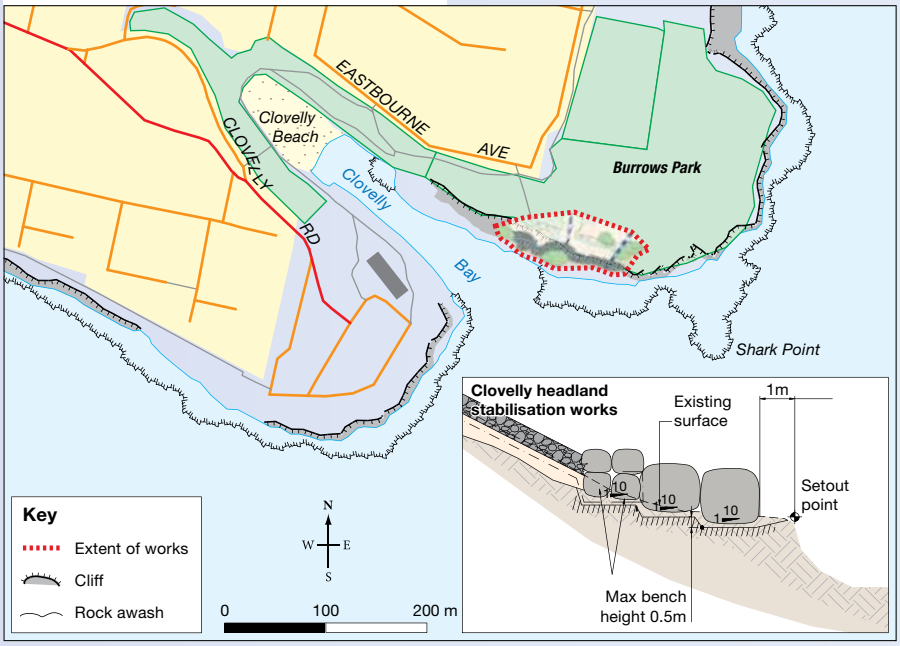
Gordon's Bay is located between Clovelly and Coogee Beaches and provides an idea of what Clovelly may have resembled in the past. Gordon's Bay has a more natural landscape, with cliffs, rock platforms and some natural vegetation. Human impacts can still be seen around the bay with dense housing, walkways and a boatshed.

1 Locate Clovelly Beach and Gordon's Bay using Google Maps. Examine the location as a satellite image.
- **a** Describe the environmental change that has occurred at Clovelly Bay and Beach.
- **b** List the advantages and disadvantages of the concrete foreshore at Clovelly Beach.
- **c** Describe whether you think Clovelly or Gordon's Bay would be a more popular area for visitors.
- **d** Predict how you think these areas will change over the next 20 years.

2 Discuss whether all forms of environmental change along coasts have negative impacts on natural coastal environments.

FIGURE 1 Clovelly beachfront

FIGURE 2 Remediation work at Clovelly



Source: Image courtesy Randwick City Council

FIGURE 3 Gordon's Bay

15.5 Why did environmental change in the Tweed impact the Gold Coast?

15.5.1 What caused the loss of beaches on the Gold Coast?

Have you ever wondered where all the sand on a beach comes from and where it goes? Wind, wave and current action is responsible for moving sand on and off a beach and along a coastline. Human-induced environmental changes along the coast can interrupt these natural processes, often creating long-term problems. One such example is located on the Gold Coast in Queensland where a human-centred, that is, a technical 'we can fix it', viewpoint was taken.

Much of the sand that ends up on the beach actually comes from inland sources, the weathering and erosion of rock and soils. Sand is then washed into rivers and transported downstream to eventually arrive at the coast. At the mouth of the Tweed River, at the southern end of the Gold Coast, sand would often block the river mouth, making it difficult for boats to pass through. As a result, a pair of **training walls** was constructed (see figure 1) 400 metres out to sea, to keep the mouth open.

These, however, effectively interrupted the longshore drift current, which moves sand along the coast.

training walls walls or jetties that are constructed to direct the flow of a river or tide

FIGURE 1 The Tweed River training walls

Further north from the river mouth, natural wave action, especially during storms, continued to strip sand from the beaches. However, without new sand arriving in the longshore drift current, the beaches eventually eroded. Local residents and tourists had lost their beach (see figure 2).

The sand destined for the beach was effectively trapped at the southern end of the training wall, where it built out the Letitia's Spit by 250 metres (see figure 3).

FIGURE 2 The effect of destructive storm waves on Duranbah Beach

15.5.2 How was the problem solved?

groyne a structure (e.g. a rock wall) that is built perpendicular to the shoreline to interrupt the flow of water and the movement of sediment

In response, various attempts have been made to restore the Gold Coast beaches. Rock walls and **groynes** were built to trap sand further up the coast. However, they made the problem worse by interfering further with the longshore drift.

Eventually a sand bypass system was installed (see figure 3). It pumped sand from the build-up on the southern end of the training walls and piped it north to the eroded beaches. Consequently, each year, 500 000 cubic metres of sand have to be moved. This has been successful in maintaining the beaches, but it is an expensive and ongoing management technique.

FIGURE 3 Sand bypass system

Coastal protection works such as groynes, sea walls and training walls are usually built to protect man-made structures such as buildings and roads against erosion. However, they usually reduce the ability of coastal processes to adjust naturally, often exacerbating the problem and actually accelerating erosion.

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Interactivity
Pumping sand
Use this interactivity to apply the geographical concepts to the management of Tweed Heads beaches.
Searchlight ID: int-3295

ACTIVITIES

IDENTIFY

1 List the various ways that sand can be moved in a coastal region.
2 What is the purpose of training walls at a river mouth?
3 Study figure 1. What effect have these training walls had on preventing a sand build-up in the Tweed River mouth?

EXPLAIN

4 Examine figure 3. Describe the direction of the longshore drift in this region.
5 Refer to figure 3. What is the approximate distance that sand has to be pumped from the sand collection jetty to the Kirra intermittent outlet?
6 One coastal geographer has stated that to manage the beaches along the Gold Coast, 'ecologically, non-intervention would be a better and more ***sustainable*** option'. This is an Earth-centred rather than human-centred attitude.
   a Do you agree or disagree with this viewpoint?
   b How could you manage this stretch of the coast without using engineering methods such as the sand bypass system?
7 How effective has the management of sand along this section of the Gold Coast been in terms of ***environmental*** and economic criteria?

PREDICT

8 What ***changes*** would you expect to see along this section of coast if the training walls on the Tweed River were removed?

15.6 How do inland activities affect coasts?

15.6.1 Bangladesh

The country of Bangladesh is a large **alluvial plain** crossed by three rivers: the Ganges, Brahmaputra and Meghna. Each river carries massive volumes of water from its source in the Himalayas, spreads out along the **deltaic plain**, and empties into the world's biggest delta, the Bay of Bengal. This makes Bangladesh's coastline one of the most flood-prone in the world.

alluvial plain an area where rich sediments are deposited by flooding

deltaic plain a flat area where a river empties into a basin

Apart from flooding by rivers in the delta, sea level rises caused by global warming will lead to the expansion of ocean waters and additional inflows from melting Himalayan snow. Scientists predict a one-metre sea level rise by 2100 if global warming continues at the current rate. The United Nations Intergovernmental Panel on Climate Change (IPCC) predicts rising sea levels will overtake 17 per cent of Bangladesh by 2050, displacing at least 20 million people.

15.6.2 The Sundarbans

The Sundarbans region, a World Heritage site, is just one area of Bangladesh at risk from increased flooding. The Sundarbans are the largest intact mangrove forests in the world. Mangroves protect against coastal erosion and land loss. They play an important role in flood minimisation because they trap sediment in their extensive root systems. Mangroves also defend against storm surges caused by tropical cyclones or king tides, both common in the Sundarbans.

The Sundarbans also provide a breeding ground for birds and fish, as well as being home to the endangered Royal Bengal tiger. By sheltering juvenile fish, the mangrove forest provides a source of protein for millions of people in South Asia. Recently, the Sundarbans have also attracted a growing human population as Bangladeshis flee overcrowding in the capital city, Dhaka, or flooding and poverty in rural areas.

Increasing human occupation poses a severe threat to the Sundarbans. Most Bangladeshis rely on wood as a source of energy, and mangroves are being cleared to make charcoal for cooking. Aquaculture industries also have a negative impact. Mangroves are cleared to accommodate huge ponds for fish breeding, which quickly become polluted by antibiotics, waste products and toxic algae. This damage to the Sundarbans destroys Bangladesh's natural defence against flooding.

15.6.3 The impact of flooding

The increase in temperature which has led to an increased melting of glaciers and snow inland in the Himalayas will exacerbate the existing problems of flooding in Bangladesh. Climate change also causes shifts in weather patterns. If the **monsoon** season (from June to October) coincided with an

monsoon a wind system that brings heavy rainfall over large climatic regions and reverses direction seasonally

unseasonal snow-melt, flooding would occur on a scale never before seen, especially with the event of tropical cyclones. Land will be lost and people displaced. Many islands fringing the Bay of Bengal are already under water, producing 'climate refugees', people who have literally nowhere to go.

FIGURE 1 Flooding in Bangladesh — some causes

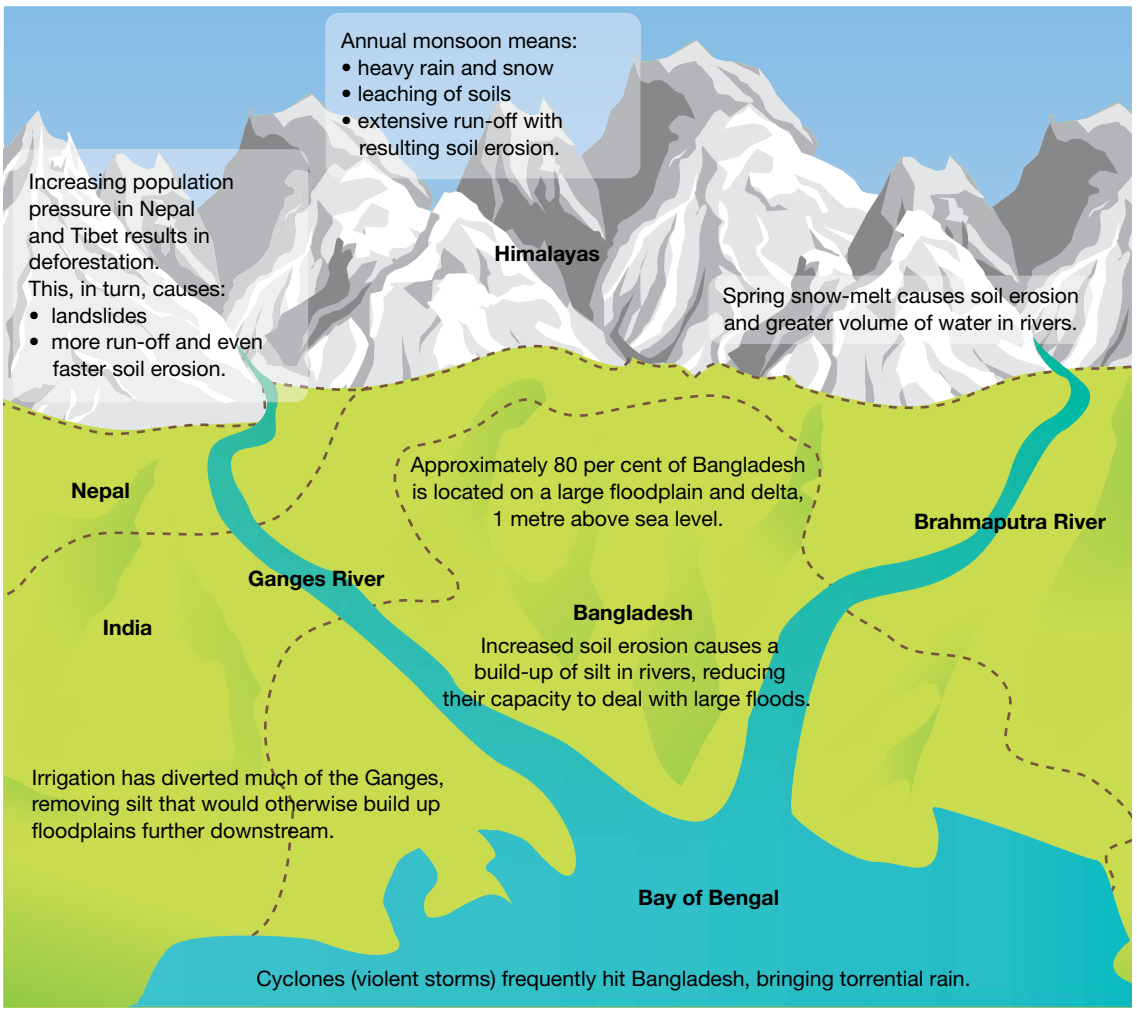

FIGURE 2 A village on one of Bangladesh's coastal islands was devastated by a cyclone in 1991. Although people in areas such as these are aware of the risk, overcrowding often prevents them from moving to safer regions.

The 1991 Bangladesh cyclone was among the deadliest tropical cyclones on record (see figure 2). The cyclone struck the Chittagong district of south-eastern Bangladesh with winds of around 250 km/h. The storm forced a six-metre storm surge inland over a wide area, killing at least 138 000 people and leaving as many as 10 million homeless.

Because of these risks, Bangladesh needs to plan and implement management strategies based on understandings of the reasons behind the changes and consideration of interactions between environmental, economic and social factors operating in the region. The government encourages farming methods that avoid deforestation, and a ban is proposed on heavy-polluting vehicles. A proposed economic solution is

ecotourism, as it attracts foreign currency while preserving the natural ecosystems and promoting sustainable development.

ACTIVITIES

IDENTIFY

1 Explain how mangroves minimise the impact of floods and coastal erosion.
2 State two reasons mangroves are being cleared in the Sundarbans.
3 Define *climate refugees*.

EXPLAIN

4 Refer to figure 1. Explain how the geography of Bangladesh makes it so vulnerable to the threat posed by climate ***change***.
5 Explain how ecotourism plays a role in preserving Bangladesh's ecosystems.

INVESTIGATE

6 List the factors that are displacing Bangladeshis and forcing them to move to the Sundarbans.

APPLY

7 Refer to figure 1.
- **a** Describe how cyclones can contribute towards flooding in Bangladesh.
- **b** List some short-term and long-term actions that neighbouring nations Tibet, India and Nepal could implement to lessen the impact of flooding in ***places*** like Bangladesh.
- **c** Divide a table into three columns with the headings 'Food production', 'Transport' and 'Settlement', and list the consequences of flooding for each category.

8 Discuss in small groups to what extent you think economic goals and objectives are important with respect to ***environmental*** goals such as reducing greenhouse gas emissions and societal ***change***. Listen respectfully to one another's views. Decide as a group what policy direction you would push if you were in a position of influence in government, and present this view jointly to the class.
9 Research a coastal case study in Australia or Asia of a location impacted by flooding and managed by multiple authorities.
- **a** Define the geographical location of the case study and the physical processes that shape it.
- **b** Describe how the area is impacted by ***change*** currently and how it may ***change*** in the future.
- **c** Outline the different groups that play a role in managing ***change*** in the area.

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Interactivity
Bangladesh awash
Use this interactivity to explore the interconnections between human changes to the Bangladesh landscape and their consequences.
Searchlight ID: int-3297

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15.7 SkillBuilder: Comparing aerial photographs to investigate spatial change over time

Why is it useful to compare aerial photographs?

Aerial photos are images taken above the Earth from an aircraft or satellite. Two images taken at different times, from the same angle, and placed side by side, show change that has occurred over time. Comparing aerial photographs is useful because each photograph captures details about a specific place at a particular time.

eLesson
Watch this video to learn how to compare aerial photographs to investigate spatial change over time.

Searchlight ID: eles-1750

Interactivity
Try this interactivity to learn how to compare aerial photographs to investigate spatial change over time.

Searchlight ID: int-3368

15.8 What are the consequences of coastal change in Merimbula?

15.8.1 Coastal change in Merimbula

Merimbula is a coastal resort town on the south-east coast of New South Wales. The 'Sapphire Coast' is a popular tourist destination because of its array of beautiful beaches, stunning scenery and mild, sunny weather. Similar to any other popular coastal location, the main pressures on this coastal system relate to the development of the town and tourist facilities. Careful management has enabled growth of the urban area while at the same time protecting many of the natural features of the coastline.

The natural landform features along this coastline include a series of headlands separated by bay head beaches. Merimbula Lake has formed from a slow and gradual build up of a sand barrier, leaving only a narrow channel for salt water to enter and fresh water to exit (see figure 1). The shallow and sheltered waters of the lake provide an ideal environment for oyster farming and recreation.

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Interactivity
Predict changes around Merimbula
Use this interactivity to consider changes to Merimbula's natural and human environments.
Searchlight ID: int-3296

FIGURE 1 Aerial view over Merimbula Lake

ACTIVITIES

Refer to the topographic map of Merimbula (figure 2) to answer the following questions.

APPLY

1 Create a précis map of Merimbula. Show, shade and label the following natural features.
- Beaches
- Merimbula Lake
- Merimbula Creek
- Rocky areas
- Back Lagoon

2 Create an overlay map to show the distribution of built-up (urban) areas. Finish your map with BOLTSS.

3 **a** Look closely at the contour lines. What is the relationship between elevation and the built-up areas?
b Approximately what percentage of built-up areas would be on land higher than 20 metres above sea level? Are there any exceptions to this rule? Where?
c Suggest a reason for your observations.

4 Mark on your map the area(s) where you would expect wave action to be the most powerful. Include a symbol for this in your legend.

5 Give a reason why sand has built up to form a beach at Middle Beach and not at Merimbula Point.

6 Would you expect the water in Back Lagoon to be fresh or salty? Use evidence from the map.

7 In what ways have people ***changed*** this coastal ***environment***? List and describe how these ***changes*** might influence the natural processes along the coast.

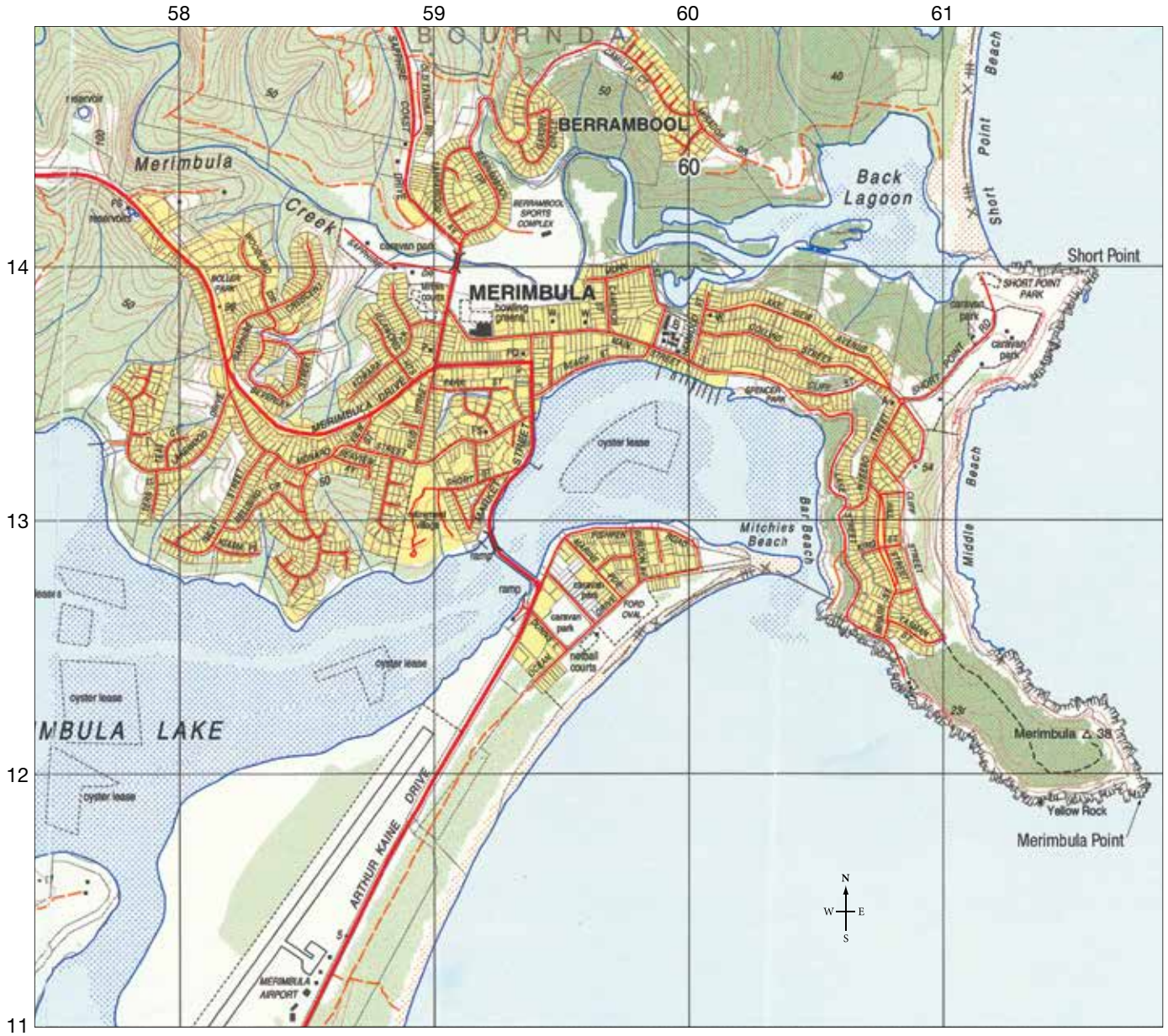
PREDICT

8 If, in the future, the sea level was to rise by 10 metres, which of the following features would be safe from the rising sea? Why or why not?
a The caravan park, located at GR613137
b Merimbula Airport, located at GR585113

9 In what direction(s) is Merimbula likely to expand in the future? Justify your decision.

10 Imagine that a series of storms erodes the sand off Merimbula Beach. The local council then decides to build a series of groynes along the beach to trap sand that moves north in a longshore drift current.
a On your map, mark in six groynes approximately 50 metres long and 500 metres apart. How might the beach change in appearance after the groynes are built?
b Draw the new shape of the beach on your map using a black dotted line. Include this symbol in your legend.
c Will sand continue to accumulate at the mouth of Merimbula Lake after the groynes are built? Explain your answer.

FIGURE 2 Topographic map extract of Merimbula



SCALE 1:25 000

0 km 0.5 1 2 km

CONTOUR INTERVAL 10 METRES

Key

- Built-up area
- Major road: paved, unpaved
- Secondary road: paved, unpaved
- Minor road: paved, unpaved
- Vehicular track
- Walking track
- Bridge
- Werong Δ 1215 — Survey landmark (with height)
- • 846 — Spot height
- 1000 — Contours
- 176 — Cliff, with relative height
- Levee or dyke
- Closed forest: 80–100% crown cover. Open forest: 50–8-% crown cover
- Woodland: 20–50% crown cover
- Perennial lake
- Intertidal flat. Sand
- Perennial stream
- Large dam or weir
- Jetty or wharf
- Rocky shoreline
- • Lauren — Building, small. Building, large.
- • A • P • E — Ambulance station. Police station.
- • FS • S • PO — Fire station. Post office.
- Local government
- County

Source: © LPI - NSW Department of Finance and Services [2013] Panorama Avenue, Bathurst 2795

15.9 Why are low-lying islands disappearing?

15.9.1 Low-lying island

As a result of climate change, many low-lying islands will be flooded by the sea. Thermal expansion of oceans and melting ice leads to rising sea levels, threatening many coastal communities. Many island groups in the Pacific and Indian Oceans will be almost completely inundated by 2050.

tsunami a powerful ocean wave triggered by an earthquake or volcanic activity under the sea

Coastal storms, **tsunamis**, flooding, inundation, erosion, deposition and saltwater intrusion into freshwater supplies present a combined threat to coastal regions. With stronger windstorms possible, many low-lying communities will be at risk from storm surges (see figure 1 and table 1).

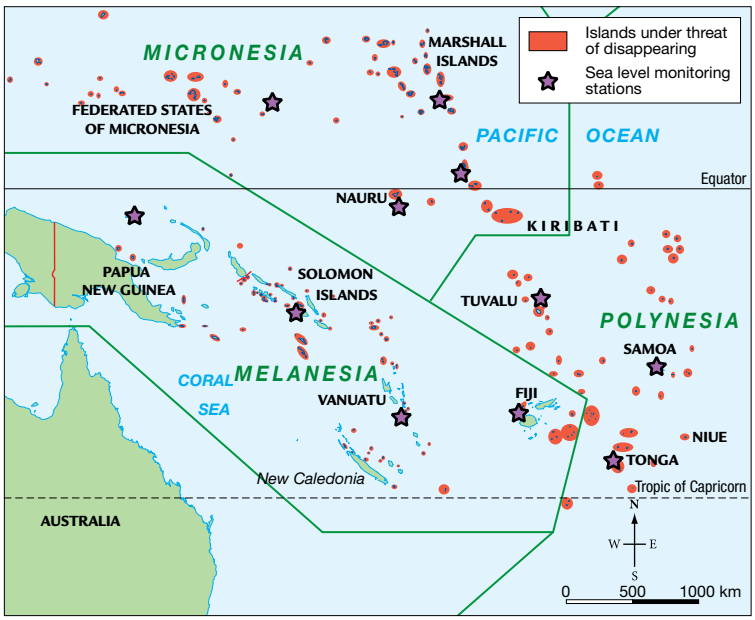
People living on low-lying islands will be among the first wave of 'climate refugees'. Due to environmental change, mainly through rising sea levels, some people have already had to move, and many more could be without a home in our lifetime.

15.9.2 Rising sea levels in the Pacific

atoll a coral island that encircles a lagoon

Many of the Pacific Islands are small and can in some cases be described as an **atoll**. Their national boundaries, which include the waters and economic zones they control, extend over vast distances. Hence, islands such as Kiribati, Tuvalu and the Marshall Islands in the south-west Pacific, which are only a few metres above sea level, are particularly vulnerable to rising sea levels and associated severe storm activity due to climate change (see figure 1).

FIGURE 1 Low-lying islands in the Pacific under threat of disappearing due to climate change



Source: MAPgraphics Pty Ltd, Brisbane

The economies of these Pacific Islands are small-scale, and earnings are not high, with a reliance on what limited natural resources occur on the islands and in the surrounding ocean waters. Due to sandy soils and low altitudes, although rainfalls can be plentiful, little can be retained as streams are few and groundwater is scarce. Hence any incursion by sea water can be devastating for agricultural produce (see figure 2), the urban environment and tourism, which has more recently become a money earner for these islands.

TABLE 1 Selected Pacific Island nations, area and population

Island	Land area (km^2)	National extent (km^2)	Population	Gross income per person per year (US$)	Highest elevation (metres above sea level)
Kiribati	717	3 550 000	100 000	1120	80
Marshall Islands	181	2 131 000	54 000	3240	10
Tuvalu	26	900 000	10 000	2440	5
Australia	7 690 000	7 690 000	23 000 000	36 900	2229

Apart from the predicted rise in sea levels due to global warming, a secondary impact on the life of Islanders will be increases in the temperature of the sea, which will affect coral reefs and fish stocks that live in that environment. As for the Great Barrier Reef in Australia, bleaching and death of coral reefs can lead to the destruction of the whole aquatic ecosystem, and this will have devastating impacts on the Islanders' main diet, which is fish and other forms of seafood.

FIGURE 2 Poulaka crops killed by salt water due to rising sea levels

What can the Islanders do?

If food crops are destroyed by rising sea levels, **storm surges** and saltwater pollution, the Pacific Islanders do not have much scope for importing food due to their remoteness, high transport costs and low earnings of individuals. Combined with loss of seafood stocks, the Islanders will need to move to other islands to find a new home and livelihood.

The Pacific Islanders are strong advocates for the policies of the **Kyoto Protocol** on climate change. The Protocol has set up a range of measures to reduce the impact of greenhouse gas emissions by introducing carbon trading schemes and energy-efficient forms of technology such as wind and solar power. The leaders of the Pacific nations have spoken at the United Nations and many international climate change forums to make others aware of their delicate situation and vulnerability to rising sea levels. They have also approached nations such as Australia and New Zealand to see whether they might be able to establish a migration policy into the future.

storm surge a temporary increase in sea level from storm activity

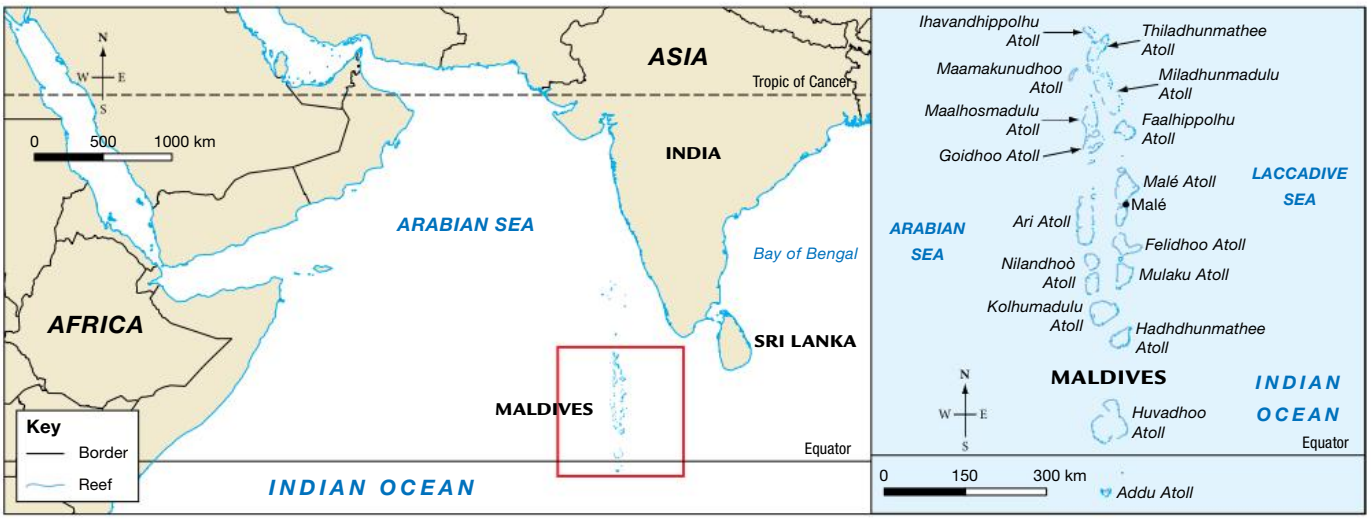
Kyoto Protocol an agreement negotiated in 1999 between 160 countries designed to bring about reductions in greenhouse gas emissions

15.9.3 Rising sea levels in the Maldives

The Maldive Islands are located in the Indian Ocean, to the south-west of India (see figure 3). There are about 1200 coral islands, grouped into 26 atolls, most of which average no more than one metre above sea level (the highest point in the island group is just 2.4 metres above sea level). Economically, the nation depends on tourism and the continuing appeal of its beautiful beaches.

The Boxing Day tsunami of 2004 exposed how vulnerable the Maldives are, when the wave swept across many low-lying islands, causing widespread destruction of their fruit plantations. The relatively low number of deaths was due to the fact that most of the population lives in Malé, which is protected by a huge sea wall (see figure 4).

FIGURE 3 Location of the Maldive Islands



Source: Spatial Vision

FIGURE 4 Malé, the capital of the Maldives, occupies an entire island of its own. Why is there a need for a sea wall?

Only nine islands were reported to have escaped any flooding, while 57 islands faced serious damage to critical infrastructure, 14 islands had to be totally evacuated, and six islands were destroyed. A further 21 resort islands were forced to close because of serious damage. The total damage was estimated to be more than US$400 million, or some 62 per cent of the GDP. One hundred and two Maldivians and six foreigners reportedly died in the tsunami.

The impact of climate change

The longer-term threat to the Maldives, however, is posed by global warming. Sea levels are currently estimated to be rising by about 2 to 3 millimetres each year. Melting glaciers and polar ice are adding to the water volume of the oceans; also, as the water warms, its volume increases. The United Nations Intergovernmental Panel on Climate Change predicts that, by the year 2100, sea levels will have risen by anywhere between 9 and 88 centimetres. In the worst case, this would see the entire nation of the Maldives virtually submerged.

What actions can save the islands?

The application of human–environment systems thinking in the form of various schemes is being examined by the Maldivian Government, including moving populations from islands more at risk, building barriers against the rising sea, raising the level of some key islands and even building a completely new island. However, these approaches offer only short-term solutions. The longer-term sustainable challenge is to deal with the basic problem: global warming itself. It is perhaps understandable that the Maldives was one of the first countries to sign the Kyoto Protocol, which sought international agreement to cut back carbon dioxide emissions.

FIGURE 5 A tsunami break wall in Malé, part of the island's defenses against future natural disasters

Unless the international community agrees to an environmental worldview that incorporates changes to make large cuts in emissions, the problems facing the Islanders will get worse. Numerous people will have to seek refuge in other countries. Without global action, eventually the Islanders will lose their countries.

ACTIVITIES

IDENTIFY

1 Many islands in the Pacific and Indian Oceans are under threat from rising sea levels. Explain why this is the case.
2 Explain what the governments and Pacific Island peoples do, both in the short term and long term, to solve the problems they will face due to climate ***change***?
3 Describe how climate ***change*** is threatening water supplies and affecting food resources.

INVESTIGATE

4 Use the **Maldives** weblink in your eBookPLUS to watch the news article on the Maldivian island of Maduwaree. Summarise what is contributing to the receding coastline. Detail what ***environmental***, social and economic impacts the ***change*** is having on the inhabitants, and outline what management solutions are proposed.

PREDICT

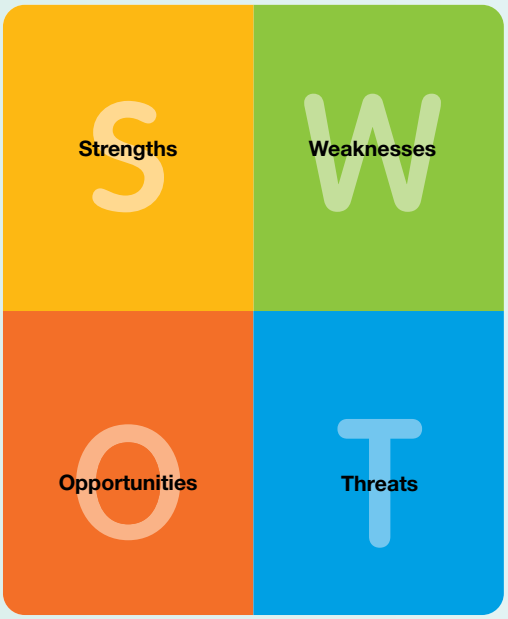
5 As a class, discuss other parts of the world you can think of that might also be threatened if sea levels were to rise by about one metre over the next 100 years. Justify your views.

APPLY

6 In groups, discuss the following statements concerning the impacts of climate ***change*** in the Pacific and Indian Oceans using ***environmental***, economic and social criteria. Alternatively you may wish to use a SWOT analysis to help in evaluating each statement.

a Australia and New Zealand should be prepared to re-settle the 100 000 people of the islands of Kiribati if sea level rises create a 'climate refugee' problem.
b Increasing the height of the sea wall around the island of Malé will solve the threats of rising sea levels in the Maldives and ensure tourism into the future.

FIGURE 6 SWOT analysis



eBookplus
Weblink
Maldives

15.10 How do we manage coastal change?

15.10.1 Changing coastlines

Coastal environments have not always been managed sustainably. In the past, decision-makers had limited knowledge about the fragile nature of many coastal ecosystems, and they had limited environmental world views about the use of coastal areas. Their aim was to develop coastal areas for short-term economic gains. This was based on the belief that nature's resources were limitless. Building high-rise apartments and tourist resorts on sand dunes seemed a good idea — until they fell into the sea when storms eroded the shoreline. Over time, people have realised that coastal management requires an understanding of the processes that affect coastal environments.

To manage the coast sustainably we need to understand:
- the coastal environment and the effect of physical processes
- the effect of human activities within the coastal zone
- the different perspectives of coastal users

- how to achieve a balance between conservation and development
- how decisions are made about the ways in which coasts will be used
- how to evaluate the success of individuals, groups and the levels of governments in managing coastal issues.

15.10.2 Protecting the coast

groundwater salinity presence of salty water that has replaced fresh water in the subsurface layers of soil

dyke an embankment constructed to prevent flooding by the sea or a river

floating settlement anchored building that floats on water and is able to move up and down with the tides

The protection of the coast through management programs is a costly business which aims to overcome problems associated with land loss, waterlogging and incursions of **groundwater salinity**.

The Netherlands and Germany together spend 250 million euros on coastal works each year. The Netherlands, a country with two-thirds of its land below sea level, has proven that protecting the coastline is possible through a large investment of capital. The most common form of coastal protection in the Netherlands are **dykes** to hold back the sea; however, a recent addition is **floating settlements** that can rise and fall as sea levels change (see figure 1).

FIGURE 1 Floating settlements anchored to the embankments along the waterfront at Maasbommel, the Netherlands

TABLE 1 Nations with the largest populations and the highest proportions of population living in low-lying coastal areas

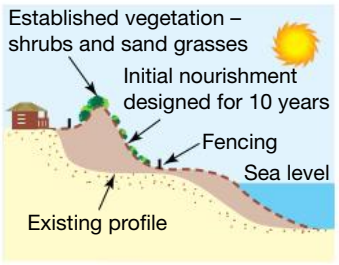
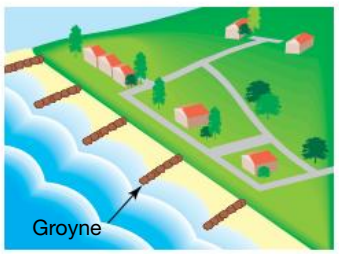
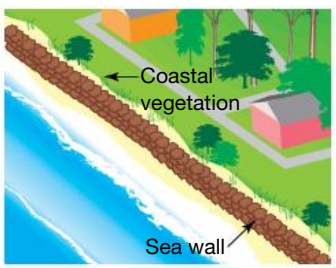
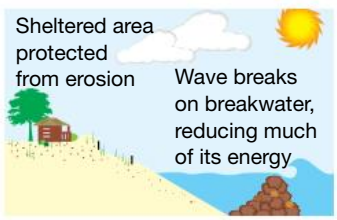
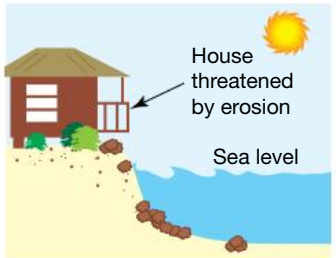
Top 10 nations classified by population in low-lying coastal regions			Top 10 nations classified by proportion of population in low-lying coastal areas		
Nation	Population in low-lying coastal regions (10^3)	% of population in low-lying coastal regions	Nation	Population in low-lying coastal regions (10^3)	% of population in low-lying coastal regions
1. China	127 038	10	1. Maldives	291	100
2. India	63 341	6	2. Bahamas	267	88
3. Bangladesh	53 111	39	3. Bahrain	501	78
4. Indonesia	41 807	20	4. Suriname	325	78
5. Vietnam	41 439	53	5. Netherlands	9590	60
6. Japan	30 827	24	6. Macau	264	59
7. Egypt	24 411	36	7. Guyana	419	55
8. United States	23 279	8	8. Vietnam	41 439	53
9. Thailand	15 689	25	9. Djibouti	250	40
10. Philippines	15 122	20	10. Bangladesh	53 111	39

15.10.3 Coastal management in Australia

If coastlines are to be protected, a wide range of strategies must be employed to combat changes to the coastline and, in particular, flooding of low-lying areas and increased erosion of beaches and bluffs. The techniques shown in table 2 are used in Australia.

The strategies are designed to protect the coastline by reducing the wave intensity or removing some human activities from the direct pathways of the waves. Each location requiring management will have different physical characteristics and will be used by the community in different ways. As a result there is no one solution to coastal management. In 2016, the wild storms associated with the collapse of homes along the Narrabeen-Collaroy coast was a case study in the natural forces that these strategies aim to address.

TABLE 2 Possible management solutions to reduce impacts of sea level rise and erosion

Solution	Description	Diagram	Advantages	Disadvantages
Beach nourishment	The artificial placement of sand on a beach. This is then spread along the beach by natural processes.		Sand is used that best matches the natural beach material. Low environmental impact at the beach	The sand must come from another beach and may have an environmental impact in that location. Must be carried out on a continuous basis and therefore requires continuous funds
Groyne	An artificial structure designed to trap sand being moved by longshore drift, therefore protecting the beach. Groynes can be built using timber, concrete, steel pilings and rock.		Traps sand and maintains the beach	Groynes do not stop sand movement that occurs directly offshore. Visual eyesore
Sea wall	A structure placed parallel to the shoreline to separate the land area from the water		Prevents further erosion of the dune area and protects buildings	The base of the sea wall will be undermined over time. Visual eyesore Will need a sand nourishment program as well High initial cost Ongoing maintenance and cost
Offshore breakwater	A structure parallel to the shore and placed in a water depth of about 10 metres		Waves break in the deeper water, reducing their energy at the shore.	Destroys surfing amenity of the coast Requires large boulders in large quantities Cost would be extremely high
Purchase property	Buy the buildings and remove structures that are threatened by erosion		Allows easier management of the dune area Allows natural beach processes to continue Increases public access to the beach	Loss of revenue to the local council Possible social problems with residents who must move Exposes the back dune area, which will need protection Cost would be extremely high Does not solve sand loss

ACTIVITIES

IDENTIFY

1 Refer to table 1. Identify which country is most susceptible to ***changing*** coastlines in terms of absolute population numbers.

EXPLAIN

2 Explain why the Netherlands spends money on coastal protection.

3 Explain how a coastal defence system such as a dyke works.

PREDICT

4 Predict the impact that a rise in sea level and erosion could have on future food security.

APPLY

5 Predict possible impacts of sea level rise and coastal erosion on the tourist industries of the Gold Coast area of Australia. What strategies of coastal protection, as mentioned in this chapter, could help solve the problems, and how might they work?

6 Evaluate the strengths and weaknesses of two of the management strategies shown in table 2.

a Which strategy would have the least ***environmental*** impact?

b Which strategy would be the most costly to maintain?

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15.11 SkillBuilder: Comparing an aerial photograph and a topographic map

What comparisons can be made between aerial photographs and topographic maps?

Comparing an aerial photograph with a topographic map enables us to see what is happening in one place. Each format shows different information. A photograph can provide a clear impression of the activities taking place on the land or under the water at a particular moment in time. Topographic maps allow the cartographer to add information that cannot be identified from the air, such as place names and building names.

eLesson

Watch this video to learn how to compare an aerial photograph and a topographic map.

Searchlight ID: eles-1751

Interactivity

Try this interactivity to learn how to compare an aerial photograph and a topographic map.

Searchlight ID: int-3369

15.12 How do coastal areas change?

15.12.1 Coastal changes

Consequences of coastal changes can vary in severity from coastal footpaths crumbling and collapsing into the sea, whole unit blocks being undermined by pounding waves and collapsing, farmland being inundated with salty water to whole communities being destroyed.

Sand dunes erode when storms cause strong winds and waves to hit the coast with greater force and higher onto beaches than usual. The front face of the sand dune becomes very steep as sand is removed. **Blowouts** develop when sand is removed by the wind if there is little protection to block the wind. Usually, coastal vegetation such as grasses, shrubs and trees helps reduce the wind speed and the root systems of these plants stabilise the dunes.

FIGURE 1 A dune blowout with marram grass growing around the edges

blowout a hollow or bare patch found in sand dunes caused by the removal of sand by the wind

FOCUS ON FIELDWORK

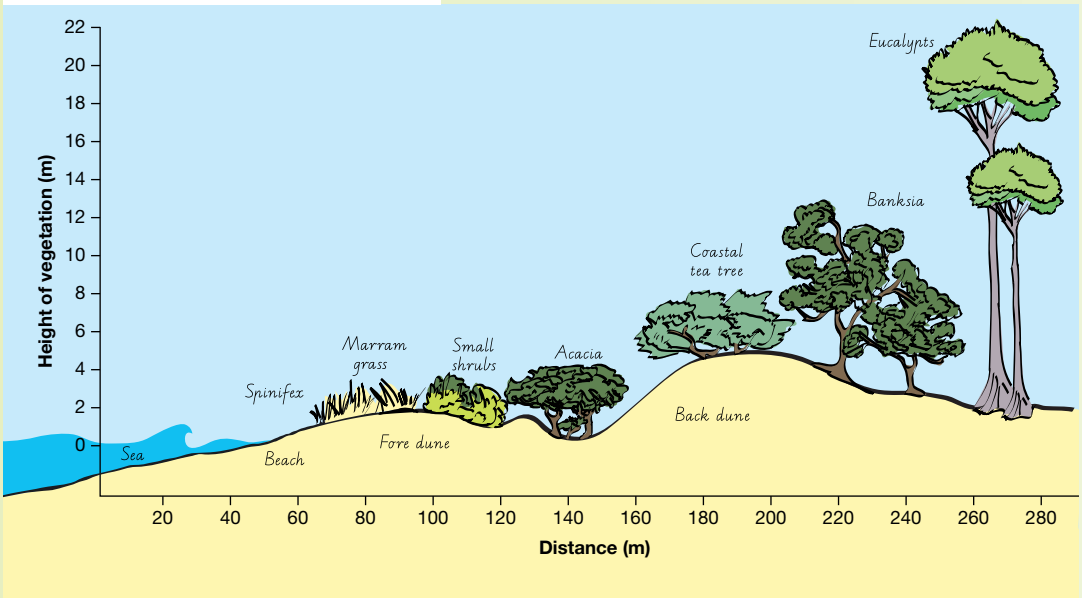
Creating a coastal vegetation transect

A consequence of environmental change along coastlines as a result of developments has been the removal or modification of coastal dune vegetation. Coastal vegetation is an important factor in stabilising coastal dunes and reducing the severity of storm surges and flooding. An investigation of coastal vegetation enables us to predict the severity of future flooding and to determine areas which will be most impacted. Refer to subtopic 15.3 to revise coastal dunes and vegetation.

Visit a beach with accessible sand dunes. You will need a coastal vegetation identification chart for your area.

1. Begin by identifying the different parts of the dune. Vegetation will generally begin at the front of the fore dune, with different species likely to be found at the back of the fore dune, the front of the back dune and the top and back of the back dune.
2. Take a measurement of the dune, and draw a basic cross section of the dune. This will be used as the basis of the vegetation transect.
3. Create a key that shows the symbols you will use to represent each species of vegetation.
4. Using your vegetation identification chart, identify the plant species found on the dunes and place symbols on your cross section showing where you found each species. Try to provide a rough indication of the height of the species found.
5. Identify the part of the dunes that have shortest and tallest species of plants growing. Provide reasons why this might be the case.
6. Compare your fieldwork with the diagram below. Discuss whether your findings are similar to the vegetation patterns evident in the transect.
7. Identify any features of plants that would enable them to survive in an area subject to salt water, high winds and limited soil nutrients.
8. Describe any evidence of human impacts on the dune vegetation.

FIGURE 2 An example of a sketch map



Severe storms brought heavy rain and gale force winds to Sydney's northern beaches in early June 2016. Homes and other waterside properties were affected by abnormally high tides and damaging surf. Waves up to 8 metres high, combined with a king tide, caused the beaches at Collaroy and Narrabeen to be eroded by about 40 metres in only two days. In Collaroy, residents lost up to 10 metres of their backyards and had the foundations of their homes undermined (see figure 3). Apart from the damage to people's homes, underground infrastructure such as sewers, cable lines and gas lines was exposed along the coastline (see figure 4).

The impact on the coast led to renewed calls for careful monitoring of Australian beaches. It is feared that climate change will lead to more erosion along the northern beaches; higher sea levels and more intense storms are likely as global temperatures increase, causing more moisture to be held in the warmer atmosphere.

FIGURE 3 Homes were destroyed by erosion at Collaroy Beach after the June 2016 storm event.

FIGURE 4 Collaroy Beach had to be closed because of significant beach erosion and exposed infrastructure.

According to predictions made by the World Ocean Review in 2010, more than one billion people, most of them in low-lying coastal areas, could experience inundation and/or erosion of their lands in the future. This change to coasts is seen as stemming essentially from climate change which, as a human-induced event, is leading to rising seas and more frequent severe storm events. A consequence will be an increase in the number of what are known as *climate refugees*, people who will have to relocate because of coastal changes.

GEOskills TOOLBOX

Design a Google Earth tour

Google Earth allows you to manually navigate the globe on your screen. It also allows you to view and create automated tours. A tour enables you to see a series of locations linked with geographical information which automatically plays like a video. You can select locations and add geographical information that relates specifically to the site to create placemarks to add to your tour.

Creating placemarks

Open Google Earth. To create placemarks, navigate the globe to a specific location. In the top/main menu, click *Add* > *Placemark* OR click *Add Placemark* in the toolbar. Name the location and add a description of the site and any other relevant multimedia. Click OK.

Creating tours

In Google Earth, create a new folder by clicking *Add* in the [top/main] menu and clicking *Folder*, and then add a series of placemarks. You can add photos, narration, videos and links to each placemark. To view the tour double-click each placemark in the left-hand menu. Ensure that you save your tour.

1 Choose a coastal area that has experienced change. Choose a series of specific locations that show evidence of the coastal change, or the cause or consequences of the coastal change. Create placemarks at each location and add information describing the site, as well as photos, links to video and websites to the placemark. Record your tour and share it to a class website or save it in your own student portfolio. Demonstrate your tour to your class.

ACTIVITIES

PREDICT

1 Predict how coastal ***change*** as a result of climate ***change*** could impact on the coastlines of Australia.

EXPLAIN

2 Conduct a class debate on Australia's roles and responsibilities in providing for the needs of climate refugees.

INVESTIGATE

3 Conduct internet research on locations around the world that will be impacted by sea level rise as a result of climate ***change***. Create an interactive wall display showing the consequences of coastal ***change*** as a result of climate ***change***.

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15.13 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

15.7 SkillBuilder: Comparing aerial photographs to investigate spatial change over time

15.7.1 Tell me

What is an aerial photo?

Aerial photos are images taken above the Earth from an aircraft or satellite. Aerial photos — either oblique or vertical — record how a place looks at a particular moment in time. They allow a place to be captured in greater detail than is possible with a photo taken at ground level. Some aerial photos are also satellite compilations; that is, they have been created by a number of images transmitted from a satellite.

Why is it useful to compare aerial photographs?

Comparing aerial photographs is useful because each aerial photograph captures details about a specific place at a particular time. Two images taken at different times, from the same angle, and placed side by side, show change that has occurred over time. Distribution patterns and the interconnection of different features are readily seen. You will find that the comparison of aerial photographs shows you a lot about places, spaces and environments, as well as change that takes place over time and the interconnection of features.

Aerial photographs are useful for showing:

- changing patterns and the implications of events
- interconnections between events and impacts
- damage caused by hazards such as landslips, cyclones and floods
- the growth of cities, especially on the urban fringe
- degradation of land over time.

Model

Use the **Hurricane Sandy** weblink in the Resources tab to see how Hurricane Sandy changed the coastline of the United States. By hovering and sliding over the image, you can see the before and after images of Casino Pier and Breakwater Beach Park. Hurricane Sandy destroyed the theme park on the Casino Pier, and the waves removed the sand on the beach, especially on the northern side of the pier. On this same side of the pier, debris built up on the sand. Inland, the water spread throughout buildings but very few of them were lost to wave surge. Storm waves have the energy to destroy buildings and move sand.

A good aerial photograph comparison:

- identifies patterns and features that are similar over time
- identifies patterns and features that have changed over time
- indicates the interconnection of features.

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Weblink
Hurricane Sandy

15.7.2 Show me

How to compare aerial photographs

You will need:

- at least two aerial photographs of the same place taken at different times but at the same angle — oblique or vertical
- or the **Hurricane Sandy** weblink in the Resources tab, which also shows change over time in aerial imagery of other global disasters (such as the Japanese Tsunami).

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eLesson
Comparing aerial photographs to investigate spatial change over time
Searchlight ID: eles-1750

Procedure:

To complete a comparison of aerial photographs, take at least two aerial photographs of the same place, taken at different times, at the same angle, and place them side by side. Alternatively, use the **Hurricane Sandy** weblink in the Resources tab.

STEP 1

Identify patterns or features that are similar over time; that is, they appear in both of the aerial photographs being studied. For example, the theme parks are identifiable in both photographs you saw via the **Hurricane Sandy** weblink in the Resources tab. Inland, the water spread throughout the buildings but very few of these buildings were lost to the wave surge. Consider other patterns and features that are similar across the aerial photographs.

STEP 2

Identify patterns and features that have changed over time; that is, they appear altered from one photograph to the next, when the photographs were taken at different times. For example, the northern coastline has changed in the 'after' aerial photograph of Breakwater Beach Park. In the earlier photo, the coastline is seen, but in the later photo the coastline is more covered by water. Another example is the end of the pier, which has been destroyed. Consider other patterns and features that have changed across the aerial photographs you are examining.

STEP 3

Try to explain the processes at work that have changed the environment. In analysing the images of Breakwater Beach Park, it is necessary to mention the power of the storm and its ability to move sand. For example, you could say: 'Storm waves have the energy to destroy buildings and move sand.'

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Interactivity
Comparing aerial photographs to investigate spatial change over time
Searchlight ID: int-3368

15.7.3 Let me do it

Developing my skills

Use the **Hurricane Sandy** weblink in the Resources tab to view the aerial photograph of the coastal area of Mantoloking, New Jersey. Now write a description of the changes that can be seen in the coastline after the storm.

Questions

1. What happened to the bridge in the storm?
2. How was the land changed by the storm?
3. What happened to the houses on the ocean side of the land?
4. Are the boat moorings still useful? Explain your answer.
5. On a scale of 1 to 5 (with 1 being 'little damage' and 5 being 'total devastation'), rate the damage caused by Hurricane Sandy to the Mantoloking coastal community. How has the area changed?

Checklist

I have:

- identified patterns and features that are similar over time
- identified patterns and features that have changed over time
- indicated the interconnection of features.

Skills questions

1. A comparison of aerial photographs shows:
   a. change over time
   b. no changes
   c. change and similarities over time
   d. not enough detail to estimate change.
2. A comparison of aerial photographs must use photographs taken:
   a. at the same time
   b. at different times
   c. at sunset
   d. at different places.
3. Why do you need to have photographs showing the same place?
4. Why do the photographs need to be taken from the same camera angle?

15.11 SkillBuilder: Comparing an aerial photograph and a topographic map

15.11.1 Tell me

What comparisons can be made between aerial photographs and topographic maps?

Comparing an aerial photograph with a topographic map enables us to see what is happening in one place. Photographs and maps may be from the same date but they may also be from different dates, and will thus show different information.

Why is comparing an aerial photograph with a topographic map useful?

Comparing an aerial photograph with a topographic map is useful because each format provides different information. The camera captures a place at one moment in time. The realistic colours in a photograph give a clear impression of the activities taking place on the land. Aerial photographs allow us to see beneath the water as well. Topographic maps allow the cartographer to add information that cannot be identified from the air, such as place names and building names.

Comparisons of aerial photographs and topographic maps are useful when:

- you want to create a new map combining elements from both
- you are trying to make comparisons about places over time
- you want to see the interconnection between phenomena on an aerial photograph and a topographic map
- oceanographers need to assess sand movement along a coast
- local councils are handling building permits
- transport authorities are undertaking long-term planning.

Model

Use Google Earth or Google Maps to locate an aerial photograph view of the same area shown in the figure 1 topographic map on the next page.

Mossman has changed since 1982, when the map was created. Then, the town was smaller, and we can see that it has developed towards the north, south-east and south-west. By 2011, Cooya, on the coast, had expanded to the south by some 500 metres along the coast. The forested areas on the Cassowary Range and the mangrove coastal area at Port Mossman, however, remain intact. The intertidal flat south of Cooya is evident in the photograph, as are the ledges about a kilometre offshore. The aerial photograph indicates the productivity of the area: some fields contain crops while others have been recently tilled. The topographic map allows us to identify Mt Beaufort and the Cassowary Range as areas within the natural environment. Like many places in coastal areas of Australia, the towns are growing over time.

A good comparison of an aerial photograph with a topographic map:

- includes dates for the photograph and map
- contains a general statement on the region
- provides specific examples, such as place names
- provides directions when showing change over time
- gives distances when showing the scale of change.

FIGURE 1 Topographic map of Mossman and the Daintree River National Park, Queensland, 1982

Source: © Commonwealth of Australia, Geoscience Australia (1982). Topographic map of Daintree National Park — Mossman, QLD. 1:100 000 Series R631, Sheet 7965, Edition 1 1- AAS. 1982.

eBook*plus*

eLesson
Comparing an aerial photograph and a topographic map
Searchlight ID: eles-1751

15.11.2 Show me

How to compare an aerial photograph with a topographic map

You will need:

- a topographic map and an aerial photograph of the same place.

Procedure:

STEP 1

Check the titles of both the topographic map and the aerial photograph to ensure they are of the same place. If the titles or areas do not exactly match, work out which part of one relates to the other by identifying common features in both.

STEP 2

Confirm the dates of both pieces of information, so that you are aware of any differences that exist between the photograph and the map as a result of being created at different times.

STEP 3

Scan back and forth from the map to the photograph, looking for similarities and differences. Clarify any information that you are not sure about. Begin a paragraph by comparing the two sets of data, ensuring you mention place names, dates and any available statistics. For example: 'Mossman has changed in the 30 years since 1982.' In some circumstances you could say 'it has changed significantly' or 'it has changed minimally'.

STEP 4

Identify the changes that you see. What aspects did you find interesting, and why? Continue your paragraph describing the differences that you see between the two sets of data. For example: 'In 1982, the town was smaller, and we can see that it has developed towards the north, south-east and south-west. By 2011, Cooya, on the coast, had expanded to the south by some 500 metres along the coast.'

STEP 5

Conclude your paragraph with a summary sentence. For example: 'The past thirty years have seen major changes in the Mossman area, especially to the towns of Cooya and Newell, which have been infilled and extended north and south along the coast.'

eBook*plus*

Interactivity
Comparing an aerial photograph and a topographic map
Searchlight ID: int-3369

15.11.3 Let me do it

Developing my skills

Using the topographic map and the aerial photograph of Merimbula in subtopic 15.8, write a paragraph comparing the information gained about Merimbula from both data sources.

Questions

1. List three features within Merimbula that can be identified on the map but not on the aerial photograph.
2. What information does the aerial photograph give you about boating in the area that is not available on the topographic map?
3. Which features of Merimbula Lake, seen on the topographic map, cannot be identified on the aerial photograph? What features in Merimbula Lake are given greater clarity by the aerial photograph?
4. What information does the map provide about the airport that cannot be gained from the aerial photograph?
5. What details does the topographic map give about the land facing Bar Beach that cannot be seen in the aerial photograph due to the oblique angle of photography?

Checklist

I have:

- included dates for the photograph and map
- provided a general statement on the region
- provided specific examples, such as place names
- provided directions when showing change over time
- given distances when showing the scale of change.

Skills questions

1. Comparing an aerial photograph with a topographic map is done in order to:
   a. describe the sea
   b. assess the climate of an area
   c. show the slope of the land
   d. provide greater detail about an area.
2. A description based on a comparison of an aerial photograph and a topographic map includes information about:
   a. change over time
   b. soils
   c. population totals
   d. rainfall.
3. Why should you check the dates of the two pieces of data carefully?
4. Why do you need to carefully check each feature of an aerial photograph and a topographic map?

15.13 Review

15.13.1 Review

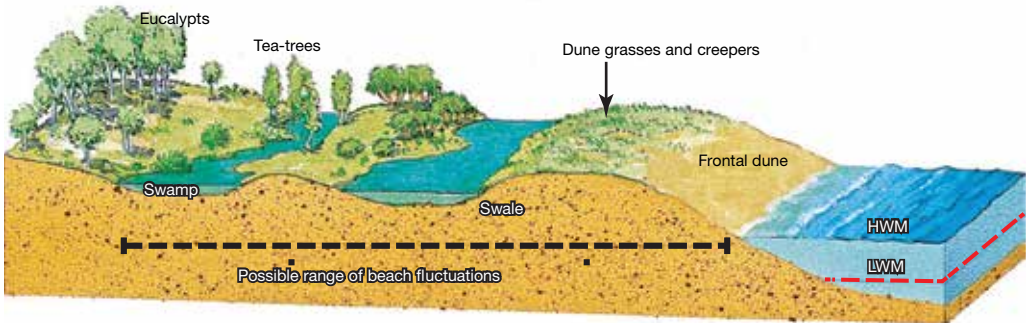
1. Nine out of ten Australians live within 50 kilometres of the coast. Why is this? Consider historical, ***environmental*** and economic reasons.
2. a. Why are coasts important for people? List examples of the different human activities that can take place along the coast.
   b. Which activities on your list are specific to coastal areas?
3. Suggest two examples where human activities could interfere with a natural system on the coast.
4. Refer to figures 2 and 3 in subtopic 15.2 'How are coastal landforms created?' and compare the features of constructive and destructive waves by copying and completing the following table.

Feature	Constructive waves	Destructive waves
Shape of wave		
Swash		
Backwash		
Impact on beaches		

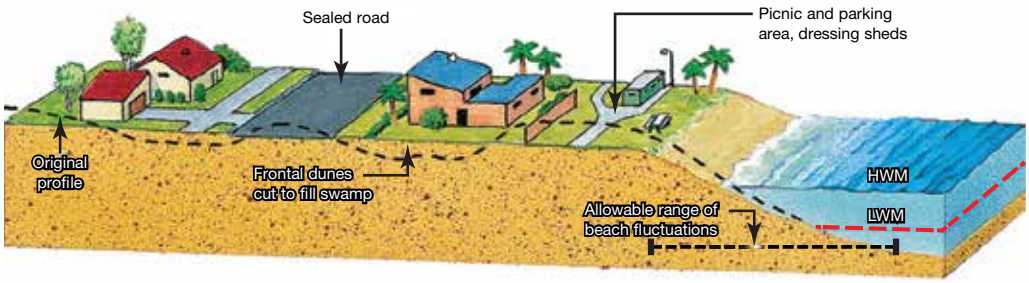
5. A common human-induced ***change*** in coastal areas is the construction of roads and buildings on the dune system. Study figure 1 and describe the ***environmental changes*** that can occur when this happens.

FIGURE 1 The impact of dune removal and building on the foreshore

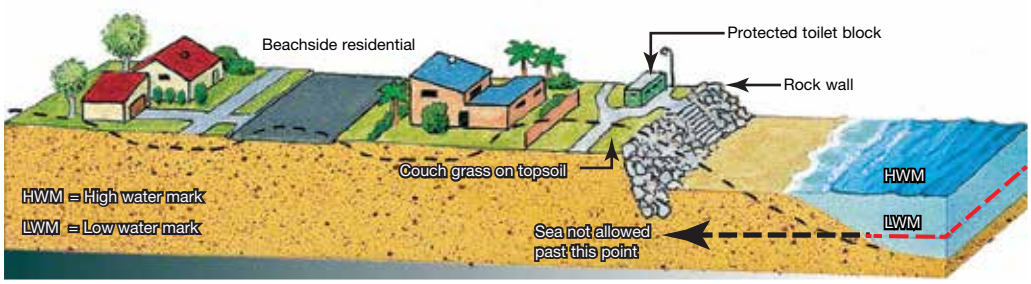
Frontal dunes and natural vegetation act as a buffer between the land and the sea.



Vegetation is cleared and dunes levelled for beachfront development.



With no natural buffer, the foreshore becomes vulnerable to wave action and erosion. Beaches may need restoring through sand pumping and enrichment programs.



6. Answer true or false to the following statements:
   a. Cliffs and headlands are more likely to form on coastlines made up of soft rocks.
   b. As cliffs erode they retreat inland.
   c. The bending of waves to adjust to the shape of the coastline is known as wave refraction.
   d. A stack is similar to a wave cut notch.
   e. If a sea cave collapses, it leaves behind a stack.
7. a. Make a sketch of figure 2. On it, label an area where wave erosion is taking place and an area where wave deposition is occurring.
   b. Would these waves be constructive or destructive waves? Give reasons for your answer.

FIGURE 2 Malibu Beach, California

Refer to figure 2 in subtopic 15.8 'What are the consequences of coastal change in Merimbula?' to answer questions 8–11.

8. a. Has Back Lagoon at GR606144 been formed by erosional or depositional processes? How can you tell?
   b. If Merimbula Creek was to flood, what might happen to Back Lagoon?
9. Mitchies Beach lies at the end of a large spit. Explain how a spit forms. Use a series of labelled sketches to show the stages of development. You might like to also refer to subtopic 15.3 'How do deposition and erosion change coasts?'.
10. In which direction would the longshore drift current be moving if it deposited sand to finally join the spit at Mitchies Beach to the other headland?
11. Oysters are farmed in oyster leases in shallow, clean, sheltered sea water; for example, at GR595135. What types of human activities in Merimbula could impact on the ***sustainability*** of oyster farming?
12. Refer to figure 1 in subtopic 15.9 'Why are low-lying islands disappearing?'. Describe the location of the Pacific Island countries most at risk of sea level rise.
13. Why are supplies of fresh water on Pacific Island countries threatened by sea level rise?
14. Explain why sea level rise due to climate ***change*** is such an issue for the Maldives islands.
15. Describe one natural and one human factor that explains why the Boxing Day tsunami in 2004 had less impact on the Maldives than on other ***places*** in the Indian Ocean; for example, Sri Lanka.

16. Suggest details of strategies that may save the Maldives islands.
17. What are the Sundarbans and why is this ***place*** so important in Bangladesh?
18. What would be the advantages and disadvantages of living on a large floodplain?
19. Refer to figure 1 in subtopic 15.6 'How do inland activities affect coasts?'. Complete this table by explaining how each factor has contributed to ***changes*** in the Sundarbans.

Factor contributing to change	Explanation
Heavy monsoonal rain in the Himalayan mountains	
Deforestation in the mountains	
Diverting water from the Ganges River for irrigation	
80 per cent of Bangladesh lies on a large floodplain and delta	

20. a. Where does the sand on a beach come from?
    b. List the different ways that sand can be delivered to a beach.
21. How does a longshore current move sand along a coast? (You may wish to refer to subtopic 15.2 'How are coastal landforms created?'.)
22. Use figure 3 to describe how a series of groynes can ***change*** the shape of beaches.
23. Refer to subtopic 15.5.
    a. What ***changes***, both positive and negative, did the construction of training walls at the mouth of the Tweed River have on the coastline?
    b. List the steps that were taken to reduce the negative impacts of the training walls.
24. Refer to figure 4.
    a. How many people in the world live in ***places*** with elevations of 500 metres compared to the number of people living at sea level?
    b. What is the relationship between population and elevation?
    c. What are the future implications of these facts?
25. a. Use the data in table 1 in subtopic 15.10 to construct a pie graph showing the 10 countries with the highest proportion of their population living in low-lying coastal regions.
    b. Which three countries from your graph have the largest percentage?
    c. What could countries do to reduce the threat of sea level rise when so many of their populations live in low-lying areas?
26. What are some of the major techniques used to protect coastlines in Australia? Comment on how successful these methods will be against rising sea levels due to climate ***change***.

FIGURE 3 How a series of groynes can change the shape of a beach

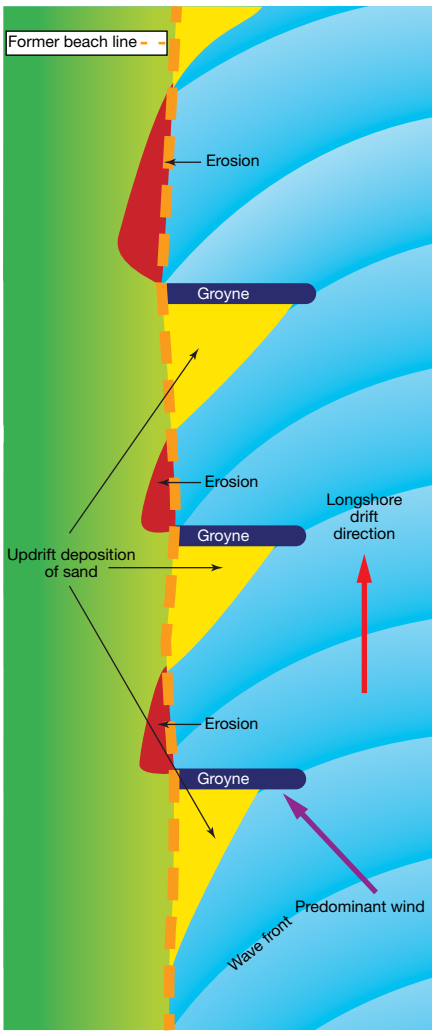
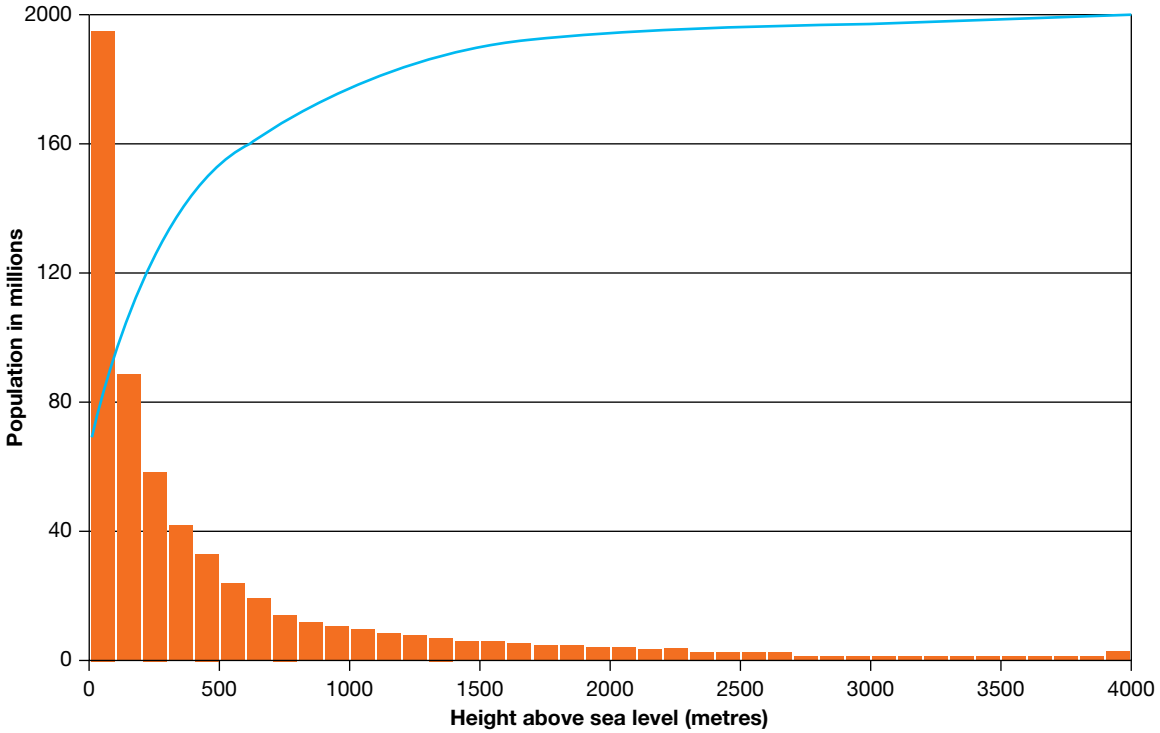


FIGURE 4 Relationship between population and land elevation



Source: Walther-Maria Scheid, Berlin, Germany for *World Ocean Review 2010*.

27. Read through the information in table 2 in subtopic 15.10.
    a. Which management method listed can be seen in figure 5 below?
    b. Why has it been necessary to use the sand bags?
    c. What are the drawbacks to this management method?
    d. Can you suggest another more ***sustainable*** method?

FIGURE 5 Management method for beach erosion

15.13.2 Reflect

28. What ***changes*** could sea level rising bring to a coastal area? Consider both ***environmental*** and human ***changes***.
29. Refer to figure 2 in subtopic 15.8. Imagine that the local council wanted to build a new boat ramp for recreational fishermen. Which of the following locations would be the most suitable and create minimal ***change*** to the natural ***environment***? Construct a table and list the advantages and disadvantages of each site.
    a. GR608124
    b. GR605128
    c. GR595129
30. Refer to subtopic 15.6. Discuss what ***changes*** need to be made to the ***interconnection*** of natural processes and human activities to reduce the destruction of the Sundarbans.
31. Evaluate the economic and ***environmental*** benefits of floating settlements such as those in figure 1 in subtopic 15.10.
32. How can we balance the needs of people with natural coastal processes? You might like to refer to the opening image and the case studies throughout topic 15.
33. With the use of specific examples, discuss the ways in which human-induced ***changes*** can challenge the ***sustainability*** of our coastlines.
34. As Pacific neighbours, Australia and New Zealand should fulfil a duty and accept environmental refugees from Pacific islands in danger of flooding from sea level rise.

FIGURE 6 Homes along the Outer Banks coast in North Carolina

    a. Debate this issue in small groups and write a statement that represents the views of your group.
    b. Evaluate how successful your group has been in:
        i. discussing the issue clearly
        ii. being able to express a common viewpoint of the group.
    c. To what extent did you personally contribute to your group's discussion?
    d. What recommendations could you make to the group, and take on personally, for improving the work of the group?
35. In the US state of North Carolina, it is now illegal to build coastal structures to protect houses built close to the shoreline. Structures such as rock walls and groynes may offer protection but disrupt the natural movement of sand along the coast.
    a. Is this approach fair to those whose houses are threatened by storms and sea level rising? Why?
    b. What would be the arguments for and against the idea of using ratepayer or taxpayer funds to build coastal structures to protect the houses threatened by storms and sea level rising?
    c. Is it equitable for all those people who use the coast? Explain your response.

CHAPTER 16

Marine environments — are we trashing our oceans?

Accumulated marine debris floating in the ocean

16.1 Overview

16.1.1 Introduction

Imagine you are on a beach. You are looking out to sea at the endless, constantly moving mass of water that stretches to the horizon. Why does it move, how does it move, what lies beneath?

Life on Earth would not be possible without our oceans. Humans are interconnected to the oceans, which provide or regulate our water, oxygen, weather, food, minerals and resources. Oceans also create a surface for transport and trade and provide a habitat for 80 per cent of all life on Earth. Our oceans are under threat as we use them to extract resources, dump waste and destroy them. It has been very much a case of 'out of sight, out of mind'.

Starter questions

1 What are your first thoughts when you view this photograph?
2 Suggest items that might be floating in this rubbish.
3 Where do you think this waste has come from, and how did it get here?
4 What waste does your family generate, and what happens to it?

Inquiry sequence

		Syllabus outcomes
16.1 Overview		
16.2 What are the natural processes that affect oceans?		GE5-2, GE5-8
16.3 What are the causes of marine pollution?		GE5-3, GE5-4, GE5-8
16.4 What are the consequences of marine pollution?		GE5-3, GE5-4, GE5-8
16.5 SkillBuilder: Using geographic information systems (GIS)	eBook plus ONLINE ONLY	GE5-7
16.6 Where does oil in the sea come from?	eBook plus ONLINE ONLY	GE5-3, GE5-4, GE5-8
16.7 The world's worst oil spill?	eBook plus ONLINE ONLY	GE5-3, GE5-4, GE5-8
16.8 What is the solution to marine pollution?	eBook plus ONLINE ONLY	GE5-5, GE5-7
16.9 How can marine pollution be managed?		GE5-5, GE5-7
16.10 How can individuals manage marine pollution?		GE5-5, GE5-7
16.11 How are ghost nets managed?	eBook plus ONLINE ONLY	GE5-5, GE5-7
16.12 SkillBuilder: Describing change over time	eBook plus ONLINE ONLY	GE5-7
16.13 Investigating topographic maps: How has coral bleaching affected Lizard Island?		GE5-5, GE5-7
16.14 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Watch this video
Thrown overboard
Searchlight ID: eles-1711

16.2 What are the natural processes that affect oceans?

Coriolis effect force that results from the Earth's rotation. Moving bodies, such as wind and ocean currents, are deflected to the left in the Southern Hemisphere and to the right in the Northern Hemisphere.

gyre swirling circular ocean current (similar to water swirling around a plug hole)

thermoline circulation refers to the flow of ocean water caused by changes in water density. Salt and temperature levels can change; for example, fresh water added by rain, snow melt or river run-off. Temperatures can change from contact with the atmosphere.

16.2.1 What are ocean currents?

Currents are movements of water from one region to another, often over long distances and time periods. Currents effectively interconnect the world's oceans and seas. They are critically important for 'stirring' the waters and transporting heat, oxygen, carbon dioxide, salts, nutrients, sediments and marine creatures.

A knowledge of currents is vital for navigation, shipping, search and rescue and the dispersal of pollutants. The direction that currents take is influenced by a number of factors, including the Earth's rotation, the shape of the sea floor, water temperature, salinity levels and the wind.

16.2.2 What are the different types of ocean currents?

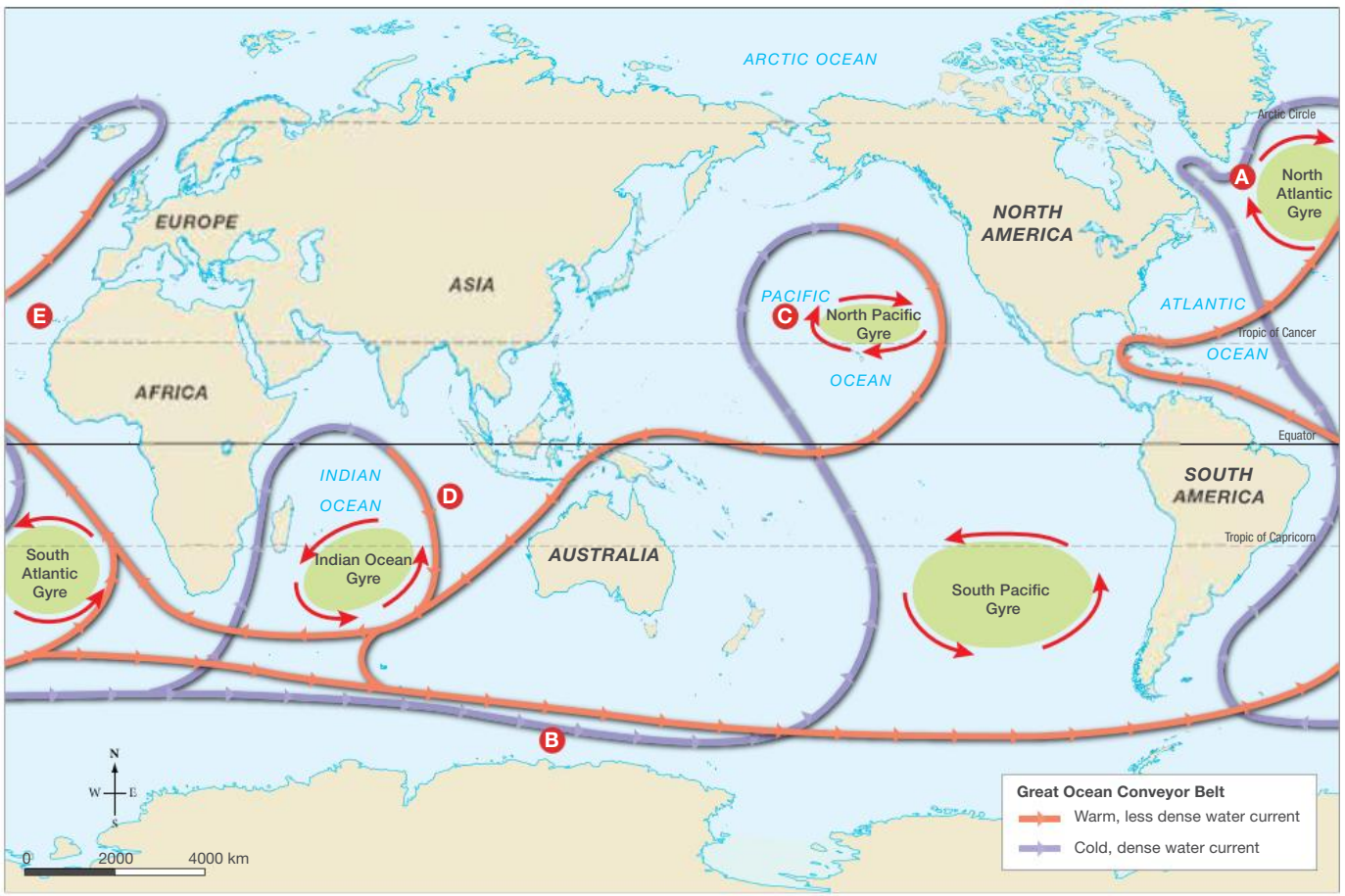
Surface currents

The action of winds blowing over the surface of the water sets up the movement of water in the top 400 metres of the ocean, creating surface currents. These currents flow in a regular pattern, but they can vary in depth, width and speed. Due to the rotation of the Earth, the **Coriolis effect** deflects currents into large circular patterns called **gyres**, which flow clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere (see figure 1).

Deep water currents

Deep water currents are powered by **thermoline circulation** and make up about 90 per cent of water movements in the ocean. Surface currents make up the remaining 10 per cent.

FIGURE 1 The Global Ocean Conveyor Belt and the five main ocean gyres



Source: Spatial Vision

Global Ocean Conveyor Belt

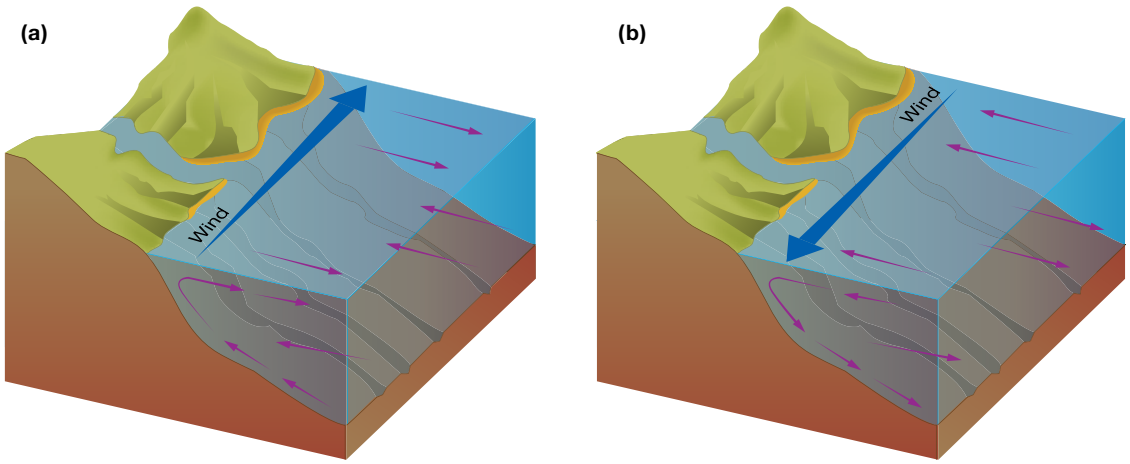
The Global Ocean Conveyor Belt is the largest of the thermoline-driven ocean currents (see figure 1). Warm water, which holds less salt and is less dense than cold water, travels from the equator near the surface into higher latitudes. There it loses some of its heat to the atmosphere. The current mixes with colder Arctic waters and this cold, salty water becomes more dense and sinks, flowing as a deep ocean current. This creates a continual looping current which moves at a rate of 10 cm/s and may take up to 1000 years to complete one loop. The quantity of water moved in the Global Ocean Conveyor Belt is more than 16 times the water volume of all the world's rivers.

Upwellings and downwellings

The movement of cold water currents from the deep sea to the surface is called an upwelling. This is shown in figure 2(a). Regions where these occur are very productive fishing grounds as the upwellings bring nutrients from the seabed, which provide food for the growth of plankton, often the start of marine food chains. Over 50 per cent of the world's fish are caught in these areas.

Downwellings, shown in figure 2(b), occur when currents sink, taking with them oxygen and carbon dioxide from the atmosphere. These currents essentially 'stir up' the water and help distribute heat, gases and nutrients.

FIGURE 2 (a) Upwelling and (b) downwelling



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Interactivity
Motion in the ocean
Use this interactivity to learn more about ocean currents.
Searchlight ID: int-3298

FOCUS ON FIELDWORK

Using an anemometer

An anemometer is an instrument with a small fan and a digital face used to measure wind speed.
To use an anemometer:

- face the direction from which the wind is blowing
- remove the cover from the fan of the anemometer
- select km/h so your measurements are in the correct scale
- raise your arm holding the anemometer and ensure nothing is blocking the flow of air to the instrument
- click the button to take a reading
- repeat this process several times to get an average reading.

Choose three locations around your school to take wind speed measurements. Create a table showing several readings at each site as well as an average reading. Consider factors that may have influenced the different results at each location.

ACTIVITIES

IDENTIFY

1 a Why do ocean currents form? What is the driving force behind surface and thermoline currents?
b Why are upwellings and downwellings important for marine ***environments***?
2 Refer to figure 1. Describe the location of the five main ocean gyres.
3 What factors influence the direction that ocean currents take?
4 Why do you think ocean currents are described as 'conveyor belts'?

5 Looking at figure 1, how does the Global Ocean Conveyor Belt current ***interconnect*** the world's oceans?
6 Refer to figure 1. Describe the route taken by the Global Ocean Conveyor Belt. At each of the locations marked A–E, name the ocean, the direction the current is taking, the continent it is passing, and its thermoline features (warm, cold, higher salt content, lower salt content).

INVESTIGATE

7 Research the ***interconnection*** between the Humboldt current (cold upwelling) on the west coast of South America and El Niño events.

PREDICT

8 Suggest what ***changes*** might happen to the Global Ocean Conveyor Belt if there was a significant melting of the polar ice caps.

APPLY

9 Why doesn't water at the equator keep getting hotter and water at the poles keep getting colder? Use your knowledge of currents to write an explanation for a younger student.

16.3 What are the causes of marine pollution?

FIGURE 1 Most marine debris starts off on land. Much of the litter in this creek in the Philippines will end up in the sea.

16.3.1 What is marine pollution?

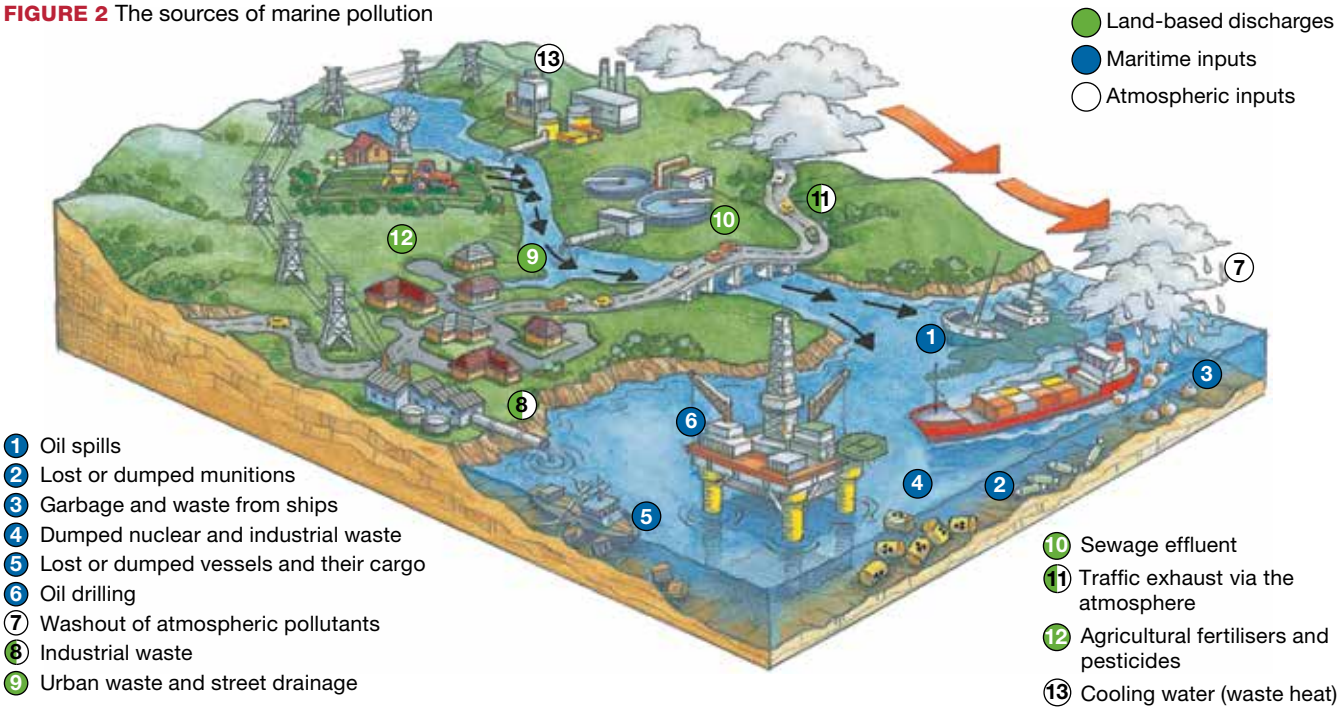
Marine pollution is any harmful substance or product that enters the ocean. Most are human pollutants including fertilisers, chemicals, sewage, plastics and other solids, including over 1000 shipping containers per year.

Close to 80 per cent of marine pollutants start off on land and are either washed or deposited into rivers, from where they make their way to the coast (see figure 1). Figure 2 examines various sources of marine pollution.

16.3.2 What is marine debris?

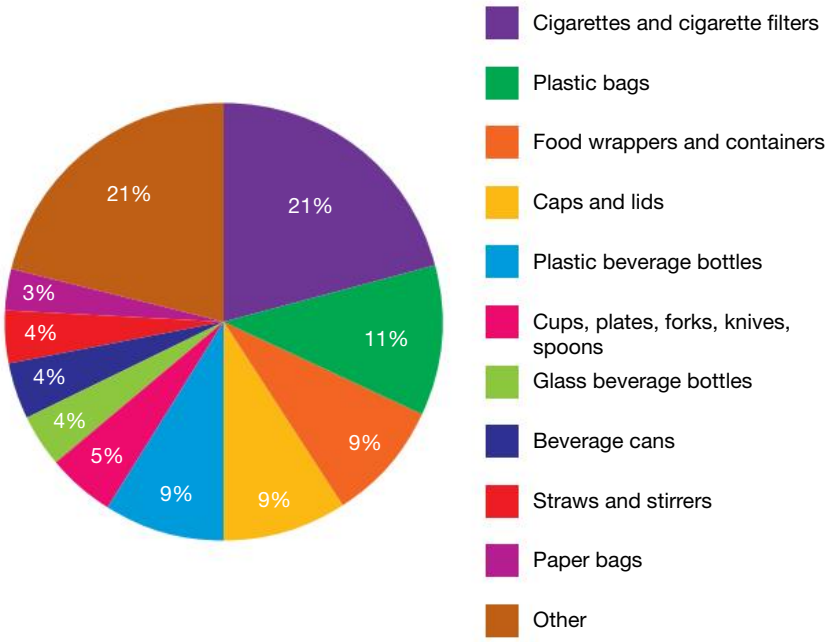
Marine debris is litter and other solid material that washes or is dumped into the oceans, much of which is plastic (see figure 3). The special features of plastic that make it such a useful product — it is

FIGURE 2 The sources of marine pollution



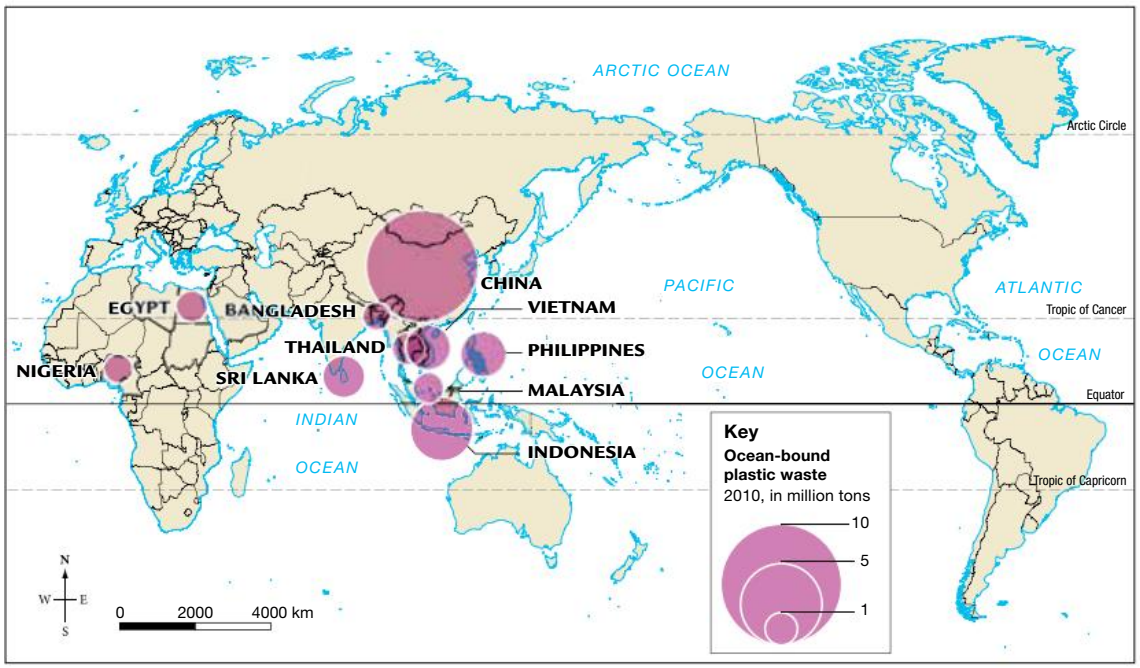
light, cheap to produce and disposable — also make it a major problem for the ocean (see figure 4). Over 100 billion tons of plastic are produced each year, approximately 55 per cent of which is recovered, recycled or sent to landfill. The rest is unaccounted for, lost in the environment and eventually washed out to sea, often ending up in the gut or wrapped around the neck of marine creatures. A recent survey of Australia's coastline found that 74 per cent of marine debris was plastic. Surface currents and wind can also move debris back on to the coast, where it can become buried in sand or swept back out to sea again. Unlike most other litter, plastics generally are not **biodegradable**. Plastic exposed to constant wind, waves, salt and sunlight breaks down into tiny fragments known as micro-plastics (20–50 microns in diameter, thinner than a human hair), which can float or sink to the seabed. Use the **Marine debris** weblink in your eBookPLUS to see where the debris comes from and what happens to it.

FIGURE 3 Top ten marine debris items



Note: Data is the result of 25 years of surveying debris collected by volunteers in annual debris clean-ups in over 100 countries.

FIGURE 4 Top 10 sources of marine plastic waste



Source: © The American Association for the Advancement of Science.

biodegradable capable of being decomposed through the actions of microorganisms

eBookplus

Weblink
Marine debris

CASE STUDY 1

Ocean pollution in China and Indonesia

China, the Philippines, Vietnam, Thailand and Indonesia contribute 60 per cent of all plastic in global waters.

More than a third of plastic bags, bottles and other plastic waste in oceans originates in China and Indonesia. Much of this waste is generated by people residing in coastal areas.

Approximately 1–3 million metric tonnes of plastic waste from China has contributed to marine debris in oceans.

Approximately 0.5–1.3 million metric tonnes of plastic waste from Indonesia has contributed to global marine debris.

CASE STUDY 2

Ocean pollution in Australia

Australia's effective waste disposal systems and public awareness of littering reduce the plastic waste from Australia entering our oceans.

In remote areas, most plastic debris is associated with commercial fishing and shipping. In areas closer to urban centres the marine debris tends to be more consumer items – soft drink bottles, plastic bags, etc. Studies have shown that a large proportion of marine debris that washes up on Australian beaches originates in South-East Asia and the Pacific.

FIGURE 5 Pollution that washes ashore in Australia often comes from countries in South-East Asia.

ACTIVITIES

IDENTIFY

1 What are the two biggest contributors to marine pollution across the world's ocean ***space***?

2 a Refer to figure 2. Give an example of a pollutant from each of the following sources of marine pollution: (i) atmospheric-based (ii) land-based (iii) marine-based.

b Which of the three sources makes up the largest component of marine pollution?

3 Use the **Plastic oceans** weblink in your eBookPLUS to view a video clip about this issue.

a Write three points that you learned from this video clip.

b How do your points compare to those of others in the class?

EXPLAIN

4 Explain how a plastic bag discarded after a picnic in Los Angeles can end up in the middle of the Pacific Ocean.

5 Refer to figure 3. How would these items compare to a survey of marine litter conducted 50 years ago? What do you think has ***changed*** the most?

6 Examine the two case studies: Ocean Pollution in China and Indonesia and Ocean Pollution in Australia.

a How are these two case studies similar and different in relation to contributions to marine pollution?

b Discuss some of the factors which may contribute to the differences between Australia and China and Indonesia.

eBookplus

Weblink
Plastic oceans

16.4 What are the consequences of marine pollution?

16.4.1 Where do we find the most marine debris?

The worst-affected places for marine debris tend to be heavily populated coastal places and popular tourist destinations; for example, the Caribbean Sea. Data collected from one year's survey of marine debris, carried out in over 100 countries, found different types of litter from different regions (see table 1).

What is the Great Pacific Ocean Garbage Patch?

A swirling sea of plastic bottles, garbage bags and other rubbish is growing in the middle of the North Pacific Ocean, thousands of kilometres from the nearest coastline. Why is it there and how did it get there? Discarded waste from the east coast of Japan and west coast of the United States gets swept up in the North Pacific gyre. The slow-moving currents and winds push material into the calmer centre of the gyre, where much of it stays and accumulates. It can take a year for material to reach the centre of the gyre from Japan and five years from the United States. The accumulation of debris has earned this region the name the 'Great Pacific Ocean Garbage Patch' (see figure 1). Very little garbage is visible on the surface; rather, it is a thick soupy mass of minute pieces of plastic with an average depth of 10 metres.

The size of the patch is estimated to be anywhere from 700 000 to more than 15 million square kilometres. Scientists have detected up to 1 million plastic particles per square kilometre in the patch. Another large garbage patch is located in the Atlantic Ocean.

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Interactivity
Garbage patch
Use this interactivity to learn more about the Great Pacific Ocean Garbage Patch.
Searchlight ID: int-3299

TABLE 1 Sources of marine debris by region

Source	Africa (%)	North America (%)	Central America (%)	South America (%)	Caribbean (%)	South-East Asia (%)	Western Asia (%)	Europe (%)	Oceania (%)
Land-based litter (general plastic litter, e.g. wrappings)	76.1	55.2	84.9	69.7	82.6	72.4	60.5	60.4	75.2
Ocean-based litter (boating/ fishing/shipping/oil drilling)	12.7	5.0	4.8	12.0	6.6	12.7	9.7	24.9	5.2
Smoking-related litter (cigarette filters, lighters, packaging)	8.4	37.2	8.0	15.4	7.7	11.2	27.7	11.1	19.7
Legal and illegal dumping of garbage and waste	1.8	1.9	1.1	2.0	1.8	1.6	1.5	2.8	1.8
Medical and personal hygiene litter (ranging from syringes to disposable nappies and tampons, usually via sewerage system)	1.0	0.7	1.2	1.0	1.3	2.0	0.6	0.8	1.1

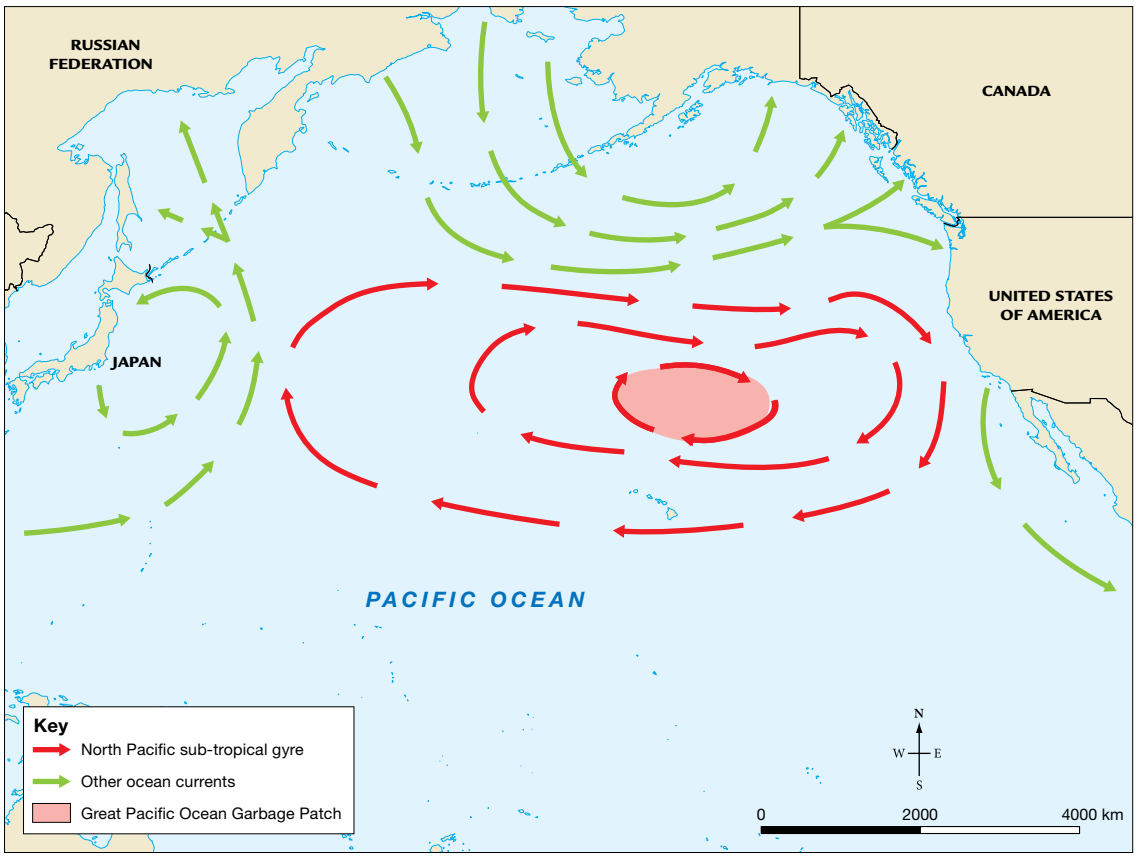
What are the environmental impacts of marine debris?

Figure 2 gives estimates for the length of time some marine debris takes to decompose. Most plastics undergo **photodegradation**, which is much slower in water than on land due to reduced exposure to the sun and cooler temperatures. As the particles break down into smaller particles, they 'thicken' the water and can release toxins. If less than 5 mm in diameter, they can be consumed by sea creatures, which in turn are eaten by bigger creatures and so on up the food chain. Marine animals such as mussels which filter seawater take up the micro-plastics, which can release toxins into their tissues. Small floating pieces of debris are often mistaken for food and are scooped up by seabirds and fed to their chicks (see figure 3).

photodegradation action of sunlight breaking down plastic into minute particles

More than 44 per cent of seabirds are known to eat plastic, while 267 marine species are known to swallow plastic bags, mistaking them for jellyfish (see figure 4). An estimated 100 000 marine mammals and up to 1 million seabirds die each year after ingesting plastic.

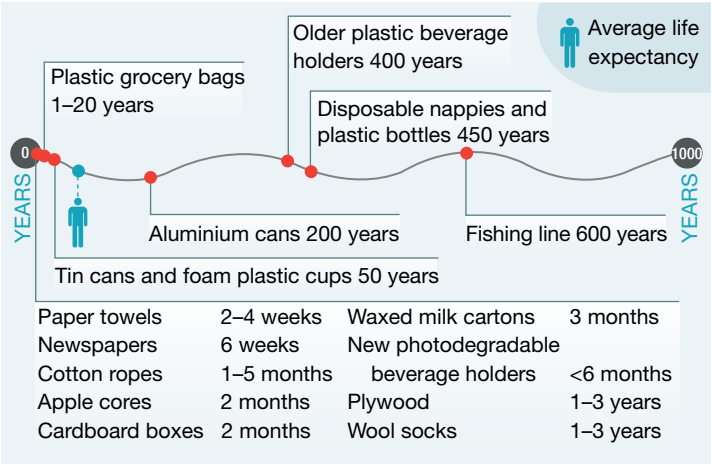
FIGURE 1 Location of the Great Pacific Ocean Garbage Patch



Source: Greenpeace International Made with Natural Earth. Map by Spatial Vision (GAT-22)

Note: The Great Pacific Ocean Garbage Patch floats between Japan and the USA just north of the Hawaiian Islands. The rotational current caused by the North Pacific gyre draws in garbage from neighbouring coastlines, where it becomes trapped in large quantities in the calmer waters of the gyre's centre.

FIGURE 2 Time periods for the decomposition of marine litter



Source: South Carolina Sea Grant Consortium, South Carolina Department of Health and Envrionmental Control (DFHC) — Ocean and Coastal Resource Management, Centers for Ocean Sciences Education Excellence (COSEE) — Southeast and NOAA 2008.

Note: Estimated individual item timelines depend on product composition and environmental conditions. Some scientists estimate that plastics fragment over time into microscopic pieces, but never truly degrade or disappear.

FIGURE 3 Foreign objects found in the stomach of a seabird. How many different items can you identify?

Ghost nets

Up to 10 per cent of marine debris is made up of abandoned and discarded fishing nets, known as ghost nets, which pose a very common threat to marine creatures (see table 2). Once tangled, they are prevented from swimming, fishing and breeding, and ultimately they drown. Over time, the nets fill with debris and form rafts which grow to hundreds of metres in diameter. These can drag across reefs or scrape along the seabed, causing considerable damage (see subtopic 16.11 in your eBookPLUS).

FIGURE 4 Discarded plastic bag resembling a jellyfish, floating in the ocean

TABLE 2 Numbers of wildlife found entangled in marine debris, from 25 years of data

	Amphibians	Birds	Corals/sponges	Fish	Invertebrates	Mammals	Reptiles	Total
Beverage bottles	3	8	0	27	47	13	2	100
Beverage cans	1	2	0	15	17	1	0	36
Crab/lobster/ fish traps	1	11	1	48	106	3	3	173
Fishing hooks	2	76	0	54	10	3	6	151
Fishing line	9	722	14	553	237	46	55	1636
Fishing nets	3	153	1	249	207	29	30	672
Bags (plastic)	13	102	0	142	91	33	23	404
Ribbon/string	0	91	0	37	29	7	2	166
Rope	4	160	0	114	53	71	24	426
6-pack holders	2	63	0	52	21	3	5	146
Plastic straps	2	30		34	12	5	5	88
Wire	1	31	1	16	13	7	6	75
Total	**41**	**1449**	**17**	**1341**	**843**	**221**	**161**	**4073**

Hitchhikers

Small marine creatures, such as barnacles, that normally spend their lives attached to rock, coral or coconut shells, can 'hitch a ride' on marine debris. The arrival of pest species in new locations can seriously affect ecosystems as they compete with native species for food or habitat.

Fishing industry

While the fishing industry contributes to marine debris, the industry itself is also affected by the litter. A survey in northern Scotland found that 92 per cent of fishermen had continual problems with marine debris in their nets, snagging nets on rubbish, and that some fishing grounds were avoided due to high litter concentrations.

aquaculture the farming of aquatic plants and aquatic animals such as fish, crustaceans and molluscs; also called fish farming

People

Due to the action of currents, garbage discarded in one country can end up on the beaches of another country thousands of kilometres away. Thus the impacts of marine litter on people are mostly found in coastal regions. Impacts include the rising cost of clearing debris from beaches, loss of tourism revenue, and debris interfering with boating and **aquaculture**.

CASE STUDY 1

Drifting Lego

Fierce storms can wash shipping containers off boats and into the ocean. Sometimes these can be recovered, but often they sink to the ocean floor. Ongoing water movement, or the jolting from falling off the ship can open the containers and release the contents into the ocean.

In 1997, the Tokyo Express container ship lost 62 containers in a storm near Cornwall, England. One of the containers was carrying nearly 4.8 million Lego pieces, including a range of Lego kits as well as 4200 black octopus, 33 941 dragons, 97 500 scuba sets and 13 000 spear guns. Many of the items have washed ashore and beachcombers are still reporting finds today.

The **Gulf Stream** ocean current has pushed the drifting Lego pieces up the English Channel and into the North Sea, and is also pushing them up the west coast of the UK. Mapping of the Lego pieces has indicated that in addition to the Cornwall area, they have washed up in Ireland, Wales, and the Netherlands. There have also been reports from Texas and Australia, but these are unconfirmed.

FIGURE 5 Shipping containers can be swept overboard, often emptying their contents into the sea.

CASE STUDY 2

Microbeads

Many facial soaps and body washes contain tiny plastic particles less than a millimetre long. These particles give beauty products a grainy texture. Microplastics have been identified as an emerging contaminant in marine environments. In many cases, plastic microbeads could be replaced with natural products, but they would increase the cost of production.

When beauty products containing microbeads are used they are washed down the drain. They are too small to be filtered out by wastewater treatment and enter our waterways. The microbeads absorb pollutants in the water and can become highly toxic.

Microscopic plants (phytoplankton) and animals (zooplankton) are at the base of many food chains, and can absorb the microbeads. Microbeads can resemble tiny fish eggs, and seabirds and fish can ingest them. The toxins contained in the microbeads are absorbed into their tissues.

FIGURE 6 Microbeads contained in beauty products

Seabirds and other marine life are at risk from choking and starvation as a result of the microbeads. The pollutants in the microbeads are passed on and accumulate up the food chain. This is known an bioaccumulation. Humans can consume the toxins in microbeads when we eat seafood.

Gulf Stream a warm Atlantic ocean current; it originates at the Gulf of Mexico, follows the east coast of the United States, then divides to create the North Atlantic Drift, the Florida Current and the Gulf Stream itself

ACTIVITIES

EXPLAIN

1 Refer to figure 2. Compare the decomposition ***changes*** for natural materials and man-made materials as seen in this time line. What does this indicate to the packaging industry and consumers?
2 Refer to table 2. What three items create the most problems for marine wildlife? Suggest reasons why.
3 Is our use of plastic a ***sustainable*** practice? Justify your answer.

INVESTIGATE

4 Use the **Plastiki Expedition** weblink in your eBookPLUS to learn about this project. Plastiki is a catamaran that was built by a team led by David De Rothschild. It is made totally out of recycled plastic bottles, and was used to sail the Pacific Ocean to demonstrate the impacts of plastic on the ***environment***. Write a newspaper report of the journey and the team's observations, and map the route they took.
5 Using the internet, and particularly social media, research the collection of ocean rubbish.
  a Investigate and describe how people record rubbish washed up on beaches.
  b Evaluate whether using social media to publicise information about ocean rubbish is an effective way of helping to find a solution to the problem of ocean debris.

APPLY

6 The Lego company uses a range of ***environmentally*** friendly practices in the creation of their products, but stated that the loss of Lego pieces at sea was the responsibility of the Tokyo Express. Discuss the role of companies in marine protection and management. Should they be accountable for the rubbish created by their companies, or should individuals ultimately take responsibility?
7 Research where Lego pieces from the container ship have washed ashore. Create a map showing their distribution.
8 Refer to figure 6. Why might people purchase products containing microbeads? What alternative ingredients could produce the same outcome?
9 Create a flow diagram showing how microbeads could impact on a marine food chain. Write a paragraph describing the process.

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Weblink
Plastiki Expedition

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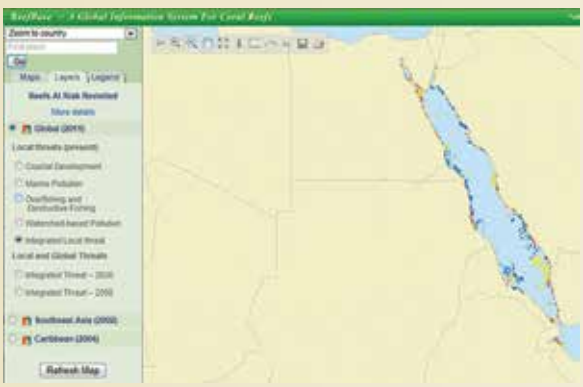
16.5 SkillBuilder: Using geographic information systems (GIS)

What is GIS?

GIS is a computer-based system of layers of geographic data. Just as an overlay map allows you to interchange layers of information, GIS allows you to turn layers on and off to make comparisons between pieces of data.



eLesson
Watch this video to learn how to use geographic information systems (GIS).

Searchlight ID: eles-1752

Interactivity
Try this interactivity to learn how to use geographic information systems (GIS).

Searchlight ID: int-3370

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16.6 Where does oil in the sea come from?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

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16.7 The world's worst oil spill?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

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16.8 What is the solution to marine pollution?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

16.9 How can marine pollution be managed?

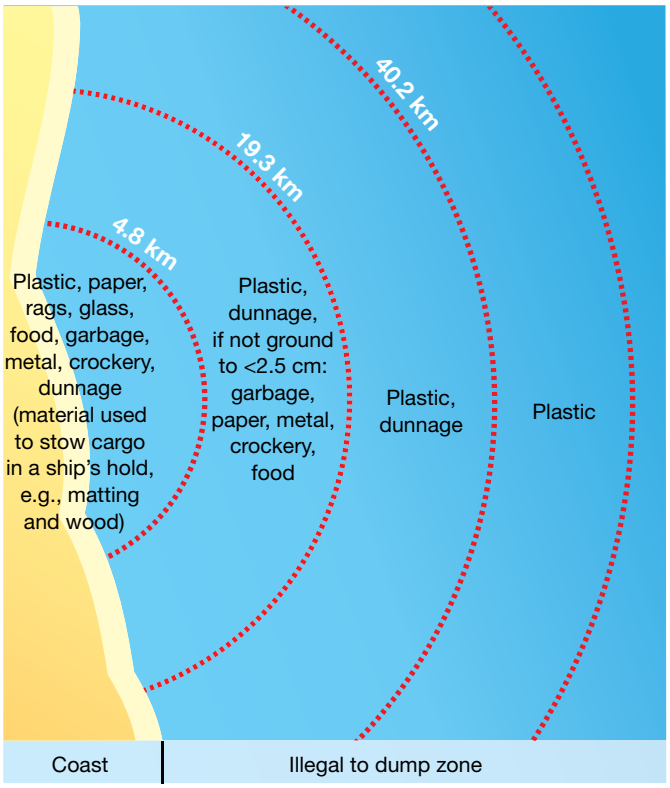
16.9.1 What can communities do?

Over 100 billion plastic bags are used each day in the United States, with less than 12 per cent recycled. Many governments and communities around the world now actively discourage the use of plastic bags. When Ireland introduced a bag levy in 2002, plastic bag usage dropped by 90 per cent. On one day of each year, volunteers from over 152 countries clean up the shores of beaches, lakes and streams, by classifying, counting and collecting garbage, as part of the International Coastal Cleanup Campaign. Over the past 25 years, this campaign has led to the removal of more than 66 million kilograms of litter, the equivalent of 330 kilometres of cars nose to tail, or 66 000 average-sized cars! The data collected via the campaign have contributed to new littering laws (see figure 1).

16.9.2 What can fishermen do?

A 'Fishing for Litter' scheme has been set up in Scotland where fishermen and port authorities have collaborated to collect all litter caught in nets. Instead of throwing this litter overboard, the debris is collected and brought back to port

FIGURE 1 Marine pollution restrictions in the United States



for managing. In 2011–12, Scottish fishermen collected over 100 tonnes of marine litter. Recreational fishermen in the United States can recycle fishing lines back to the manufacturer via collection points. Since the US scheme started in 1990, it has prevented over 15 million kilometres of fishing line entangling wildlife.

16.9.3 What can manufacturers do?

In recent years, manufacturers have become much more environmentally aware. Six-pack bottle and can holders can now be made in a new photodegradable product, which can break down within weeks. Coca-Cola now produces the PlantBottle, the first ever 100 per cent recyclable PET bottle, which has 30 per cent of its material based on plant matter (sugar cane and molasses). Over 2.5 billion of the new bottles were introduced in 2010 in the first year of production.

16.9.4 What can the international community do?

The United Nations Environment Programme (UNEP) has launched an intensive publicity campaign to help raise awareness of marine debris. They are working at a regional level to promote schemes such as recycling, waste separations and other land-based actions. International agreements such as the International Convention for the Prevention of Pollution from Ships (known as MARPOL) prohibit the disposal of all plastic into the sea, and ships cannot dispose of food waste within 12 **nautical miles** of land. Such regulations are extremely difficult to police and have no impact on the amount of waste entering the ocean from land-based sources.

nautical miles a unit of measurement used by sailors and/or navigators in shipping and aviation. It is the average length of one minute of one degree along a great circle of the Earth. One nautical mile corresponds to one minute of latitude; thus, degrees of latitude are approximately 60 nautical miles apart.

CASE STUDY 1

Managing marine waste in Australia

The influence of a person's worldview on environmental management was discussed in chapter 12. A range of worldviews are represented in Australia and these all influence the way that marine environments and marine pollution are managed. An individual or company may have an egocentric worldview, and value their own profit or convenience above other considerations such as environmental quality. This may mean that they would prefer to dump rubbish into the ocean than to dispose of it responsibly. Another individual or an environmental group may have an ecocentric worldview and consider the protection of the environment as the most important consideration. They may prefer that no human impact be allowed on our waterways and oceans. Different stakeholders have competing demands and sometimes opposing ideas about how resources should be used and managed. In Australia all of these views are represented through various levels of government, where laws, regulations and by-laws are enacted to protect the environment in a way that does not hinder economic development.

The Australian government consulted with a range of stakeholders, such as conservation and industry groups, in the creation of the Threat Abatement Plan for the impacts of marine debris on vertebrate marine life. This was designed to address the impact of marine debris on endangered species such Marine Turtles and Grey Nurse Sharks.

Take 3 is a Clean Beach Initiative encouraging people to pick up three pieces of rubbish each time they go to the beach. The organisation encourages a reduction of plastic waste by publicising the 5Rs:

- Refuse disposable plastic
- Reduce
- Reuse
- Recycle
- Respond by picking up rubbish.

Australia's waste disposal management processes are also effective in limiting the amount of rubbish entering our waterways and the ocean.

CASE STUDY 2

Managing marine waste in China

The production of waste from households and individuals is a major contributor to rubbish entering waterways in China. The influence of capitalism and consumer culture in China has resulted in the rapid development and growth of major cities and a subsequent increase in waste production. The growth of affluent households and the adoption of mass consumerism has been coupled with a decline in social responsibility in some sections of society and a growing prevalence of an egocentric worldview.

Effective management of pollution entering marine environments in China is affected by the attitude of 'suibian', meaning 'without concern' or 'doing as one pleases'. The increasing issue of littering, particularly amongst the upper middle class in urban areas of China, is creating huge waste management issues resulting in vast amounts of waste entering waterways.

Technology may provide a means of addressing littering in Hong Kong. The Nature Conservancy and Ecozine magazine ran a campaign to shame litterers. They collected litter samples, extracted DNA samples and then used DNA technology to create possible facial snapshots showing what the litterer may look like. These were then put on billboards around the city. Individual people weren't actually identified, but the images provided general facial features to get people's attention. In Hong Kong people can be fined for littering, but enforcement is inconsistent.

ACTIVITIES

INVESTIGATE

1 How successful would an international agreement where all countries decide to reduce land-based marine pollution be? What would be the advantages and disadvantages?
2 Research the problem of marine pollution in Australia and China. Investigate the causes, extent and consequences of marine pollution in both countries. Present this information as a video, infographic or pictorial essay.
3 Compare pollution management strategies in Australia with those in China. How are they similar and different? How do you account for these differences?

16.10 How can individuals manage marine pollution?

16.10.1 What can be done?

The way we consume and discard our resources has created one of the biggest environmental challenges in the world. Our throwaway society has literally thrown all our waste into the oceans! 'The water in our oceans is like blood for our planet. If we continue to fill it with toxic materials such as plastic, it will be to the detriment of life on Earth' (D. Woodring, Project Kaisei director).

Marine debris might start as a local problem, but it also creates a global problem as it often travels a great distance from its original source, crossing both geographic and political boundaries. Marine debris will be reduced only if land-based sources can be controlled. Communities and governments need to develop effective waste reduction schemes if we want to manage our oceans sustainably (see figure 1).

FIGURE 1 What message is this advertisement sending?

Can't we just scoop it up?

Scooping up marine debris is not as easy as it sounds. Firstly, debris like the Great Pacific Ocean Garbage Patch is constantly moving in response to shifts in winds and currents. Secondly, much of the garbage is in the form of minute particles suspended beneath the ocean's surface. To scoop it up would mean collecting marine life that inhabits these waters as well.

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Weblinks
- Plastic to rope
- Plastic to handbags

CASE STUDY 1

Individual action in Australia

The Surfrider Foundation in Australia and the United States is responsible for the 'Rise Above Plastics' campaign. The aim of the campaign is to get people to think about how they can make a difference and prevent marine debris. They suggest 10 ways to reduce your personal plastic footprint. There are also many innovative ways to recycle plastic products that can be found on YouTube, such as converting plastic bags to rope or handbags (use the **Plastic to rope** and **Plastic to handbags** weblinks in your eBookPLUS to view these videos).

Ten ways to reduce your personal plastic footprint

1. Choose to reuse when it comes to shopping bags and bottled water. Use cloth bags and metal or glass reusable bottles if possible.
2. Refuse single-serving packaging, excess packaging, straws and other 'disposable' plastics. Carry reusable utensils in your bag, backpack or car.
3. Reduce everyday plastics such as sandwich bags and juice cartons by replacing them with a reusable lunch bag or box that includes a thermos.
4. Bring your to-go mug with you to the coffee shop, smoothie shop or restaurants that let you use them. This is a great way to reduce lids, plastic cups and/or plastic-lined cups.
5. Go digital! No need for plastic CDs, DVDs and jewel cases when you can buy your music and videos online.
6. Seek alternatives to the plastic items you use.
7. Recycle. If you must use plastic, try to choose #1 (PETE) or #2 (HDPE), which are the most commonly recycled plastics. Avoid plastic bags and polystyrene foam as both typically have very low recycling rates.
8. Volunteer at a beach clean-up. Surfrider Foundation Chapters often hold clean-ups monthly or more frequently.
9. Support plastic bag bans, polystyrene foam bans and bottle recycling bills.
10. Spread the word. Talk to your family and friends about why it is important to 'Rise Above Plastics'!

CASE STUDY 2

Individual action in China and Indonesia

Packaging

Companies supplying goods to Asia often sell consumer goods in very small quantities to improve their affordability. This increases the amount of packaging per product compared to when sold in larger quantities. Individuals can choose to buy products with less packaging to reduce the amount of waste they produce.

Plastic bags

In Bali, Indonesia the locals are being encouraged to reduce their use of plastic bags by using reusable bags when shopping. The Tas Pasar campaign is providing cloth bags to replace plastic bags.

Littering

In China, an important individual action to address marine pollution is rubbish disposal. Littering is an increasing issue that can easily be addressed by individuals disposing of rubbish responsibly.

Recycling

Garbage pickers sift through rubbish looking for recyclable plastics that can be sold. This increases the amount of plastic being recycled and reduces that amount entering oceans. Unfortunately, this only addresses high-value plastics and leaves much of the rubbish including plastic bags to enter waterways and oceans.

FOCUS ON FIELDWORK

Undertake a plastic bottle survey at home

Check your kitchen, laundry and bathroom and count the number of plastic bottles, jars and other containers you find (only count containers). Collate your results in graph form. Compare your results with other students in your class. You may choose to share these results using an online collaboration tools like Google docs. Write a summary of your findings.

ACTIVITIES

EXPLAIN

1. Is the old saying, 'Think global, act local' applicable to marine pollution? Justify your answer.
2. Examine the types of individual actions that are proposed for Australians. List a range of other actions Australians could take to reduce their contributions to marine pollution.
3. China and Indonesia are the largest contributors to marine pollution globally. Discuss how the individual actions suggested in case study 2 are similar and different to those suggested for Australia.

APPLY

4. How can you reduce your school's plastic footprint? You may like to use the **School** weblink in your eBookPLUS for ideas. Brainstorm ideas as a class and then develop one idea in detail. How can you promote your idea? You may like to create a slogan and poster, address a school group or assembly or write a proposal to the school administration.

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Weblink
School

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16.11 How are ghost nets managed?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

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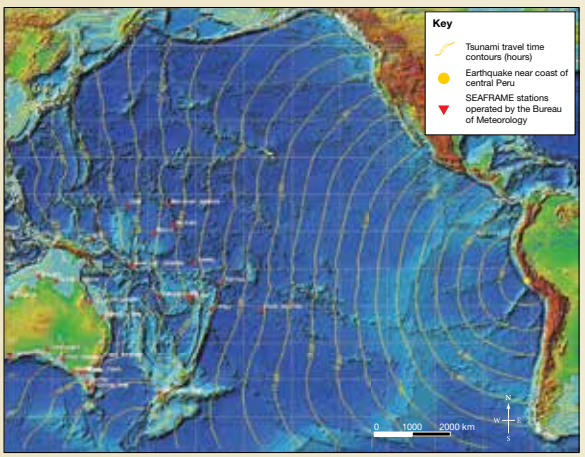
16.12 SkillBuilder: Describing change over time

What is a description of change over time?

A description of change over time is a verbal or written description of how far a feature moves, or how much it is altered, over an extended time period, and can alert us to the possible impacts of a change or changes over a wider region.



Source: © Bureau of Meteorology.

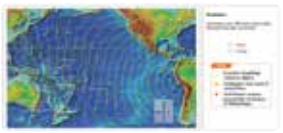
eLesson

Watch this video to learn how to describe change over time.

Searchlight ID: eles-1753

Interactivity

Try this interactivity to learn how to describe change over time.



Searchlight ID: int-3371

16.13 How has coral bleaching affected Lizard Island?

16.13.1 Lizard Island

Lizard Island National Park is made up of six islands covering 1013 hectares. Located in the northern part of the Great Barrier Reef, the island hosts the Lizard Island Resort and the Lizard Island Research Station.

Lizard Island and the surrounding area are 'no take' zones where fishing and collecting are prohibited, with the exception of one small beach where people are allowed one fishing line and hook. Activities such as swimming, boating, snorkelling and sailing are allowed. In 2016, increased ocean temperatures caused the worst coral bleaching seen in Lizard Island in 15 years.

FIGURE 1 Lizard Island zoning

Source: Queensland Department of National Parks, Sport and Racing; Queensland Department of Natural Resources and Mines.

ACTIVITIES

IDENTIFY

1 Refer to figure 2.
- a Identify the quadrant of the map that Lizard Island is found in.
- b Identify the direction of Lizard Island from:
  - i Cape Flattery
  - ii Nymph Island
  - iii Linnet Reef
  - iv Helsdon Reef
  - v Point Lookout.

2 Describe the relative location of Lizard Island.

EXPLAIN

3 Refer to figure 1. Suggest reasons for the location of the reef anchorage areas.

APPLY

4 Examine figures 1 and 2. Explain why Crystal Beach and North Point on the north-eastern side of Lizard Island might have a different zoning to other parts of the Great Barrier Reef and Lizard Island.

5 Refer to figures 1 and 2. Suggest reasons for the location of the resort on the island.

6 Using the internet, research coral bleaching at Lizard Island and the role and function of the Lizard Island Research Station.
- a How might this impact on the activities of tourists in the area?
- b What impact might this have on the success of the Lizard Island Resort?
- c What opportunities might the coral bleaching present for researchers at the Lizard Island Research Station?

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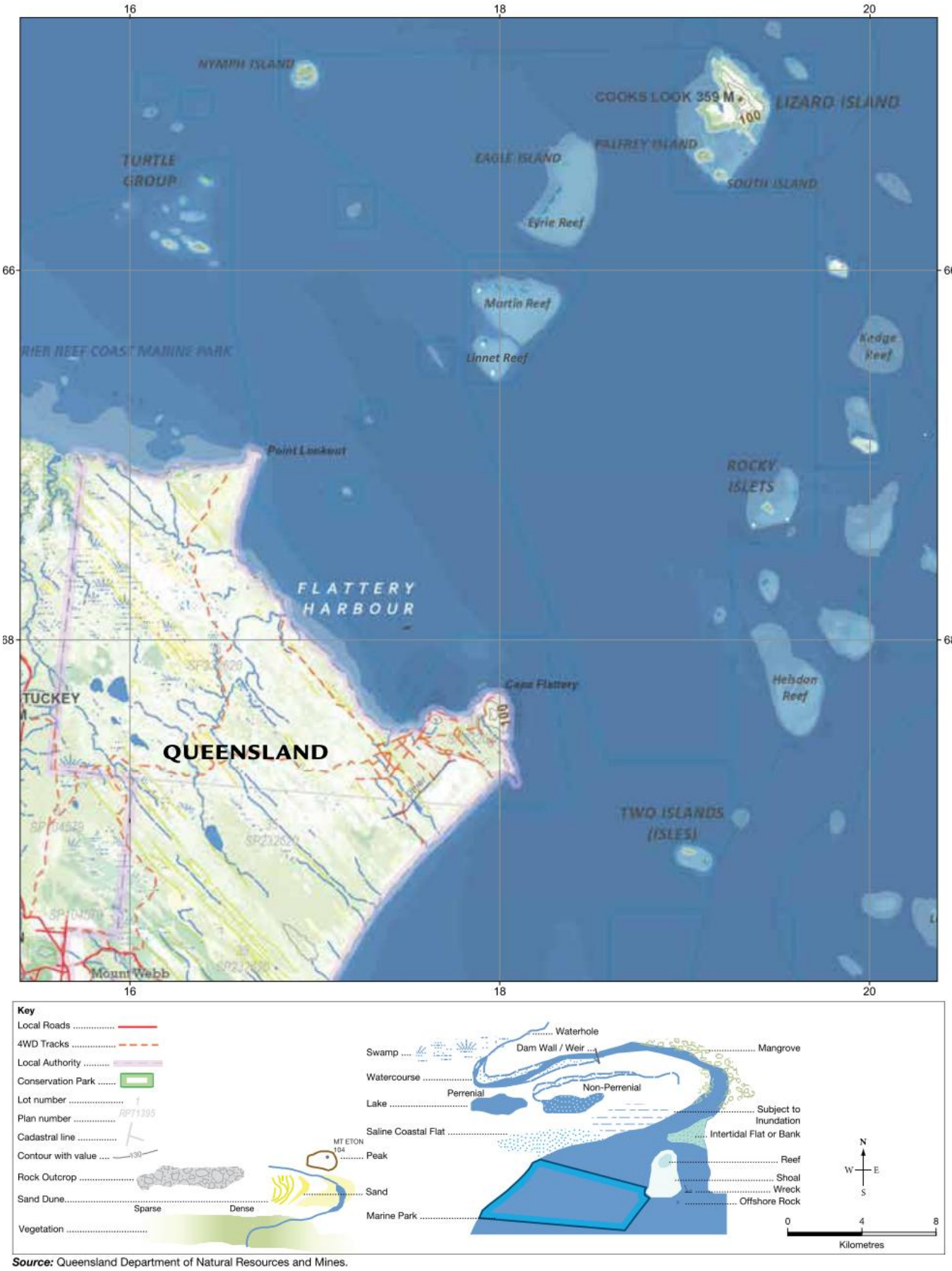
16.14 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

FIGURE 2 Topographic map of Lizard Island



Source: Queensland Department of Natural Resources and Mines.

16.5 SkillBuilder: Using geographic information systems (GIS)

16.5.1 Tell me

What is GIS?

GIS is a computer-based system of layers of geographic data. Just as an overlay map allows you to interchange layers of information, GIS allows you to turn layers on and off to make comparisons between pieces of data.

Why is GIS useful?

GIS is a sophisticated system of presenting data. The information is based on primary data that has been gathered and mapped. At any one time, you can look at a single series of data or as many as you need in order to see the interconnections between the data. For example, you may turn on one layer to see the topography. Then you might turn on the road system to see if the land has influenced the pattern of roads. To this you might add settlements to see if both the road system and topography have influenced town locations. Then you might turn off the road system to see if the greater influence was indeed the topography.

GIS is useful when:

- you want to see the interconnections between features
- you need to show an overlay of features across a region
- retailers want to determine the best location for a new store; for example, fast food chains use this technique to determine site selection
- emergency services want to predict risk situations, such as the spread of bushfires and flood waters
- you need to map global trends, such as the movement of refugees between countries.

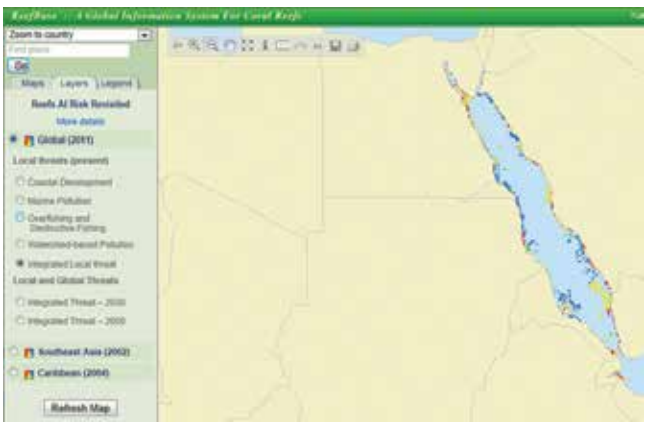
Model

Like most reefs across the world, coral reefs in the Red Sea are under threat from natural and human impacts. The Red Sea reefs are fringing reefs, making them prone to a range of diseases, especially in a 1200-kilometre stretch along the east coast. Coral bleaching occurs at only a low level because the number of degree heating weeks is low. (A degree heating week measures thermal stress on a reef. A degree heating week occurs when sea surface temperatures are 1 °C warmer, for one week, than the expected summertime maximum.) The reefs most at risk in the Red Sea appear in the north-west; otherwise, reefs at risk are scattered across the region. Most of the risk is from marine pollution. The risk to the Red Sea coral reefs is expected to increase by 2030, and by 2050 they will show significant impacts. Monitoring of the northern reefs is ongoing, and some areas in the north, in particular, have been set aside as marine protected areas. The coral reefs of the Red Sea need constant management to ensure the sustainability of the environment.

Using GIS involves:

- using GIS-mapped geographic data
- interpreting map legends
- interpreting map layers
- looking for interconnections between map layers
- clearly representing and communicating data.

FIGURE 1 Studying marine reefs using GIS on the Red Sea



Source: © Reefbase/Worldfish.

16.5.2 Show me

How to use GIS

You will need:

- a computer or tablet connected to the internet
- a website developed with GIS techniques
- an atlas.

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eLesson
Using geographic information systems (GIS)
Searchlight ID: eles-1752

eBookplus

Weblink
ReefBase GIS

Procedure:

You need to identify a GIS website. Use the **ReefBase GIS** weblink in the Resources tab, for example, to access a great deal of mapped data on coral reefs around the world.

Open the ReefBase site shown in figure 2.

FIGURE 2 A base map on the ReefBase website

Source: © Reefbase/Worldfish.

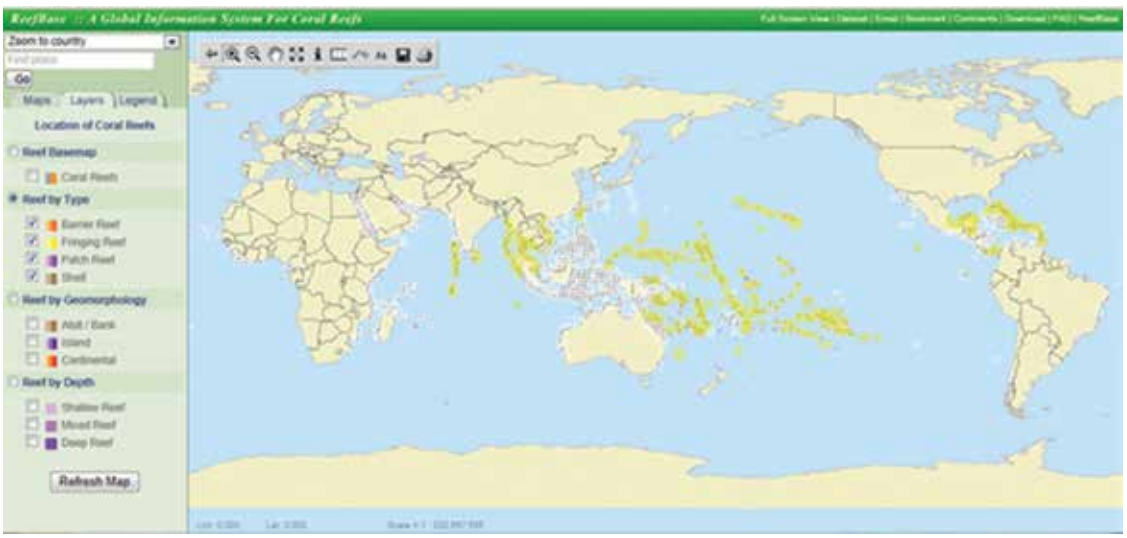
STEP 1

As with any map that you explore, you need to begin by checking the information provided to assist your interpretation of the maps. On the left of the ReefBase website, you will find a table of contents (see figure 2). The Maps tab provides a list of 12 maps, including a photo site. Select any of these for the map to open.

STEP 2

In the same table of contents, once a map is opened, the different layers available on that map are listed. Choose a map and explore some of these layers. Select one of the circles or boxes to apply an aspect of the layer, and then select Refresh Map at the bottom of the layers panel, so that a new map appears. In figure 3, the Location of Coral Reefs map has been selected and the table of contents shows the layers available for this map. The Legend tab will help explain terminology.

FIGURE 3 Layers available in map of location of coral reefs

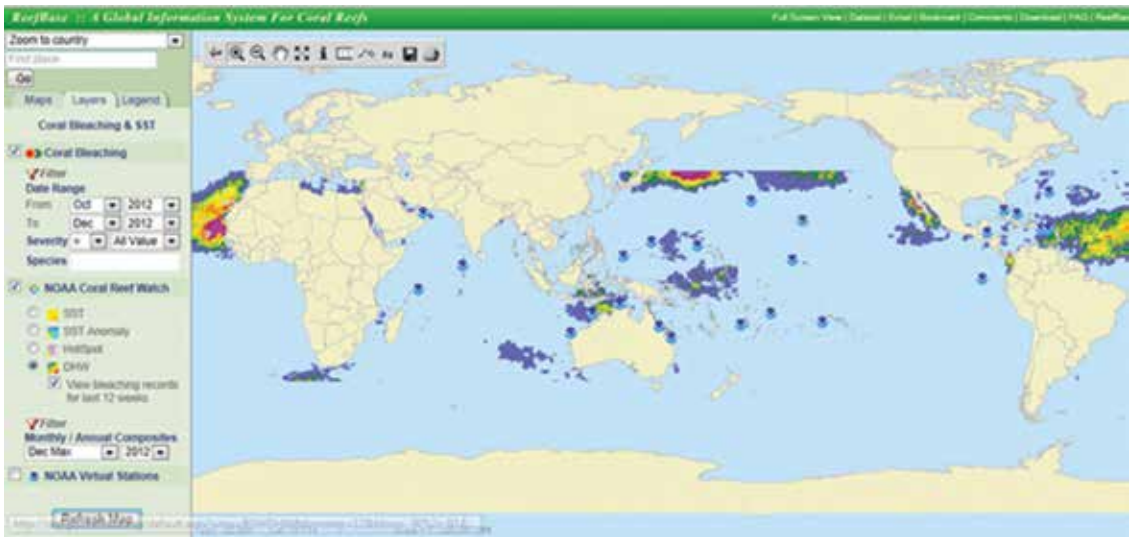


Source: © Reefbase/Worldfish.

Between each choice that you make, you need to select Refresh Map to ensure your map updates with the new layers you have selected.

Figure 4 shows another example of the material available from the coral bleaching map.

FIGURE 4 Coral bleaching, October to December 2012

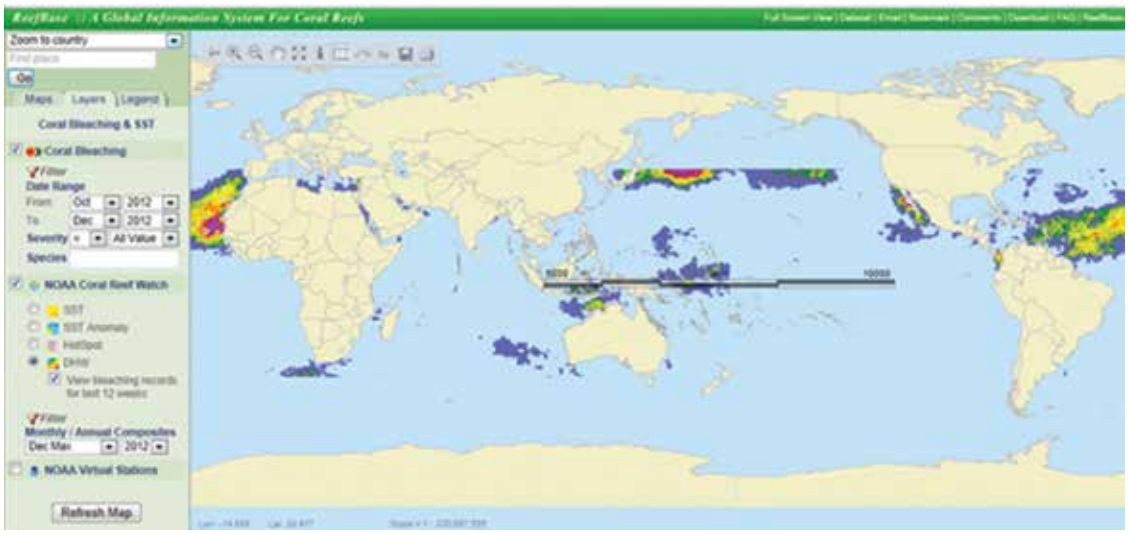


Source: © Reefbase/Worldfish.

STEP 3

Along the top of the map, there is also a tool bar to explore (see figure 5). When you hover over each symbol, an explanation of its use is provided. The Distance tool is especially useful, because you can use the linear scale that appears at the base of the map to measure distances on the map. It can be moved to wherever you want it (see figure 5).

FIGURE 5 Applying the distance tool on the coral bleaching map



Source: © Reefbase/Worldfish.

Being able to shift the linear scale allows you to calculate distance and area. In this instance, the scale is set to calculate the area of coral bleaching north-east of the Solomon Islands. Alternatively, if you want to calculate a distance between two points, select the Distance tool, move the cursor to the first point and select it; then drag the cursor to the second point, and the number of kilometres will appear on the screen.

STEP 4

On the global map, zoom in on the coral reefs of the Red Sea. Did you know there were reefs there? Turn the various layers on and off until you have an understanding of the state of the coral in this region. Also consider the layers that show the management of the region.

FIGURE 6 Coral reefs in the Red Sea experiencing diseases, 1970–2013

Source: © Reefbase/Worldfish.

STEP 5

A description of the natural and human impacts on the Red Sea coral reefs can now be developed. The management processes that are in place to ensure the sustainability of the environment can also be discussed. A paragraph should begin with an opening sentence. Where possible, provide evidence of using the site by quoting specific numbers. The paragraph should conclude with a statement about the sustainability of the environment. See the paragraph under the heading 'Model' in section 16.5.1 for an example.

16.5.3 Let me do it

Developing my skills

Continue to use the ReefBase site to explore the layers of information about the Great Barrier Reef, using the features and data available in the maps, layers and legend. Write a paragraph describing the natural and human impacts on the reef and the management processes that are in place to ensure the sustainability of the environment.

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Interactivity
Using geographic information systems (GIS)
Searchlight ID: int-3370

Questions

Each of the following questions requires you to change maps, layers and legend.

1. Name three diseases that have affected the Great Barrier Reef.
2. Which part of the Australian coastline has experienced the worst coral bleaching since 2000?
3. How do you rate the threats to the Great Barrier Reef? (*Hint:* The legend provides a colour rating.) Turn on the layers for diseases and coral bleaching to see if these threaten the Great Barrier Reef.
4. With the aid of an atlas, name the coastal places where the reef is at greatest risk.
5. What types of management programs are used on the Great Barrier Reef?
6. Turn on all the layers applicable to the Great Barrier Reef. List the range of issues affecting the Great Barrier Reef near Cairns.

Checklist

I have:

- used GIS-mapped geographic data
- used the map legends
- used the map layers
- made interconnections between map layers
- clearly represented and communicated the data.

Skills questions

1. GIS is used to show:
   a. a specific piece of geographic data at a place
   b. a range of geographic data at a place
   c. a range of geographic data across a region
   d. a specific piece of geographic data across a region.
2. GIS never includes information about:
   a. temperature
   b. distance
   c. soils
   d. cloud types.
3. Which provides greater detail: an overlay map or a GIS application?
4. Why are geographers so keen to use GIS applications?

16.6 Where does oil in the sea come from?

16.6.1 How does oil get into the ocean?

You have probably seen images of birds covered in sticky oil, usually as a result of the most dramatic type of marine pollution: oil spills and shipping accidents. The impact of oil on ocean and coastal ecosystems is often localised over a relatively small area, but may last for many years.

Almost all of the Earth's supply of oil and natural gas is found in deep underground reservoirs. Reservoirs can be under a landmass, under the seabed and under **continental shelves**. Extracting oil from the seabed accounts for nearly 30 per cent of the world's production. Offshore drilling takes place on huge floating platforms, in waters up to 2 kilometres deep and as far as 300 kilometres from the coast. More than 50 per cent of countries around the world drill for offshore oil and gas.

The most obvious and visible kinds of marine oil spills usually involve tanker accidents, or leaks from offshore oil rigs. However, oils enter the ocean from a variety of sources, with both natural and land-based sources accounting for a much larger proportion than disasters (see figure 1). There has been a decrease in the number of tanker accidents in recent years, mostly due to improved ship design and greater safety methods. However, with more ships and supertankers being built, the potential risk of an accident is still high.

continental shelf a shallow area of sea which is a gentle continuation of the neighbouring landmass. It is usually less than 300 metres deep. After the shelf, the continental slope drops into deep ocean.

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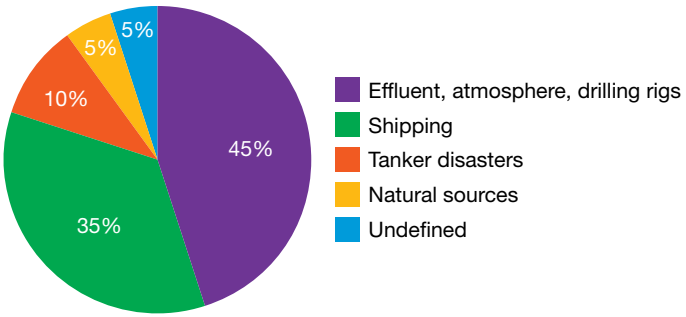
Oil slick
Use this interactivity to learn more about what happens to oil spills in the ocean.
Searchlight ID: int-3300

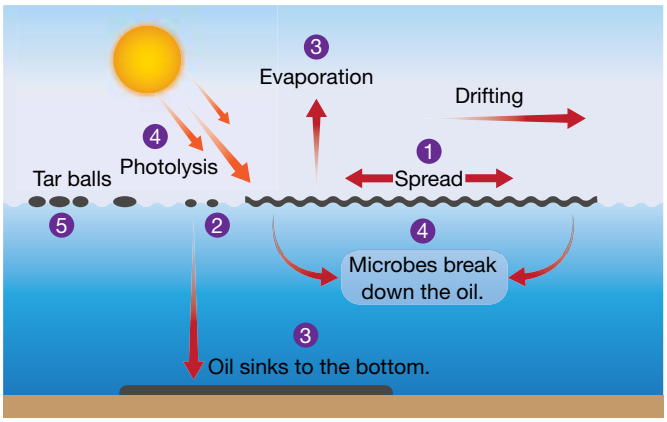
FIGURE 1 Main sources of marine oil pollution



16.6.2 What happens to oil in the ocean?

Each oil spill is different and there are various physical, chemical and biological factors that will influence the behaviour of spilt oil. The type of oil, temperature of the water, wave and current action, and the nutrient content of the water are all critical influences. The stages in the breakdown of oil can be seen in figure 2.

FIGURE 2 What happens to oil in the ocean?



1. When oil is released into the ocean it immediately forms large slicks which float on the surface. It can take only 10 minutes for one ton of oil to disperse over a radius of 50 m and be 10 mm thick.
2. After a few hours, weathering by wind and waves breaks down the slick into narrow bands, or windrows, that float parallel to the wind. The oil may be less than 1 mm thick but can now cover 12 km^2. After the slick thins down it breaks up into fragments and fine droplets that can be transported over larger distances.
3. Some of the oil evaporates or sinks.
4. Some of the oil can be chemically broken down by sunlight or bacteria.
5. Finally the oil solidifies into tar balls (clumps), which are more resistant to bacterial decomposition.

16.6.3 What does oil do to the environment?

Oil spills can result in both short- and long-term environmental change, with some damage lasting for decades. A spill in open waters is usually less destructive than a spill near coastal waters, where most fish and bird breeding takes place. Oil pollution is less visible in the open ocean, especially once it disappears from the surface, but it is still capable of being moved via ocean currents.

Coastlines

The geography of the coastline can influence the degree of impacts from an oil spill. Impacts are less on exposed coasts due to strong wave action. A long, sheltered, sandy coastline is vulnerable as the oil can soak into the sand, which is extremely difficult to clean. Mangroves, salt marshes and extensive sandbanks are also sensitive as the oil soaks into the fine sediments and can be taken up by plants. This affects wildlife that live in this habitat, and the loss of vegetation increases the risk of coastal erosion, as shown in figure 3 (a) and (b). Coral reefs are possibly the most vulnerable to oil spills, and they are extremely slow to recover.

FIGURE 3 (a) Oil damage to wetland habitat (b) The same area of wetlands one year after the oil spill

Wildlife

Any oil on the surface of the sea will kill birds that swim and dive for their food there. Feathers covered in oil rob birds of waterproofing and insulation. Ingesting the oil can poison them. Oil spills also damage coastal nesting and breeding grounds. Oil can block the blow holes of marine mammals such as whales, dolphins and seals, making breathing difficult. If oil coats their fur, they become vulnerable to hypothermia. Animals' food supply is also poisoned by floating oil. Fish, especially shellfish, suffer immediate effects of an oil accident. Reduced reproduction, birth defects and other abnormalities develop in the next generation of wildlife exposed to oil spills, creating a longer-term impact.

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Weblink
Oil spill

ACTIVITIES

IDENTIFY

1 What percentage of the world's oil comes from the seabed?
2 Examine figure 2. Why is it important that oil spills are treated as quickly as possible?
3 Examine figures 3 (a) and (b) and describe the ***changes*** that you can see in the two ***environments***.
4 Use the **Oil spill** weblink in the Resources tab to examine a sequence of maps that track the distribution of the oil spill from the Deepwater Horizon oil rig explosion on 20 April 2010 until 3 August 2010. Select the 'Loop current' button and the 'Oil on shoreline' button to view the additional features these show. You may also like to view the satellite images.
   a What were the main directions that the spill travelled in? What factors would have influenced the directions?
   b What other ***places*** may have been affected had the oil spill moved in the Loop Current?

EXPLAIN

5 a Examine figure 2. Select the conditions from those listed below that would be most likely to encourage the rapid breakdown of an oil spill.
   - Cold ocean water/warm ocean water
   - Calm seas/choppy seas
   - Ready supply of bacteria/limited supply of bacteria
   - High level of oxygen in the water/low level of oxygen in the water
   - High number of bacteria-eating organisms/low number of bacteria-eating organisms

   b Justify each of your choices in part (a).
6 Suggest one ***environmental***, economic and technological factor that can contribute to marine oil pollution.
7 List the ways in which oil creates ***environmental change*** in the ocean.
8 Compare some of the advantages and disadvantages of drilling for oil in the ocean compared to drilling for oil on land.

INVESTIGATE

9 Research the potential impact of oil spills on the Great Barrier Reef. How does the Great Barrier Reef Marine Park Authority manage the park ***sustainably*** to prevent oil spills?

16.7 The world's worst oil spill?

16.7.1 What happened with the Gulf of Mexico oil spill?

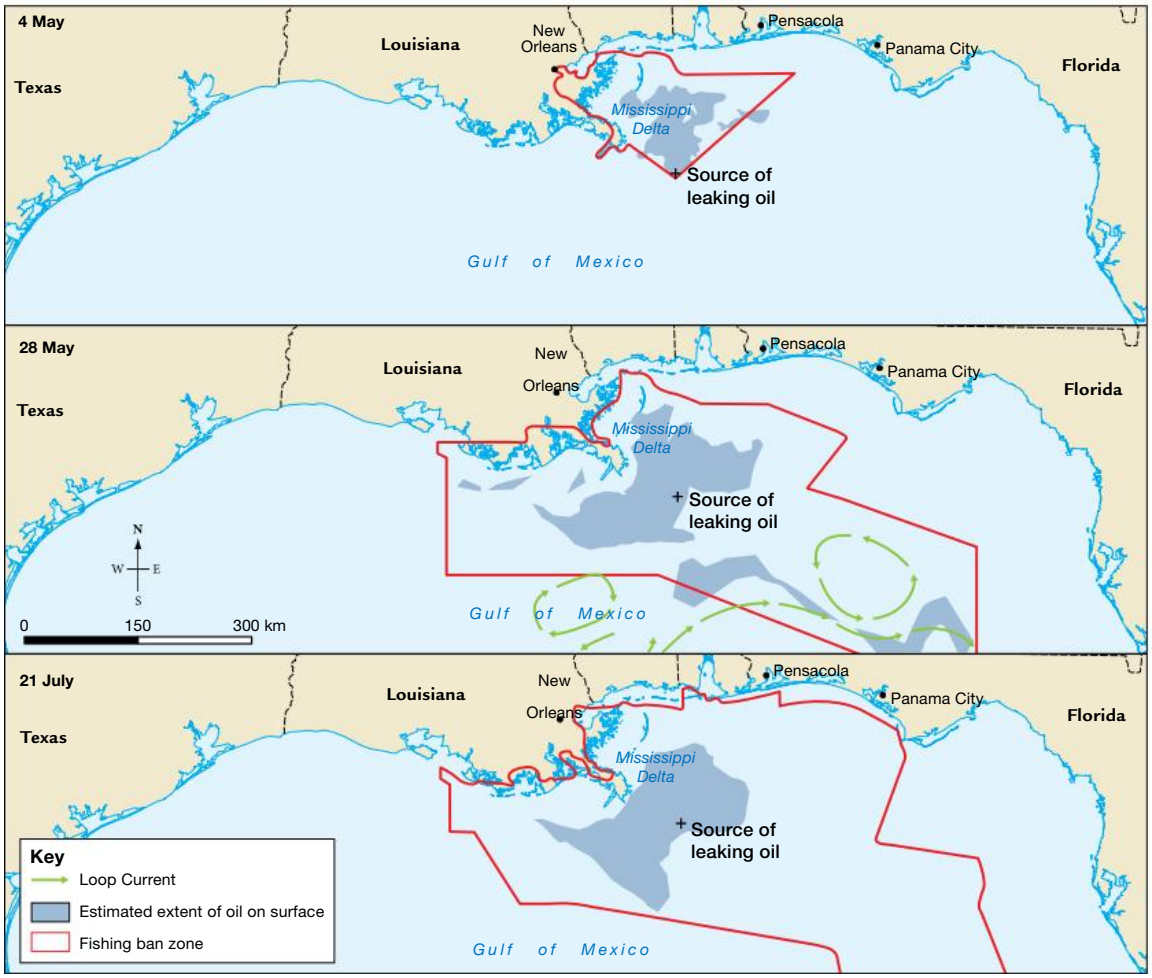
The Gulf of Mexico is rich in natural resources and, in particular, oil. More than 4000 active offshore oil well platforms are distributed along the northern region, attached to thousands of pipelines delivering oil and gas to the mainland. Ninety per cent of America's offshore drilling takes place here. It was the site of the world's second biggest oil spill.

On 20 April 2010, an explosion on the Deepwater Horizon drilling platform, located 74 kilometres off the Gulf coast, caused the rig to burn and sink, killing 11 workers (see figure 1).

As a result, oil began leaking into the Gulf from ruptures in the drilling pipe, more than 2000 metres below the surface, creating the largest spill in American history. Over the course of 87 days, an estimated 4.9 billion **barrels of oil** were released into the sea (see figure 2). Over 35 per cent, or 2650 kilometres, of the Gulf coast was fouled. Use the **BP oil spill** weblink in the Resources tab to view an interactive map that allows you to click on text boxes to learn more about the impacts.

FIGURE 1 The Deepwater Horizon oil rig on fire

FIGURE 2 Mapping the extent of the Gulf oil spill (a) 4 May, (b) 28 May and (c) 21 July 2010



Source: Conservation Biology Institute, Publication Date: 7/5/2010 Map by Spatial Vision.

barrel of oil unit of measurement of crude oil. One barrel = 42 US gallons or 158.9 litres. Elsewhere, oil is measured in either cubic metres or tonnes.

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BP oil spill

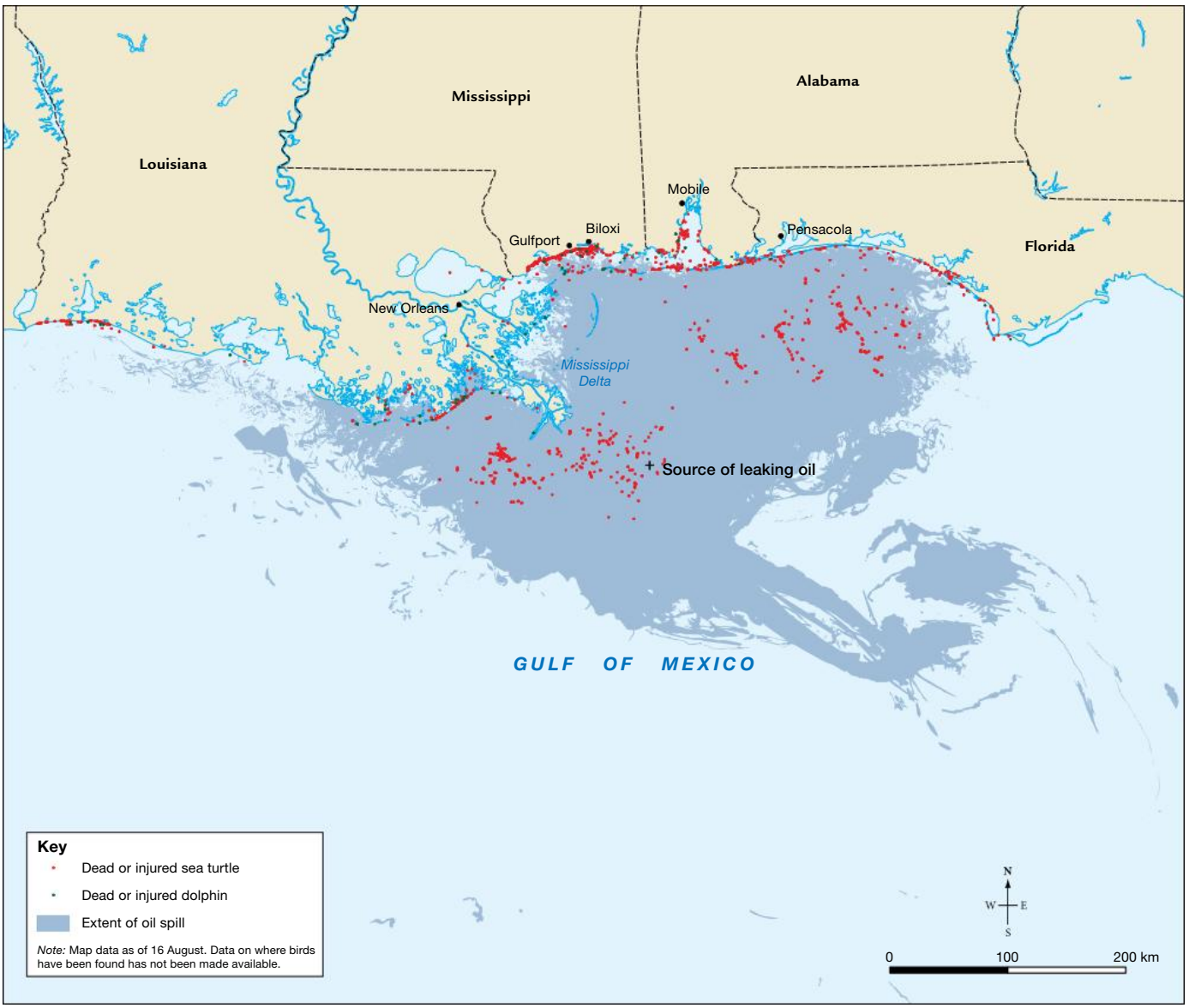
How did ocean currents affect the oil spill?

There was a risk of the oil being caught up in the Gulf Loop Current, which then had the potential to feed oil into the Gulf Stream Current, a powerful ocean conveyor belt that carries warm water north along the east coast of America, moving at a rate of approximately 80–160 km/hour. Had this happened, the extensive wetlands of the Florida Keys and important tourist beaches would have been badly affected. The Loop Current is constantly shifting, and fortunately, during the period of the spill, it actually shifted out of the danger area.

How much damage occurred?

Scientists were able to track and map the oil spill on a daily basis. The distribution of oil changed regularly, largely due to weather and tide conditions and the efforts of clean-up teams. The fact that the oil was leaking in deep water certainly reduced some of the impact, as did the relatively calm weather during this time. For the first month, the oil stayed mostly at sea, but by June, the oil had reached the Louisiana wetlands to the north-west and the Florida coastline to the north-east. Early records of dead or injured turtles and dolphins can be seen in figure 3 and table 1.

FIGURE 3 The effect of the Gulf oil spill on the marine ecosystem, 17 May to 15 August 2010



Source: Conservation Biology Institute, Publication Date: 7/5/2010. Map by Spatial Vision.

TABLE 1 The effect of the Gulf oil spill on sea turtles, dolphins and birds as of 2 November 2010

	Found alive	Found dead	Total found
Sea turtles			
Visibly oiled	456	18	474
Not visibly oiled	79	319	398
Dolphins			
Visibly oiled	2	4	6
Not visibly oiled	7	92	99
Birds			
Visibly oiled	2079	2263	4342
Not visibly oiled	0	3827	3827

Source: © National Oceanic and Atmospheric Administration, www.noaa.gov.

Animal death counts would have been higher if not for the efforts of rescue teams who collected 25 000 turtle eggs and relocated them to Florida's Atlantic coast. In the same time period, inland flooding of farmland provided alternative wetlands for migratory birds that normally would have inhabited the coastal wetlands.

What were the impacts of the spill on people?

To minimise the risk to humans of eating contaminated seafood, more than 150 000 km^2 of federal waters were closed to fishing. The Gulf fishing industry was estimated to have lost $247 million from the fishing ground closures. Continual impacts of lost or degraded commercial and recreational fisheries to the year 2020 could be as high as $8.7 billion, with a potential loss of 22 000 jobs. The initial loss to the tourism industry in 2013 was $22.7 million. The Deepwater Horizon rig was drilling oil wells for petroleum company, BP. Since the spill, BP has paid out more than $13 billion in damages claims to state governments, individuals and businesses. Hundreds of millions of dollars have been spent trying to encourage people back to the region.

ACTIVITIES

IDENTIFY

1 List three things that helped reduce the ***environmental changes*** of the oil spill.
2 What weather conditions could have worsened the Gulf disaster?

EXPLAIN

3 Study figure 3.
  a What was the furthest distance from the oil source that dead or injured marine creatures were found?
  b What problems may arise from the build-up of dead marine creatures on local beaches? What effects may this have on the tourism industry?
4 Study the maps in figure 2. Why was there a need for a fishing ban region?
5 Using the **Oil spill tracker** weblink in the Resources tab, evaluate the most significant impacts of the oil spill. Were the impacts greater for people or the ***environment***? Discuss.

INVESTIGATE

6 a One of the biggest ***environmental*** disasters from a marine oil spill was the spill by the *Exxon Valdez* ship off the Alaskan coast in 1989. Research the disaster and then create a newspaper front page account of the accident. Include a location map, cause of the accident, examples of the impacts and methods used to clean it up. Annotated photographs could be used for illustration.
  b What are the similarities and differences between the *Exxon Valdez* and Gulf oil spills?

PREDICT

7 Describe the geographic features of a beach that you are familiar with. You may wish to create a labelled sketch or annotate a Google image of the area. Predict the likely ***changes*** from an oil spill on this stretch of coast for both people and the ***environment***.

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Weblink
Oil spill tracker

16.8 What is the solution to marine pollution?

16.8.1 How can we clean up oil spills?

The solution to pollution is not dilution. For many years it was thought that any pollutants that ended up in the ocean would just disappear — the oceans were so vast and so deep. We now know better. Despite wonderful advances in technology, we still have marine accidents, specifically related to the oil industry.

There are two ways to deal with oil spills: **remediation** and prevention. A combination is used, depending on location, weather and the type of spill.

remediation act or process of correcting a fault

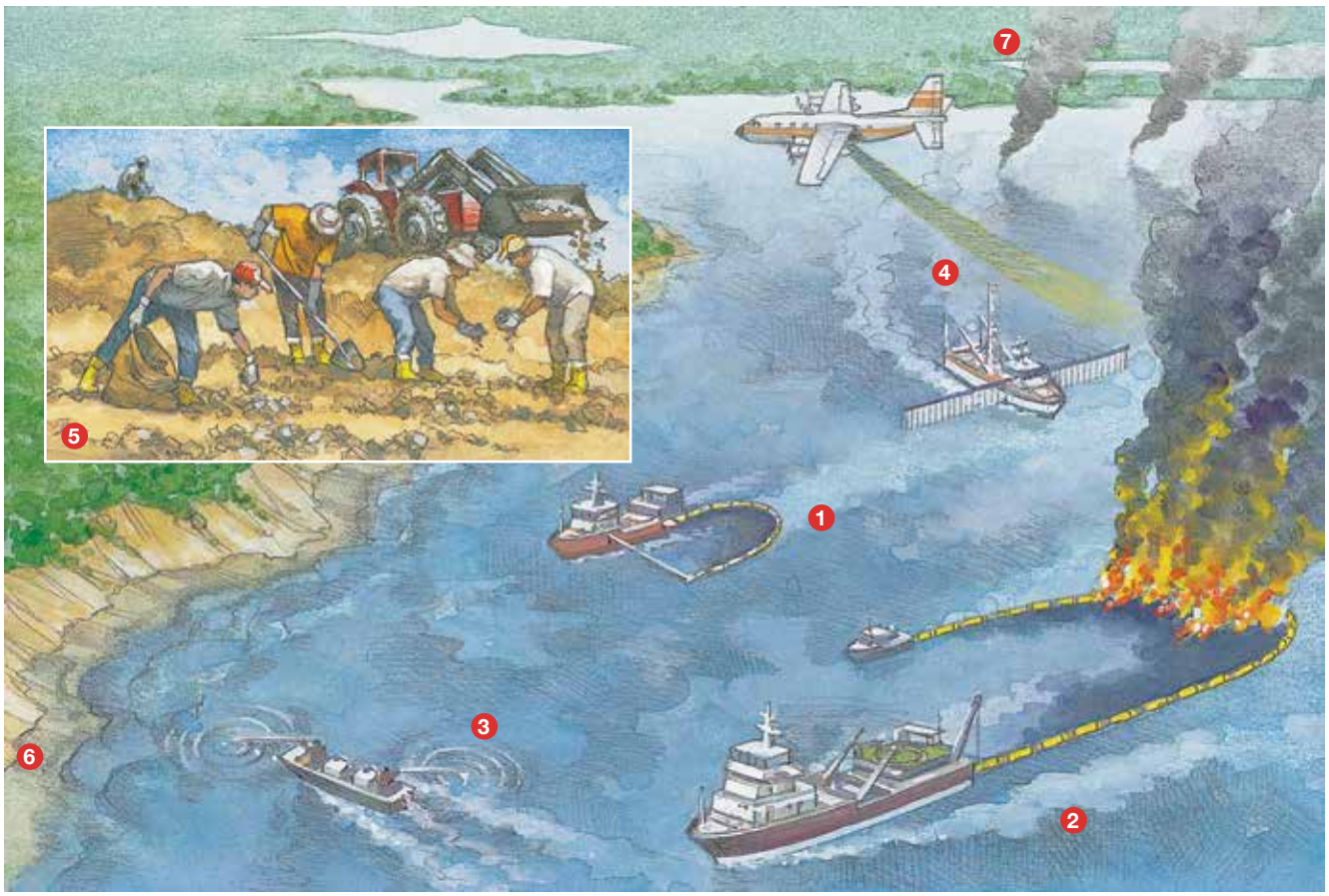
booms floating devices to trap and contain oil

bioremediation the use of biological agents, such as bacteria, to remove or neutralise pollutants

Remediation

It is extremely difficult to contain and clean up any size oil spill, and many of the earlier methods used often caused more environmental damage than the oil itself. For instance, consider the impact of a high pressure hose on a fragile ecosystem, or the spraying of toxic chemicals to absorb the oil. There is a range of remediation methods for cleaning up an oil spill (see figure 1).

FIGURE 1 Different methods of cleaning up oil spills



1. Boats with **booms** attached skim oil off the water's surface.
2. Oil collected by booms is then burned off the surface of the water.
3. **Bioremediation** techniques use microorganisms and fertilisers to break the oil down into less harmful compounds.
4. Boats and planes spray chemical dispersants, similar to detergents, on the oil to break it down into droplets.
5. Manual/mechanical methods: People with rakes and spades as well as heavy equipment physically remove oil from along beaches.
6. Natural processes: Often the impact of cleaning up is greater than the oil damage itself in fragile environments. Over time, naturally occurring microorganisms, sunlight and wave action will slowly break the oil down.
7. Absorbent material such as hay, wood shavings and even human hair (collected from hairdressers and stuffed into nylon casings) can be used to help mop up oil (see figure 2).

FIGURE 2 Recycled human hair turned into oil-absorbent logs for soaking up oil spills

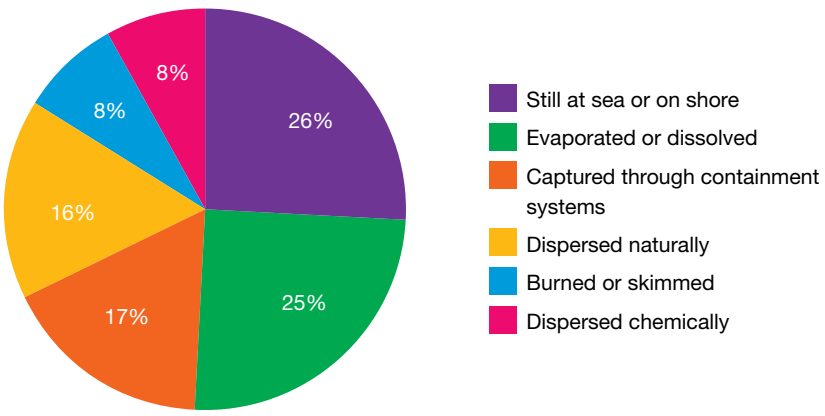
Prevention

The most important way to deal with oil spills is to prevent them from happening. International cooperation has seen the United Nations treaty MARPOL (MARine POLlution) established in 1983 to deal with the growing problem of marine pollution. Individual countries have also established new rules and regulations. For example, by 2015, all tankers operating in United States waters must be double hulled, so that if the outer hull is damaged the inner hull can still hold the fuel. The oil industry must now have detailed response plans for cleaning up any spills.

16.8.2 How was the Gulf disaster cleaned up?

In April 2010, an explosion aboard the Deepwater Horizon oil rig in the Gulf of Mexico created a large-scale environmental disaster (see subtopic 16.7). Figure 3 shows the results of the clean-up following the oil spill, 103 days after the accident. Favourable weather conditions at the time enabled authorities to put some defensive measures in place, including more than 4000 kilometres of booms, to protect coastal land.

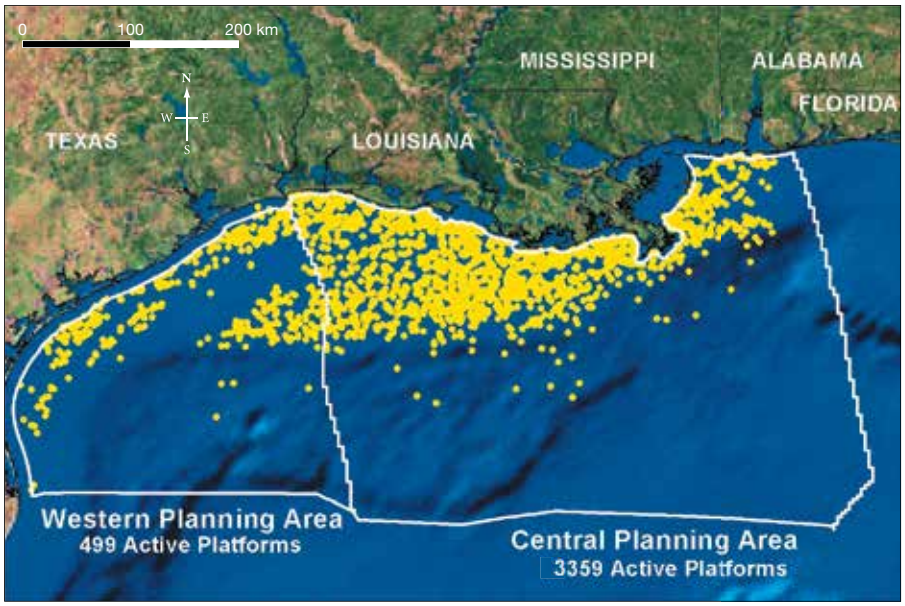
FIGURE 3 How the Gulf of Mexico oil spill was cleaned up



In all, an estimated 6.4 million litres of dispersants were used on the spill. Scientists believe that nearly 50 per cent of the oil spilt and nearly 100 per cent of the methane gas released has stayed deep in the ocean. As much as 3200 square kilometres of ocean floor is thought to be polluted. Patches of oil are still emerging in different locations, years after the accident. Some is being swept up the sea bed by currents and moved by storm waves. On the sea bed, coral reefs are still showing signs of damage, and on land, some marshes are still giving off toxic fumes.

Due to the high number and distribution of oil wells in the Gulf of Mexico (see figure 4), the threat of future accidents remains. In Florida, it has been estimated that the annual value of tourism and fishing along the state's eastern Gulf coast is three times higher, and considerably more sustainable, than the value of any oil or gas that might be found there. The US Federal Government has a ban on offshore oil and gas drilling in any new areas.

FIGURE 4 Distribution of oil wells in the northern Gulf of Mexico



Source: National Oceanic and Atmospheric Administration, Office of Ocean Exploration and Research, U.S. Department of Commerce. Adapted by Spatial Vision.

ACTIVITIES

IDENTIFY

1 Why is it important to treat an oil spill quickly?

2 a Study figure 3. What percentage of the oil spill had been treated at this time? What percentage of the oil had dispersed naturally or evaporated?

b Why do you think only a small percentage was chemically dispersed?

3 Imagine that you spill a whole bottle of cooking oil on your kitchen floor. Describe three different remediation methods that you could use to clean up the spill. Select from booms, skimmers, bioremediation, manual/mechanical, dispersants and absorbers. Would one method be more effective than another? Give reasons.

EXPLAIN

4 Construct a table to suggest the possible advantages and disadvantages of the seven methods of remediation shown in figure 1. Consider the influence of the following factors: weather conditions, timing, location of treatment area (at sea or on coast), size of area to be treated, ***environmental*** impacts, practicality, economic viability and social justice.

5 Why is there is no one solution to cleaning up oil spills?

INVESTIGATE

6 Investigate the cause and impacts of the Montara oil rig explosion off the north-west coast of Western Australia in 2009. Why was this not as severe as the Gulf accident?

APPLY

7 Has the US Government made the right decision in banning drilling for oil in any new ***places***? What did it factor into its decision? Discuss.

16.11 How are ghost nets managed?

16.11.1 What are ghost nets?

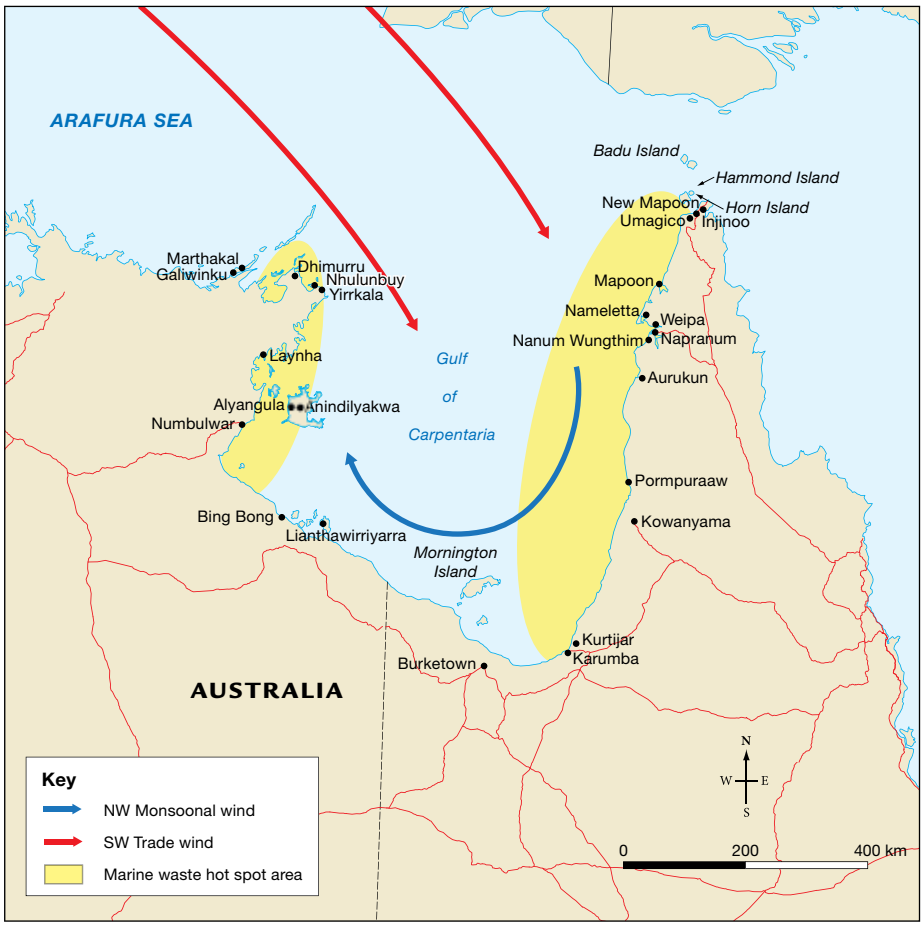
The humble fishing net, once a simple handmade rope construction, has largely been replaced by thousands of metres of nylon webbing. If accidentally lost or purposely discarded, these massive rafts of netting drift around the oceans as **ghost nets**, waiting to trap any unwary sea creature or bird.

ghost nets rafts of plastic fishing nets that have been lost at sea, abandoned or deliberately discarded. They can continue to float in ocean currents and trap fish, birds and anything else that crosses their path.

16.11.2 Where are ghost nets a problem in Australia?

Marine debris occurs around the coast of Australia, especially in places close to major population centres. It is also a major problem in northern Australia, particularly in the Gulf of Carpentaria. Here densities of nets can reach up to three tonnes per kilometre, among the highest in the world. The coastlines in this region are pristine environments and support six of the world's seven marine turtles. Turtles make up 80 per cent of marine creatures captured in the nets. Over 90 per cent of the debris that collects is derived from the fishing industry, most of it originating from South-East Asia, with the remaining 8.6 per cent being Australian in origin. Most of the nets come from the Arafura Sea, an important fishing ground, especially for the Indonesian fishing industry. More than 62 per cent of the nets are trawling nets – the Arafura Sea being the only region of Indonesian waters where trawling is not banned. Under the influence of the south-east trade winds and north-west monsoon winds, a circular gyre pattern develops, which allows the build-up of ghost nets to develop, similar to the Great Pacific Ocean Garbage Patch (see figure 1).

FIGURE 1 Distribution of ghost net hot spots around northern Australia



Source: © Commonwealth of Australia Geoscience Australia 2013. Ghost Nets Australia, http://www.ghostnets.com.au/index-.html.

16.11.3 What is being done?

GhostNets Australia is an alliance of over 22 Indigenous communities in remote coastal places of Western Australia, Queensland and the Northern Territory, funded by the Federal Government. Since its establishment in 2004, over 13 000 ghost nets have been captured by locally trained rangers (see figure 2).

FIGURE 2 Captured trawler nets being collected by rangers

Often, helicopters are used to spot the ghost nets washed ashore, which are then checked for trapped wildlife. Live turtles are tagged and data recorded before they are returned to the sea. Nets are dragged up above the **high tide line** to be identified, collected and disposed of later. The project works on a '6R' principle:

high tide line the line on land where the water's surface is at maximum height reached by a rising tide

1. **R**emove ghost nets from waters and coastline of the Gulf of Carpentaria.
2. **R**ecord the number, size, type and location of nets.
3. **R**escue animals trapped in nets.
4. **R**eport the activities that the community has done to increase awareness.
5. **R**educe the number of nets in the Gulf by working together.
6. **R**esearch factors that influence the distribution, movement and impact of ghost nets.

This program is part of a Caring for our Country initiative in the region, which promotes stewardship of Aboriginal customary lands and seas.

What can be done with the debris?

Traditionally, fishing nets were made of more eco-friendly materials, such as flax or hemp, but they are now increasingly made of nylon, which makes them stronger, cheaper and more buoyant. However, they are also harder to dispose of as they take a very long time to break down. Nets can also range in size from 30 cm to 6 km in length. There are three options for disposal of the waste: burning, placing in landfill, or recycling. Each, however, has disadvantages, and all methods require the waste to be collected over long distances and difficult terrain.

Disadvantages of burning fishing nets include:

- burning plastic is illegal in most countries
- after burning, the residue is a huge, heavy, immovable mass of melted plastic, which is a visual eyesore
- health risks associated with burning plastic.

Disadvantages of disposing of fishing nets in landfill include:

- expense of transporting the waste over large distances to a landfill site
- often waste is burned in tips, and these tips are close to settlements.

Disadvantages of recycling or reusing fishing nets include:

- remoteness of and distances to recycling plants (South Australia and Taiwan have plants big enough to cope with fishing nets)
- expense of transporting the waste over large distances
- the need for large machinery to chop plastic into manageable pieces
- the need to find a local use for the recycled waste material.

What is GhostNets Australia's solution?

cottage industry an industry where the creation of products and services is home-based rather than factory-based

While only a partial solution to the large quantity of nets accumulating, GhostNets Australia promotes the reuse of nets by providing local artists with netting material. The artists use traditional weaving techniques to create artworks (see figure 3). This type of **cottage industry** brings economic and social benefits as well as raising awareness of the problem of marine debris.

FIGURE 3 Woven basket made of recycled fishing net

ACTIVITIES

IDENTIFY

1 Why are ghost nets a problem in northern Australia?
2 Why are fishing nets an ***environmental*** problem?

EXPLAIN

3 Refer to figure 1. On which side of the Gulf would you expect ghost nets to build up:
   a during the north-west monsoon season
   b during the south-east trade wind season?
4 Why is an understanding of local wind patterns useful to Rangers?
5 Why is transporting nets to South Australia for recycling not a viable option?
6 Evaluate the ***environmental***, economic and social aspects of the GhostNets program.

INVESTIGATE

7 If you have access to a beach, walk along the high tide line and see if you can collect and identify different forms of marine litter. Collate and record your findings. What were the most common forms of litter that you identified? Where have they come from?
8 Research information on the different types of fishing nets used: gill, purse, seine and trawl nets.
   a Construct a table to list the advantages and disadvantages of each from a fishing and an ***environmental*** perspective.
   b Which net design might prove to be the most damaging to the ***environment*** if lost or discarded?

16.12 SkillBuilder: Describing change over time

16.12.1 Tell me

What is a description of change over time?

A description of change over time is a verbal or written description of how far a feature moves, or how much it alters, over an extended time period.

Why is a description of change over time useful?

A description of change over time is used to show us the distance that a feature has moved, or the extent to which it has altered, and to alert us to the possible impacts over a wider region. For example, the intensity of earthquake tremors indicates that energy has moved across a region.

The study of change over time is useful for:

- describing cyclones and indicating a potential path
- providing tsunami warnings from one side of an ocean to the other
- anticipating the location of waste in oceans as ocean currents shift the waste
- mapping the spills from mining activities, whether it be in oceans or in rivers.

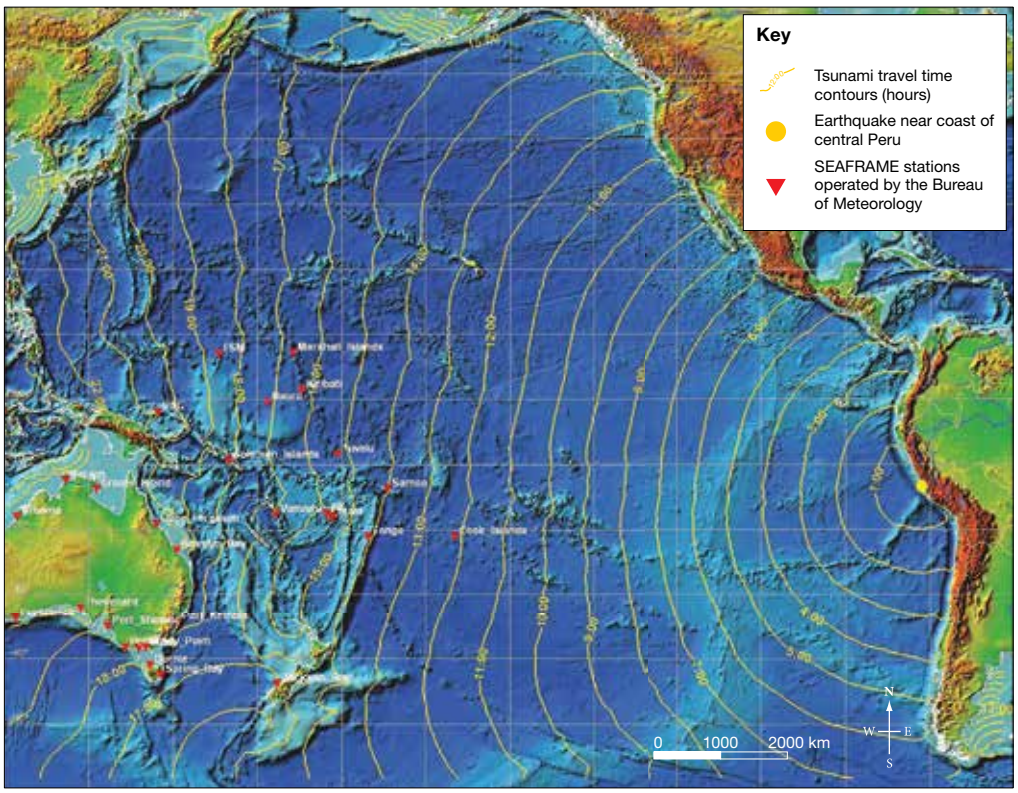
Model

The Peru 2007 magnitude 8.0 earthquake was monitored and a warning was sent across the Pacific, based on the timeframes of the tsunami's energy movement (see figure 1). The tsunami began off the coast of Peru. Authorities estimated that within three hours the wave energy would reach the Galapagos Islands, 1500 kilometres away. The energy continued to spread in concentric circles for nine hours until the energy spread into parallel lines as it neared French Polynesia. The Cook Islands would not expect to see any change in the ocean until 12 hours after the earthquake struck, providing ample time for precautions to be taken. The energy patterns were distorted further by the landmasses they met: the islands throughout the Pacific, New Zealand and Australia. Countries across the Pacific had been monitored in order to decide the likelihood of any impact on Australia. In Port Kembla, New South Wales, more than 11 200 kilometres from the epicentre, a small wave change occurred 18 hours after the Peru earthquake. Although the world watched and waited for a tsunami, the impact was minimal.

A good description of change over time:

- refers to a map with timeframes marked
- uses scale to indicate distance
- discusses direction
- clearly represents and communicates the data.

FIGURE 1 Tsunami mapping from Peru, 2007. A magnitude 8.0 earthquake occurred on 15 August 2007 near the coast of Peru. A tsunami was detected by Seaframe (sea-level fine resolution acoustic measuring equipment) stations located on Pacific islands.



Source: © Bureau of Meteorology.

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eLesson
Describing change over time
Searchlight ID: eles-1753

16.12.2 Show me

How to describe change over time

You will need:

- a map with movement timeframes on it
- an atlas to name places and calculate distances
- a piece of paper to help you use scale and calculate distances.

Procedure:

To track change over time, you need a map constructed by an authorised organisation — that is, a reliable source. Figure 1 was distributed by the Pacific Tsunami Warning Center using advanced monitoring equipment identified as Seaframe.

STEP 1

In order to understand the topic that has been mapped, read the map title, key or legend, and any captions attached.

STEP 2

Study the movement lines across the map and relate these to places, either by name, latitude and longitude, or direction from other places. An atlas will be helpful here. For example, in figure 1, the tsunami began off the coast of Peru. Authorities estimated that within three hours the wave energy would reach the Galapagos Islands, a distance of 1500 kilometres.

STEP 3

Begin writing an analysis of the map by using an opening statement that generalises about what has been mapped. For example, 'In figure 1, the Peru 2007 magnitude 8.0 earthquake was monitored, and a warning was sent across the Pacific based on the timeframes of movement of the tsunami's energy.'

STEP 4

Next, focus on some specific statements about places impacted close to the time of origin of the event. For example, within three hours the wave energy would have reached the Galapagos Islands, a distance of 1500 kilometres.

STEP 5

From the timeframes discussed in Step 4, infer what impact the event will have on people and places at different times. For example, the Cook Islands would not expect to see any change in the ocean until 12 hours after the earthquake occurred. Another place that you might mention is New Zealand, which would experience tidal movement two hours later, at the same time as Samoa.

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Interactivity
Describing change over time
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STEP 6

Conclude your analysis with an overall statement about the level or magnitude of the event.

The 'Model' text in section 16.12.1 has this example: 'Although the world watched and waited for a tsunami, the impact was minimal.'

16.12.3 Let me do it

Developing my skills

Use the **Oil spill** weblink in the Resources tab to view interactive maps showing change over time, and write an analysis of the event.

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Weblink
Oil spill

Questions

1. Which area of the United States was most affected by the oil spill?
2. What distance, and in which directions, did the oil spread?
3. How long did it take for the Gulf of Mexico to be clear of oil movement?
4. What role did ocean currents play in the movement of the oil?
5. Did the oil spread further than predicted?

Checklist

I have:

- referred to a map with timeframes marked
- used scale to indicate distance
- discussed direction
- clearly represented and communicated the data.

Skills questions

1. Describing change over time is used to show:
   a. the weather at a place
   b. the land of a place
   c. the changes at a place
   d. the environment of a place.
2. When describing change over time, geographers include information about:
   a. temperature
   b. distance
   c. slope
   d. soils.
3. Why would a geographer be interested in seeing and analysing change over time?
4. Why is a sense of scale important when describing change over time?

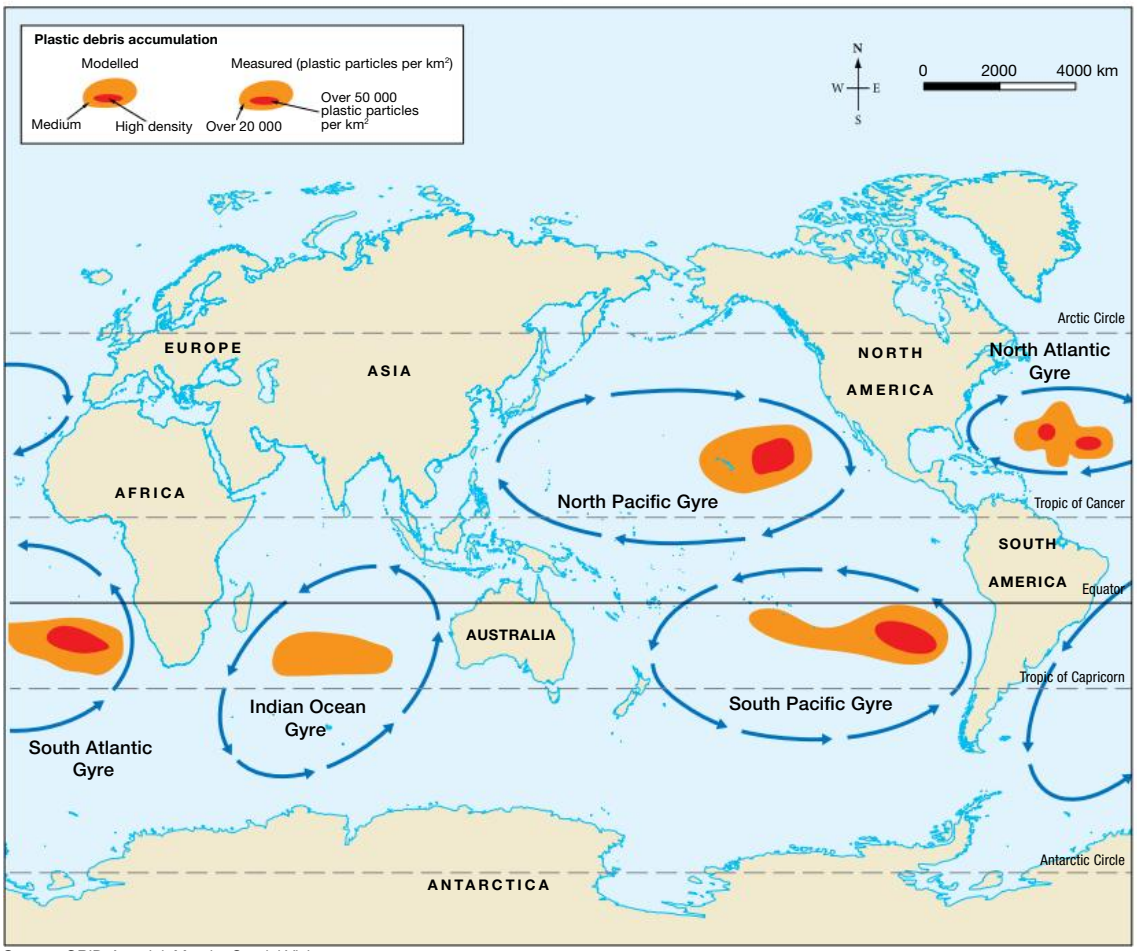
16.14 Review

16.14.1 Review

Ocean currents

1. What are ocean currents? What functions do they perform?
2. Study figure 1.
   a. Which ocean gyre has the highest concentrations of plastic debris? Use figures in your answer.
   b. Which ocean gyre has the largest area of plastic debris? Use the ***scale*** on the map to calculate approximate area covered.

FIGURE 1 Plastic debris accumulation in the world's oceans



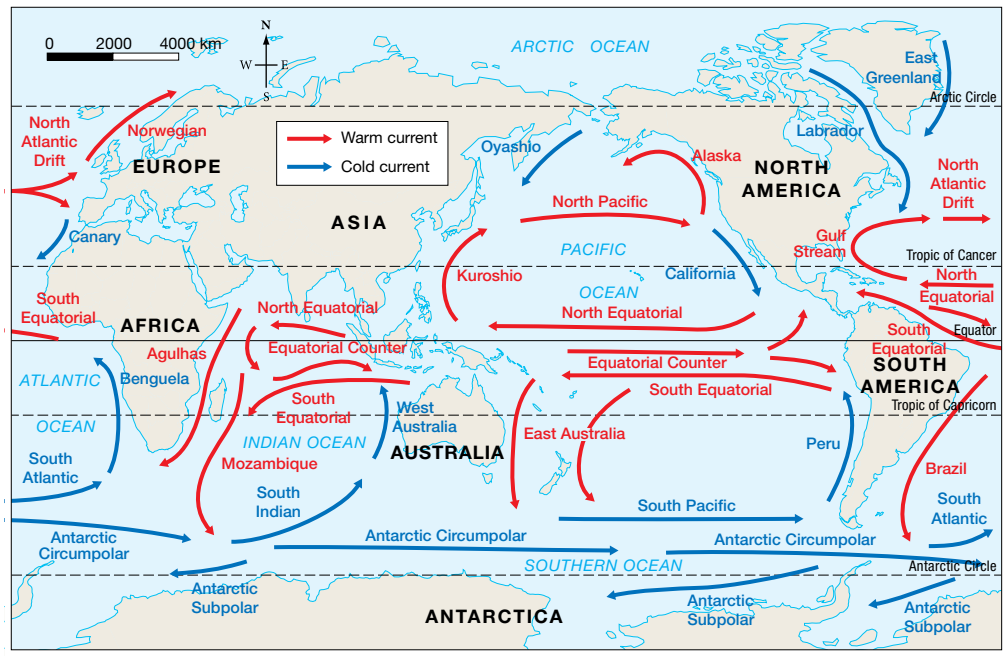
Source: GRID-Arendal. Map by Spatial Vision.

Marine litter

3. Refer to figure 2(a) and (b).
   a. Create a sketch map of Australia and map the location of Chilli Beach, near the mouth of the Lockhart River in northern Queensland. (You may need to do an internet search to find the location). Refer to figure 2(b) to mark and label the major ocean current for this region.
   b. Where do you think the thongs and other debris washed up on this beach have come from?

FIGURE 2(a) 4500 thongs found washed up on Chilli Beach in Far North Queensland

FIGURE 2(b) Oceans of the world and their currents



Source: © Spatial Vision.

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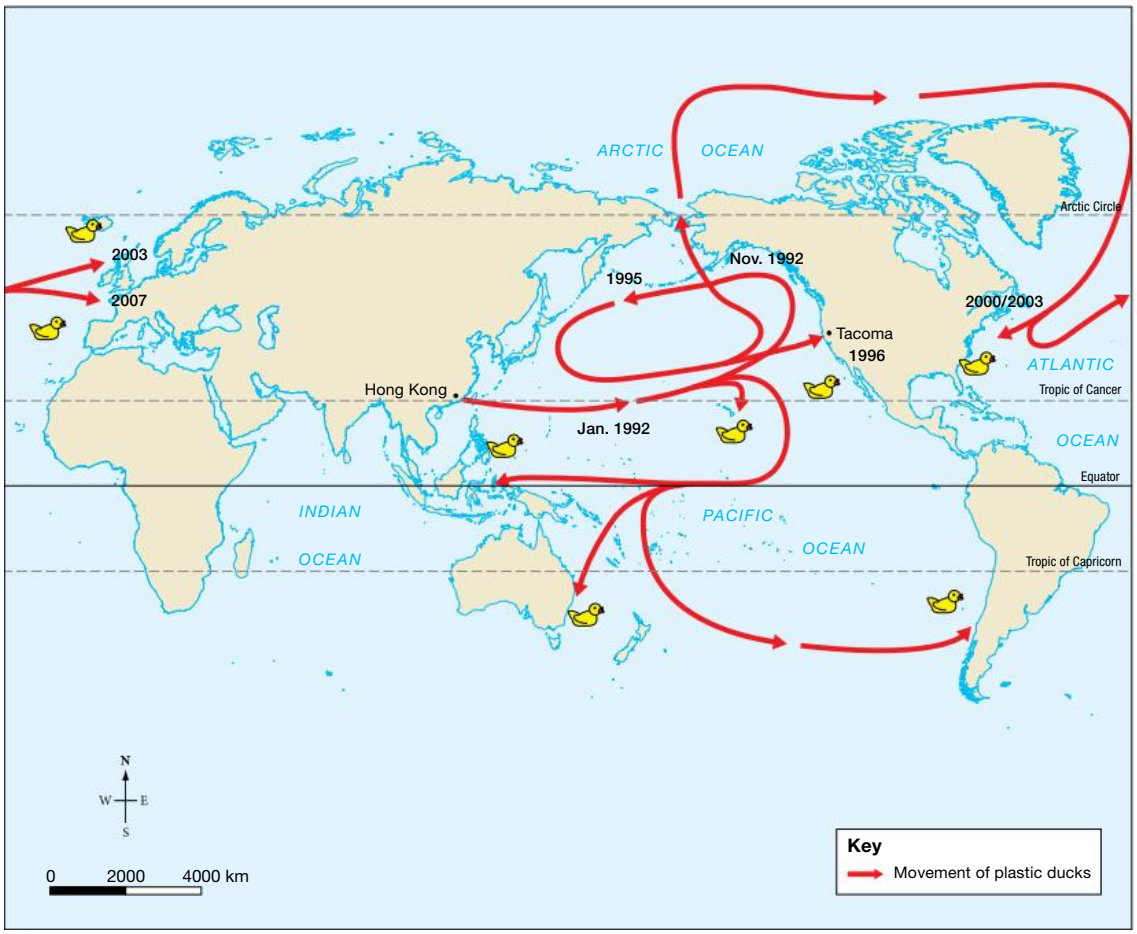
Weblink
Plastic to rope

4. What are the features of plastic that make it such a problem in oceans?
5. Describe how plastic can enter a food chain.
6. Try making your own recycled rope out of plastic bags, by following the instructions found at the **Plastic to rope** weblink in the Resources tab.

7. What do you think is the most effective ***scale*** for dealing with the issue of marine debris: local, national or international? What would be the advantages and disadvantages of these ***scales*** of management?
8. In September 2012, marine scientists discovered plastic fragments in four different ***places*** in the Southern Ocean and around Antarctica. They calculated a density of 50 000 fragments per square kilometre, a rate comparable to the world average. The waters in this region have always been considered pristine. With reference to figure 2(b), is it possible that the debris came from the northern hemisphere?
9. Refer to figure 3 and to subtopic 16.2 'What are the natural processes that affect oceans?'.
   a. Describe the ***change*** in the distribution of plastic ducks between 1992 and 2007.
   b. Refer to figure 1. How did the South Pacific Gyre influence the movement of the ducks to Australia and to the South American continent?
   c. Why would intercepting the ducks in the mid Pacific Ocean have been an effective response to this pollution?

FIGURE 3 Mapping the movement of plastic ducks that were lost at sea in January 1992 when a storm hit the ship they were being transported on. Of the 28 000 toys that were lost, more than 2000 are still floating in ocean currents.



Source: Mother Nature Network Made with Natural Earth. Map by Spatial Vision.

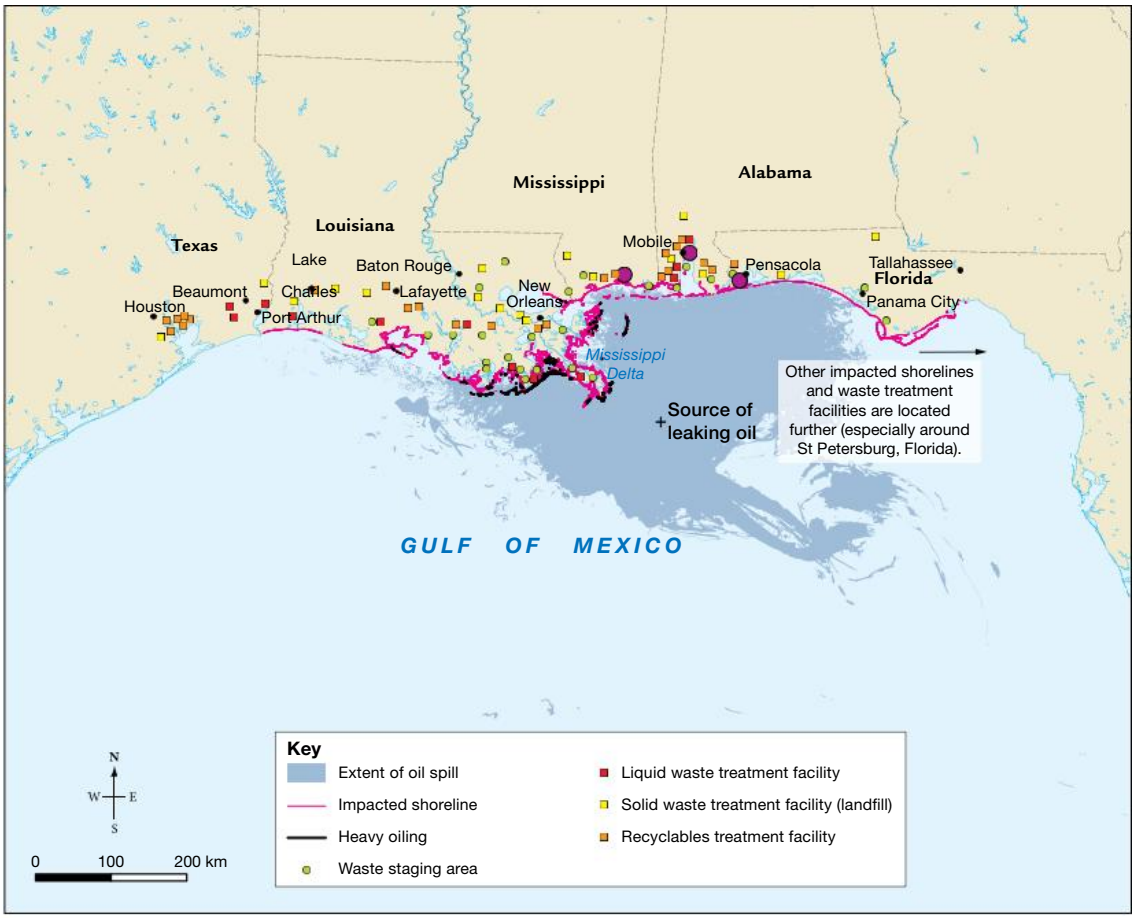
Marine oil spills

10. a. Using this data, construct a bar graph to show the number of oil rigs in different regions of the world.
    Europe 400, Middle East 700, North Africa 100, west coast of Africa 380, Australia 17, Asia 950, South America 340, Gulf of Mexico 4000, west coast of the United States 30, west coast of Canada 14
    b. Which ***places*** in the world have the most offshore oil rigs?

c. Where are Australia's offshore rigs located? Show these on a labelled sketch map.
d. Given that an oil rig may have a life span of only 20 years, what can you do with them once they are decommissioned?

11. Refer to figure 4. A disaster of this ***scale*** often has both direct and indirect impacts. What type of indirect impact is shown in the map?

FIGURE 4 Disposal of waste from Deepwater Horizon oil spill, April–June 2010



Source: GRID-Arendal Conservation Biology Institute, Publication Date: 7/5/2010. Map by Spatial Vision.

12. a. Construct a mind map to show both direct and indirect impacts of the Gulf oil rig disaster. Refer to subtopic 16.7 and the **BP oil spill** weblink in the Resources tab.
    b. Classify the direct and indirect impacts in your mind map according to whether they would bring short-term or long-term ***changes***. Use two different symbols on your flow diagram to show this information.
    c. Do ***environmental*** impacts tend to be short-term or long-term? Why?
13. Refer to figure 2 in subtopic 16.7. Construct a table to show the ***changes*** that have taken place between the dates shown. Use the following as a guide:
    - date
    - furthest distance surveyed from source of spill
    - main direction of estimated and surveyed spill
    - distance to Loop Current
    - number of land sites reported
    - approximate area of fishing ban (furthest points).
14. What could be done to improve the ***environmental*** risks associated with offshore oil drilling and oil tanker transport?
15. The natural method of remediation is often considered to be 'doing nothing'. Do you agree or disagree with this viewpoint? Give reasons for your answer.
16. How effective do you think international agreements are in dealing with oil drilling and oil tanker movements?

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BP oil spill

17. How might a marine disaster such as the Gulf oil spill ***change*** the way oil is viewed, extracted and transported?
18. Use the **Gulf oil spill: one year later** weblink in the Resources tab to view the impacts of the Gulf oil spill. For the impacts illustrated in images 1–10, 12, 14, 16, 21, 25, 27, 31, 33 and 34, state how you could best repair the damage.

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Weblink
Gulf oil spill: one year later

16.14.2 Reflect

What happened to the tsunami debris?

The horrendous tsunami on the north-east coast of Japan in March 2011 generated up to 5 million tonnes of debris that was dragged out to sea by the retreating waves. About 70 per cent of this sank and the remaining 1.5 million tonnes is still floating there. It is predicted that 95 per cent of any material that has not sunk will probably end up in the Great Pacific Ocean Garbage Patch. Scientists, using their knowledge of ocean currents, have been able to model the likely movement of the debris. Use the **Japan tsunami debris tracker** weblink in the Resources tab to view this movement.

A few larger pieces of debris, a fishing ship and large pieces of broken wharf, have already landed on the west coast of North America. The debris is cleaned with high pressure hoses to destroy any marine hitchhikers that could be invasive pests.

You can view the possible current location of the debris using the **Japan tsunami debris location** weblink in the Resources tab.

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Weblinks
Japan tsunami debris tracker
Japan tsunami debris location

19. a. Identify, using the **Japan tsunami debris tracker** weblink in the Resources tab, the main current(s) that would have moved the debris to this location.
    b. If the prevailing winds shift to the north-west, what ***places*** in the Pacific might be affected by the debris? (You might like to refer to a map of the area in your atlas.)
    c. Is it possible for some of the tsunami debris to wash up on the Australian coast? Use your understanding of ocean currents to explain.
20. What are the benefits and drawbacks of this type of modelling of real-life conditions?

Oil spills

21. In light of your study on oil spills and the Gulf disaster, is offshore oil drilling an ***environmentally sustainable*** practice?
22. 'It is the activities of man on land that are largely responsible for the trashing of our oceans.' Do you agree or disagree with this statement? Write a detailed response summarising your viewpoint and supported with evidence from the chapter.

General capabilities

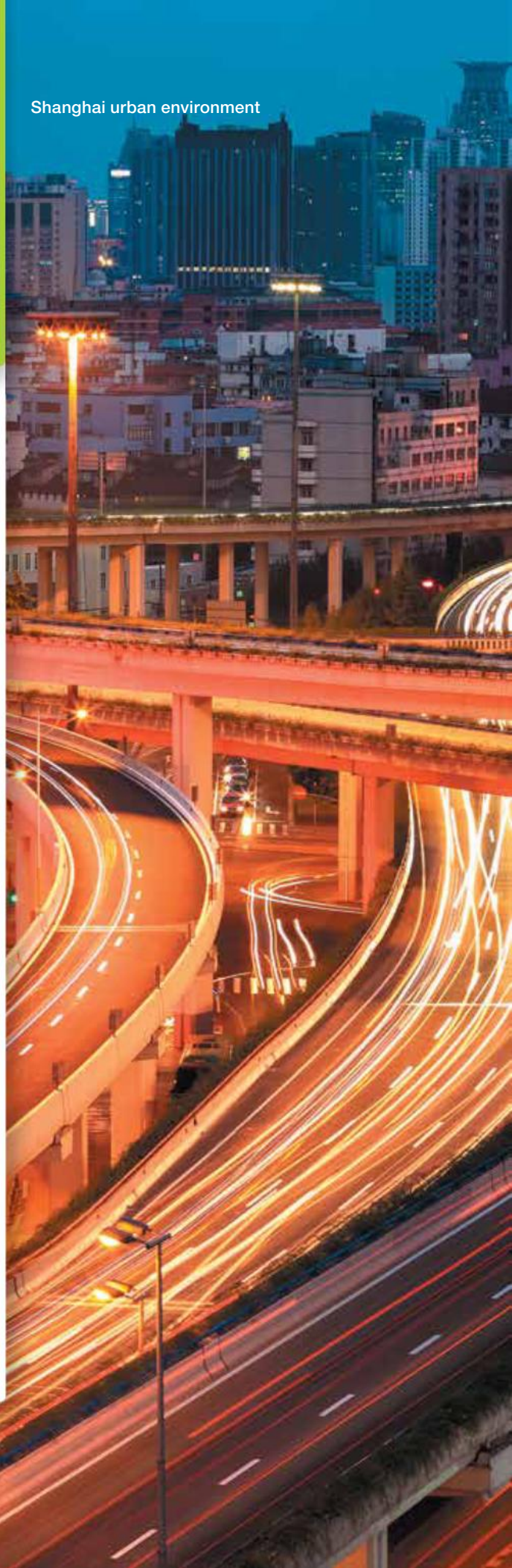
23. The most effective ways of reducing marine pollution have to start on land. What are our obligations and duties as global citizens to reduce waste and pollution?
24. a. With a partner, use the criteria of workability (how practical or feasible something is) to evaluate the effectiveness of the following methods used to combat marine oil spills:
    - remediation
    - bioremediation
    - prevention.

    b. Suggest and apply two other criteria to evaluate these methods. For example:
    - the time it takes
    - economic viability
    - degree of difficulty
    - environmental impacts.

    Note: This may require further research.

CHAPTER 17

Sustaining urban environments



Shanghai urban environment

17.1 Overview

17.1.1 Introduction

Urban environments provide homes, places of work and all the conveniences of modern-day life for their citizens. They are often a magnet for people living in small rural townships, as goods and services abound and social and economic opportunities for a better life are seen as more possible in the big cities.

The complexity of urban environments can be seen in a modern city such as Shanghai, with all its multi-layered buildings, bridges, roadways, electricity, water supplies and services. The need to deal with the huge amounts of waste generated by the population of a city of this size is a concern for its urban planners and managers. To ensure a city of this size is viable into the future, sustainable solutions to the wide range of problems that exist in big cities must be found.

Starter questions

1 What ***changes*** would have been made to the natural ***environment*** to build the urban ***environment*** shown on these pages?
2 How might this urban ***environment*** affect wind movement and run-off of rainfall?
3 Would you like to live in this urban ***environment***? Why?

Inquiry sequence

		Syllabus outcomes
17.1 Overview		
17.2 How do urban environments develop?		GE5-2, GE5-3, GE5-8
17.3 How do cities change the environment?		GE5-2, GE5-3, GE5-7, GE5-8
17.4 Why do urban areas decline?		GE5-2, GE5-3, GE5-8
17.5 What are the challenges for fast-growing cities?		GE5-4, GE5-7, GE5-8
17.6 SkillBuilder: Constructing a land use map	eBook plus ONLINE ONLY	GE5-7, GE5-8
17.7 SkillBuilder: Building a map with geographic information systems (GIS)	eBook plus ONLINE ONLY	GE5-7, GE5-8
17.8 Has Melbourne sprawled too far?		GE5-4, GE5-5, GE5-7, GE5-8
17.9 Investigating topographic maps: How has urban sprawl affected Narre Warren?		GE5-7
17.10 Can we stop Venice from sinking?		GE5-4, GE5-5, GE5-7, GE5-8
17.11 What is the future of our urban environment?		GE5-4, GE5-5, GE5-7, GE5-8
17.12 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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Sprawling cities
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17.2 How do urban environments develop?

17.2.1 Impacts of the growth of urban environments

urban environment the human-made or built structures and spaces in which people live, work and recreate on a day-to-day basis

The earliest forms of the **urban environment** consisted of shelters to protect people from the elements and provide security from the attacks of predators. From these simplest forms, the highly complex modern urban environment has developed. The United Nations predicts that by the year 2050, 70 per cent of the population in developed nations and 40 per cent in **developing nations** will live in large urban complexes.

developing nation a country whose economy is not well developed or diversified, although it may be showing growth in key areas such as agriculture, industries, tourism or telecommunications

Rapid growth in city populations has led to problems such as urban sprawl, traffic congestion and air and water pollution, with significant impacts on the natural environment. Social problems such as unemployment; inadequate housing, **infrastructure**, water, sewerage and electricity supplies; pollution; and the spread of slums and crime are further problems. In addition, with prospects of climate change through global warming, many of the world's coastal cities are under threat of rising sea levels. The application of **human–environment systems thinking** will be the key to evaluating and solving these economic and social issues.

infrastructure the facilities, services and installations needed for a society to function, such as transportation and communications systems, water and power lines

The United Nations estimates that a staggering 90 per cent of the worlds' population growth is taking place in the cities of the developing nations. For many of the people in these countries, pressures such as extreme poverty, famine and civil unrest often draw them away from rural areas towards cities, 'pulled' by the promise of jobs, shelter and protection.

human–environment systems thinking using thinking skills such as analysis and evaluation to understand the interaction of the human and biophysical or natural parts of the Earth's environment

FIGURE 1 Contrasts in urban development in Manila, Philippines

17.2.2 Development of cities

The earliest cities emerged five to six thousand years ago in Mesopotamia (present-day Iraq), Egypt, India and China. These cities became centres for merchants, craftspeople, traders and government officials and were dependent on agriculture and domesticated animals from surrounding rural areas.

Industrial Revolution the period from the late 1700s into the 1800s that saw the widespread introduction of mechanical processes in industry

Before the year 1800, over 90 per cent of the world's population lived in rural agriculture-based societies. With the **Industrial Revolution**, people started moving from rural areas to cities or migrated to other countries to take advantage of jobs in factories and to improve their standard of living. In 1850, only two cities in the world—London and Paris—had a population above one million. By 1900 there were 12, by 1950 there were 83, by 1990 there were 286 and, 10 years later in 2000, there were 411.

Megacities

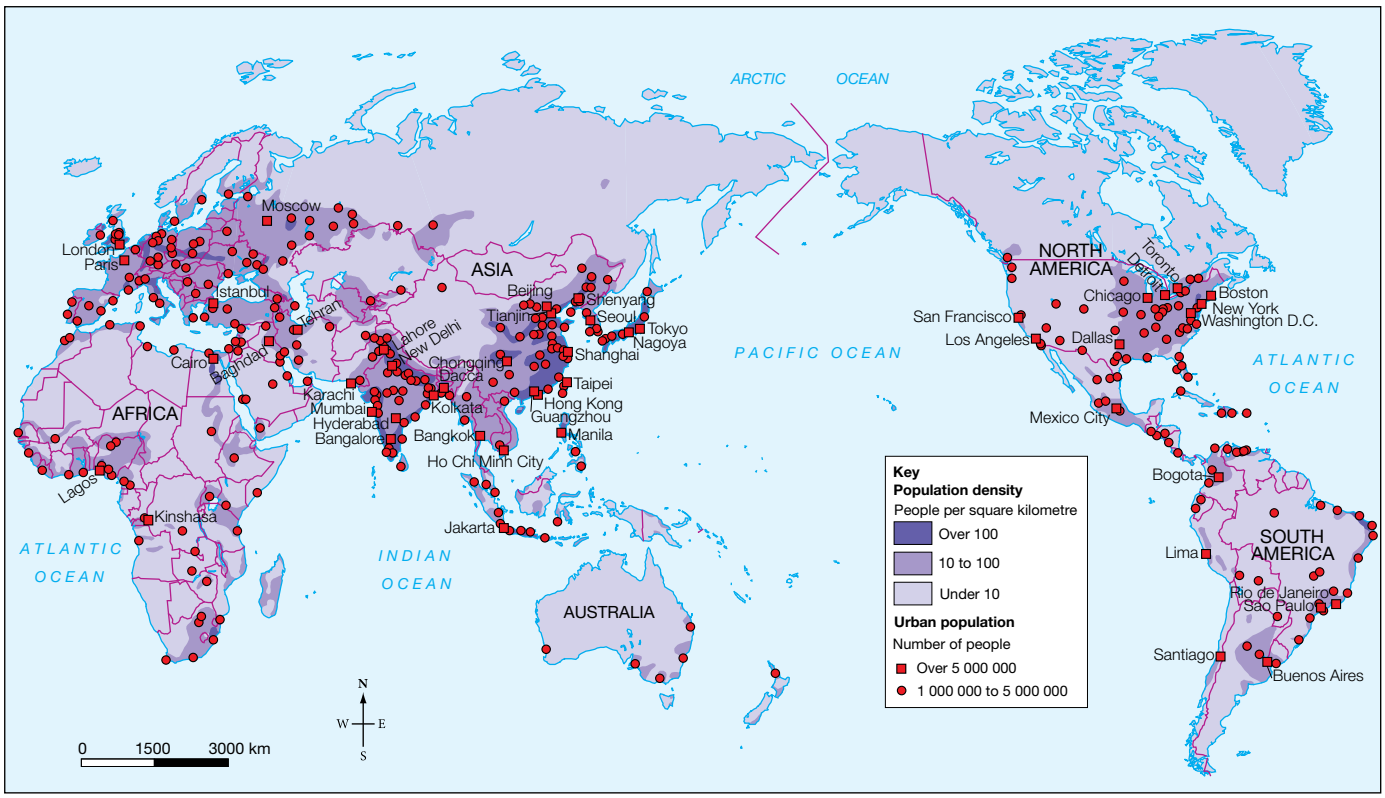
The term 'megacity' commonly refers to urban settlements of 10 million inhabitants or more. Currently, about 280 million people live in at least 25 megacities across the world. This population figure is expected to rise to 3 billion by 2025.

Europe and Asia have many large cities, and Africa and Oceania have proportionally fewer (see figure 2). In Papua New Guinea and Burundi, only 10 per cent of the population is urbanised, whereas in Singapore this figure is 100 per cent.

Of the 15 largest megacities, only four are located in highly industrialised countries: Tokyo, New York, Los Angeles and Osaka–Kobe–Kyoto. Three-quarters of these cities are in developing countries; they include gigantic **conurbations** such as São Paulo (17.8 million inhabitants in 2000), Mexico City (18.4 million) and Mumbai (18 million) (see table 1).

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

FIGURE 2 Distribution of the world's urban population



Source: MAPgraphics Pty Ltd, Brisbane

TABLE 1 Populations of the 10 largest cities, 1950 to 2025

Rank	1950 population	2000 population	2025 population
1	New York (12.3)	Tokyo (26.4)	Tokyo (35.2)
2	London (8.7)	Mexico City (18.4)	Mumbai (26.4)
3	Tokyo (6.9)	Mumbai (18.0)	Delhi (22.5)
4	Paris (5.4)	São Paulo (17.8)	Dhaka (22.0)
5	Moscow (5.4)	New York (16.6)	São Paulo (21.4)
6	Shanghai (5.3)	Lagos (13.4)	Mexico City (21.0)
7	Essen (5.3)	Los Angeles (13.1)	New York (20.6)
8	Buenos Aires (5.0)	Kolkata (12.9)	Kolkata (20.6)
9	Chicago (4.9)	Shanghai (12.9)	Shanghai (19.4)
10	Kolkata (4.4)	Buenos Aires (12.6)	Karachi (19.1)

Note: All population figures are in millions.
Source: United Nations.

ACTIVITIES

IDENTIFY

1 When and where did the first cities develop?
2 Why did cities experience rapid growth and development after the Industrial Revolution?

EXPLAIN

3 a What factors are driving the process of urbanisation in the world?
b In which regions of the world is this occurring most quickly? Why?
4 What are some of the major economic and social issues facing rapidly developing cities in the world?
5 What are some other urban problems, besides those mentioned in this section, that arise as cities develop?
6 What do you think are some of the advantages of living (a) in a large city, (b) in a small town and (c) on a farm? Which would you prefer? Why?

APPLY

7 Construct a bar graph to represent the expected populations for the projected 10 largest cities in the world in 2025. Also research and represent these cities' current populations on the same graph. Locate each of these cities on a map and annotate this map to show which cities will grow the most and which will grow the least. Suggest why.

PREDICT

8 What impact do you think global warming and rising sea levels will have on coastal cities around the world by 2025 and beyond?

myWorldAtlas Deepen your understanding of this topic with related case studies and questions.
› World urbanisation
› Urbanisation in Australia

17.3 How do cities change the environment?

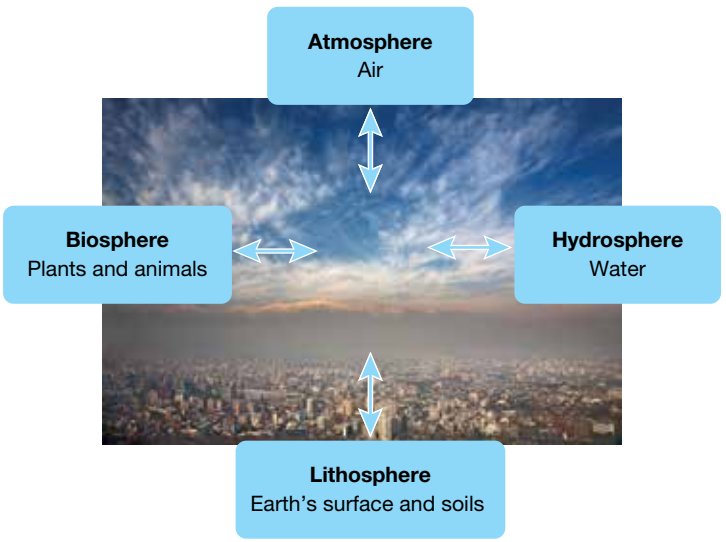
17.3.1 What are the limits and changes?

All forms of urban environments are interconnected with the **biophysical environment**. The 'bio' elements are all forms of plant and animal life including people and all their activity and industry. The 'physical' elements are the atmosphere, hydrosphere and lithosphere or Earth's surface.

biophysical environment all elements or features of the natural or physical and the human or urban environment including the interaction of these elements

The biophysical elements impose limits on the development and sustainability of all forms of urban environment. On the other hand, the urban environment imposes significant human-induced change on the biophysical world. The understanding of this interconnection is particularly important in a world of increasing human numbers and pressure for resources on the biophysical environment (see figure 1).

FIGURE 1 Interaction between the urban environment and the biophysical environment



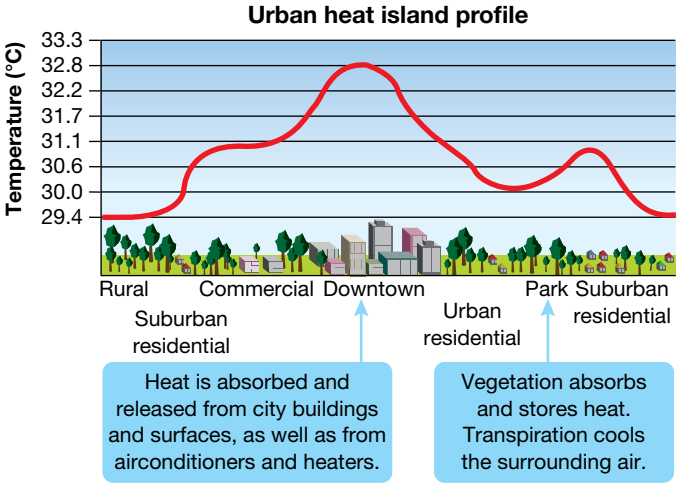
17.3.2 How does the urban environment affect the atmosphere?

Where sources of potentially dangerous gaseous emissions are high, such as from buildings, transport systems and industry, atmospheric pollution can be a problem. Examples such as hazy conditions, photochemical smogs, light and noise pollution, and acid rain are significant problems that need to be addressed. Hence, the development of clean air policies

controlling emissions of gases into the atmosphere is important. Some examples are the introduction of lead-free petrol, banning the burning of household waste and emission control systems on factory furnaces.

Cities and industries have huge demands for energy, and the by-product of this is heat. What is known as the 'heat island effect', whereby urban environment structures such as buildings and roads absorb heat from the sun, raises the temperature of the city environment compared to rural surrounds (see figure 2).

FIGURE 2 The 'heat island effect' of cities



The production of greenhouse gases such as carbon dioxide and methane by urban environments is recognised as probably the greatest contemporary climate issue. Global warming leading to climate change is the result of emissions of these gases into the atmosphere, particularly in large urban centres.

17.3.3 How does the urban environment affect the hydrosphere?

As the urban environment is closely dependent on the hydrosphere, it is not surprising that the provision of clean water and/or what is known as water security and **water rights** are important management objectives for a sustainable future. One of the most important aims for urban planners in cities is to ensure supplies of clean water and to manage the waste water from cities by schemes such as urban wetlands.

water rights the right through ownership to use water from a water source such as a river, stream, pond or groundwater source

In general, all urban centres are trying to find increasing supplies of water for domestic and industrial consumption from rivers, groundwater and, more recently, desalinisation sources.

Infrastructure in the form of dams, pipelines, artesian waters at the local level and major water management schemes such as the Snowy Mountains Scheme in Australia are ways that water is gathered. Water pollution caused by urban environments is also important as polluted waters are a risk to all life forms in any environment. Considerations for biomes and ecosystems of rivers, wetlands and swamps in terms of protecting habitats and maintaining biodiversity is also a major management aim.

FIGURE 3 The banks and channel of the Seine River have been heavily modified by people, just like those of many rivers in the world.

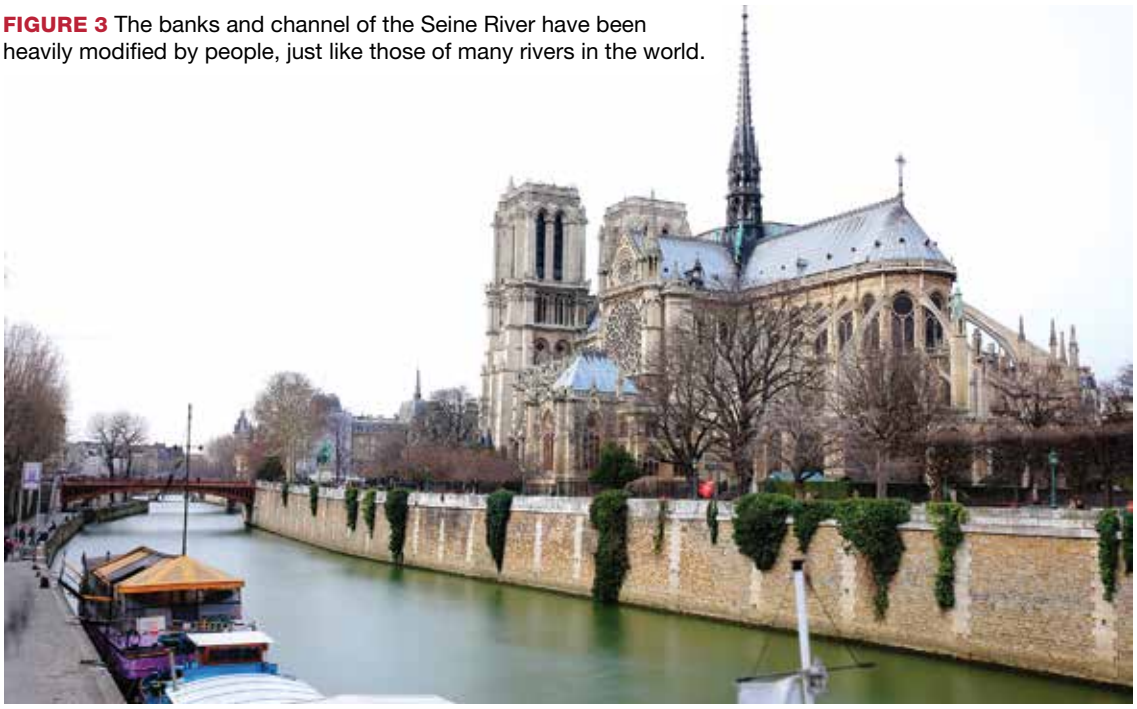


FIGURE 4 One of the world's largest car parks will be located in the Dubai World Central International Airport (shown in the model below). It will have over 100 000 parking spaces for its employees, Dubai residents, tourists and other users.

17.3.4 How does the urban environment affect the lithosphere?

Apart from the impact on the land of the 'tar and cement' structures of cities, there is the sheer size of today's megacities. These urban structures can cover areas of up to 100 square kilometres, and this can lead to problems of urban sprawl, such as extended commuting times, congestion, air pollution and slums. Other problems include the disposal of the enormous amount of garbage and waste that cities produce, and the general impacts on agriculture, plants and animal life in adjacent habitats and ecosystems.

Urban environment surfaces such as car parks generate two to six times more run-off than a natural surface. Rain that falls on car parks can be contaminated with petroleum residues, fertilisers, pesticides and other pollutants.

eBook*plus*

Interactivity
Urban impacts on the environment
Use this interactivity to classify urban impacts on the four Earth spheres.
Searchlight ID: int-3301

FOCUS ON FIELDWORK

Using surveys to find out how sustainable your area is

As a class, create a survey to discover the issues existing in your local area that need to be improved in order to achieve a sustainable urban environment. Distribute the survey amongst family, friends and relatives and collate all the data to analyse your findings. Use graphs and statistics to support your analysis.

1. Describe the range of issues that exist in the biophysical environment.
2. Discuss whether the issues are easy to manage.
3. Describe the causes of issues in your local area.
4. Discuss whether these issues are a direct result of urban growth.

ACTIVITIES

IDENTIFY

1. What is the 'bio' part of the biophysical ***environment***?

EXPLAIN

2. Give reasons why urban ***environments*** can have such a major impact on the Earth's ***atmosphere***.
3. Why do most of the large urban centres of the world have high-rise buildings?
4. How do wetland systems operate and why are they successful in 'cleaning up' storm waters ***from*** cities?

PREDICT

5. How might rising sea levels, predicted to be a result of global warming, affect the ***place*** and ***space*** of a city such as New York?
6. How will the supply of fresh water affect the development of cities in the future?

APPLY

7. Identify any transport infrastructure problems that exist in the capital city of your region and comment on how they are being overcome and how this will lead to a more ***sustainable*** urban ***environment***.

myWorldAtlas Deepen your understanding of this topic with related case studies and questions.
› **Polluted cities**
› **Mexico City**

17.4 Why do urban areas decline?

17.4.1 Reasons for decline of urban environments

Over the ages and even in recent times there have been many cities, towns and villages that have declined or been abandoned.

Environmental factors

Over time, all forms of urban environments will deteriorate with age and require renovation or renewal. Extreme atmospheric events such as cyclones, hurricanes and tornadoes, which exhibit strong winds and flooding rains, can have devastating short-term impacts on urban environments. Longer-term events, such as **desertification** and climate change, can also have negative impacts.

Movements of the earth such as those due to earthquakes, volcanoes and tsunamis can also destroy urban environments. Two of the most famous events are the destruction of the mythical city of Atlantis by earthquake and subsidence, and the burying of the region of Pompeii and Herculaneum (see figure 1) by volcanic ash in AD 79.

FIGURE 1 Ruins of the Roman city of Pompeii with Mt Vesuvius in the background

FIGURE 2 Main temple complex, Angkor Wat, Cambodia

Human factors

Human factors, which include changes in the social, economic and political elements of a region, can be a cause of the decline of cities and their urban environment. The destructive elements of war on the social fabric and economy of a nation, which have significant impacts on urban environments, is one example.

Angkor Wat, the capital city of the Khmer Empire in Cambodia, and thought to be the largest city in the world at the time, was abandoned in the fifteenth century due to a combination of wars and a series of droughts (see figure 2). The destruction of its economy, which was based on management of water and rice production, meant the city was no longer viable.

In modern times, there are many examples of towns and cities with extensive urban environments that have declined. Some reasons for change include depletion of mineral supplies and mining operations, changes in demand for industrial production and manufactured goods (affecting the **manufacturing and industrial base**), and **downturn of the global economy**. Paradoxically, the city of Ordos in China has been built ahead of its time and remains unoccupied due to insufficient population (see figure 3).

Other examples of urban environments that have declined due to human-induced factors can be seen in figure 4.

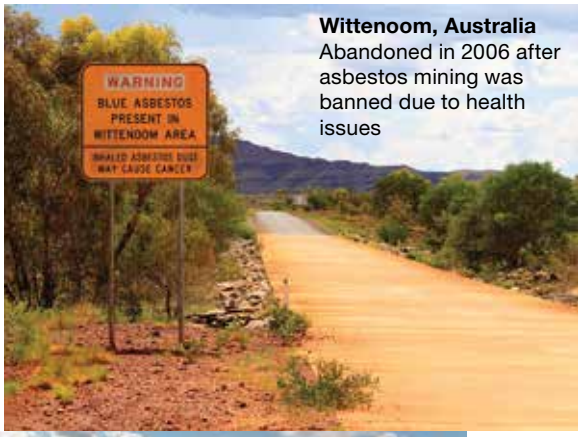
FIGURE 3 Ordos, inner Mongolia, China. Deserted roads and unoccupied high-rise apartments in 2011. A larger population needs to move to this area to take up ownership and use the facilities.

desertification the transformation of land once suitable for agriculture into desert by processes such as climate change or human practices such as deforestation and overgrazing

manufacturing and industrial base all factories or companies producing goods or related services on a large or medium scale in a country or region, considered in relation to the economy as a whole

downturn of the global economy a recession or downturn in a nation's economic activity which includes increased unemployment and also decreased consumer spending

FIGURE 4 Cities abandoned due to changing human and physical factors



Wittenoom, Australia
Abandoned in 2006 after asbestos mining was banned due to health issues

Oradour-sur-Glane, France
Deserted in 1944 but kept as a memorial after its population was massacred during World War II

Pripyat near Chernobyl, Ukraine
Abandoned in 1986 after nuclear accident and radiation contamination

Ghost town, Bodie, United States
Abandoned after gold-mining boom concluded in 1915

Kowloon (shanty town), Hong Kong
Abandoned and then demolished by government order in 1993 to 'clean up the city, reduce squalor and crime'

Note: This photograph was taken prior to the demolition of Kowloon.

ACTIVITIES

IDENTIFY

1 What ***environmental*** hazards can lead to destruction or damage to urban ***environments***?
2 Why was the town of Pripyat near Chernobyl in the Ukraine abandoned?

EXPLAIN

3 The Miss World Competition was held in 2012 in the town of Ordos, Inner Mongolia, China. Suggest reasons why China would be keen to have the event held in that ***place***.
4 Why was water essential to the survival and decline of the city of Angkor Wat?
5 Is there a future for ghost towns?
6 Use the internet to find out more about the decline of the cities of Gary and Detroit in the United States, and make a list of reasons why these cities have declined and how they might be re-invigorated.

PREDICT

7 What impact might a rise in sea level have on a city such as Venice?
8 If ore bodies are depleted in the mining town of Broken Hill, how might the town ***sustain*** its existence into the future?

17.5 What are the challenges for fast-growing cities?

17.5.1 The growth of Mumbai

Mumbai is the most populous city in India, and the fourth most populous city in the world, with a total metropolitan area population of approximately 20.5 million. In 2009, Mumbai was named an **alpha world city**. Although the richest city in India, with the highest **gross domestic product (GDP)** of any city in south, west or central Asia, it also has much substandard housing and many people living in squalor.

alpha world city a city generally considered to be an important node in the global economic system

gross domestic product (GDP) a measurement of the annual value of all the goods and services bought and sold within a country's borders; usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

The large numbers of people and rapid population growth have contributed to serious social, economic and environmental problems for Mumbai. Mumbai's business opportunities, as well as its potential to offer a higher standard of living, attracted migrants from all over India seeking employment and a better way of life. In turn, this made the city a melting pot of many communities and cultures. The population density is estimated to be about 20 482 persons per square kilometre, and the living space 4.5 square metres per person.

Despite government attempts to discourage the influx of people, the city's population grew at an annual rate of more than 4 per cent per year (see table 1). The number of migrants to Mumbai from outside Maharashtra during the 2001–2011 decade was over one million, which amounted to 54.8 per cent of the net addition to the population of Mumbai.

Many newcomers end up in abject poverty, often living in slums or sleeping in the streets. An estimated 42 per cent of the city's inhabitants live in slum conditions. Some areas of Mumbai city have population densities of around 46 000 per square kilometre—among the highest in the world.

TABLE 1 Population growth in Mumbai

Census	Population	% change
1971	5 970 575	—
1981	8 243 405	38.1
1991	9 925 891	20.4
2001	11 914 398	20.0
2011	12 478 447	4.7

Source: Mumbai Metropolitan Region Development Authority. Data is based on Government of India Census.

17.5.2 Challenges

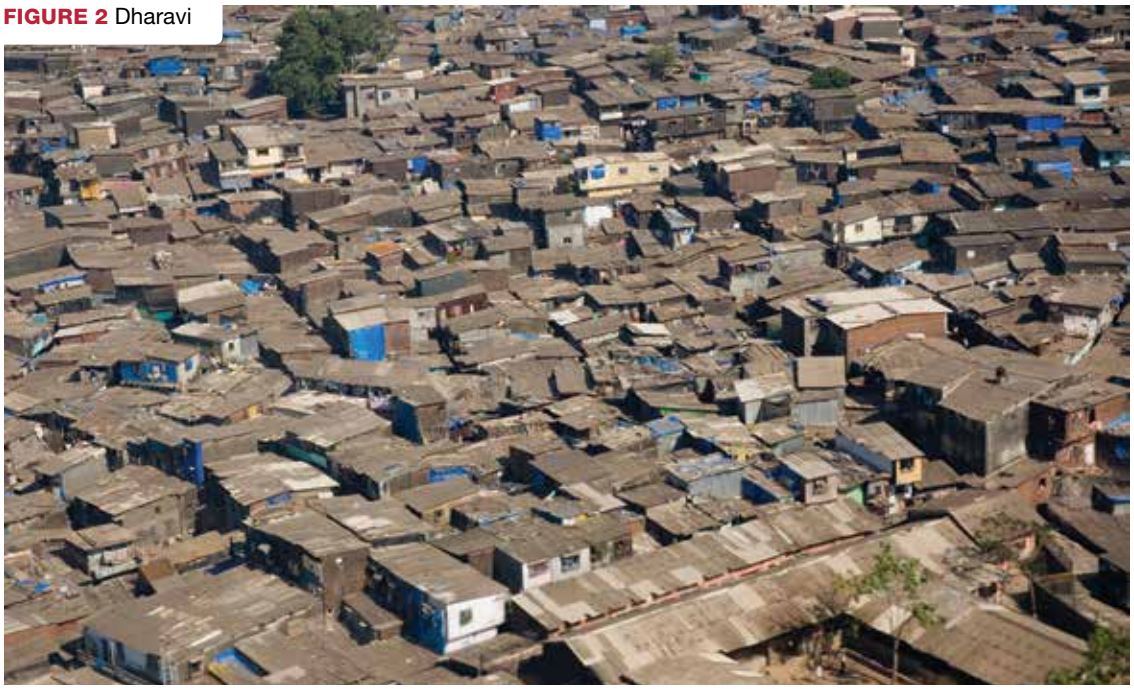
Mumbai suffers from the same major urbanisation problems seen in many fast-growing cities in developing countries: widespread poverty and unemployment, urban sprawl, traffic congestion, inadequate sanitation, poor public health, poor civic and educational standards, and pollution. These pose serious threats to the quality of life in the city for a large section of the population. Automobile exhausts and industrial emissions, for example, contribute to serious air pollution, which is reflected in a high incidence of chronic respiratory problems. With available land at a premium, Mumbai residents often reside in cramped, relatively expensive housing, usually far from workplaces and therefore requiring long commutes on crowded public transport (see figure 1) or clogged roadways. Many of them live in close proximity

FIGURE 1 Mumbai train rush hour

slum rundown area of a city with substandard housing

to bus or train stations, although suburban residents spend significant time travelling southwards to the main commercial district. Dharavi, Asia's second-largest **slum** (see figure 2), is located in central Mumbai and houses more than one million people.

FIGURE 2 Dharavi



17.5.3 Dharavi's recycling entrepreneurs

Dharavi sprawls over 222 hectares of land in the centre of Mumbai. Hidden amid the labyrinth of ramshackle huts and squalid open sewers are an estimated 15 000 single-room factories, employing around a quarter of a million people and turning over a staggering US$1 billion each year through recycling. Jewellery and pottery are also predominant trades.

In developed countries, communities recycle because there is the understanding that it contributes to sustaining the planet's resources. However, for some of the poorest people in the developing world, recycling often isn't a choice, but a necessity of life.

In India, almost 300 000 people make their living by recycling waste. These people are known as 'ragpickers' (see figure 3) and are made up of India's poorest and most marginalised groups. The ragpickers wade through piles of unwanted goods to salvage easily recyclable materials such as glass, metal and plastic, which are then sold to scrap dealers who process the waste and sell it on either to be recycled or to be used directly by the industry.

Due to the lack of formal systems of waste collection, it falls to Mumbai's ragpickers to provide this basic service for fellow citizens. Without them, solid waste and domestic garbage would not be collected or recycled, let alone sorted.

Recycling is still very much the focus of many developing countries, who continuously strive to improve their recycling endeavours. Despite many of the social and ethical controversies surrounding the recycling industry in India, Dharavi is seen as the 'ecological heart of Mumbai', recycling up to 85 per cent of all waste material produced by the city, an excellent example of human–environment systems thinking in action.

If we look at the United Kingdom's recycling figures, over the last decade less than 20 per cent of the waste produced has been recycled. The United Kingdom produces 30.5 million tonnes of waste each year. This is equivalent to 23.9 million tonnes of waste in landfills. If the United Kingdom could sustain the recycling rates of Mumbai, it would leave only a quarter of existing waste entering landfills per year (around 6 million tonnes), reducing costs in sourcing materials.

In Dharavi, there is only one toilet for every 1440 people. This results in floods of human excrement during the monsoon season. Much of the water becomes contaminated because of this, and death rates tend to be 50 per cent higher in Mumbai's slums than in upper- and middle-class areas.

FIGURE 3 Ragpickers make a meagre living by recycling waste.

There are currently plans to demolish and redevelop Dharavi, a project that not all residents of the slum are in support of, as Mumbai is working on a facelift in order to become a world city. This redevelopment would transform the slum into a series of high-rise housing facilities, and each of Dharavi's 57 000 registered families would get 21 square metres of living space apiece.

However, many Dharavi residents are unhappy about this plan, as they are content with their current lifestyle. Most residents of the slum do not mind squatting near Mahim Creek, and prefer not to have their own flush toilets. Most are working and making a living, and many have lived their entire lives in Dharavi and do not want to trade their culture for the redeveloped life.

ACTIVITIES

IDENTIFY

1 List Mumbai's challenges.
2 Why are migrants attracted to Mumbai?

EXPLAIN

3 What human influences caused Mumbai to develop over time?

APPLY

4 Discuss the advantages and disadvantages of replacing slums with high-rise low-income housing.
5 Use the **Mumbai slums** weblink in your eBookPLUS to watch the video *Slums in Mumbai*.
   a Describe the everyday living conditions.
   b What percentage of Mumbai's population lives in Dharavi? What percentage is this of Mumbai's area?
   c What are the challenges facing the residents?

INVESTIGATE

6 Find out more about the natural and human influences on the development of cities. Examples for research could include Canberra, Australia (a planned city); Cape Town, South Africa (a port city); Rotenburg, Germany (a walled city); Geneva, Switzerland (where a river meets a lake); Johannesburg, South Africa (near a mining site); Chicago, United States (where north–south and east–west railway routes cross); Jerusalem, Israel (an ancient religious city); Bath, England (located at the site of a natural supply of mineral waters).

eBookplus

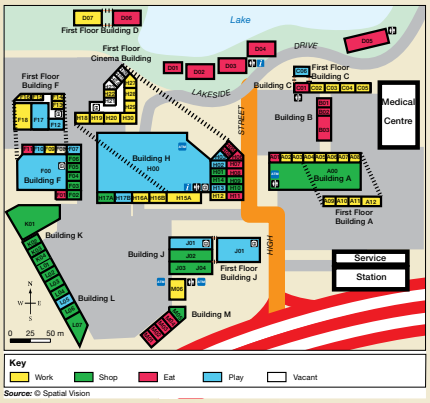
Weblink
Mumbai slums

eBook*plus* ONLINE ONLY

17.6 SkillBuilder: Constructing a land use map

What is a land use map?

A land use map may be drawn from a topographic map, an aerial photograph, a plan or during fieldwork. It shows simplified information about the uses made of an area of land. This type of map is useful when focusing on an aspect of an environment or when comparing the interconnections between two or more data sets.



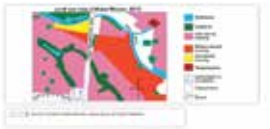
eLesson

Watch this video to learn how to construct a land use map.

Searchlight ID: eles-1755

Interactivity

Try this interactivity to learn how to construct a land use map.



Searchlight ID: int-3373

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17.7 SkillBuilder: Building a map with geographic information systems (GIS)

What is GIS?

GIS is a computer-based system that consists of layers of geographic data. Just as an overlay map allows you to interchange layers of information, GIS allows you to turn layers on and off to make comparisons between data.

eLesson

Watch this video to learn how to build a map with geographic information systems (GIS).

Searchlight ID: eles-1754

Interactivity

Try this interactivity to learn how to build a map with geographic information systems (GIS).

Searchlight ID: int-3372

17.8 Has Melbourne sprawled too far?

17.8.1 Where do you put all the people?

What does a city do when it runs out of room? Across the world cities are expanding at a rapid rate, bringing unprecedented change to the built and natural environments. To accommodate growing populations there is a need for more housing and the infrastructure to support so many people. How can this be done?

Melbourne today sprawls over a huge area of 9000 square kilometres and has a population of more than 4 million. By the year 2050, this population will increase to 6 million, with a need for over 500 000 additional households. To house this number, urban planners have basically two choices. They can either infill (**urban infilling**), or 'create' land in the inner and middle suburbs. This can be done by dividing older larger blocks into smaller new blocks, **urban renewal** of old industrial sites, or building up and increasing population density with high-rise apartments as seen in figure 1.

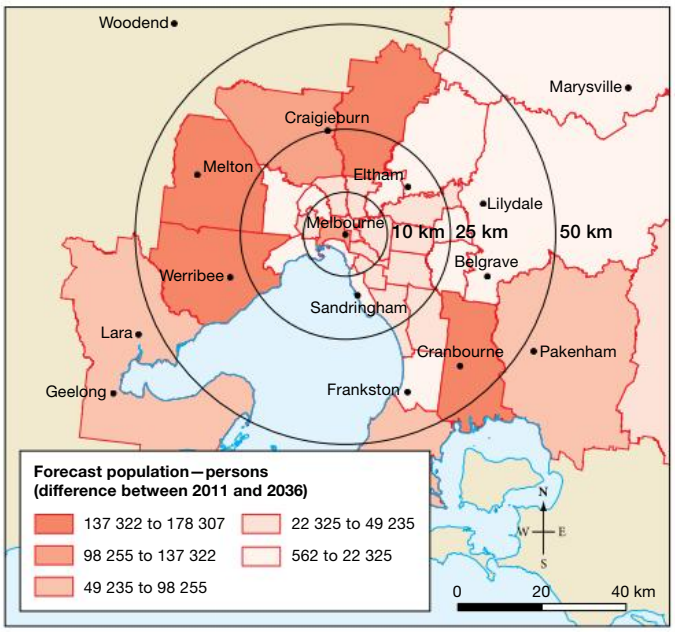
The second option is to expand space by extending the city outwards into a zone known as the rural–urban fringe. Figure 2 shows the predicted population growth for Melbourne. Note the location of those suburbs expected to have the greatest population increases.

urban infilling the division of larger house sites into multiple sites for new homes

urban renewal redevelopment of old urban areas including the modernisation of household interiors

FIGURE 1 These apartments are an example of high-rise housing in a large-scale urban renewal project at Docklands in Melbourne.

FIGURE 2 Future population growth for Melbourne



Source: © The State of Victoria, Department of Environment and Primary Industries 2013

17.8.2 How can we increase density in established suburbs?

To increase the density of housing in older suburbs, one concept is to establish activity centres. These consist of higher-density housing in specific locations, where people shop, work, meet, relax and live in the local environment. These centres are focused on existing infrastructure, transport networks, popular shopping centres, employment opportunities and community facilities. New housing tends to be medium-rise (three to five storeys) apartments built along main transport routes.

17.8.3 What changes are taking place on the rural–urban fringe?

The rural–urban fringe is typically the urban zone that is undergoing the most rapid change. Former farmland, often market gardens and orchards, are sold off and new housing and industrial

estates are built. These are usually low-density, planned estates sometimes built around a theme or geographical feature such as a built lake or wetland.

Urban expansion into the rural–urban fringe brings environmental, economic and social impacts.

What are the effects of change on the rural–urban fringe?

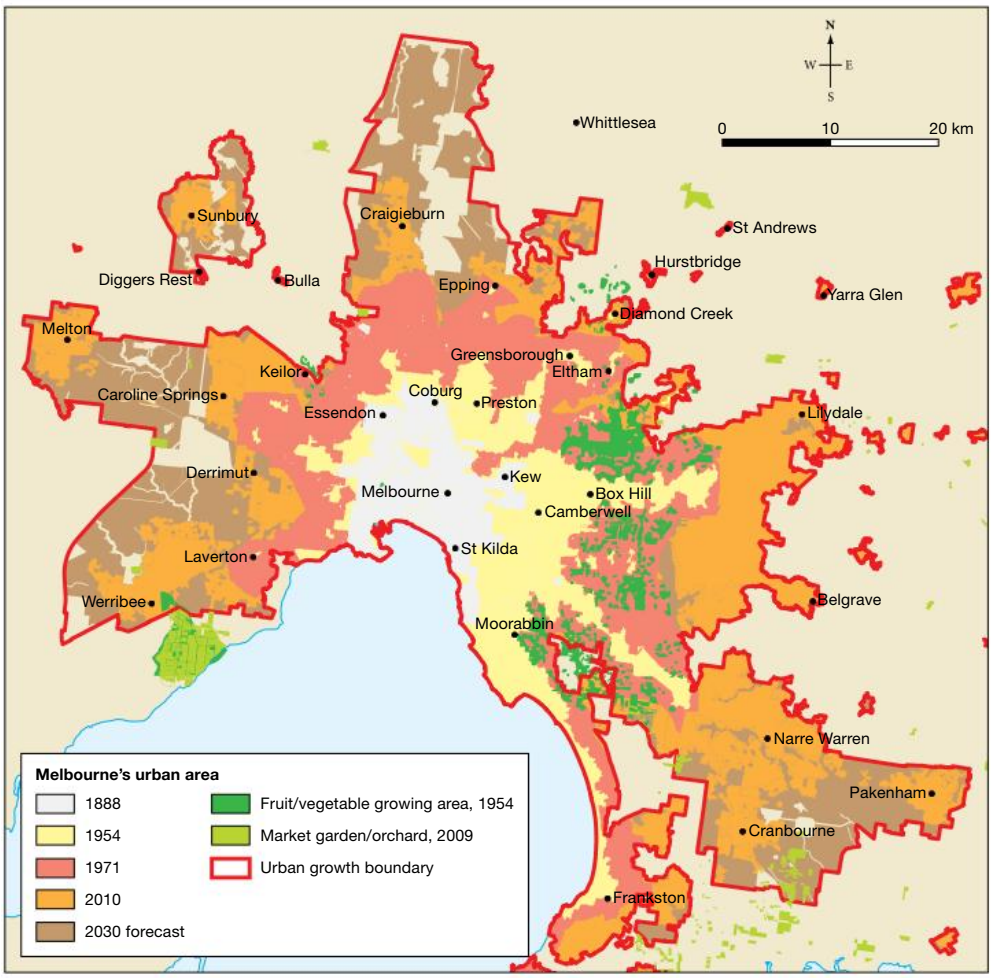
Cost of infrastructure

A major problem of urban sprawl is the cost to provide infrastructure (for example, roads and other transport systems and services such as water, gas and electricity) to new areas on the rural–urban fringe. New suburbs such as Narre Warren, in the City of Casey, are examples of planned developments designed to meet the needs of the families who will live there. Being on the urban fringe, the blocks vary in size, and are more affordable for first home buyers and young families. These suburbs will develop activity centres that will include shopping complexes, medical centres, open spaces, schools and recreational facilities such as green zones, although there are often time delays in construction until a population is established.

Loss of fertile farm lands

Possibly the largest issue with urban sprawl is the loss of fertile farmlands. The Casey Council, 48 kilometres south-east of Melbourne's city centre, has resisted moves for subdivision of farmlands at Clyde, arguing that the sandy loam soils that produce most of Melbourne's fruit and vegetables should be set aside for growing food, not houses (see figure 3).

FIGURE 3 Growing over our food



Source: © The State of Victoria, Department of Environment and Primary Industries 2013

As a newspaper article has put it: 'We've already built over the best soils in this state — the soils around Melbourne. Why would you keep building over it and subdividing it when in the next 50 years we're facing an era of incredible uncertainty and major changes to climate, to fuel supplies and to energy markets?'

Some local farmers have different viewpoints on this matter as re-zoning their properties into the urban boundary immediately boosts the value of their land. These farmers prefer to relocate further out and reap the financial gains from the sale of the land for housing.

Loss of green spaces

The expansion of urban areas can significantly alter the natural environment. Clearing of vegetation can reduce habitat and biodiversity. Natural drainage and topography can be altered, with streams redirected or even converted to pipes. Today there is a growing awareness of the need to preserve environments for the important functions they provide for wildlife and people. There is a trade-off, however, as the push for housing into rural areas can increase bushfire risks. Planners these days try to incorporate and retain as much of the natural environment as possible when developing housing estates.

'Green zones' are open landscapes set aside to conserve and protect significant natural features as well as resources such as farms, bushland and parks. They ensure habitats for native flora and fauna

are preserved. The construction or expansion of wetlands in the rural–urban fringe can have many benefits, including:

- acting as flood retention basins and receiving and purifying stormwater run-off from residential areas
- providing habitats which can increase plant and animal biodiversity
- providing recreational opportunities.

Use the **Narre Warren wetlands** weblink in your eBookPLUS to view how the wetlands help control waters in the Hallam Main Drain and act as a green zone.

FOCUS ON FIELDWORK

Investigating the liveability of your area

Working with a partner or in small groups, undertake a fieldwork investigation of your local area in terms of:

- types of dwellings – create a map showing where low-, medium- and high-density housing is located.
- transport facilities and issues – map transport facilities and note any transport issues you observe. Conduct surveys of local residents to gather their opinions on the reliability and regularity of public transport, traffic congestion and any issues related to transport in the local area.
- shopping and other community services available – map the location of shopping facilities. Note the types of commercial activity found in each shopping precinct.
- amount of open spaces and parkland, and associated recreation facilities – map the parkland and open spaces in the local area. Note the types of activities the spaces are used for.
- opinions of liveability – interview someone from your local council or conduct surveys of local residents to canvas their opinions of how liveable your local area is.

Document your findings in a report that assesses the liveability of your local area. Include maps, photographs and data (e.g. tables, pie charts), and list any references. Ensure that your report includes the following.

a A description of the pattern of housing in your local area

b A discussion of the range of issues associated with transport. Is there any relationship between housing patterns and transport issues?

c An analysis of the shopping facilities provided in your local area. What is the relationship between housing patterns, transport routes and shopping areas?

d An examination of the location and type of open spaces and parkland provided for your local area. Is it sufficient to provide for a range of activities? Is it evenly distributed?

ACTIVITIES

IDENTIFY

1 What are the two main ways that additional housing can be established in an expanding city?

2 Study figure 1 and the image available via the **Narre Warren wetlands** weblink in your eBookPLUS. Construct a table to compare the advantages and disadvantages of living in an inner-city high-rise apartment and a housing estate on the rural–urban fringe.

3 Refer to the image available via the **Narre Warren wetlands** weblink in your eBookPLUS. How do you think the natural ***environment*** has been ***changed*** for this housing estate?

EXPLAIN

4 Study figure 2. Describe the location of those suburbs of Melbourne that are expected to show the greatest increase. What is the average distance of those suburbs from Melbourne's CBD?

5 **a** Refer to figure 3. What has happened to the areas of market gardening (fruit and vegetable farming) between 1954 and 2009? Use distances and directions in your answer.

b What would be the benefits of market gardening being located close to urban areas?

c Predict the future location of this land use in Melbourne in 2030.

6 Suggest how urban planners can reduce some of the ***environmental***, social and economic impacts of expansion into the rural–urban fringe.

eBook*plus*

Weblink
Narre Warren wetlands

Interactivity
Changes on the rural–urban fringe
Use this interactivity to describe changes to an urban environment.
Searchlight ID: int-3302

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. **› Urbanisation in Australia**

17.9 How has urban sprawl affected Narre Warren?

17.9.1 Urban sprawl in Narre Warren

Narre Warren is a suburb located 42 kilometres south-east of Melbourne's city centre. It is an area of flat plains and undulating hills, which has previously been used mainly for agricultural and pastoral purposes (see figure 1).

Narre Warren currently has a population of 25 882, with an average age of 34 years. There are 6993 families living in 9198 private dwellings, and an average of two motor vehicles per family. However, the area is undergoing significant change. Narre Warren has been selected as an ideal location for future population growth, partly as a result of its close proximity to the Monash Freeway and Princes Highway and the Casey commercial area. The Narre Warren South Development Plan indicates that the 1000ha in southern Narre Warren will become home to another 25 000 people. Housing developments planned for the area will be medium- and high-density housing, with constructed wetlands and drainage ponds to alleviate problems associated with the floodway zones and provide visual attractions.

GEOskills TOOLBOX

Using grid references

A grid reference is a six-figure number, with GR at the beginning, showing an exact point in the grid square. The third and sixth figures represent one-tenth of the distance between the two grid numbers. However, these divisions are not written on the map, so they must be estimated.

ACTIVITIES

IDENTIFY

For further details on Narre Warren, use the **About Narre Warren** weblink in your eBookPLUS.

1 Study figure 1. What evidence is there on the map to suggest that this area is part of the rural–urban fringe?

APPLY

2 a Create a map to show the main land uses in Narre Warren in 1966. Include other key features such as main roads and railway lines. Refer to SkillBuilder 17.6 'Constructing a land use map' in your eBookPLUS.

b Using tracing paper, make an overlay map of built-up areas from the 2013 map (figure 2), and attach your overlay to your base map. Complete your map with full BOLTSS.

3 Study your complete map and overlay.

a What was the main land use in this area in 1966?

b What was the main land use for the area in 2013?

c Study both maps and describe three other ***changes*** in land use in Narre Warren from 1966 to 2013.

INVESTIGATE

4 a The area at GR485880 in figure 2 is subject to flooding (inundation). Use evidence from the maps to suggest two reasons why it is flood prone.

b How have planners used this flood-prone land when designing this housing estate? Use the **Narre Warren wetlands** weblink in your eBookPLUS to find an image that might help answer this question.

5 Study figure 2. List and give grid references for any new forms of infrastructure established. Consider schools, shopping centres, parks and transport.

6 Suggest one human and one ***environmental*** factor that make this ***place*** suitable for a housing estate.

eBookplus

Weblinks

- About Narre Warren
- Narre Warren wetlands

FIGURE 1 Topographic map extract of Narre Warren, 1966

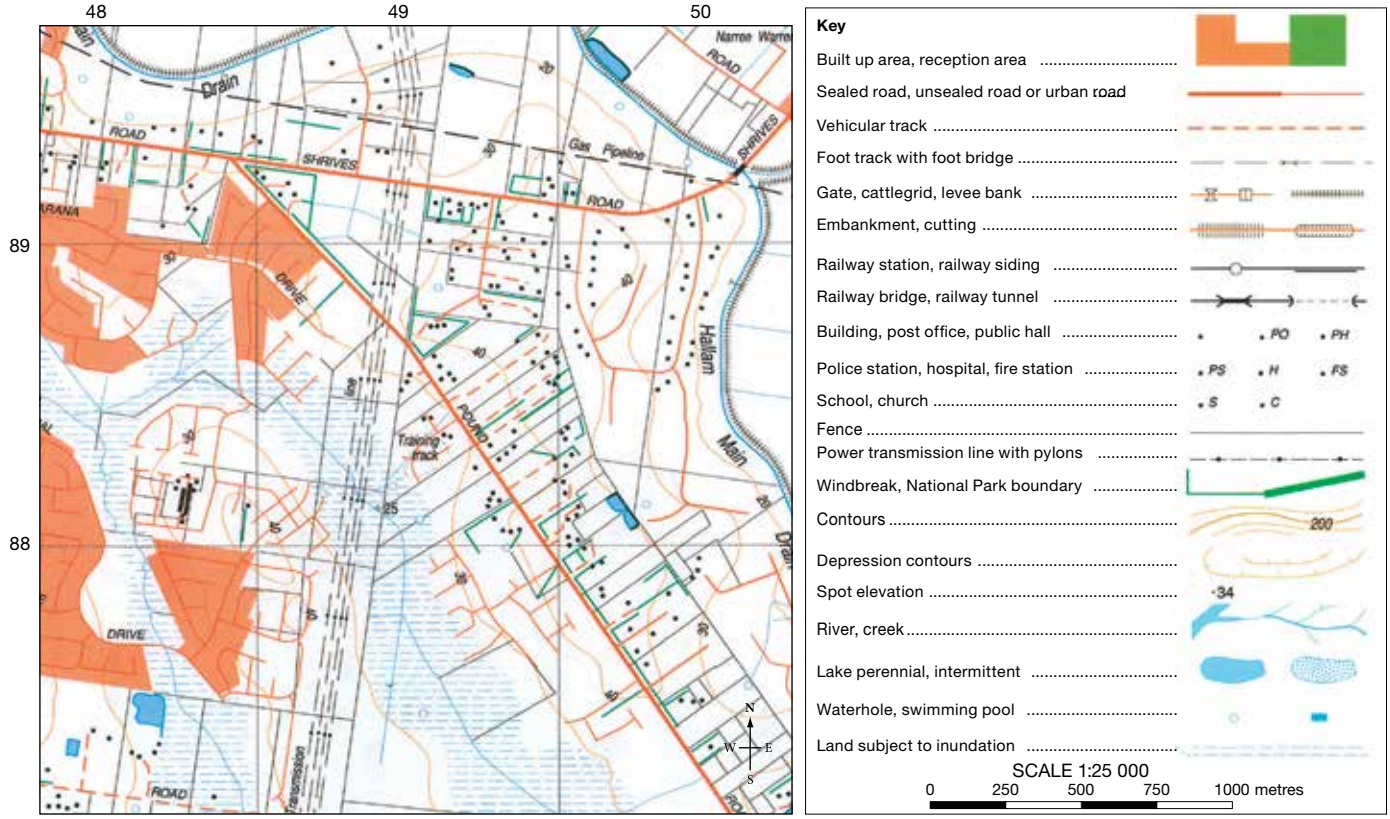


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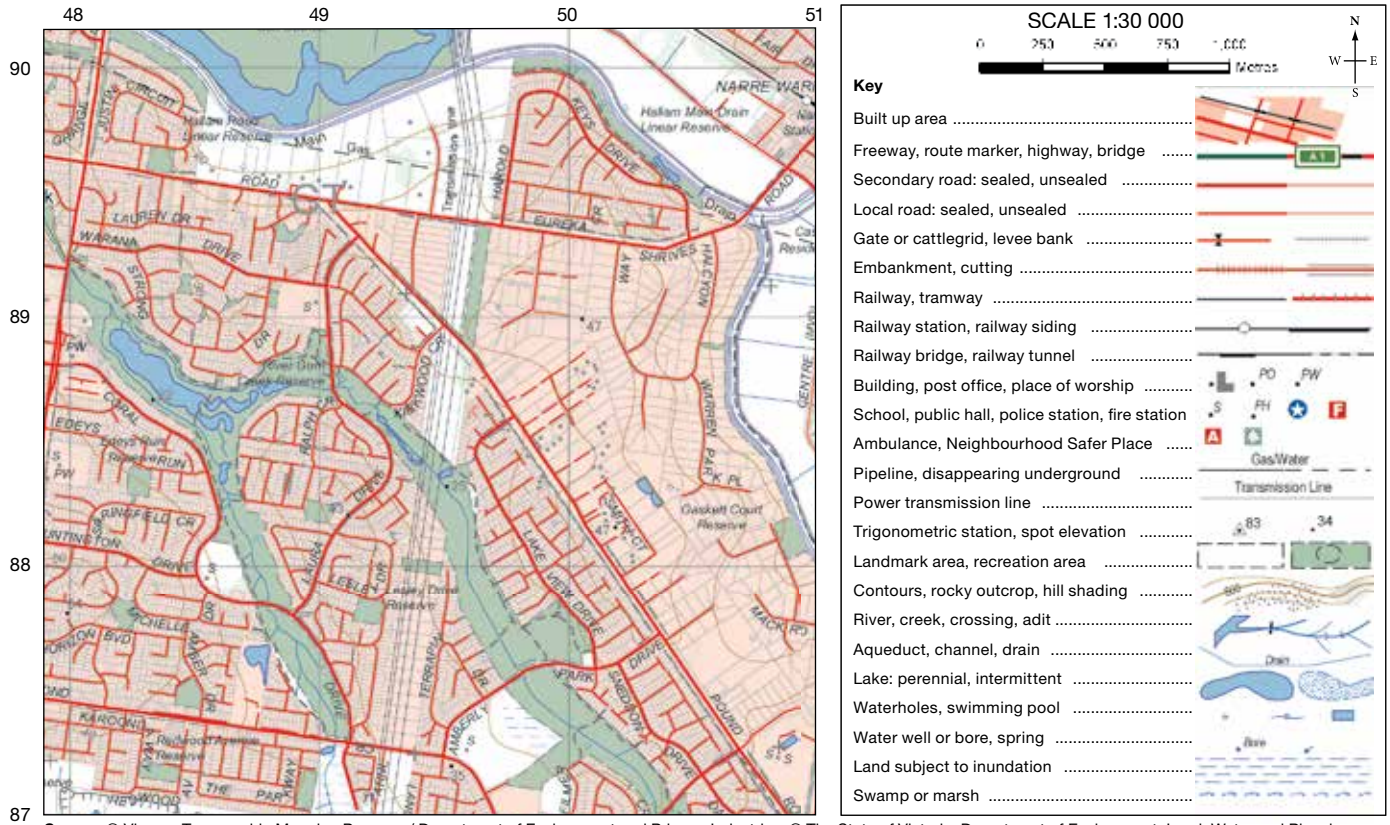
FIGURE 2 Topographic map extract of Narre Warren, 2013



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17.10 Can we stop Venice from sinking?

river delta a landform composed of deposited sediments at the mouth of a river where it flows into the sea

lagoon a shallow body of water separated from the sea by a sand barrier or coral reef

historical architecture urban environment that has significant value due to its unique form and history of development

17.10.1 Venice

Urban centres that are built on low-lying coastal plains, where features such as **river deltas**, wetlands, lagoons, sand dunes, bars and barriers are found, are susceptible to the environmental impacts of the sea. Storms and high tides, when added together, can lead to destructive surges causing erosion and damage to cities. The prospect of rising sea levels as a result of the melting of ice caps due to global warming will require specialised management techniques such as the construction of coastal defence works to protect property and life.

Venice, Italy, is a city built on mud islands in a coastal **lagoon** at the head of the Adriatic Sea (see figures 1 and 2). Although Venice has a population of only 60 000, its **historical architecture**, life on the canals and cultural events such as Carnivale attract over two million tourists per year. Not surprisingly, the Venetians are keen to protect their heritage and manage the impacts of erosion and rising sea levels into the future.

FIGURE 1 Venice and surrounding areas

Source: © OpenStreetMap contributors.

FIGURE 2 Aerial view of Venice showing the built area in the lagoons and the canals

17.10.2 Why is Venice sinking?

When Venice was established almost 2000 years ago, the sea level was two metres lower than current levels and buildings seemed secure from the impacts of the sea. Over time, the sea level has risen, and in more recent times this rate of increase has accelerated due to global warming. Also affecting the stability of buildings was the removal of fresh water from artisan wells near Venice in the 1950s. This practice, which fortunately has stopped, led to building subsidence. Another problem has been the erosive force of waves generated by powerful motor boats splashing corrosive sea salt onto the buildings.

17.10.3 Floods or 'aqua alta'

Venetians refer to floods as 'aqua alta' or high water. In December 2008, high sea waters with a depth of 1.56 metres above average

sea levels caused the fourth highest flood level in Venice for the past 22 years. A combination of high tides and winds forced waters over the canal banks and into buildings and public areas (see figure 3). This type of flooding, which has increased dramatically in the recent past, has seen up to 40 flooding events a year. This has led to reduced tourist numbers as buildings and public areas are flooded and transport is curtailed because boats cannot fit under bridges.

FIGURE 3 Flooding in Venice

17.10.4 How will Venice reduce the impact of floods?

The MOSE (MOdulo Sperimentale Elettromeccanico) or Experimental Electromechanical Module Project has been proposed to reduce the impact of floods on Venice. It consists of rows of mobile gates that are able to isolate the lagoon and canals from high tides that are above a level of 110 centimetres to a maximum of 3 metres. Use the **MOSE** weblink in your eBookPLUS to read about this project in more detail. The project has been criticised by some who say that flushing of the canals would be reduced and the huge cost of the project could not be justified as it may be effective for only a few years if sea levels continue to rise. If this project is not to go ahead, then clearly other management strategies need to be found or Venice will one day sink into the sea.

ACTIVITIES

IDENTIFY

1 Where is Venice located?

EXPLAIN

2 How would you employ human–environment systems thinking to solve the flooding of Venice? (*Hint:* Make a list of ***environmental*** impacts and human management responses.)

INVESTIGATE

3 a Use the **MOSE** weblink in your eBookPLUS to find details of the MOSE Project in Venice and explain how it works in holding back the sea.

b Evaluate the MOSE Project in terms of its:

i ***environmental*** impact

ii social impact (i.e. its value in preserving a unique city with a long history.)

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Weblink
MOSE

17.11 What is the future of our urban environment?

17.11.1 How is urbanisation being managed?

Cities throughout human history have changed as new forms of technology have developed. For instance, high-rise buildings such as skyscrapers could not exist without modern cement-and-steel methods of construction and the development of high-speed lifts. What will be the nature of cities as technology progresses, and how can the social, economic and environmental elements of cities be managed in a fair and sustainable manner?

The United Nations (UN) has established the Sustainable Development Goals (SDGs), which call for action from all countries to take steps to end poverty, fight inequalities and build economic growth. The SDGs are not legally binding, although governments are expected to implement national frameworks that reflect the 17 goals.

The 17 goals are as follows:

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well-being for all at all ages.
4. Ensure inclusive and quality education for all and promote lifelong learning.
5. Achieve gender equality and empower all women and girls.
6. Ensure access to water and sanitation for all.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote inclusive and sustainable economic growth, employment and decent work for all.

9. Build resilient infrastructure, promote sustainable industrialisation and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts.
14. Conserve and sustainably use the oceans, seas and marine resources.
15. Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
16. Promote just, peaceful and inclusive societies.
17. Revitalise the global partnership for sustainable development.

It has been estimated by UN studies that the global urban population, which is currently 50 per cent, will increase to about 4.9 billion in 2030, which means 60 per cent of the total world's population will be living in cities. This increase means that approximately 2 billion people will need new housing, basic urban infrastructure and services. To achieve this, the equivalent of seven new megacities will need to be created annually.

FOCUS ON FIELDWORK

Comparing your ecological footprint

Use the **Ecological footprint** weblink in your eBookPLUS to calculate your ecological footprint. Use the data to create a class average. Construct a column graph to show a comparison between your ecological footprint, the class average and the Australian average.

1 How do the three sets of data compare?
2 How could you reduce your ecological footprint?

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Weblink
Ecological footprint

17.11.2 What are the challenges for cities?

Many cities throughout the world have extensive areas of slum housing and a general lack of infrastructure to support what may be called a socially just and economically fair lifestyle. Particularly in the poorest or least developed countries there are significant environmental management issues associated with large cities. Some of these issues are detailed in table 1. It should also be noted that there are issues even in cities that could be called wealthy or most developed.

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Interactivity
Where am I?
Use this interactivity to identify places based on their degree of urbanisation in 2025.
Searchlight ID: int-3303

TABLE 1 Urban challenges

Level	Challenges to be addressed to ensure a sustainable urban environment
Least developed countries	• Poverty and inequality • Rapid and chaotic development of slum housing • Increasing demand for housing, urban infrastructure, services and employment • Education and employment needs of the majority population of young people • Shortage of skills in the urban environment sector
Transition countries	• Slow (or even negative) population growth and ageing • Shrinking cities and deteriorating buildings and infrastructure • Urban sprawl and preservation of inner-city heritage buildings • Growing demand for housing and facilities by an emerging wealthy class • Severe environmental pollution from old industries • Rapid growth of vehicle ownership • Financing of local authorities to meet additional responsibilities
Developed countries	• Recent mortgage and housing markets crises • Unemployment and impoverishment due to changing availability of jobs • Large energy use of cities caused by car dependence, huge waste production and urban sprawl • Slow population growth, ageing and shrinking of some cities

There are a wide range of cities in the world that face social and economic challenges. A short list, as defined by the UN and based on cities with large-scale slum conditions, includes Rio de Janeiro (Brazil), Phnom Penh (Cambodia), Kolkata (India), Durban (South Africa), Lusaka (Zambia) and Mexico City (Mexico).

17.11.3 How can we plan for the future?

By promoting sustainable urban environments at all levels of scale (local, regional, national and global), problems can be overcome.

Some management strategies that will foster sustainable urban environments include:

- building energy-efficient houses based on materials and energy sources that reduce the **ecological footprint** of cities
- reducing waste by recycling and reusing materials
- improving public transport systems to reduce reliance on cars
- redeveloping to include **medium-density housing** to reduce urban sprawl
- exchanging ideas between governments about planning and building policies and best and successful practice in design.

ecological footprint the amount of productive land required by each person in the world for food, water, transport, housing and waste management

medium-density housing a form of residential development such as detached, semi-attached and multiunit housing that can range from about 25 to 80 dwellings per hectare

urbanisation the social and economic processes whereby cities increase in size largely due to population growth

ACTIVITIES

IDENTIFY

1 How many people in the world in 2030 will need new housing based on current predictions of **urbanisation**?

PREDICT

2 How would migration help solve the problems of ageing populations in developed Western cities?

APPLY

3 Use the **Energy-efficient technology** weblink in your eBookPLUS to view a diagram of a modern house. Comment on how this house can save energy and solve waste management problems. What features of this house do you have in your own ***place*** of residence? Are there other features you would like to include in your home? Why?

4 It has been said that if all nations have the same ecological footprint as the developed countries (e.g. the United States, Australia and most European nations), we will need four new worlds the size of planet Earth to accommodate the growth in resource consumption. In what ways can we achieve energy, food and water security with an aim of ***sustainability*** into the future?

5 Refer to the 17 Sustainable Development Goals.
- **a** Which one(s) will directly improve social conditions in urban ***environments***?
- **b** Which one(s) will directly improve ***environmental*** conditions in urban ***environments***?

Give reasons for each of your answers to (a) and (b).

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Weblink
Energy-efficient technology

eBookplus ONLINE ONLY

17.12 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

17.6 SkillBuilder: Constructing a land use map

17.6.1 Tell me

What is a land use map?

A land use map may be drawn from a topographic map, an aerial photograph, a plan or during fieldwork.

A land use map shows simplified information about the uses made of an area of land. In a built environment, a land use map may show a shopping centre, a local shopping strip, or the types of houses in a street. In a rural environment, a land use map may show vegetation types or agricultural activities.

Why is a land use map useful?

A land use map is useful when focusing on an aspect of an environment or when comparing the interconnections between two or more data sets. It allows us to simplify data and express it in a map format, using blocks of colour to represent generalised information. A land use map breaks down information into key elements and allows us to more readily identify and describe patterns.

Land use maps are useful for:

- displaying historic features of tourist towns
- outlining transport routes
- determining crop plantings
- helping pedestrians to access shops.

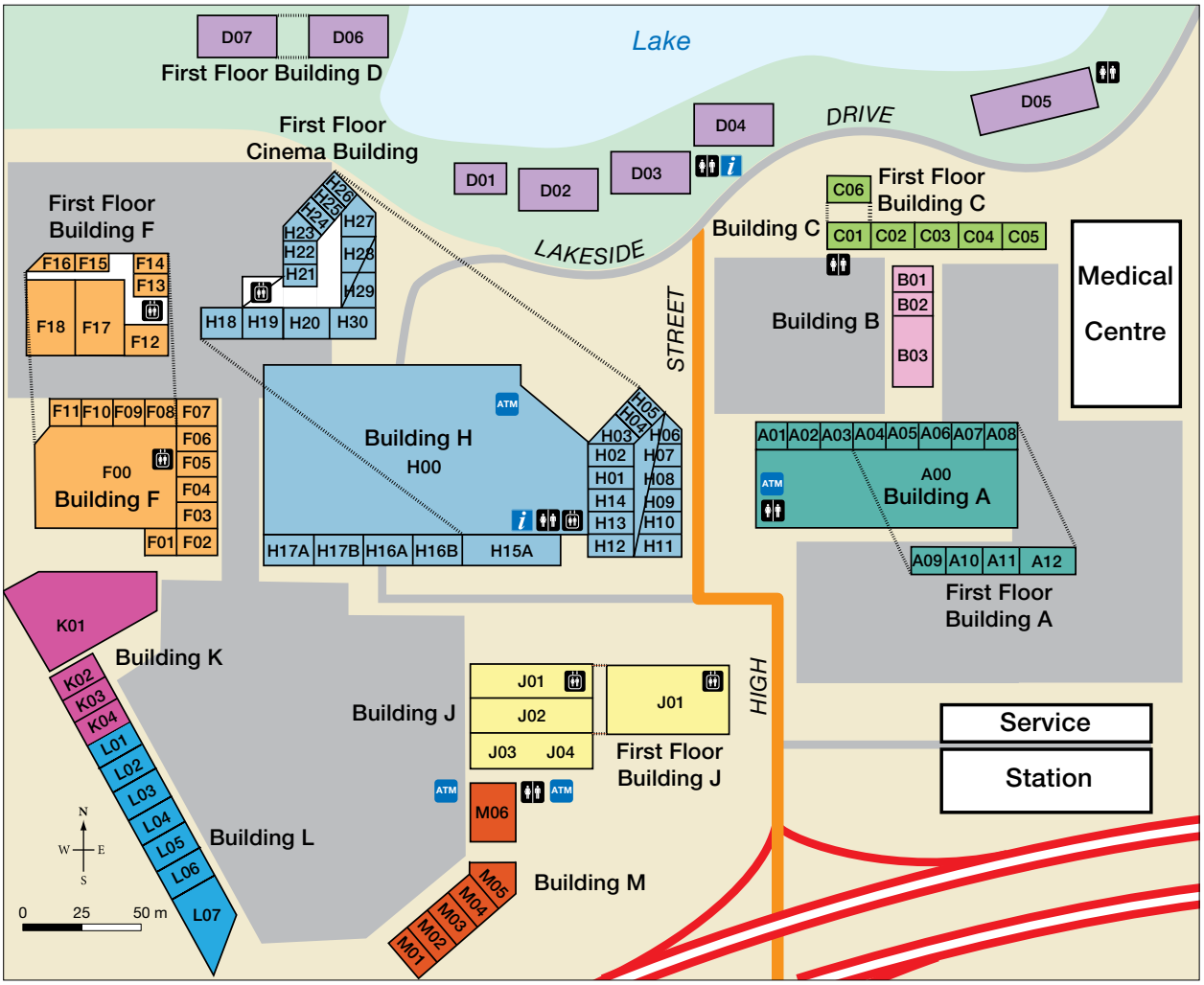
Model

Blue Lake Shopping Centre has a range of facilities. Large areas of the centre are devoted to shopping, eating and 'playing', as the key shows (figure 1a). At the centre of the complex is a library and cinema area. In this complex, there are also professional offices such as law firms, dentists and property management firms (which all fall under the 'work' heading). Beside the lake is a restaurant area, although there are other eateries throughout the complex. Shoppers are well catered for, with a variety of transport available to bring them to the centre. Buses service the centre, a taxi rank is provided, and there is ample car parking. Visitors to the shopping centre would find most of their needs fulfilled.

A good land use map:

- is drawn in pencil
- is coloured
- incorporates a key/legend
- includes labelled features if necessary
- includes a clear title.

FIGURE 1(a) Blue Lake Shopping Centre plan and key



Work
Professional services and banks

A01	Family Eye and Vision Centre
A03	Century 21 Victoria Point
A04	Ray White
A05	Shine Lawyers
A06	Westpac
A07	Westpac
A08	Westpac
A09	Frank Bauer & Associates
A10	Centre Management Office
A11	Centre Management Office
A12	Place Real Estate
C02	Dignified Funerals
C03	JP Ryan
C04	The Professionals
C05	The Professionals
D07	Weightwatchers
F09	Red Door Acupuncture and Massage
F13	Dylan & Perez Financial Planning
F14	Dylan & Perez Financial Planning
F15	Spick & Span Cleaners
F16	Spick & Span Cleaners
F18	Spick & Span Cleaners
H12	Aussie Home Loans
H15	H & R Block
H16A	Kumar Dentistry
H16B	Blue Lake Medical Clinic
H18	Aligned Chiropractors
H19	Smith & Aziz Chartered Accountants
H20	Kate Bowen MP
H22	Fresh Start Training Group
H27	Wong Podiatry
H28	Davis & Sharp Lawyers
H29	Davis & Sharp Lawyers
H30	Blue Lake Physiotherapy
M06	Centrelink

Shop
A great variety of retail stores

A00	Woolworths
F02	Blue Lake Florist
F03	Black Cat Newsagency
F04	Black Cat Newsagency
F05	Black Cat Newsagency
F06	Point Break Surfwear
H01	Crystal's Clothing
H09	The Wooden Spoon Kitchenware
H10	The Point Homewares
H14	Samadi Hair & Beauty Products
H17A	Mathers
J02	Dwyer's Pharmacy
J03	West's Auto Service Centre
J04	West's Auto Service Centre
K01	Spotlight
K02	Blue Lake Lawnmowers
K03	The Outdoor Shop
K04	The Outdoor Shop
L01	Blue Lake Pool Service
L02	Fraser's Fishing and Tackle
L03	Lifeline Victoria Point
L04	Hardy's Lighting
L06	Stegbar
L07	Blue Lake Marine Supplies
M05	Blue Lake Cleaning Supplies

Eat
Restaurants, cafés and food

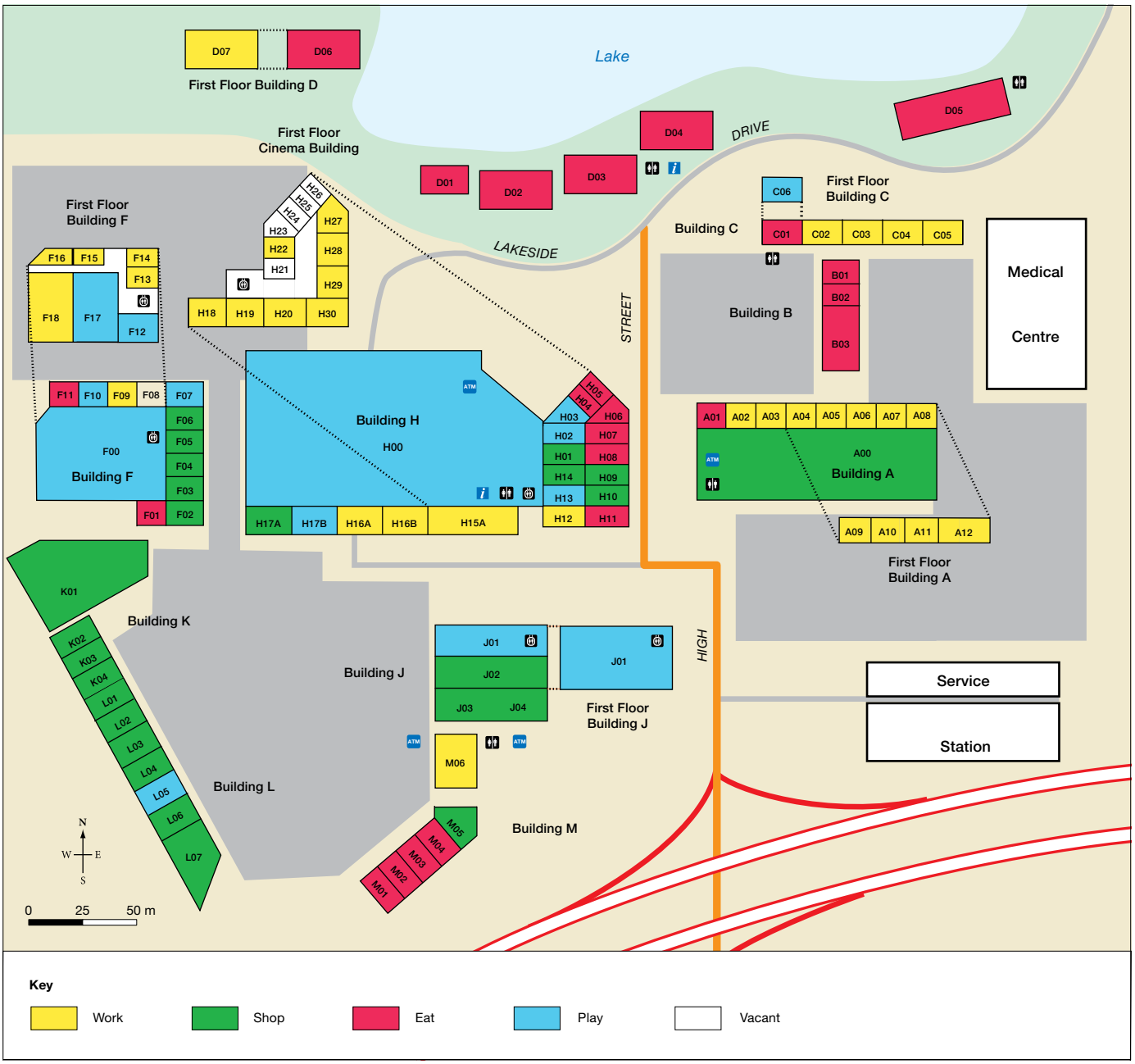
A01	Full Moon Café
B01	Brian's Meats
B02	Brian's Meats
B03	Big Orange Fruit Barn
C01	Bo Thai
D01	Udaipur Indian Restaurant
D02	Paganini's
D03	Piggy's Café
D04	Perfumed River Vietnamese
D05	Tabouli Lebanese Restaurant
D06	The Kasbah
F01	The Double Shot
F11	Decadent Desserts
H04	Time Out Restaurant and Bar
H05	Time Out Restaurant and Bar
H06	Okonomiyaki
H07	Bob's Burgers
H08	Blue Lake Icecreamery
H11	Baker's Delight
M01	Nan & Pop's Bakehouse
M02	The Battered Cod Fish Restaurant
M03	Shanghai Joe's Chinese Restaurant
M04	Nonya Malay Restaurant

Play
A great range of activities

C06	Bright Star Coaching & Tutoring
F00	Blue Lake Library
F07	La Bohème Nails & Beauty
F10	Painterly Art Classes
F12	Yamamoto Music Lessons
F17	Blue Lake Library
H00	Cineplex
H02	Crazy Amusement Centre
H03	Crazy Amusement Centre
H13	Diane Lane Hair Salon
H17B	Blue Lake Tattoos
J01	WorkOut Gym
L05	Madame Georgia's Dance Academy

Source: Spatial Vision

FIGURE 1(b) Land use map of Blue Lake Shopping Centre



Source: Spatial Vision

17.6.2 Show me

How to construct a land use map

You will need:

- an aerial photograph or map (topographic or plan) of the area being considered or undertaken as fieldwork
- a base map that is to be coloured
- a predetermined key/legend
- coloured pencils.

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eLesson
Constructing a land use map
Searchlight ID: eles-1755

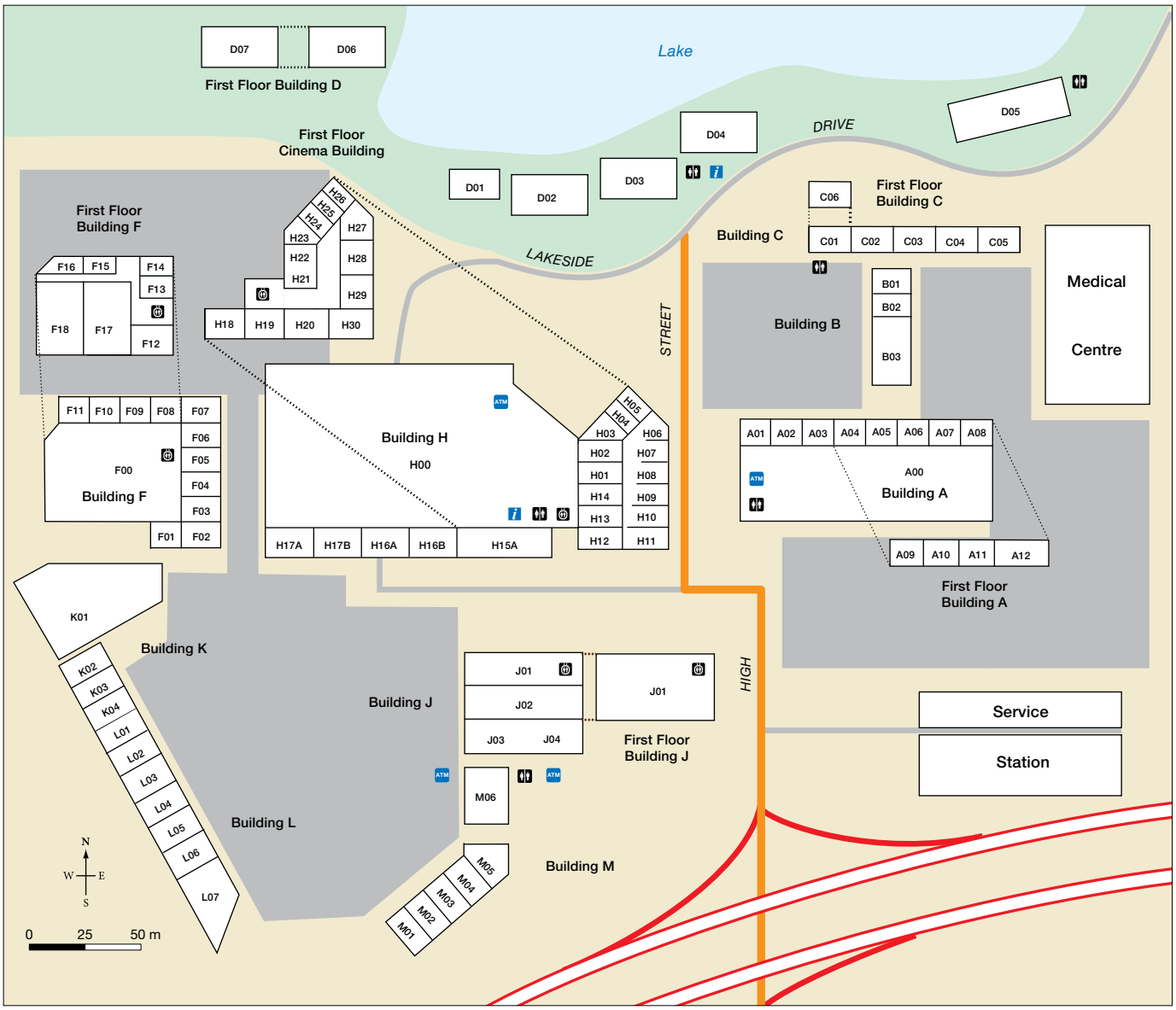
Procedure:

To complete a land use map from an aerial photograph or map, or during fieldwork, you must determine the area to be mapped and acquire or create a base map of that area.

STEP 1

Orientate the base map and the aerial photograph or, if on fieldwork, orientate yourself with the base map (see figure 2).

FIGURE 2 Base map of Blue Lake shopping complex

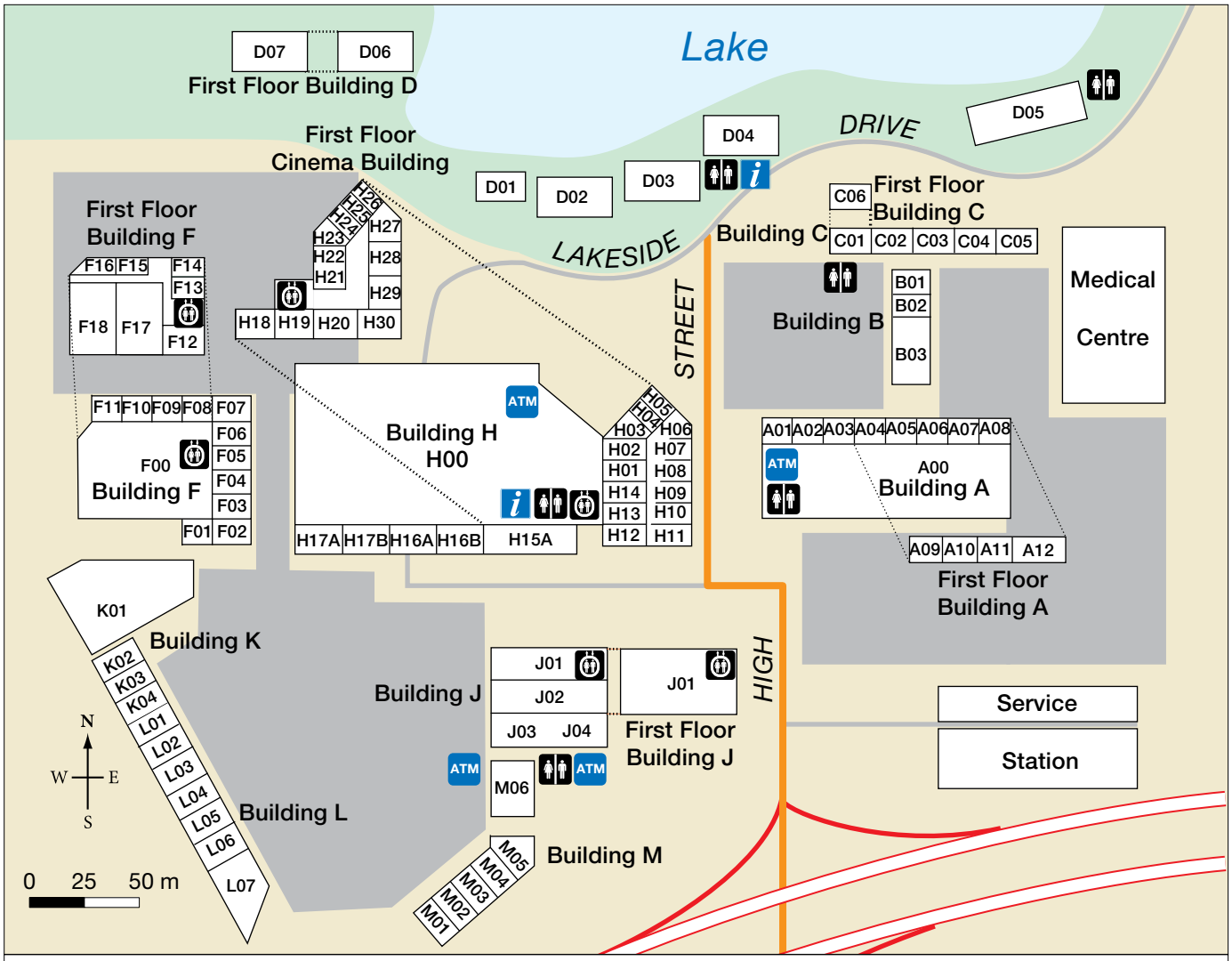


Source: Spatial Vision

STEP 2

What is the theme of your mapping? Is it land use or types of shops, for example? What categories are you expecting to find? Create a key/legend that you will use for the colouring of your map. Figure 3 shows a range of shop types colour coded in the legend.

FIGURE 3 Base map with legend



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D07	Weightwatchers
F09	Red Door Acupuncture and Massage
F13	Dylan & Perez Financial Planning
F14	Dylan & Perez Financial Planning
F15	Spick & Span Cleaners
F16	Spick & Span Cleaners
F18	Spick & Span Cleaners
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H03	Crazy Amusement Centre
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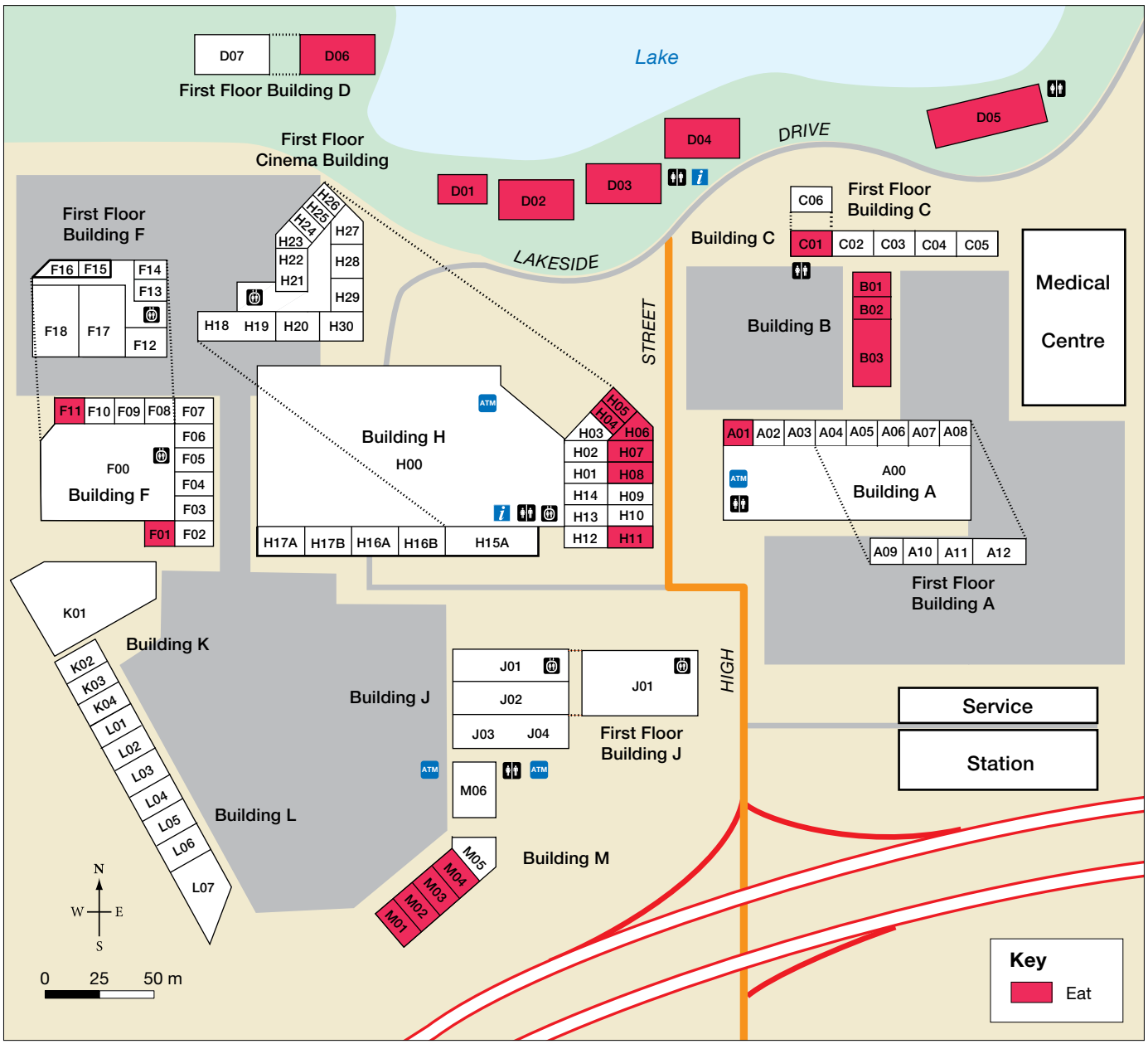
H17B	Blue Lake Tattoos
J01	WorkOut Gym
L05	Madame Georgia's Dance Academy

Source: Spatial Vision

STEP 3

Identify a starting point to colour your base map according to your pre-determined key (see figure 4). Take care to be accurate and neat. Identify reference points to check off on the base map.

FIGURE 4 Colouring of the base map has commenced.



Source: Spatial Vision

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Interactivity
Constructing a land use map
Searchlight ID: int-3373

STEP 4

When the map is complete, ensure that the key is attached. Check that the BOLTSS are complete. The map should look like figure 1(b).

17.6.3 Let me do it

Developing my skills

Complete a land use map of your local area by walking along a street and mapping the land uses. First, create a base map by identifying the main features of the environment such as major roads, waterways, vacant land and parks. Colour the various land uses on your base map and add those colours to the key. Complete the task according to the instructions above.

Questions

1. With which land use is most of the map taken up?
2. Which of the land uses on your map have been built by people?
3. What proportion of your land use map is natural ***environment***?
4. Suggest why there are trees in the built ***environment***.
5. Suggest how the ***environment*** might ***change*** over time.

Checklist

I have:

- drawn in pencil
- added colour
- incorporated a key/legend
- included labelled features as necessary
- included a clear title.

Skills questions

1. Land use maps are used to show information that is:
   a. detailed
   b. selected
   c. simplified
   d. complex.
2. A land use map is most frequently used by:
   a. meteorologists mapping rainfall
   b. students studying climate
   c. shopkeepers deciding on a pricing strategy
   d. local council planners devising new residential areas.
3. Why do land use maps show blocks of colour rather than details?
4. Can land use maps show significant features like major roads, rivers or airports?

17.7 SkillBuilder: Building a map with geographic information systems (GIS)

17.7.1 Tell me

What is GIS?

GIS is a computer-based system that consists of layers of geographic data. Just as an overlay map allows you to interchange layers of information, GIS allows you to turn layers on and off to make comparisons between data.

Why is GIS useful?

GIS is a sophisticated system of presenting data. The information is based on primary data that has been gathered and mapped. At any one time, you can see one series of data or as many as you need to see the interconnections between the data. For example, you may turn on one layer to see the topography. Then you might turn on the road system to see if the land has influenced the pattern of roads. To this you might add settlements to see if both the road system and topography have influenced town locations. Then you might turn off the road system to see if the greater influence was indeed the topography.

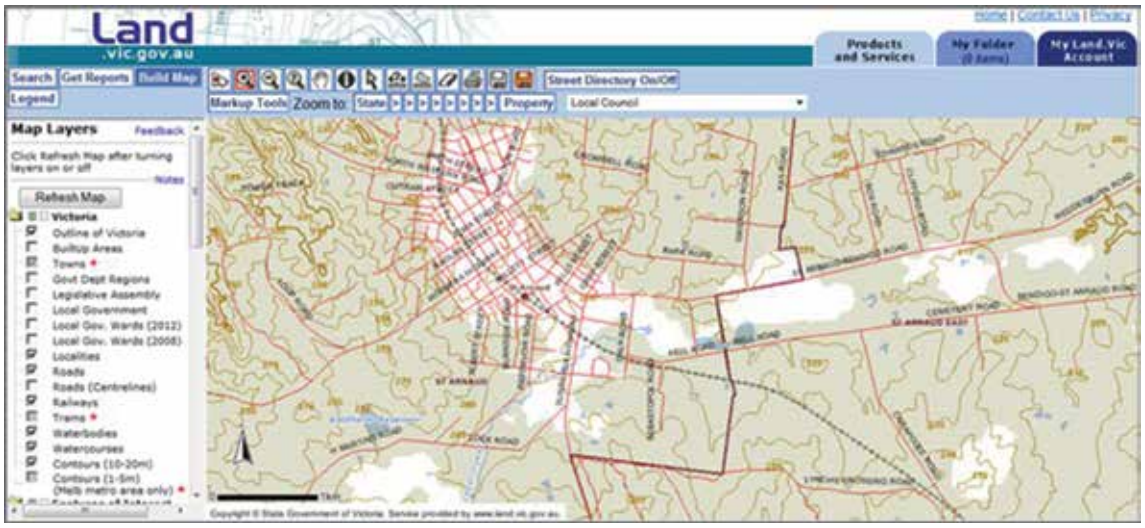
GIS is useful when:

- you want to see the interconnections between features
- you need to show an overlay of features across a region
- retailers want to determine the best location for a new store; for example, fast food chains use this technique to determine site selection
- emergency services want to predict risk situations, such as the spread of bushfires and flood waters
- you need to map global trends, such as the movement of refugees between countries.

Model

St Arnaud (see figure 1) is a town north-west of Melbourne. It lies east of a range of hills that rises to 300 metres. The built environment follows the railway line, and major regional roads pass through the town. The area has a few waterways, and a reservoir provides town water. The town is surrounded by land that is prone to bushfire, and some streets, particularly in the south-west and west, are at risk. In future, any growth in the town is likely to be along the railway line and Sunraysia Highway, in order to avoid fire-prone areas, and will probably be on the flatter land toward the south.

FIGURE 1 St Arnaud and its environs



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Using GIS involves:

- using GIS-mapped geographic data
- interpreting map legends
- interpreting map layers
- looking for interconnections between map layers
- clearly representing and communicating data.

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eLesson
Building a map with geographic information systems (GIS)
Searchlight ID: eles-1754

17.7.2 Show me

How to use GIS

You will need:

- a computer or tablet connected to the internet
- a website developed with GIS techniques.

Procedure:

Use the **Land Victoria** weblink in the Resources tab to locate the map shown in figure 2.

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Weblink
Land Victoria

STEP 1

As with any map that you explore, you need to begin by checking the information that is provided. On the left of the screen you will find a list of the map layers (see figure 3). Select the option of Build Map. Select any box to turn on a layer of the map. Note that some layers apply only at a specific scale; the cursor will tell you this when you try to turn on the layer.

FIGURE 2 A base map of Victoria

Source: © The State of Victoria, Department of Environment and Primary Industries, 2013. Reproduced by permission of the Department of Environment and Primary Industries.

STEP 2

Select Horsham and you will see surrounding towns. Next, select St Arnaud and make this the focus of a study of its built environment. To build a map on St Arnaud and its immediate environs, choose a scale that will give you more detail. To do this, use the tool bar at the top of the map. Hover your mouse over the > symbols to the right of the words 'Zoom to'. A scale ratio will then appear in a box below each > symbol. A good choice here would be 1:25 000 (see figure 4).

FIGURE 3 Beginning to build a map

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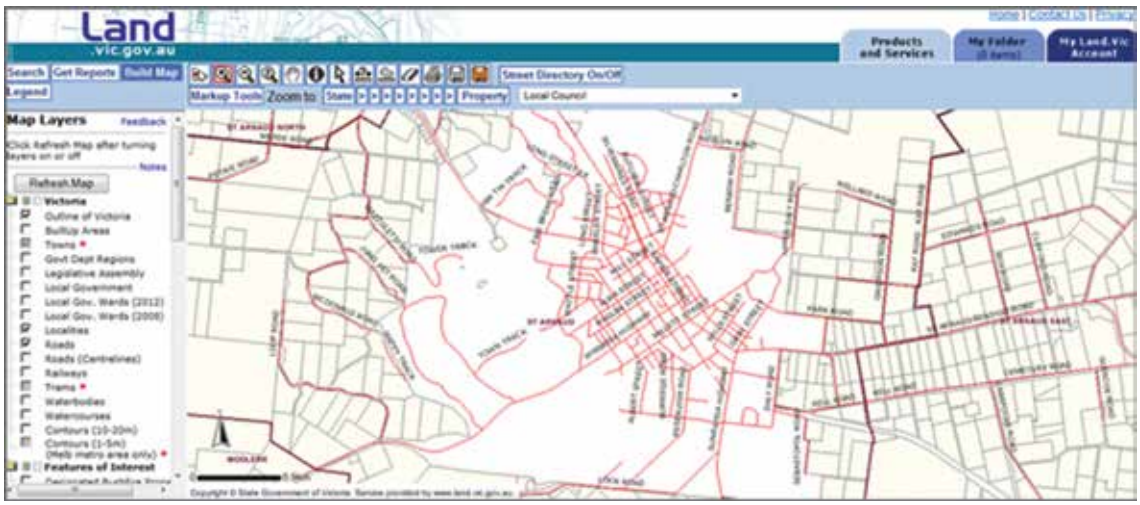
FIGURE 4 St Arnaud 1:25 000



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STEP 3

Choose some layers to explore on the map. To apply a layer, select the box and then select the Refresh Map panel at the top or bottom of the list; an updated map will then appear. In figure 5, the map of St Arnaud has the layers of roads, waterways, railway lines and built environment turned on.

After each choice that you make, in order for your map to be updated with the new layer, you need to select the Refresh Map panel at the top or bottom of the list.

Figure 6 shows another example with additional layers (contour lines 10–20 metres) turned on for the St Arnaud region.

FIGURE 5 Sample layers available in map of St Arnaud region

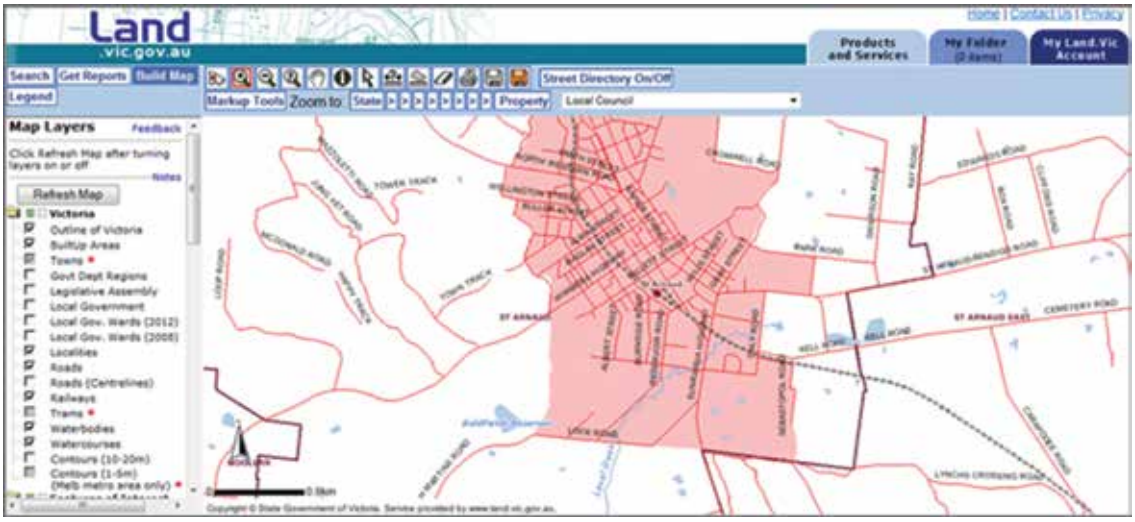

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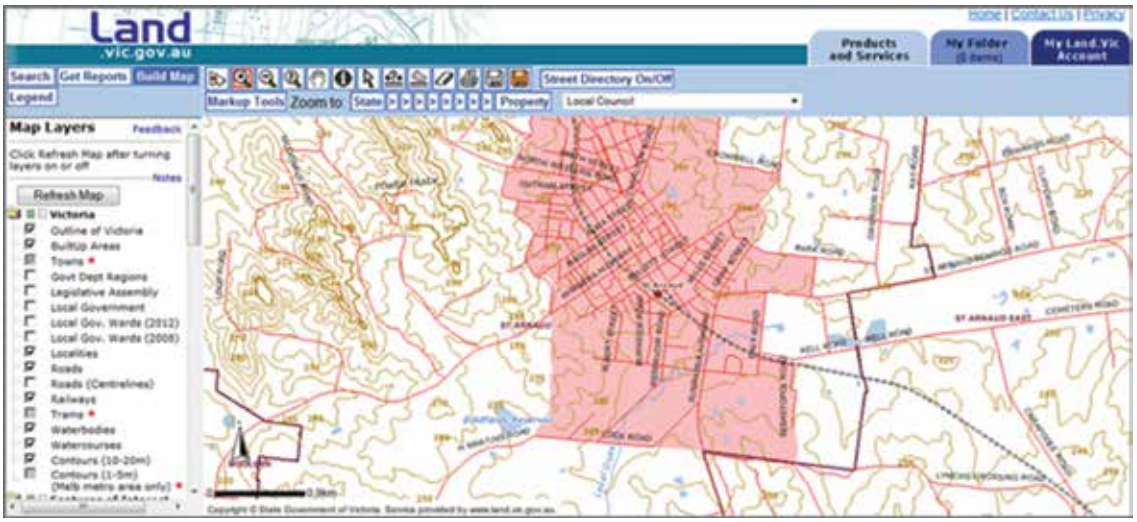
FIGURE 6 St Arnaud region with contours of 10–20 metres added



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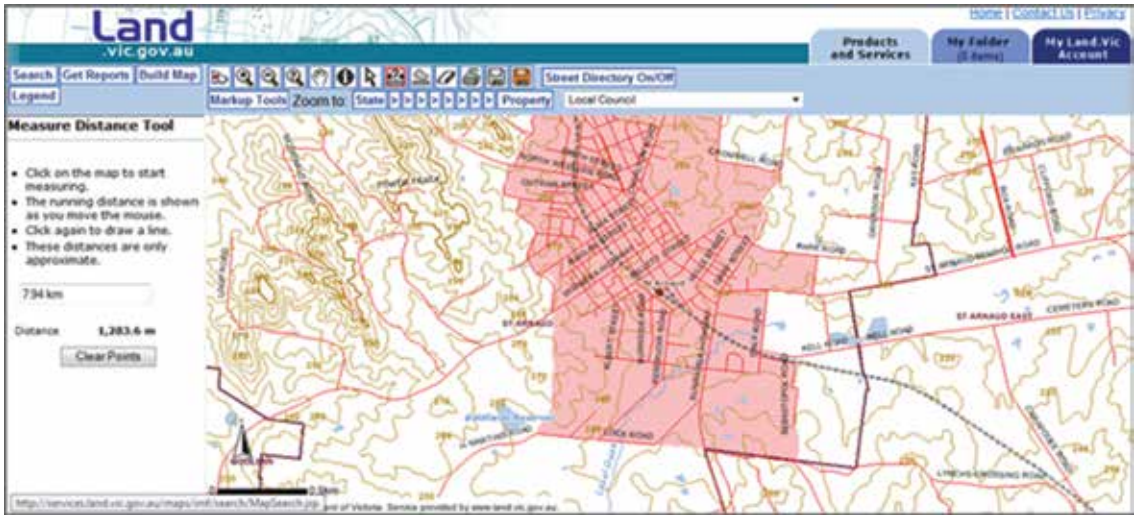
STEP 4

Along the top of the map there is also a tool bar to explore. Hover over each of the symbols and the name of the tool will pop up. The Distance tool and the Area tool are especially useful. If you select a tool, an explanation of how to use it appears to the left of the map. Note that these are running measurements, so you need to be organised in determining the points between which you want to measure. In figure 7, the distance of Box Road (see bright red colour in north-east of figure 7) is 1283.6 metres. (Note that the distances are approximate, and depend on the exact points that you select.)

FIGURE 7 Applying the distance tool on the St Arnaud map



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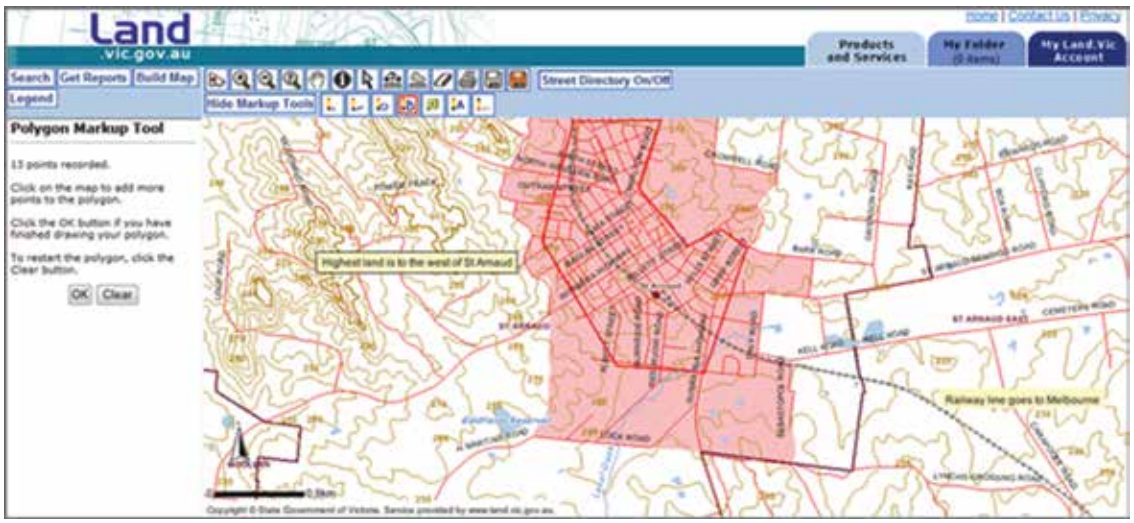
STEP 5

Now select the Markup Tools button. These tools allow you to highlight significant points or areas and to label anything you wish to comment on. Figure 8 uses the Polygon Markup tool to mark the boundary of the main streets of St Arnaud; the Callout Text Markup tool to indicate high land; and the Text Markup tool to indicate the main train line to Melbourne.

FIGURE 8 Labelling on the St Arnaud map



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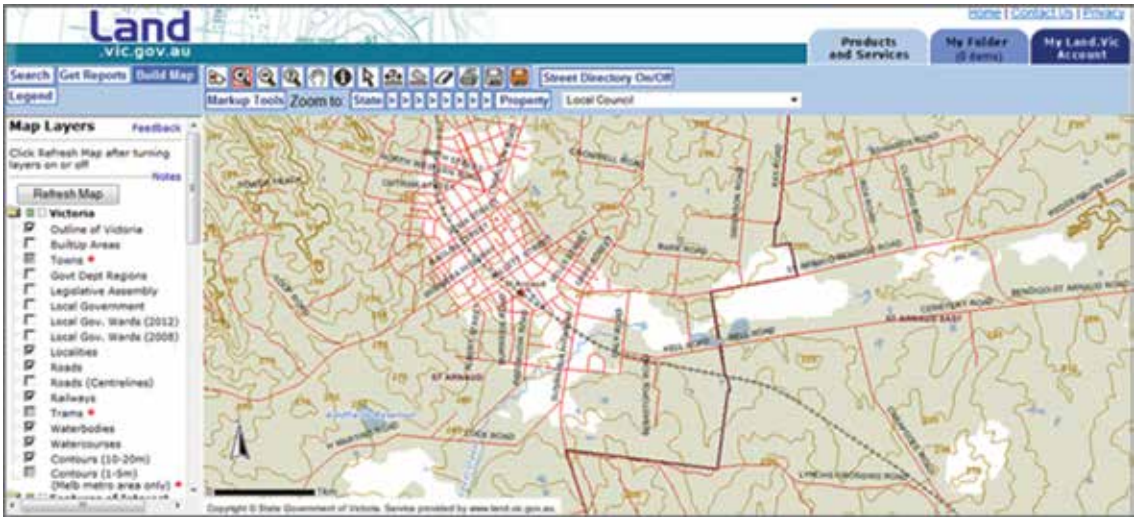
STEP 6

In applying your information about the area, you might like to turn on the layer for bushfire hazard (see figure 9). Are there streets in St Arnaud that are in the bushfire risk area?

FIGURE 9 St Arnaud with an overlay of bushfire risk



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STEP 7

Describing the built environment of St Arnaud requires you to make a statement about each of the layers that you have turned on and to discuss any implications that the layer might have for the development of the town. For example, the town is likely to continue to grow along the railway and the major road, the Sunraysia Highway.

17.7.3 Let me do it

Developing my skills

Continue to use this site to explore the layers of information on other built environments in Victoria. Choose somewhere else to explore. Write a paragraph describing the natural environment and the way in which it affects the development of the built environment.

Questions

Each of the following questions requires you to change maps and layers.

1. Does water play a significant role in the ***environment*** that you are studying?
2. Name and measure a significant road on your map.
3. Use the Area tool to calculate the size of your built ***environment***.
4. Use at least two Markup tools to add information to your map.
5. Using the Bushfire Risk layer, assess the risk of bushfire in your chosen built ***environment***.

Checklist

I have:

- used GIS-mapped geographic data
- interpreted map legends
- interpreted map layers
- looked for interconnections between map layers
- clearly represented and communicated data.

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Interactivity
Building a map with geographic information systems (GIS)
Searchlight ID: int-3372

Skills questions

1. GIS is used to show:
   a. the total population of an area
   b. the annual rainfall of an area
   c. the features of an environment
   d. the extinct fauna of an area.
2. GIS always includes information about:
   a. weather
   b. rock types
   c. air quality
   d. land.
3. What are the benefits of being able to turn a map's layers on and off?
4. Why do geographers enjoy the use of GIS applications when studying environments?

17.12 Review

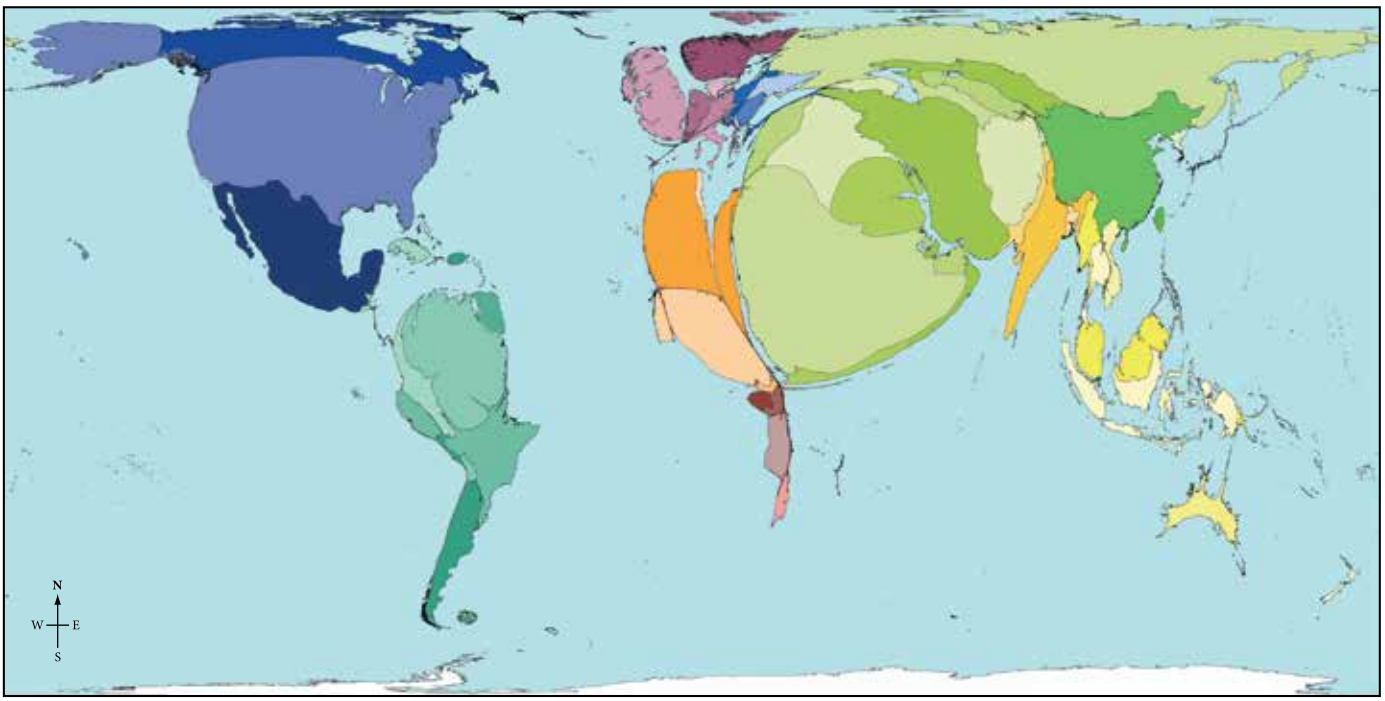
17.12.1 Review

1. Make a list of the advantages and disadvantages of living in a large city. Based on your analysis, explain why people are attracted to life in cities.
2. Use the data in table 1 in subtopic 17.2 'How do urban environments develop?' to draw a column graph for the years 2000 and 2025. What cities will experience the greatest growth and why would this be the case?
3. The United Nations has developed 17 Sustainable Development Goals (SDGs) to guide governments and organisations towards ***sustainable*** urban ***environments***. Considering the issue of slums in developing nations, what aspects of the SDGs apply to slums and what strategies have been suggested to overcome the problems of slums?

17.12.2 Reflect

4. It is hoped that modern technology will transform energy use in urban complexes to more ***environmentally*** friendly and ***sustainable*** formats.
   a. Study figure 1 and make summary comments on the use of energy in various high and low energy use nations of the world.
   b. What aspects of urban ***environments*** and their infrastructure can be used to account for more ***sustainable*** energy use in various nations?
   c. What different types of energy use could make consumption more ***environmentally*** friendly and ***sustainable***?

FIGURE 1 World energy use cartogram. The size of a country is proportional to the percentage of world energy usage.



Source: www.worldmapper.org

5. Desalinisation plants have been built in a number of Australia's main cities to solve water resource problems.
   a. Investigate how a desalinisation plants operates.
   b. How may desalinisation plants solve the problem of water supply to capital cities?
6. Most Australians would perceive slums negatively. Refer to the information of Dharavi, India, in subtopic 17.5. How does each of the following support a more positive perception of slums?
   - The role of rag pickers
   - Recycling
7. 'Let it sink. Venice is not worth saving.'
   Write an argument that supports and then an argument that would challenge this viewpoint.

CHAPTER 18

Geographical inquiry: Developing an environmental management plan

18.1 Overview

18.1.1 Scenario and task

Task: Prepare an environmental management plan that deals with a specific environmental threat.

There are many environmental changes that have an impact on different environments. Organisations or their specialist consultants often prepare environmental management plans (EMPs). EMPs recommend the steps to be undertaken to solve identified problems in managing the environment. They are also useful for predicting and minimising the effects of potential future changes. These strategies are designed to either remove or control the problem(s).

Your task

Each class team will research and prepare an EMP that deals with a specific environmental threat and then present it to the class. Decide on an environment and the threat it faces and then devise three key inquiry questions you would like to answer.

18.2 Inquiry process

18.2.1 Process

Open the ProjectsPLUS application for this project located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start project' button and set up your class group. Save your settings and the project will be launched.

- **Planning:** In pairs or groups, decide on a particular environmental issue and devise a series of three key inquiry questions that will become a focus of your study and a means of dividing the workload. Download the EMP planning template to help you think about and decide which environments your team will choose to research. Navigate to your Research Forum. Use the research topics to select the environments your team has chosen. The following steps will act as a guide for your report writing.

18.2.2 Collecting and recording data

Find out about the issue and why an EMP is needed. Identify potential environmental threats or changes that may occur. Describe the issue, the scale of potential changes and their significance. Prepare a map, or series of maps, to show the location of the issue. This may be sourced from a street directory,

atlas, Google maps or an online reference. Additional data can be researched and collected; for example, you may wish to survey people's opinions on the issue, use census data to determine the number of people affected in the region or find climatic data for the area. (Your teacher may guide you at this point.) Decide on the most suitable presentation method for your data; for example, graphs, maps and annotated photographs. You may wish to refer to relevant SkillBuilders to help you present your data.

18.2.3 Processing and analysing your information and data

Review and discuss with your team members the information that you have collected. Has it come from reliable sources? What patterns, trends and interconnections can you identify from your data?

Come up with two or three possible options that will address the issue(s) you have collected information about. It would be beneficial to include diagrams and/or photographs of strategies currently operating in different places that could be used or adapted to your site.

Evaluate which option would be most effective based on the following criteria:

- economic viability (affordable)
- social justice (fair to all people involved)
- environmental benefit (minimal environmental impact and with future sustainability).

Make concluding recommendations based on your research and evaluation of options. This should be in the form of a suggested course of action to follow in managing the environment and reducing any negative changes.

18.2.4 Communicating your findings

Present your report to the class and be prepared to answer questions from the audience. Use the EMP template to help you structure your report. Use graphics such as maps, graphs, images and charts in your EMP.

18.3 Review

18.3.1 Reflecting on your work

Review your participation in the production of your EMP by completing the reflection document in your Media Centre.

Print out your Research Report from ProjectsPLUS and hand it in with your EMP and reflection notes.

Your ProjectsPLUS application is available in this chapter's Resources tab in your eBookPLUS. Visit **www.jacplus.com.au** to locate your digital resources.

Suggested software

- ProjectsPLUS
- Microsoft Word

Media Centre

Your Media Centre contains:

- an EMP planning template
- an EMP template
- a reflection document
- weblinks to research sites
- an assessment rubric.

Human wellbeing varies from place to place around the world.

TOPIC 4

HUMAN WELLBEING

Human wellbeing varies from place to place across the world. Being able to measure and compare wellbeing in different places and the impacts of these variations can help governments, groups and individuals devise programs that attempt to improve wellbeing for their own as well as other countries.

KEY INQUIRY QUESTIONS

- What makes human wellbeing a geographical issue?
- How can the spatial variations in human wellbeing and development be measured and explained?
- What are the economic, social and environmental impacts of variations in development and human wellbeing?
- How do governments, groups and individuals respond to inequalities in development and human wellbeing for a sustainable future?

CHAPTER 19

Human wellbeing and development

Do these children from Swaziland have a good life?

19.1 Overview

19.1.1 Introduction

We all want a better life for ourselves, our families and our children, no matter where we live. We care about the progress of our communities, our state or territory, and our country. But how can we measure this progress? What does progress really mean? What do we count when we measure progress? How do we know if we are succeeding, and what is the concept of wellbeing?

Starter questions

1 How would you define *wellbeing*?
2 What does it mean to have a *good life*?
3 Do all Australians have a good life?
4 What could be improved in your life or community?

Inquiry sequence

		Syllabus outcomes
19.1 Overview		
19.2 What is wellbeing?		GE5-1, GE5-6
19.3 SkillBuilder: Constructing and Interpreting a scattergraph	eBookplus ONLINE ONLY	GE5-7
19.4 How do we measure development?		GE5-6, GE5-7
19.5 What are quantitative indicators?		GE5-6, GE5-7
19.6 What are qualitative indicators?		GE5-6, GE5-7
19.7 SkillBuilder: Intepreting a cartogram	eBookplus ONLINE ONLY	GE5-7
19.8 What are some trends in wellbeing — health?		GE5-6, GE5-7
19.9 What are some trends in wellbeing — malaria and TB?		GE5-6, GE5-7
19.10 What are some trends in wellbeing — sustainability?		GE5-6, GE5-7
19.11 Investigating topographic maps: Is Norway the best place on Earth?		GE5-1, GE5-6, GE5-7, GE5-8
19.12 Review	eBookplus ONLINE ONLY	
Key terms	eBookplus ONLINE ONLY	

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Watch this video
The good life?
Searchlight ID: eles-1713

19.2 What is wellbeing?

19.2.1 What is wellbeing?

In the past decade, a new global movement has emerged seeking to produce measures of progress that go beyond a country's income. Driven by citizens, policy-makers and statisticians around the world and endorsed by international organisations like the United Nations, the concept of **wellbeing** offers us a new perspective on what matters to us.

wellbeing a good or satisfactory condition of existence; a state characterised by health, happiness, prosperity and welfare

indicator a value that informs us of a condition or progress; it can be defined as something that helps us to understand where we are, where we are going and how far we are from the goal

quantitative indicator easily measured and can be stated numerically, such as annual income or how many doctors there are in a country

qualitative indicator usually consists of a complex set of indices that measure a particular aspect of quality of life or describe living conditions; useful in analysing features that are not easily calculated or measured, such as freedom or security

development according to the United Nations, defined as 'to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community'

gross domestic product (GDP) a measurement of the annual value of all the goods and services bought and sold within a country's borders; usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

Wellbeing is experienced when people have what they need for life to be good. But how do we measure a good life? We can use **indicators** of wellbeing to help us. Indicators are important and useful tools for monitoring and evaluating progress, or lack of it. There are **quantitative indicators** and **qualitative indicators**.

Traditionally, development has been viewed as changing one's environment in order to enhance economic gain. Today, the concept of **development** is not only concerned with economic growth, but includes other aspects such as providing for people's basic needs, equity and social justice, sustainability, freedom and safety. We have built on this traditional concept for measuring progress by considering wellbeing, which emphasises what is positive and desirable rather than what is lacking. The most successful development programs address all areas of wellbeing, rather than simply focusing on economic, health or education statistics. There is a growing awareness that human beings and their happiness cannot simply be reduced to a number or percentage. We can measure development in a variety of ways, but the most common method remains to use economic indicators that measure economic progress using data such as **gross domestic product (GDP)**.

How do we use indicators?

Indicators can be classified into a range of broad categories (see figure 1).

Economic indicators measure aspects of the economy and allow us to analyse its performance.

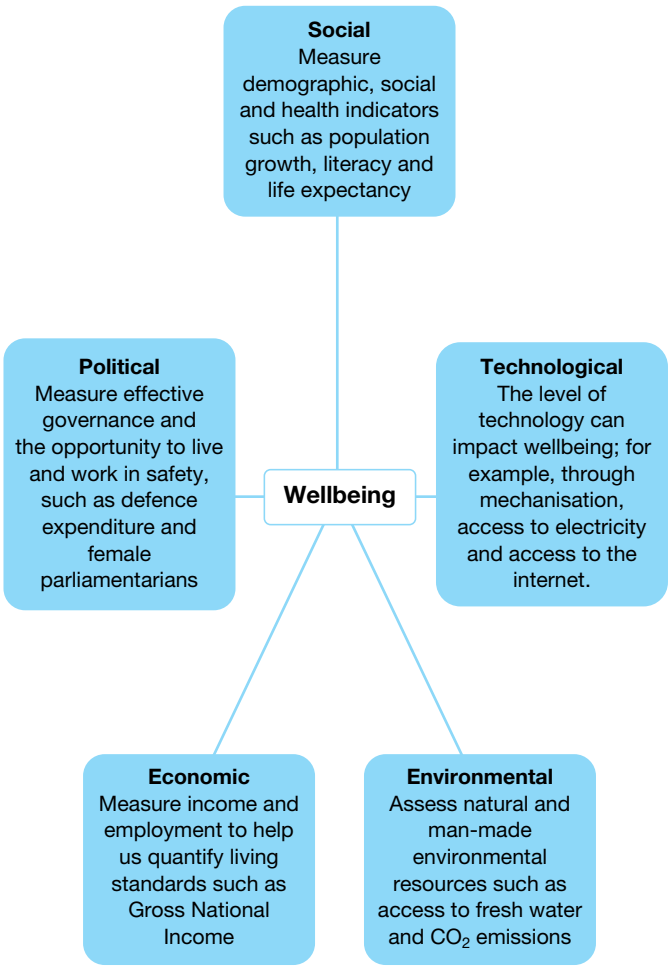
Social indicators include demographic, social and health measures.

Environmental indicators assess resources that provide us with the means for social and economic development, and gauge the health of the environment in which we live.

Political indicators look at how effective governments are in helping to improve people's standard of living by ensuring access to essential services.

Technological indicators in such fields as transport, industry, agriculture, mining and communications also contribute to wellbeing.

FIGURE 1 Categories of wellbeing indicators



Where and why?

Geographers use the spatial dimension, which helps us to identify patterns of where things are located over Earth's space and attempt to explain why these patterns exist. Identifying patterns across the globe may help to explain why the world is so unequal. Factors that affect equality across areas in a positive way may include the

availability of natural resources or an educated workforce, whereas susceptibility to natural disasters or corruption may create more inequality.

Inequalities may exist between individuals, but also within and between countries, regions and continents (often referred to as 'spatial inequality').

ACTIVITIES

EXPLAIN

1 a Classify the following as either quantitative or qualitative indicators: motor vehicles, proportion of seats held by women in national parliaments, unemployment, electric power consumption, forest area, obesity, quality of teaching at your school, freedom of speech, how safe you feel walking in the city at night, how much you trust your neighbours, access to public transport.

b Using figure 1 as a guide, categorise the indicators listed in part a.

2 Does your pet dog or cat have a good life? What indicators would you use to measure the wellbeing of your pet? Write a selection of 10 quantitative and qualitative indicators to help determine their wellbeing.

PREDICT

3 Look back over the indicators in question 1. Indicators can also imply further information about a country's progress, rate of ***change*** or development. Could these indicators be clues to the factors affecting the development of a country? If so, what else do they tell you?

4 Select one of the indicator categories: social, economic or ***environmental***. In pairs or small groups, brainstorm the various indicators that you think might be used to measure it. Create a short list of at least five before checking the World Statistics section of your atlas to see which indicators are commonly used.

INVESTIGATE

5 Use the **Gauging interconnections** weblink in your eBookPLUS to discover some of the ***interconnections*** that exist between indicators. List two strong ***interconnections***.

6 Are you better off or worse off? As a teenager in Australia, you might think you have it tough. But, when we look at the indicators, is that really the case? Decide whether you are better off or worse off for each indicator in table 1 by evaluating the data. What reasons could account for these differences?

7 The concept of wellbeing is relative to who you are and the ***place*** where you live. Consider the following statements. Does the term 'wellbeing' have any relevance to these people? Does wellbeing hold any relevance for people in the direst poverty?

Person A: 'We live in constant fear, starvation; there is a lack of government. Personal safety is crucial, so wellbeing is not there yet. Things are very difficult as people are living in despair.'

Person B: 'Before, we always talked of improving living standards, which mostly meant material needs. Now we talk of the importance of relationships among people and between people and the environment.'

Person C: 'The land looks after us. We have plenty to eat, but things are changing. There are no fish now, not like when my father was a boy.'

TABLE 1 Australia versus the world — a selection of quantitative indicators (2014)

Quantitative indicator	Country	Value	Country	Value
Life expectancy (years)	Australia	82	Sierra Leone (Africa)	46
Mobile phones (subscriptions per 100 people)	Australia	131	Eritrea (Africa)	6
Adolescent fertility rate (births per 1000 women 15–19 years of age)	Australia	11	Switzerland (Europe)	2
Proportion of seats held by women in national parliament (%)	Australia	26	Rwanda (Africa)	64
Gross National Income per capita ($US)	Australia	42 880	Qatar (West Asia)	133 580
Literacy rate (% of youth aged 15–24)	Australia	99	Chad (Africa)	48

Source: The World Bank.

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Weblink
Gauging interconnections

myWorldAtlas Deepen your understanding of this topic with related case studies and questions. › World population

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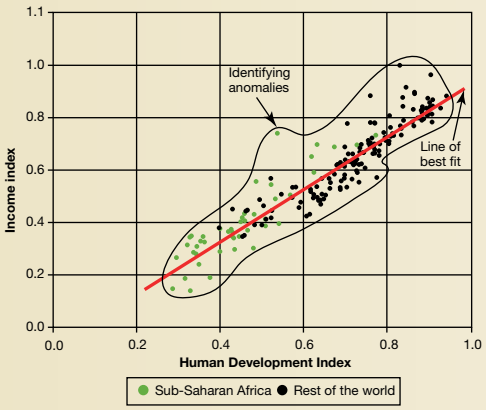
19.3 SkillBuilder: Constructing and interpreting a scattergraph

What is a scattergraph?

A scattergraph is a graph that shows how two or more sets of data, plotted as dots, are interconnected. This interconnection can be expressed as a level of correlation. Scattergraphs are used to show us a visual image of the interconnection of factors.



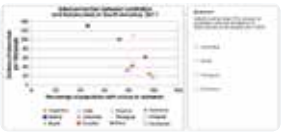
eLesson

Watch this video to learn how to construct and interpret a scattergraph.

Searchlight ID: eles-1756

Interactivity

Try this interactivity to learn how to construct and interpret a scattergraph.



Searchlight ID: int-3374

19.4 How do we measure development?

19.4.1 How do we describe development?

Whichever method of classifying development or wellbeing we choose, it is important to understand the terms that have been used, the values that underpin it, and what perspective (often Western) we take. With an overwhelming amount of data available to us, the world is often divided simplistically into extremes such as 'rich' or 'poor'. Is this the best way?

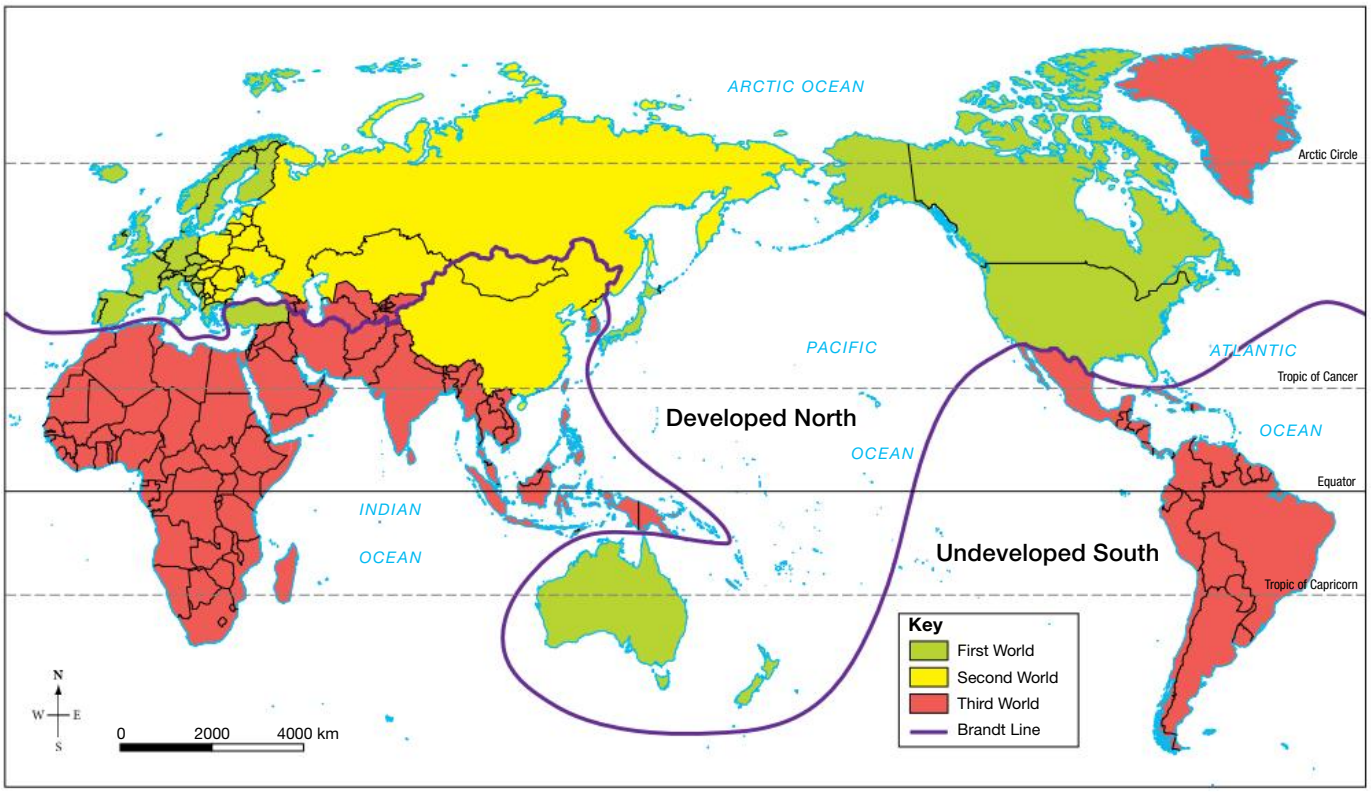
The annotated classifications in figure 1 have been used in the past century, but they are very general and as such have been questioned by geographers for their accuracy (and sometimes offensiveness). Today, we use terminology such as more economically developed country (MEDC) and less economically developed country (LEDC) to describe levels of development — in the economic, social, environmental and political spheres. A newly **industrialised** country (NIC) is one that is modernising and changing quickly, undergoing rapid economic growth. Emerging economies (EEs) are places also experiencing rapid economic growth, but these are somewhat volatile in that there are significant political, monetary or social challenges.

industrialised having developed a wide range of industries or having highly developed industries

19.4.2 What is poverty?

There is a strong interconnection between development and poverty. The United Nations defines poverty as 'a denial of choices and opportunities, a violation of human dignity … It means not having enough to feed and clothe a family, not having a school or clinic to go to, not having the land on which to grow one's food or a job to earn one's living … It means susceptibility to violence, and it often implies living in marginal or fragile environments, without access to clean water or sanitation.' However, poverty is most often measured using solely economic indicators. More than 1 billion people live in poverty, as shown by figure 2.

FIGURE 1 World map showing various definitions of development



Source: Spatial Vision

Developed or developing?
One of the most common ways of talking about the level of development in various places is to label them as 'developed' or 'developing'. These terms assume that development is a linear process of growth, so each country could be placed on a continuum of development. Countries that are developing are still working towards achieving a higher level of living standard or economic growth, implying that the country could ultimately become 'developed'.

North or South?
In 1980, the Chancellor of Germany, Willy Brandt, chaired a study into the inequality of living conditions across the world. The imaginary Brandt Line divided the rich and poor countries, generally following the line of the equator. The North included the USA, Canada, Europe, the USSR, Australia and Japan. The South represented the rest of Asia, Central and South America, and all of Africa. Once again, these terms have become obsolete as countries have developed differently and ignored these imaginary boundaries.

First World or Third World?
The terminology First, Second and Third Worlds was a product of the Cold War. The Western, industrialised nations and their former colonies (North America, western Europe, Japan and Australasia) were the First World. The Soviet Union and its allies of the Communist bloc (the former USSR, eastern Europe, China) were the Second World.

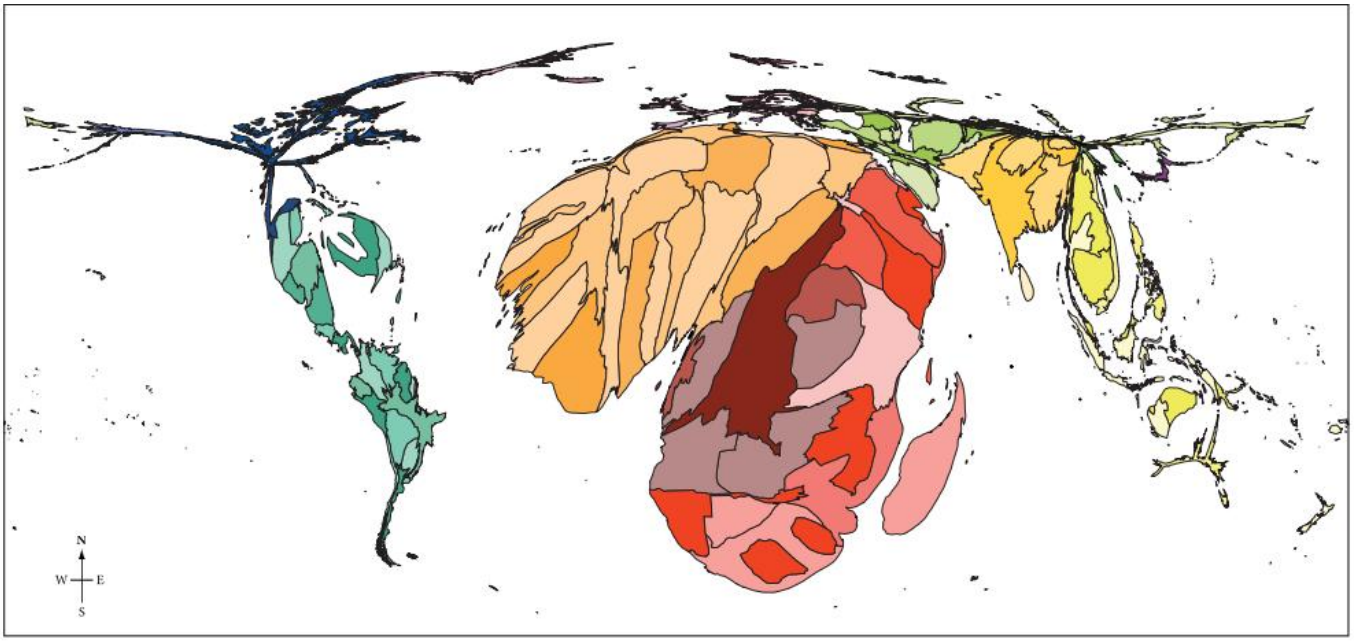
The Third World referred to all of the other countries. However, over time this term became more commonly used to describe the category of poorer countries that generally had lower **standards of living**.

The Second World ceased to exist when the Soviet Union collapsed in 1991.

West or East?
Another viewpoint on the differences in development based on a spatial component involves dividing the world loosely by cultural rather than geographical boundaries. Developed prior to the 1920s it became a more accepted construct after WWII. The 'West' is seen to include many of the same nations as the North, with the exception of parts of Asia.

standard of living a level of material comfort in terms of goods and services available to someone or some group; often measured on a continuum, for example a 'high' or 'excellent' standard of living compared to a 'low' or 'poor' standard of living

FIGURE 2 The proportion of the world's population (shown as a cartogram) living on less than US$1.25 per day



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 Identify two examples of ***places*** that would have been classified as 'developed North' and two that would have been classified as 'undeveloped South'.

EXPLAIN

2 What do you think about Australia being labelled a part of the 'developed North'?

3 Although indicators are measuring different aspects of quality of life, they are also ***interconnected***. For example, if a country goes through an economic recession, other indicators will be affected. Explain with examples (a flow chart may be useful to step out your thinking).

INVESTIGATE

4 How are MEDCs and LEDCs different? Complete table 1 (try to include your own explanations where possible).

TABLE 1 Comparison of MEDCs and LEDCs

	MEDC	LEDC
Birth rate		High — many children die so the birth rate increases to counteract fatalities
Death rate	Low — good medical care available	
Life expectancy	High — good medical care and quality of life	
Infant mortality rate		High — poor medical care and nutrition
Literacy rate	High — access to schooling, often free	
Housing type		Poor — often no access to fresh water, no sanitation, infrequent or no electricity

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Interactivity
Living on less than $1.25 a day
Use this interactivity to find out more about the global distribution of poverty.
Searchlight ID: int-3304

myWorldAtlas
Deepen your understanding of this topic with related case studies and questions.
- Indigenous Australians
- Wellbeing in Western Sydney
- Wellbeing in Sudan
- Child labour around the world

19.5 What are quantitative indicators?

19.5.1 Quantitative indicators

A wellbeing approach to development takes into account a variety of quantitative and qualitative indicators. Quantitative indicators are the most common as they allow for the easiest possible way of comparing changes (hopefully improvements) between time periods and countries. One quantitative indicator of wellbeing is the distribution of wealth which varies significantly.

Figure 1a shows the distribution of the world's wealth in 1992, while figure 1b shows the distribution in 2016. Today, the top 1 per cent of income earners have 50 per cent of the world's income; within that, the 80 richest people have as much wealth as the bottom half of the world combined — nearly 4 billion people.

FIGURE 1a 'Champagne-glass' distribution of the world's wealth in 1992

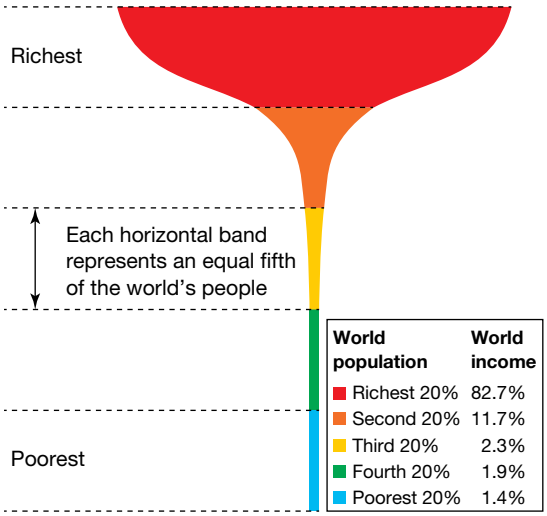
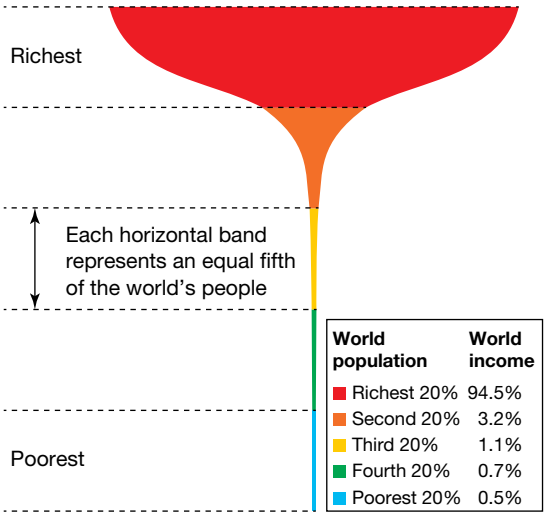


FIGURE 1b What the distribution of the world's wealth looks like in 2016



19.5.2 Economic indicators

The major economic indicators used globally are either gross domestic product (GDP) or **gross national income (GNI)**. Whilst these seem similar and are sometimes used interchangeably they measure slightly different things. GDP is a measurement of the value of all goods and services bought and sold within a country's borders. It includes goods and services that are produced within a country but that may actually be produced by an international business that has operations within that country. As a result profits made by the business may not stay in the country where the good was made, but rather will return to the country where the business headquarters are located, for example major trans-national corporations (TNCs), such as Nike, will sell footwear in Australia, which will contribute to Australia's GDP. However the profits made from the sale will find their way back to the United States.

gross national income (GNI) a measurement of the value of goods and services produced by citizens and firms of a specific country no matter where they take place, normally discussed as GNI per capita

Is this the best measure of wellbeing?

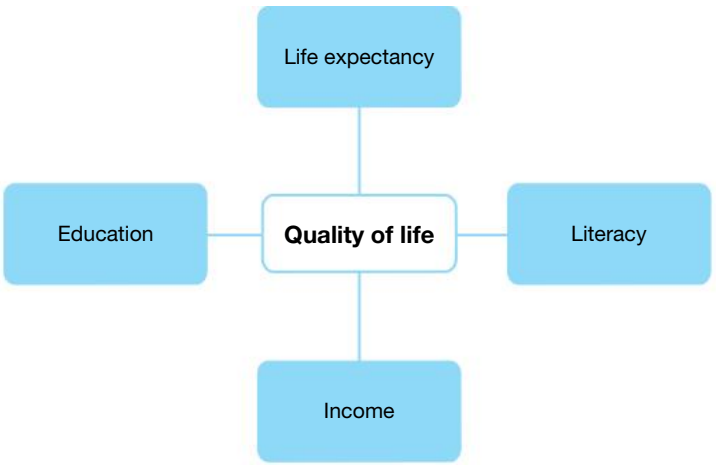
Over time, different societies have measured progress in different ways. A GDP-led development model focuses solely on boundless economic growth on a planet with limited resources — and this is not a balanced equation. The HDI has become one of the most common ways to measure wellbeing, but it has also attracted criticism for its narrow approach. These measures do not recognise some of the greatest environmental, social and humanitarian challenges of the twenty-first century such as pollution or stress levels.

Why is GNI better?

GNI is perhaps more accurate as it takes the value of GDP but it removes the income that is payable to residents or business that are from overseas and includes incomes and profits earned overseas by

local residents or businesses. For example, if golfer Jason Day wins a tournament in Scotland the prize money would be counted towards Scotland's GDP (it was produced in that country); however, as he is an Australian citizen it would count as part of Australia's GNI. One concern with GDP or GNI is that they make no distinction between transactions that add to wellbeing and those that detract from it.

FIGURE 2 Measuring quality of life encompasses many indicators.



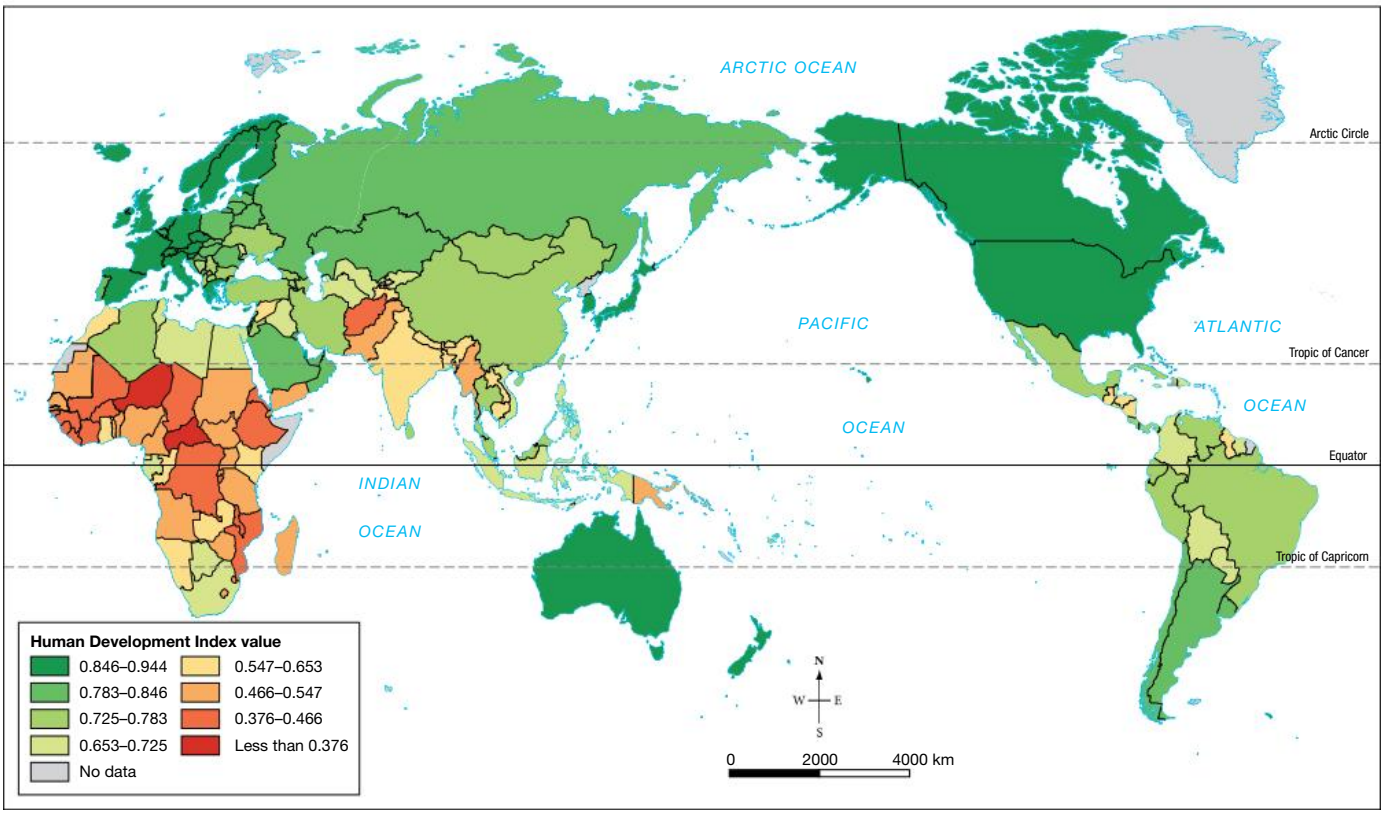
19.5.3 What is a multiple component index?

A single indicator gives us only a narrow picture of the development of a country. A country may have a very high GDP but, if we dig a little deeper and look at each individual's share in that country's income or their **life expectancy**, we may not find what we expected. Inequalities may be revealed. A combination of many indicators will create a more accurate picture of the level of wellbeing in a particular place. Much like using our five senses to try a new cuisine, a combination of indicators will give us better insight into a country's wellbeing. The **Human Development Index (HDI)** is one such index. It was developed in 1990 to measure wellbeing according to four indicators (see figure 2).

life expectancy the number of years a person is expected to live, based on the average living conditions within a country

Human Development Index (HDI) measures the standard of living and wellbeing in terms of life expectancy, education, literacy and income

FIGURE 3 HDI choropleth map



Source: Human Development Reports, United Nations Development Programme

ACTIVITIES

EXPLAIN

1 Refer to figure 2.
   a In your own words, explain three indicators used to calculate the HDI.
   b Is the HDI the best indicator of a country's development? Give reasons for your answer.
2 Describe the pattern of wealth distribution shown in figures 1a and 1b.

APPLY

3 In 2011 the HDI was revised to use GNI as its economic measurement rather than GDP. Why do you think this was done?

INVESTIGATE

4 As an individual or as a class, use the **Human development tree** weblink in your eBookPLUS.
   a What indicators are you asked to give assessments for?
   b Choose a country you may have links to (through family, holidays or even a favourite food). How are they represented on the tree?
   c Is this better or worse off than your prediction? Why is that the case?
5 Use the **Human development reports** weblink in your eBookPLUS and use the data to complete a table comparing a country from each continent. Include in it their current HDI ranking score and where they are in world rankings.
6 Why is global wealth so unevenly distributed (e.g. between Australia, the United States, Qatar and parts of the developing world)?
7 What are the factors that you believe are responsible for this?

PREDICT

8 Use figure 1a to predict what will happen to the shape of this 'glass' in the future.

Continent	Asia	Africa	Europe	North America	South America
Country					
HDI score					
HDI rank					

eBookplus

Weblinks
- Human development tree
- Human development reports

19.6 What are qualitative indicators?

19.6.1 Qualitative indicators

Qualitative indicators are used to determine particular aspects of quality of life or to describe living conditions. These indicators are often more difficult to measure and compare as the information used is more time consuming to collect. This is because they are made up of surveys and interviews rather than simple numerical values such as income or life expectancy.

19.6.2 Which country is the happiest?

The new Happy Planet Index (HPI) results (see figure 1) map the extent to which 151 countries across the globe produce long, happy and sustainable lives for the people that live in them.

Each of the three component measures — life expectancy, experienced wellbeing and **ecological footprint** — is given a traffic-light score based on thresholds for good (green), middling (amber) and bad (red) performance. These scores are combined to an expanded six-colour traffic light for the overall HPI score. To achieve bright green (the best of the six colours), a country would have to perform well on all three individual components.

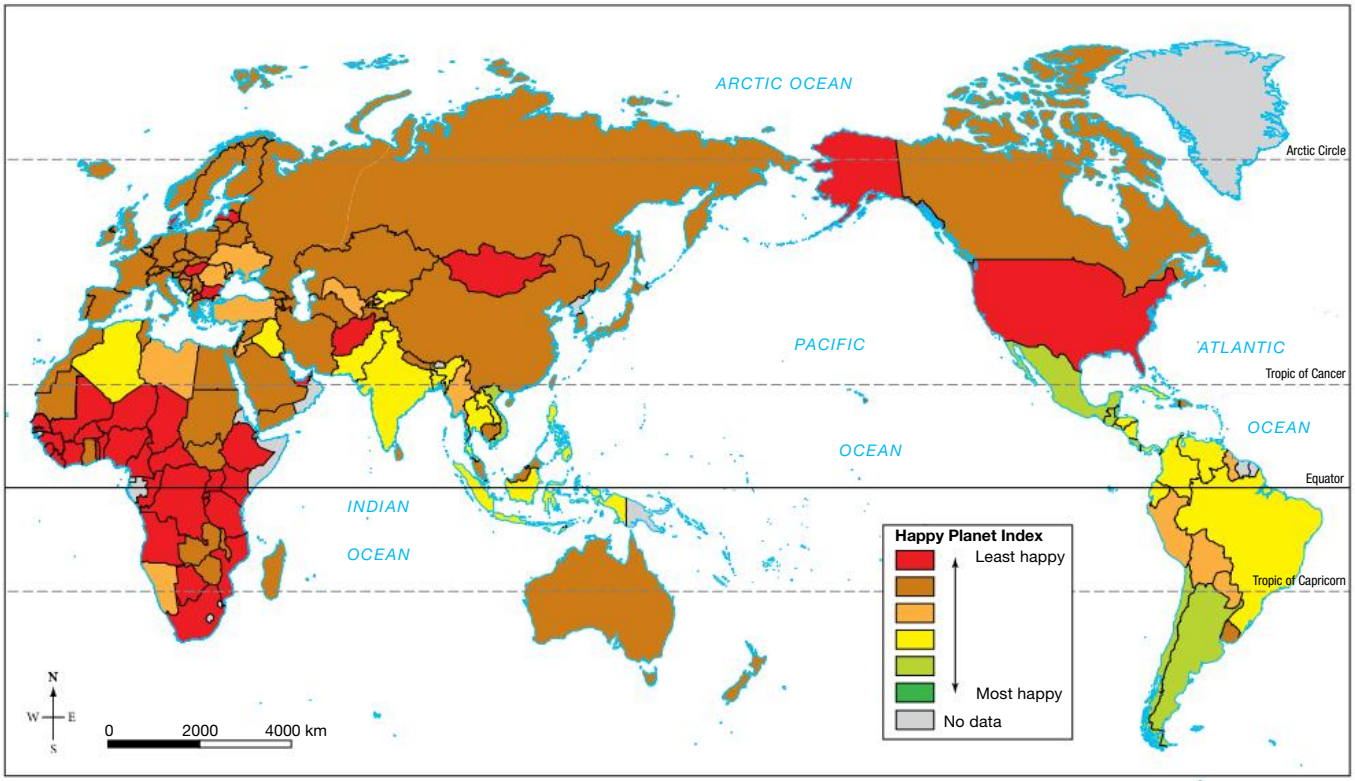
ecological footprint the amount of productive land needed on average by each person in a selected area for food, water, transport, housing and waste management

$$\text{Happy Planet Index} = \frac{\text{experienced wellbeing} \times \text{life expectancy}}{\text{ecological footprint}}$$

What is Gross National Happiness?

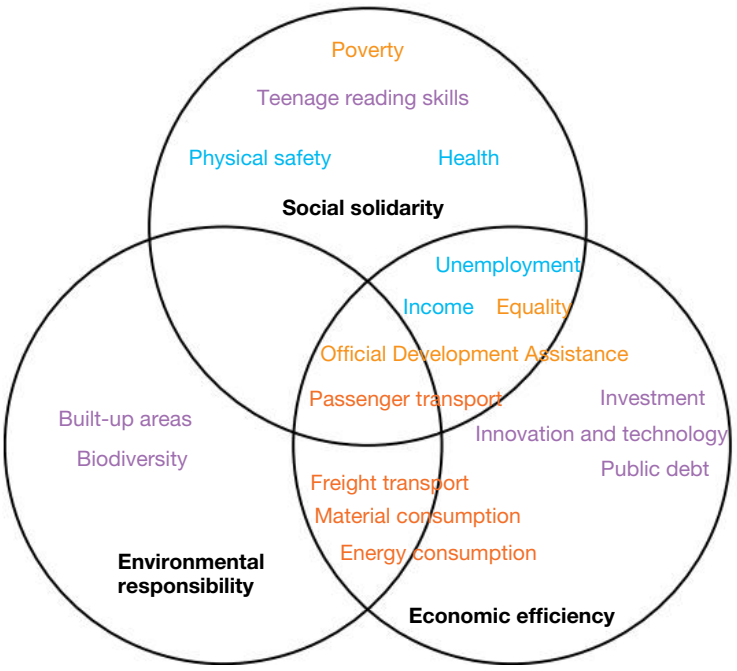
In 2011, the Prime Minister of Bhutan (Central Asia) demonstrated his country's commitment to its wellbeing by developing the world's first measure of national happiness, and he encouraged world economies to do the same. UN Secretary-General Ban Ki-moon supported this innovation: 'Gross

FIGURE 1 The happiest countries in the world according to the Happy Planet Index



Source: The Happy Planet index: 2012 Report. A global index of sustainable wellbeing.

FIGURE 2 Switzerland's overview of key national indicators, categorised according to three qualitative objectives: social, environmental and economic.



Indigenous
Australia's Indigenous peoples are made up of Aboriginal people (who live all around Australia) and Torres Strait Islanders (who settled the many small islands to the north of Cape York Peninsula in Queensland)

national product (GNP) … fails to take into account the social and environmental costs of so-called progress … Social, economic and environmental wellbeing are indivisible. Together they define gross global happiness.' Australia is in the process of developing the Australian National Development Index (ANDI), which will incorporate 12 indicators measuring elements of progress including health, education, justice and **Indigenous** wellbeing. Measures such as this demonstrate a new direction in articulating wellbeing, recognising that happiness is not directly proportionate to our bank balance or how long we expect to live. This new measure of wellbeing will reflect what is important to Australians to feel happy as individuals, as well as the happiness of our communities.

Freedom of speech

Freedom, and in particular freedom of speech, is something we often take for granted in Australia. The access to this type of freedom is a significant qualitative measure and one which can be difficult

to calculate. One way in which freedom is measured is through the World Press Freedom Index. According to the WPFI, the five countries with the best scores in 2016 were Finland, Netherlands, Norway, Denmark and New Zealand, while the five countries with the worst scores were China, Syria, Turkmenistan, North Korea and Eritrea.

ACTIVITIES

IDENTIFY

1 Hide figure 1. Name three ***places*** you would expect to rank highly on the Happy Planet Index and three you would expect to rank low. Now, check your predictions on the map. Were you correct?

EXPLAIN

2 Comment on the distribution of the happiest/unhappiest countries across the world according to the data in figure 2. What do you think would make a country unhappy?

3 Refer to figure 2. Discuss why a Venn diagram is an appropriate method to illustrate these indicators.

INVESTIGATE

4 **a** Locate Bhutan on a world map. Describe its location.
b Find Bhutan in figure 1. How does it rate on the Happy Planet Index?

5 It has been well-documented that as people move beyond a certain income level, they do not become any happier. Try measuring your own happiness using the **HPI survey** weblink in your eBookPLUS. How does your happiness rate against that of your classmates?

6 A number of countries have already adopted a national measure of wellbeing. Either individually or in pairs, research the history of one of the following indexes, identify the indicators used to measure it and evaluate its success.
- Gross National Happiness (Bhutan)
- Key National Indicator System (USA)
- Canadian Index of Wellbeing (Canada)

APPLY

7 Should wellbeing or happiness be a core goal of a country's government? Debate this in a small group.

8 State which of the indicators would be considered quantitative if measured on their own.

9 Compare the locations of the best countries for WPFI to those of the worst. What trends can you see?

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Weblink
HPI survey

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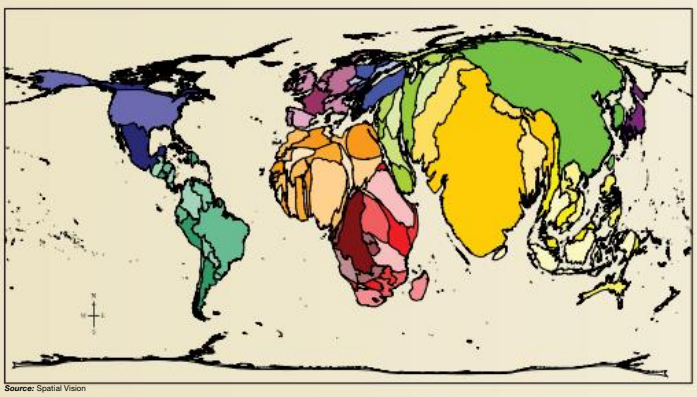
19.7 SkillBuilder: Interpreting a cartogram

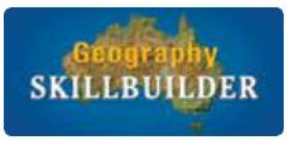
What is a cartogram?

A cartogram is a diagrammatic map that uses a single feature, such as population, to work out the shape and size of a country. Therefore, a country is shown in its relative location but its shape and size may be distorted. Cartograms are usually used to show information about populations and social and economic features.



Source: Spatial Vision

eLesson
Watch this video to learn how to interpret a cartogram.



Searchlight ID: eles-1757

Interactivity
Try this interactivity to learn how to interpret a cartogram.

Searchlight ID: int-3375

19.8 What are some trends in wellbeing — health?

19.8.1 Health

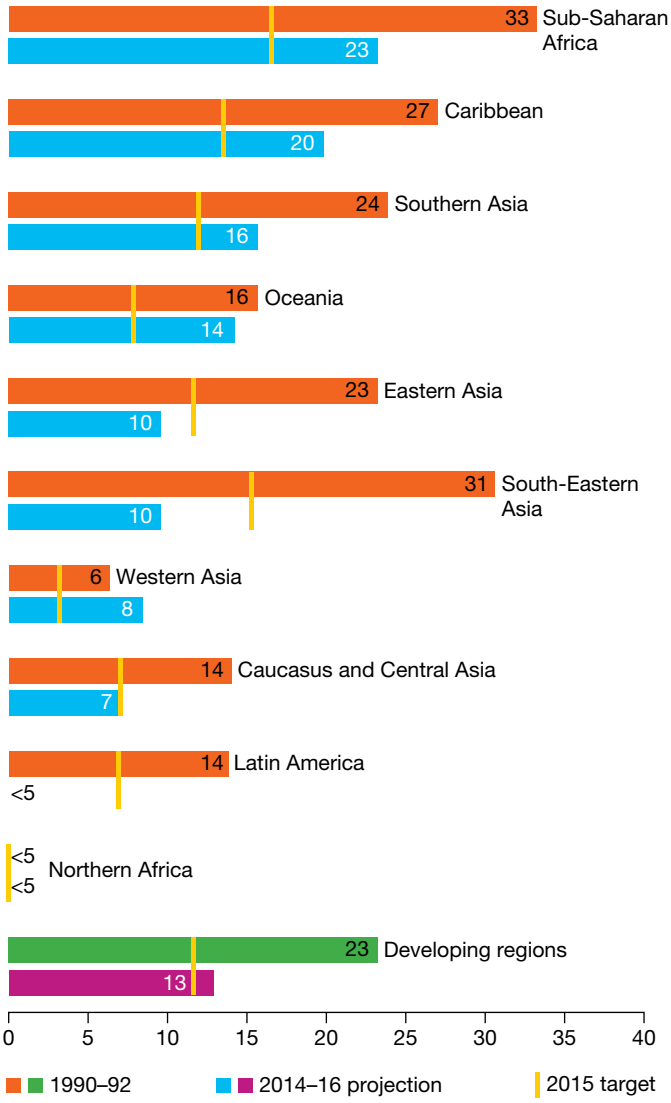
Traditionally, a major concern of wellbeing and development focused upon health, specifically on food and nutrition. Towards the later part of the twentieth century and into the early twenty-first century we have been concerned with extreme hunger and malnutrition. In fact the UN listed the eradication of hunger and extreme poverty as its Millennium Development Goal 1, and now as Sustainable Development Goals 1 and 2.

In September 2000, Kofi Annan (then Secretary-General of the UN) reminded us of those who had not benefited from development: 'In an age where human beings have learnt the code of human life, and can transmit their knowledge from one continent to another in seconds, no mother in the world can understand why her child is left to die of malnutrition or preventable disease.'

19.8.2 Why is this important?

Those areas most at risk include countries within the developing world; those in Asia, Africa and South America. Improving access to food and clean water is the simplest way to enhance people's health, which is vital because currently 1 in 8 people are undernourished globally. This makes them more susceptible to disease, less productive at school or work, more likely to be a burden on family and more likely to die younger. Dirty water is responsible for problems such as diarrhoea, cholera and typhoid.

FIGURE 1 Undernourished people, 1990–2016 (%)



Overweight

Problems associated with being overweight and obese include heart disease, diabetes, stroke, arthritis and multiple forms of cancer. Not only does obesity place a large financial stress on public health spending, it is also a leading cause of premature death. Most of the world's population lives in countries where more people die from being overweight or obese than die from being underweight.

Obesity was once confined to the developed world; however, this trend is moving into the developing world, particularly among the BRICM nations (Brazil, Russia, India, China and Mexico). The World Health Organization (WHO) has identified that obesity has doubled since 1980. More than 1.9 billion adults were overweight and 600 million were obese; that is, 39 per cent and 13 per cent respectively. This has seen the development of a new term: 'globesity'.

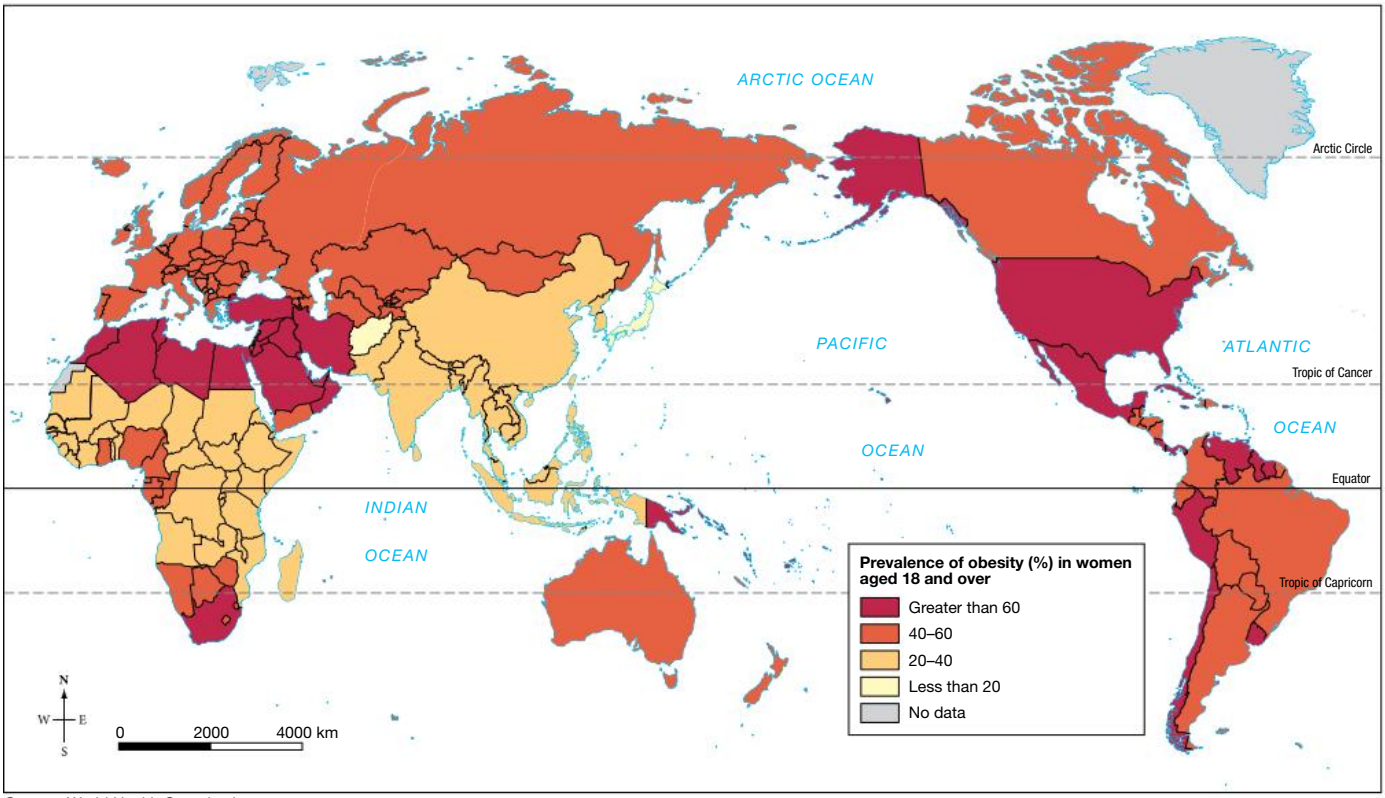
TABLE 1 The global burden of poor health

	Developing nations	Developed nations
Then	• Infectious disease • Undernutrition	• Overweight/obesity
Now	• Infectious disease • Undernutrition • Overweight/obesity	• Overweight/obesity

How is BMI calculated?

Body Mass Index (BMI) and calorie intake are most common measurements for overweight and obesity. BMI is a simple index of weight-for-height that is commonly used to classify persons as overweight or obese. It is calculated as a

FIGURE 2 Age-standardised prevalence of obesity in women aged 18 years and over (BMI ≥ 30 kg/m^2), 2014



Source: World Health Organization

person's weight divided by the square of their height, and is expressed in kg/m^2. The World Health Organization defines a BMI of ≥ 25 as overweight and ≥ 30 as obese.

What are the causes?

The primary cause of overweight/obesity is an imbalance between calories consumed (what is eaten) and calories expended (energy burned during movement and exercise).

Globally there has been:

- an increase in intake of energy-dense foods that are high in fat
- a decrease in physical activity due to the increasingly sedentary nature of many types of work, changes to transport and increasing urbanisation.

What action is being taken?

Many initiatives have been adopted in both the developed and developing world to combat this problem. These are taking place at individual, community and industry level.

FIGURE 4 A health worker helping educate deprived children in Ecuador

GEOskills TOOLBOX

The issues we deal with in Geography, particularly those in terms of development, can often be very distressing. Uneven access to resources including food, water and shelter is a real problem. One way of trying to deal with these issues is by using satire. Satire is the use of humour, irony, exaggeration or ridicule to expose and/or criticise people's behaviour or a particular situation. It is a way of trying to make light of a serious situation or circumstance through the use of humour.

1 Use the internet to create your own satirical meme centred on the current trend of health-related issues. These could include malnutrition, obesity, aid programs or disease control.

ACTIVITIES

IDENTIFY

1 Compare the ***changes*** that have occurred in terms of the proportion of undernourished people in the regions listed in figure 1 between 1990–1992 and 2014–2016.

EXPLAIN

2 What are some of the negative consequences linked to being undernourished?

3 Which are the BRICM countries?

INVESTIGATE

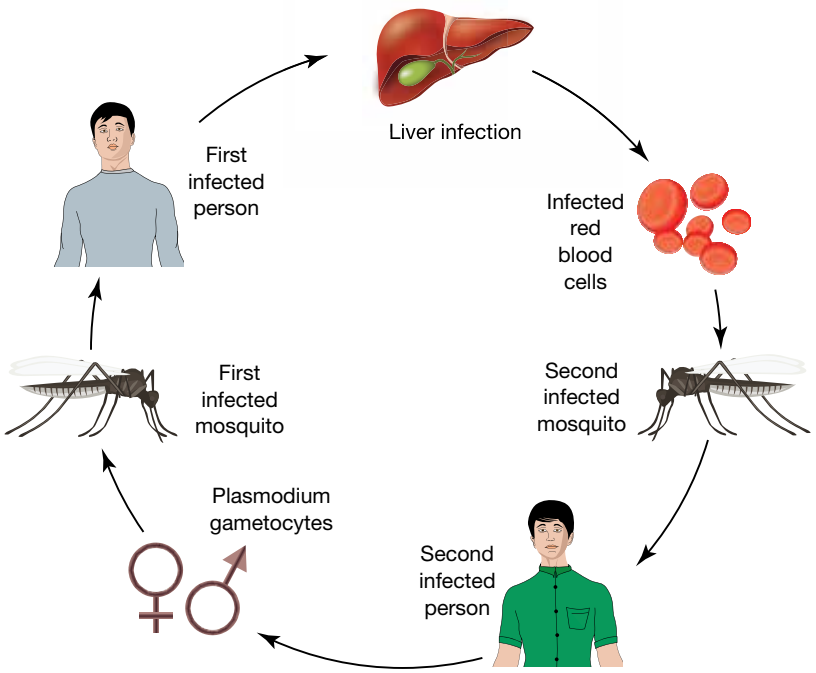
4 Within your class, divide into groups and assign each a BRICM country. Research which health issues are most prevalent in that country. How does that compare with the issues in Australia?

19.9 What are some trends in wellbeing — malaria and TB?

19.9.1 Disparities in wellbeing

One of the major disparities in health and wellbeing between nations of the developed and developing world has to do with the existence of disease. The United Nations Millennium Development Goal 6, which was set between 2000–2015, has since been replaced by Sustainable Development Goal 3 — to ensure healthy lives and promote wellbeing for all at all ages. Both of these had a specific aim of reducing infectious diseases including malaria and tuberculosis (TB).

FIGURE 1 The malaria transmission cycle



19.9.2 Malaria

Malaria is a life-threatening blood disease caused by a parasite that is transmitted to humans by the *Anopheles* mosquito. Malaria is a preventable and treatable disease.

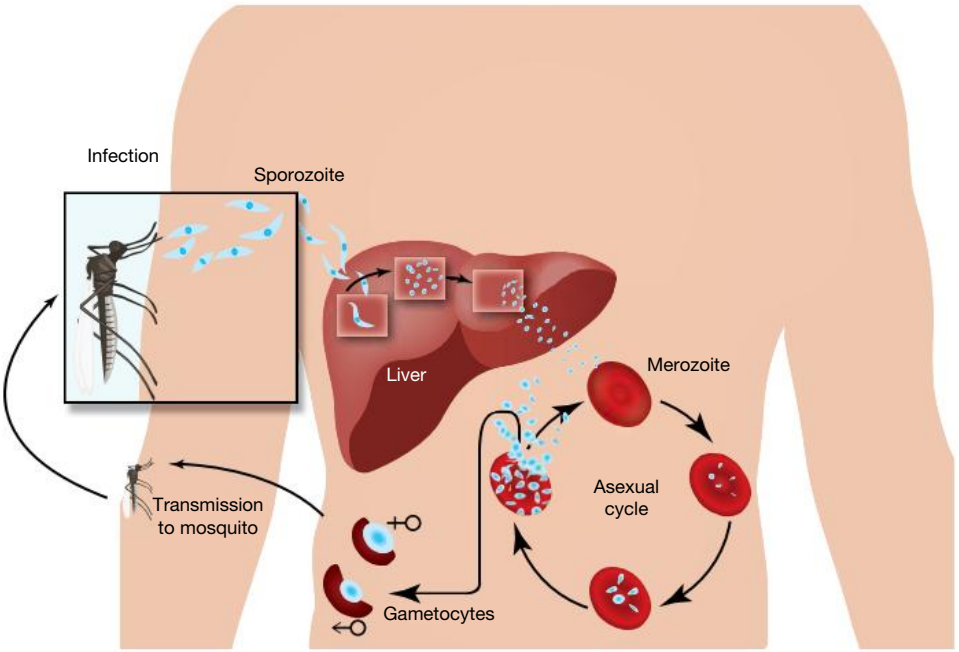
Malaria is estimated to claim the lives of 2000 children every day and is one of the major contributors to illness in the developing world. Those nations most at risk lie within the tropics and the World Health Organization (WHO) believes almost half the world is at risk of malaria (see figure 3). Approximately 90 per cent of all malaria deaths occur in Africa. As with many diseases, malaria disproportionately affects people already afflicted by poverty. Table 1 identifies some of the risk factors for both malaria and TB.

One study, based on data from sub-Saharan Africa, estimated that the net benefits associated with a complete package of malaria interventions were about 18 times greater than the cost.

TABLE 1 Risk factors for malaria and TB

Disease	Risk factors	Treatment
Malaria	• Poverty • More likely to live in slums or countryside • Less able to undertake prevention (mosquito nets) • Less likely to get treatment once sick	DDT
Tuberculosis (TB)	• Living in overcrowded conditions (airborne disease) • Poor nutrition • Inadequate sanitation	Range of drugs taken for a minimum of 6 months

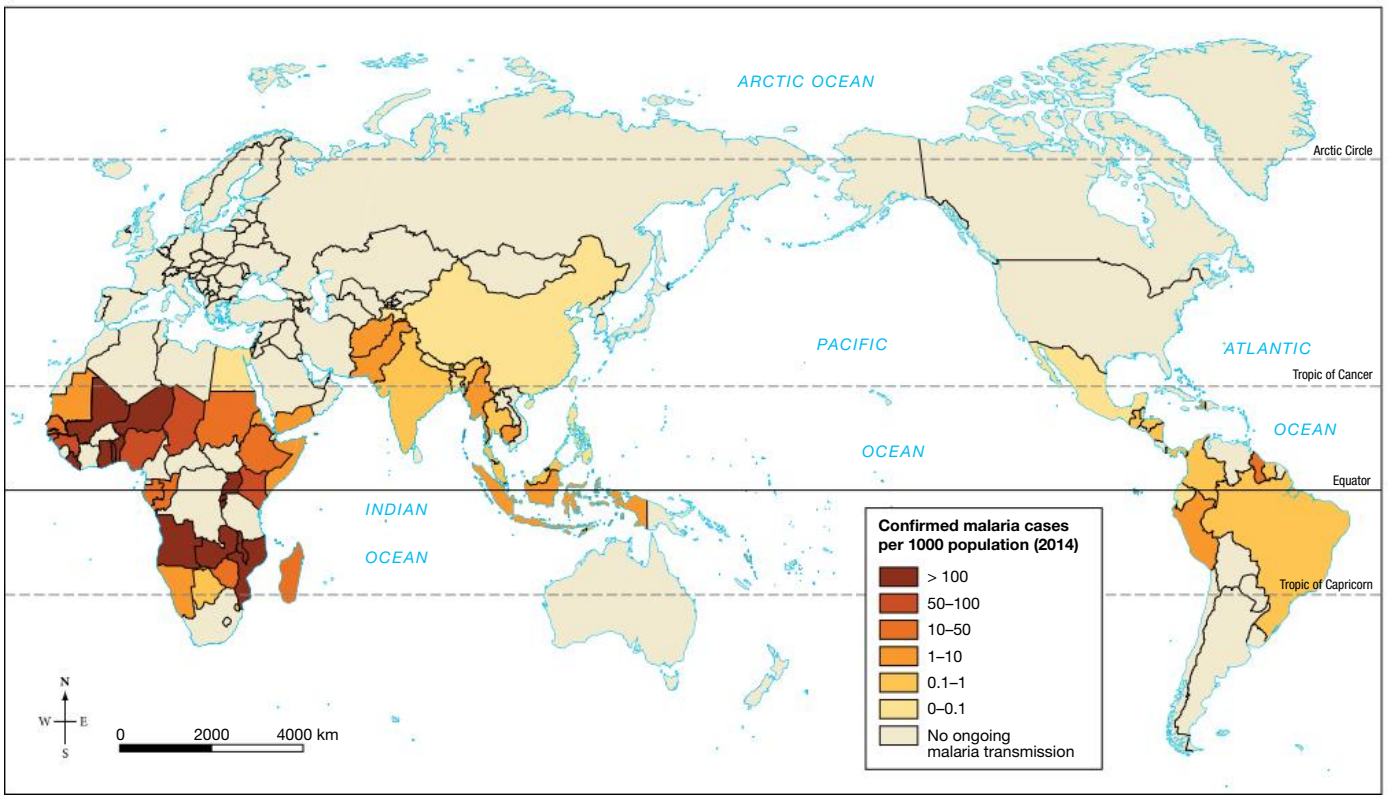
FIGURE 2 The malaria parasite life cycle



Problems associated with treatment

DDT is a chemical that is an extremely effective insecticide; it has been banned from use in much of the developed world, including the United States in the 1970s and Australia in the 1980s. While it is known to be valuable in the prevention of malaria, it raises ethical issues about supplying an insecticide for poorer nations that is illegal in rich ones. Potential prevention measures also include the introduction of ecosystem-compatible predators such as fish. Alternatively, the use of a bacterial larvicide could be introduced. This is a type of insecticide that targets the larvae to kill them before they have the chance to develop into insects (mosquitoes).

FIGURE 3 Prevalence of malaria across the world (adapted from WHO)



Source: National Malaria Control Program Reports

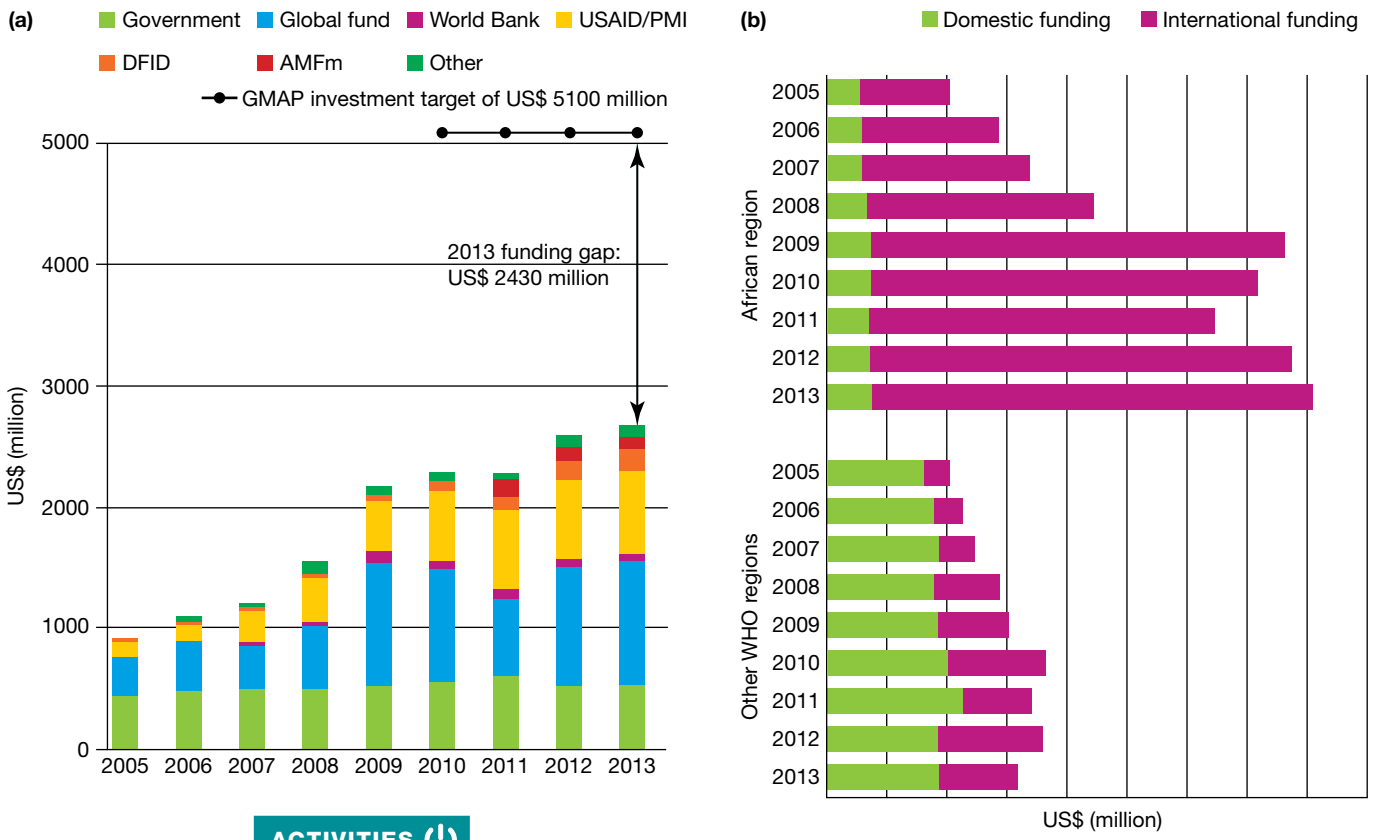
19.9.3 Tuberculosis

Tuberculosis or TB was uncommon in the developed world and many believed it had been conquered. Over 2 billion people, almost one third of the world's population, are infected with the TB bacteria. Most people who carry the bacteria in their body have no symptoms but in 2014 9 million people fell ill with TB and 1.5 million died from the disease. Over 95 per cent of TB deaths occur in low- and middle-income countries, and it is among the top five causes of death for women aged 15 to 44. In 2013, an estimated 550 000 children became ill with TB and 80 000 HIV-negative children died of TB. TB is a leading killer of HIV-positive people, causing one fourth of all HIV-related deaths.

The costs associated with the treatment of TB are not just on the sufferers. In India over 300 000 children leave school to care for their parents who are sick with TB. Some estimates place the cost of TB in developing countries at around $12 billion annually.

Some success stories in world health are shown in figure 4. A specific case is that of TB in China where they adopted the DOTS (directly observed treatment, short-course) strategy.

FIGURE 4 Total funding for malaria (WHO)



ACTIVITIES

IDENTIFY

1 What were the previous development goals of the United Nations called? What time period did they cover?

EXPLAIN

2 Referring to figure 1, explain how the malaria transmission cycle works.

APPLY

3 What are the problems associated with the treatment of malaria in the developing world?

INVESTIGATE

4 Identify an organisation that aims to fight malaria. Research and report on where they are located, what initiatives they are undertaking and what their successes and failures have been.

5 How many people are affected by TB? How does this differ from the number of people who carry the TB bacteria?

6 Use figure 4 (a and b) to answer the following.

- **a** Comparing 2006 to 2013, who was responsible for the most funding for TB?
- **b** Which year saw the greatest relative increase in funding in the African region?
- **c** Calculate the value and year of the highest overall funding worldwide.
- **d** What does this figure suggest about the funding of malaria control?
- **e** Account for the disparity between domestic and worldwide funding.

19.10 What are some trends in wellbeing — sustainability?

19.10.1 Stewardship

Understanding the link between ecological services, human actions and wellbeing is important as it can lead to more sustainable practices. By having a greater focus on the sustainability of our environment we can potentially develop higher levels of human wellbeing. Undertaking the approach of **stewardship** in the management of environments benefits not only the environment, but also the wellbeing of those people who use the environment.

stewardship an ethic that embodies the responsible planning and management of resources

A greater understanding of the way in which all aspects of the environment link to human wellbeing (figure 1) means that to increase the wellbeing of people there is a need to ensure environments are managed in a sustainable manner.

With a greater understanding of **ecological services** we are better placed to be able to manage them in a sustainable way, thereby ensuring increased wellbeing for citizens of the world. Figure 2 shows the way in which ecological services are linked to one another and how managing them is important in maintaining the habitability and livelihood of people on the planet.

ecological services any beneficial natural process arising from healthy ecosystems, such as purification of water and air, pollination of plants and decomposition of waste

The Sustainable Society Index (SSI; discussed earlier in subtopic 12.9) originally placed a value on 21 different factors that could be categorised as either social, political, economic or environmental (see figure 3).

FIGURE 1 Interaction of environmental change and human wellbeing

FIGURE 2 Ecological services

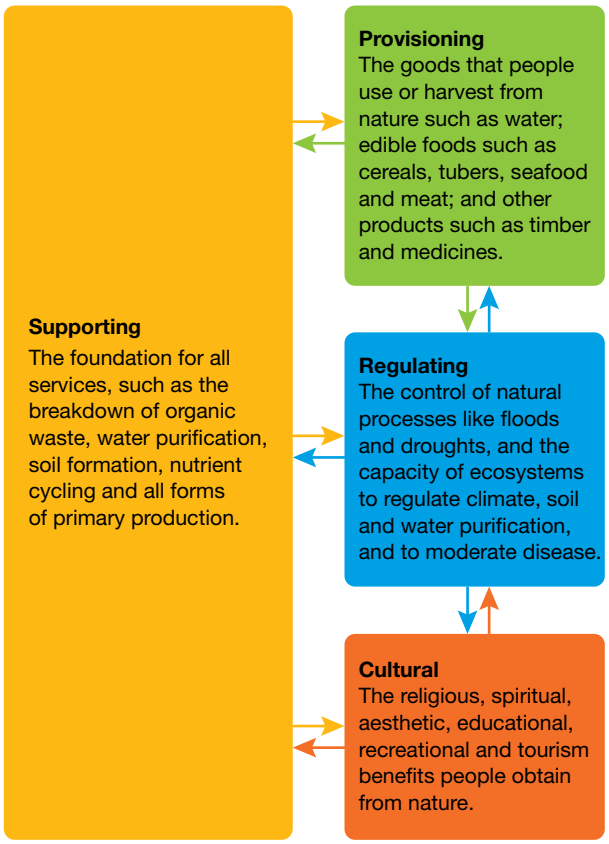
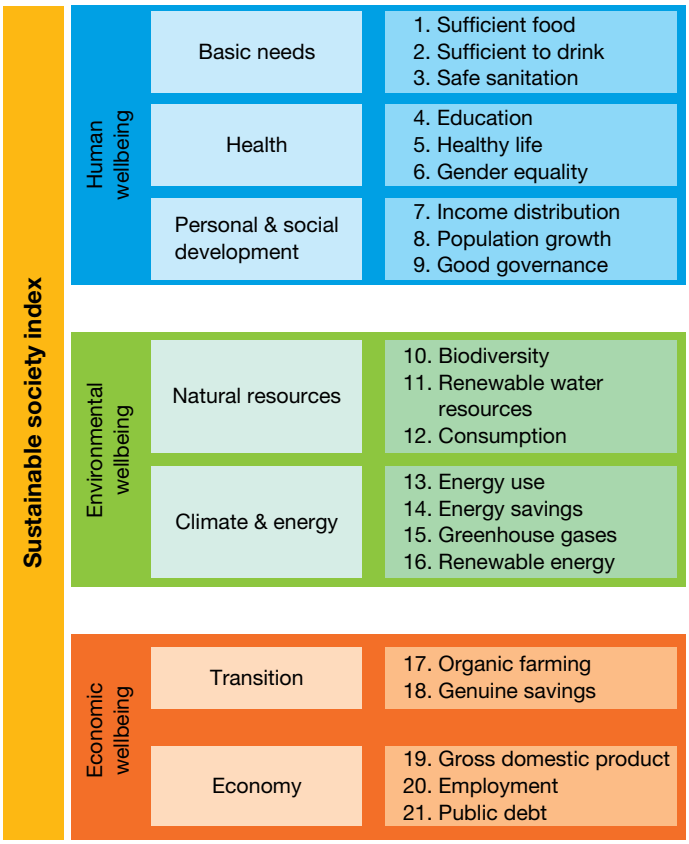


FIGURE 3 Sustainable Society Index (SSI) framework



The SSI can be used to calculate a 'score' for nations in each of the 21 different categories, with the score being a representation of how well that particular area is being managed. The aim is for nations to see their graph as large and round as possible. The spider web reveals the score for each indicator: the centre of the web represents a score of 0 or no sustainability, while the outer circle represents a score of 10, or full sustainability. Figures 4 and 5 shows the difference in SSI between two very different nations in Asia: Japan (developed) and India (developing). It can be seen that Japan has a more regular and much broader shape.

FIGURE 4 SSI for Japan

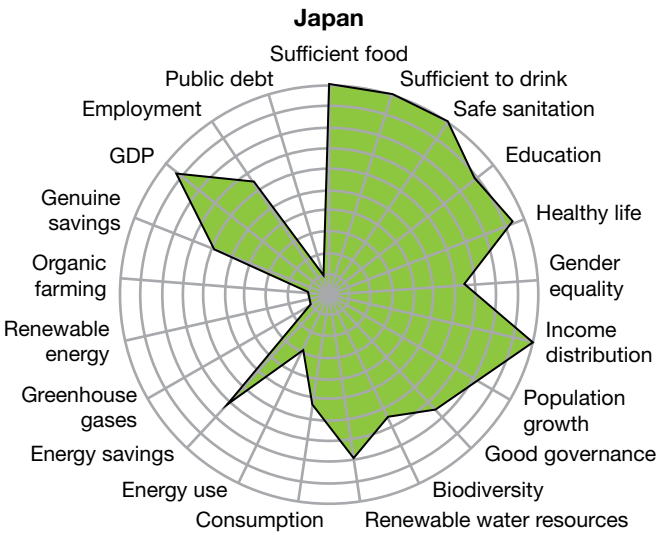


FIGURE 5 SSI for India

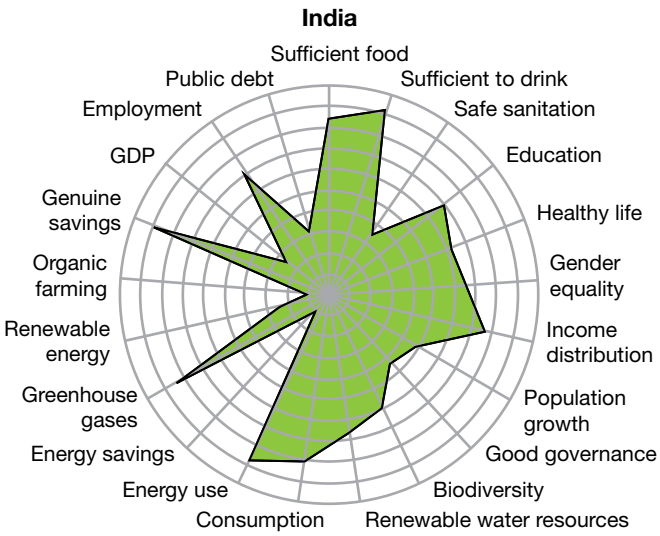


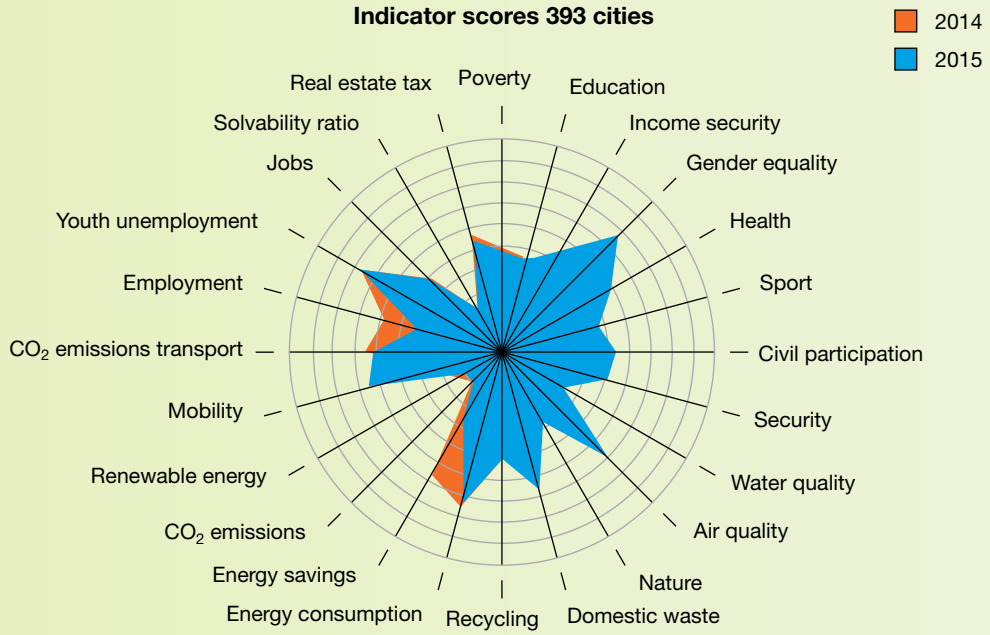
FIGURE 6 Compare the working conditions in these two factories in Japan and India. How do you think the condition in each factory contributes to the economic wellbeing of its workers?

FOCUS ON FIELDWORK

Create your own index

The SSI has been updated for use by Dutch cities and now has 24 different indicators (see figure 7). To create one for your local area, select at least eight of these indicators to create your own spider web. Once you have chosen these, you need to conduct some primary research. You can do this in person with your classmates or friends, or by using an online survey tool such as SurveyMonkey. Once you have your results, draw your own web. You could compare it to those of your classmates to see the different results. *Note:* If other classes have completed this activity, you could compare your results to theirs.

FIGURE 7 The weighted average scores of the 24 indicators for all 393 cities in The Netherlands (a developed country) in 2014 and 2015



ACTIVITIES

IDENTIFY

1 Refer to figure 1 and list how each of the ***environments*** has a positive impact on human wellbeing.
2 Refer to figure 2 and create your own acronym to help you remember the ecological services.

EXPLAIN

3 How are the ecological services interconnected?

APPLY

4 Using figures 4 and 5, compare the indicators for Japan and India.
   a Which components does Japan score highest in? Why is this the case?
   b Which components does India score highest in? Why is this the case?

19.11 Is Norway the best place on Earth?

19.11.1 Norway

Norway has consistently held the number one position in the Human Development Index (HDI) rankings for 10 of the past 12 years. This is largely because of its high levels of development in health, education and the economy. Norway makes up the western part of Scandinavia and shares borders with Sweden, Finland and Russia (see figure 1).

FIGURE 1 Norway and Scandinavia

Source: Spatial Vision

Much of Norway's wealth is derived from its location on the North Sea and its proximity to oil. In 2015 Norway ranked fifteenth in the world in oil production, producing almost two million barrels per day. The value to the economy is around A$88 billion, which is 46 per cent of their exports.

Norway has around 40 accredited, plus several private, higher education institutions. With the exception of some private university colleges, all higher education institutions are state-run and in general, tuition fees are not required.

Norway spends just under US$10 000 per person per year on health care, the highest in the world. Health care is free for children aged 16 or younger, and for pregnant and/or nursing women. Everyone else must pay a fee, which is currently on average US$325 a year. This entitles them to coverage of all immediate healthcare costs in the event of having to be admitted to a hospital's emergency department.

ACTIVITIES

IDENTIFY

Refer to figure 2 to answer the following.

1. Which quadrant has the highest elevation?
2. What is the aspect of the slope at Brimnes?
3. Estimate the area of the snow-covered mountain Hardangerjokulen on the eastern side of the map.
4. What is the gradient between the highest point of the mountain and the spot height 1306 metres just south of Brimnes?
5. What is the local relief between the highest point of the mountain and the spot height 1306 metres just south of Brimnes?

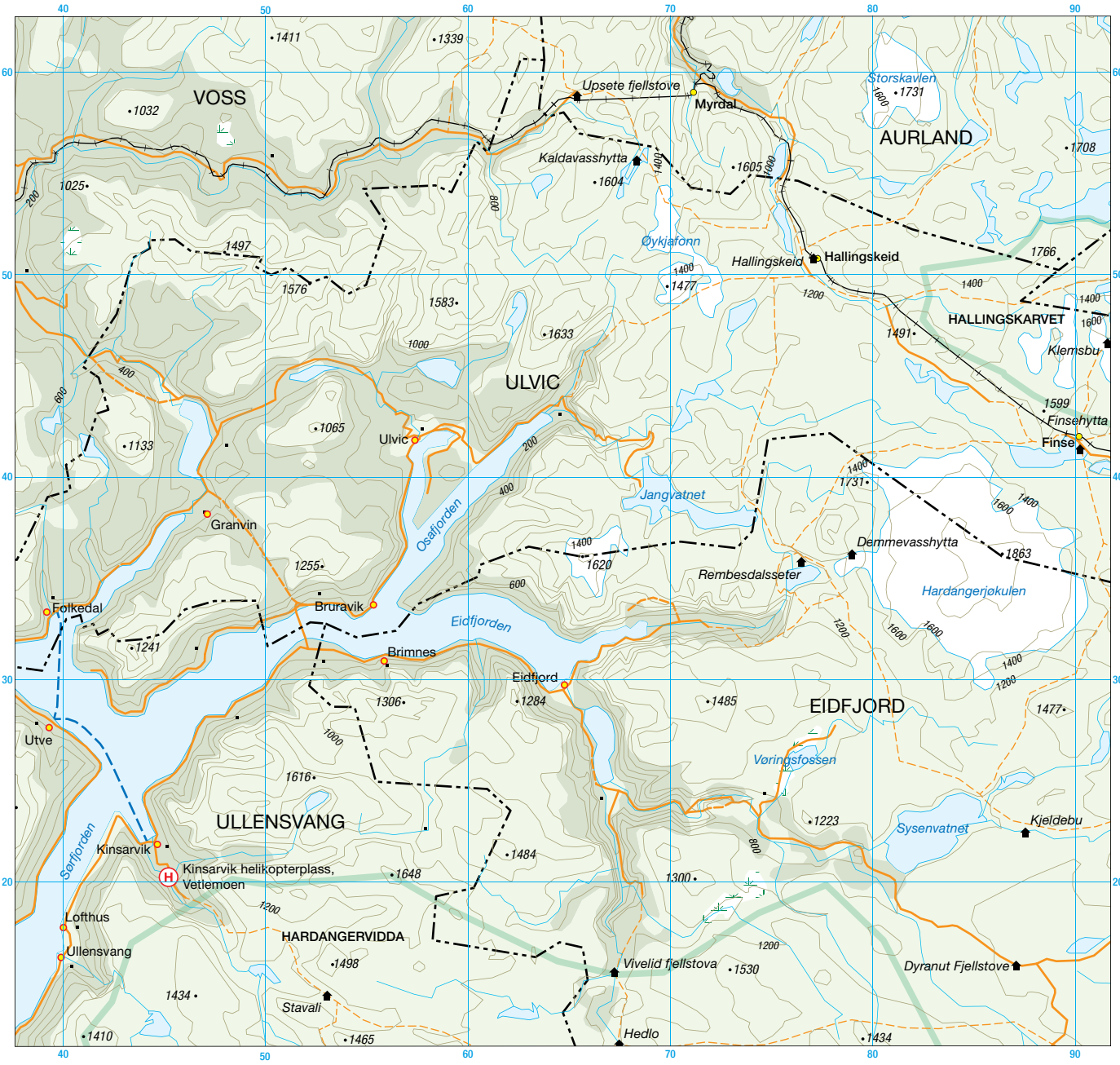
PREDICT

6. a Suggest impacts that drilling for oil could have upon human wellbeing and the environment.
   b How might these impacts affect the HDI of a country?

INVESTIGATE

7. Norway scores highly in a number of other categories as well as those on the HDI. Create a brochure aimed at convincing a person to emigrate to Norway. Include images and information as to why someone would want to live there.

FIGURE 2 Topographic map of Ulvik



Source: © Kartverket, www.kartverket.no

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19.12 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

19.3 SkillBuilder: Constructing and interpreting a scattergraph

19.3.1 Tell me

What is a scattergraph?

A scattergraph is a graph that shows how two or more sets of data, plotted as dots, are interconnected. This interconnection can be expressed as a level of correlation.

Why is a scattergraph useful?

Scattergraphs are used to show us a visual image of the interconnection of factors. Sometimes it is difficult to see the relationship until the sets of data are presented visually. You will find that the graphs clearly show the interconnection of factors where clusters of dots form, while other dots stand out alone.

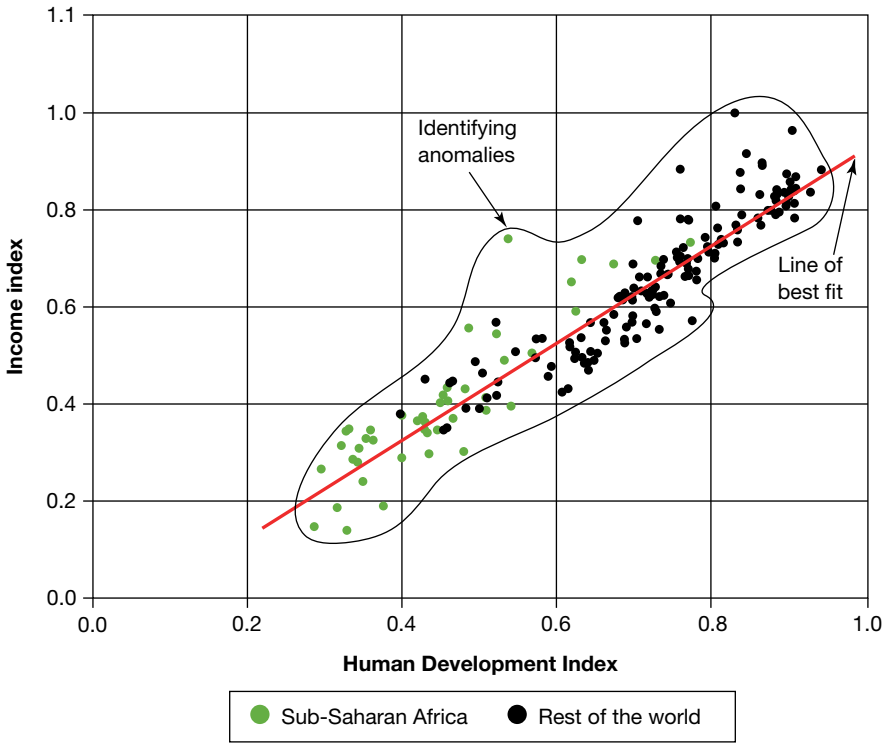
Scattergraphs are also useful for:

- analysing the degree of connection — perfect correlation, positive correlation, negative correlation and no correlation
- testing our hypothesis on a topic
- testing whether there is a relationship between sets of data gathered during fieldwork.

Model

Interpretation of this scattergraph shows a positive correlation between income and the Human Development Index. As the level of income increases, the level of human development increases. Countries in sub-Saharan Africa (green dots) can be seen predominantly at the lower end of the line of best fit. This indicates that a low level of income puts these countries at the low end of the Human Development Index. Most of these countries fall at less than 0.4 on both axes — the Human Development Index and the income index. There are a few countries in the sub-Saharan region that do better but these do not get beyond 0.8 on either index.

FIGURE 1 Scattergraph showing the interconnection between income and the Human Development Index for sub-Saharan Africa and the rest of the world, 2011



Source: © UNDP.

A good scattergraph:

- is drawn in pencil
- has ruled axes
- has labelled axes
- uses small dots plotted accurately
- shows a line of best fit
- includes a clear title.

A good interpretation of a scattergraph:

- identifies and communicates key features such as the levels of each feature on each axis and the relationship to the line of best fit.

19.3.2 Show me

How to construct and interpret a scattergraph

You will need:

- two sets of data
- a piece of graph paper
- a light-grey lead pencil
- a ruler.

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eLesson
Constructing and interpreting a scattergraph
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Weblink
Human Development Report 2012 Africa

Procedure:

To complete a scattergraph, you must have two sets of information about which you want to test the interconnection. Use the **Human Development Report 2012 Africa** weblink in the Resources tab to find a range of indicators that you can compare for a few countries (see pages 154–67 of the report). In the following example, we use the data on food supply and road network density (pages 156–57 and 162–63 of the report).

Creating a scattergraph

STEP 1

Choose two sets of data for a topic that might be interconnected. In other words, there might be a cause-and-effect relationship between the two factors — for example, road network density might affect food supply.

TABLE 1 Food supply and road density in Africa

Countries	Food supply, Kcal per capita per day 2005–2007	Road density network, metres per capital 1999–2008
Angola	1949.3	3.7
Benin	2512.3	2.6
Botswana	2235.0	13.8
Burkina Faso	2669.0	6.7
Burundi	1679.7	1.8
Cameroon	2259.0	3.0
Cape Verde	2549.3	3.1
Central African Republic	1956.0	6.6
Chad	2040.0	4.0
Comoros	1857.3	1.6
Congo, Democratic Republic of the	1585.3	2.8
Congo, Republic of	2512.7	4.7
Côte d'Ivoire	2514.7	4.4
Equatorial Guinea	–	5.5
Eritrea	1586.7	1.1
Ethiopia	1951.7	0.6
Gabon	2730.0	6.8
Gambia	2345.3	2.6
Ghana	2849.0	2.7
Guinea	2529.3	5.1
Guinea-Bissau	2288.0	2.7
Kenya	2060.0	1.8
Lesotho	2468.3	3.0
Liberia	2163.3	3.7
Madagascar	2132.7	3.2
Malawi	2127.0	1.3
Mali	2579.3	1.4
Mauritania	2822.7	3.4
Mauritius	2935.7	1.6
Mozambique	2071.0	1.4
Namibia	411.0	35.1
Niger	449.4	1.3
Nigeria	1513.1	1.4
Rwanda	1679.1	1.6

(continued)

Countries	Food supply, Kcal per capita per day 2005–2007	Road density network, metres per capital 1999–2008
Sao Tomé and Príncipe	3407.8	2.3
Senegal	1168.4	1.3
Seychelles	–	5.9
Sierra Leone	1429.5	2.5
South Africa	4212.0	8.1
South Sudan	–	–
Swaziland	1176.5	3.3
Tanzania, United Republic of	1240.0	2.1
Togo	1191.6	2.1
Uganda	1566.4	2.7
Zambia	2266.8	6.5
Zimbabwe	503.5	7.7

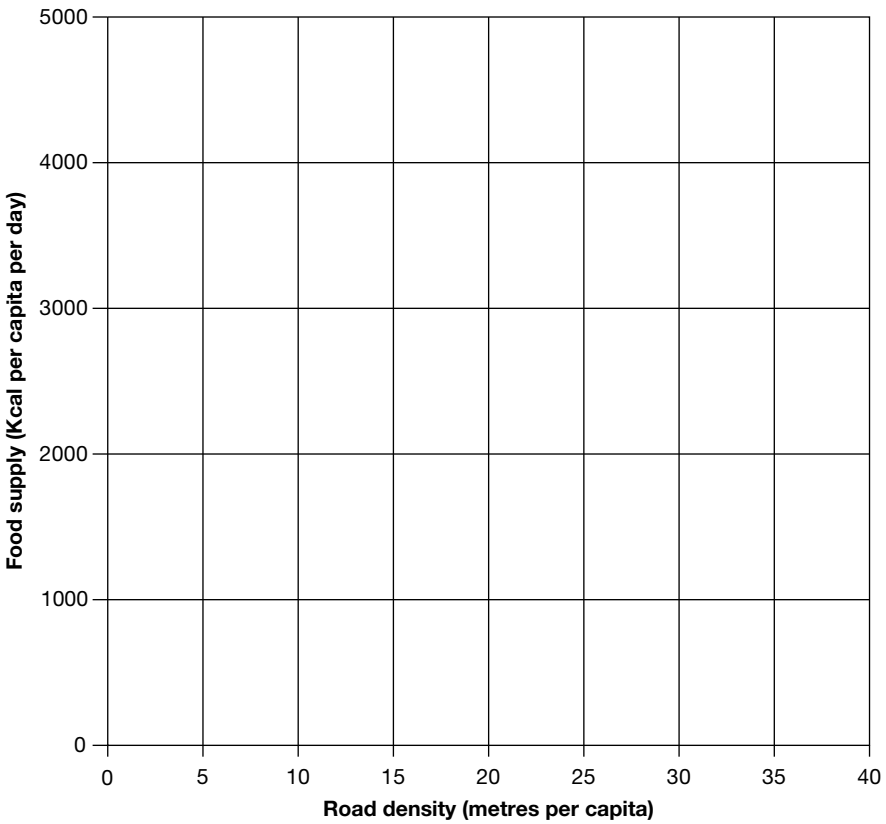
STEP 2

Decide which factor you will place on the base line, or horizontal axis, and which factor you will place on the vertical axis. In this case, we will place road density on the horizontal axis and food supply on the vertical axis.

STEP 3

Look at the range of numbers in the data to be plotted and decide on a scale for each axis. Ensure that the maximum and minimum numbers will fit on the scale. Draw a graph outline and label the axes, including the units of measurement.

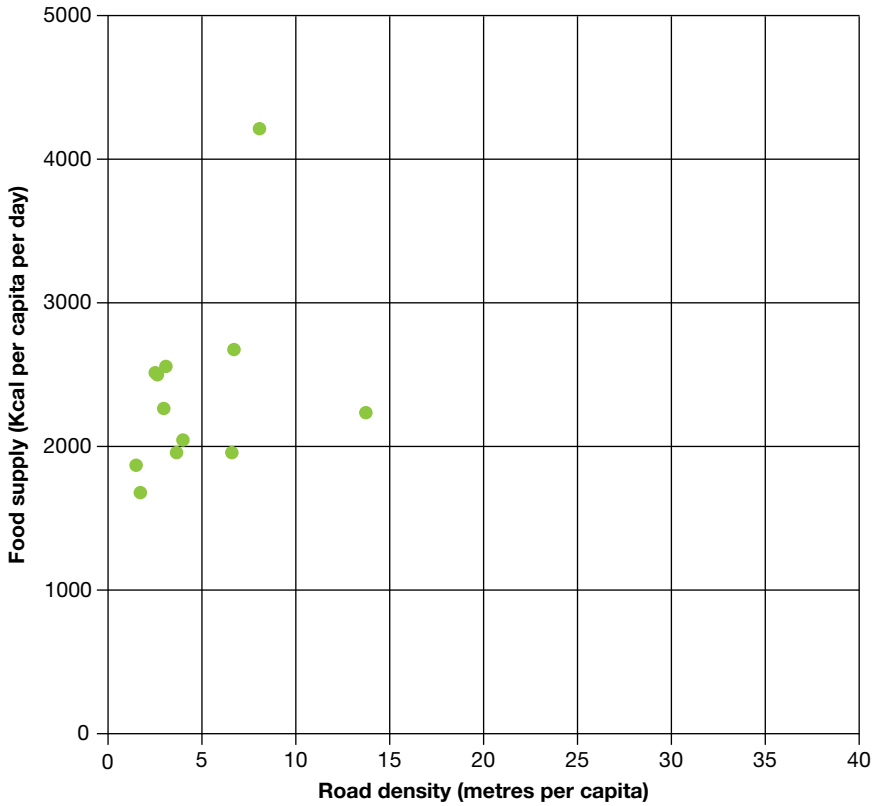
FIGURE 2 The graph base



STEP 4

Plot all the data on the graph. Mark with a small dot the point where both data values intersect. Angola's data, for example, would intersect at about the 2000 line on the vertical axis and just before the 5 line on the horizontal axis.

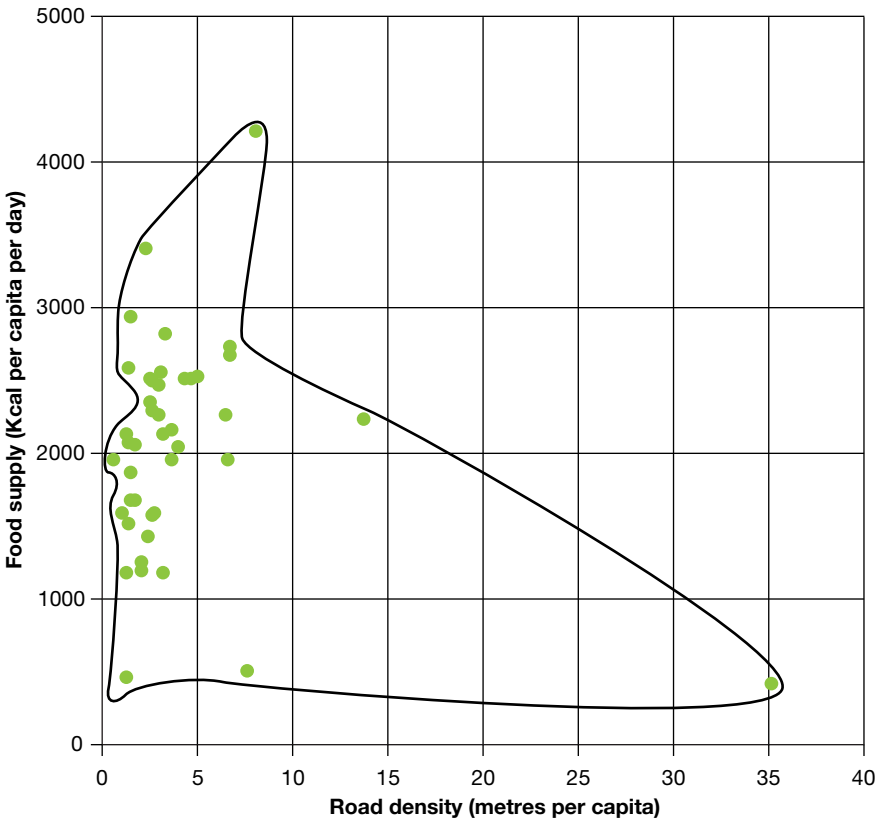
FIGURE 3 Starting to plot the data



STEP 5

Now draw a pencil outline around all the dots. This will show you the trend of the data and identify the anomalies. These anomalies occur where the outline bulges.

FIGURE 4 Identifying the trend



STEP 6

Now draw a line of best fit — that is, a line that has equal points either side of it. To do this, sit your ruler on its narrow edge on the graph and move it around until there is a roughly equal number of dots on both sides of the ruler. Draw along the ruler's edge to create the line of best fit, or trend line.

STEP 7

Using the models in figure 6 below, determine whether the shape shows:

- positive correlation — the line of best fit goes from bottom left to top right
- negative correlation — the line of best fit goes from top left to bottom right
- a perfect correlation — all dots sit on the line of best fit rather than on either side of it
- no correlation — the dots are randomly scattered rather than in a straight line.

The closer the points are to the line, the stronger the relationship. Note that the 'odd' points are considered anomalies.

FIGURE 5 Drawing the line of best fit

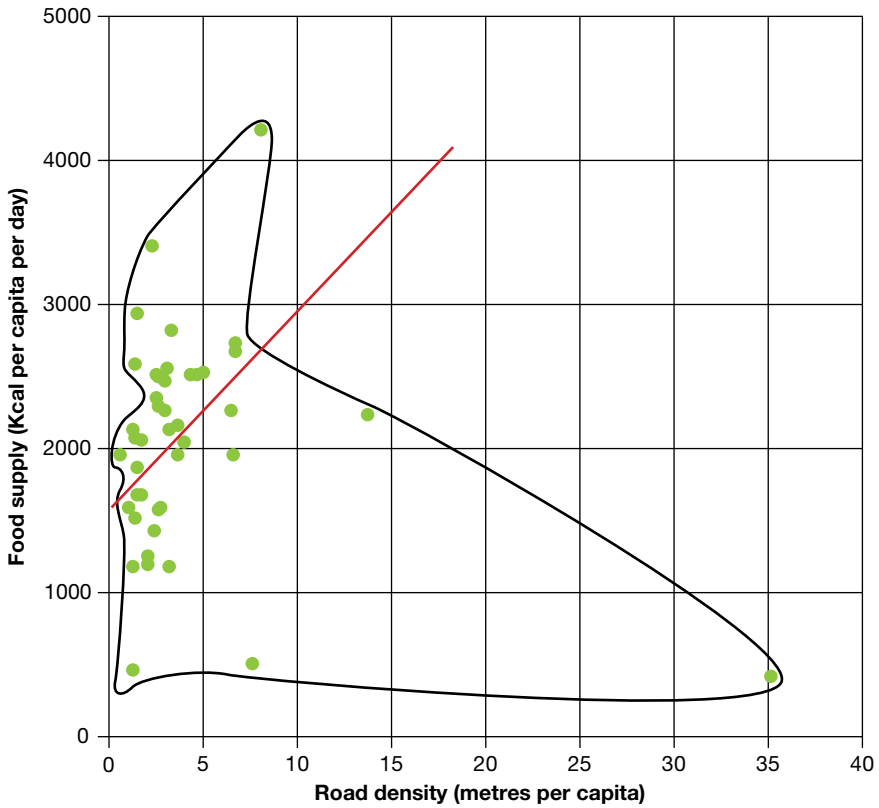
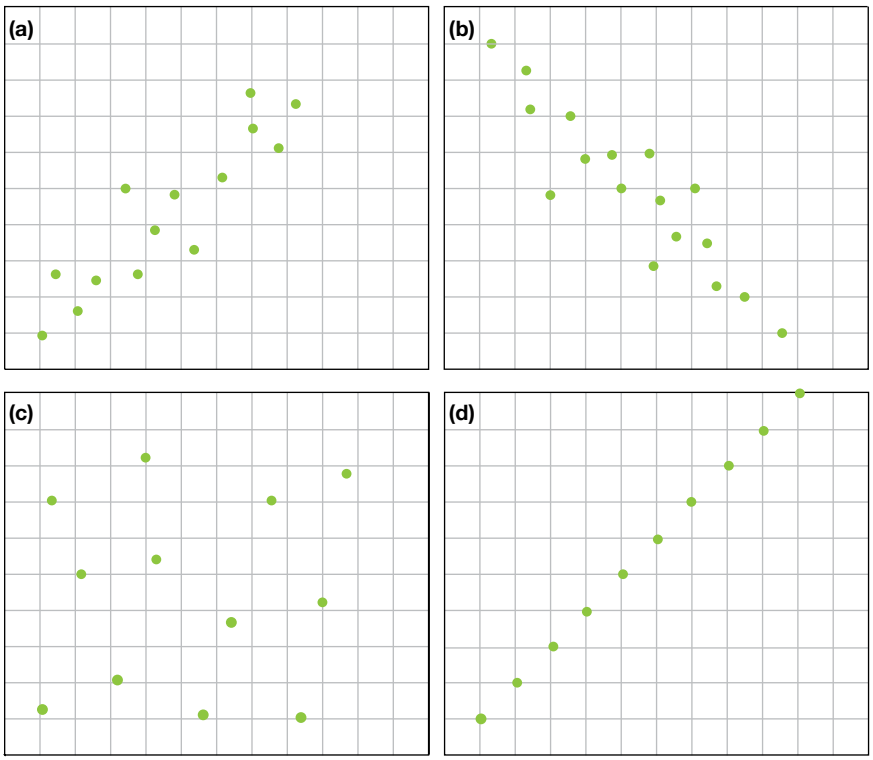


FIGURE 6 Correlation patterns (a) Positive correlation (b) Negative correlation (c) No correlation (d) Perfect correlation



STEP 8

Give your graph a title.

Interpreting a scattergraph

To interpret a scattergraph is to write a few sentences explaining your findings. Use the following format.

- State the type of correlation.
- Describe what is happening on the graph regarding the two factors.
- Discuss any anomalies.
- Be specific about any particular places or countries you want to use as an example.
- Write a concluding statement.

19.3.3 Let me do it

Developing my skills

Using the following data, complete a scattergraph to show the relationship between life expectancy and years of schooling. Write a paragraph interpreting the finished graph, using the steps outlined above.

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Interactivity
Constructing and interpreting a scattergraph
Searchlight ID: int-3374

TABLE 2 Life expectancy and years of schooling, selected countries, 2012

Country	Life expectancy (years) HDI Report 2012	Years of schooling HDI Report 2012
Australia	81.8	12.0
China	73.5	7.5
Democratic Republic of the Congo	48.4	3.5
Egypt	73.2	6.4
India	65.4	4.4
Japan	83.4	11.6
Kenya	57.1	7.0
Norway	81.1	12.6
Syria	75.9	5.9
USA	78.5	12.4

Questions

1. Is there a correlation between life expectancy and years of schooling?
2. What type of correlation can you identify?
3. In your scattergraph, are there any anomalies?
4. What type of relationship between the two factors would result in an anomaly?
5. From this correlation pattern, where would you expect the following countries to fit on the graph?
   a. United Kingdom
   b. Indonesia
   c. New Zealand
   d. Brazil

Checklist

I have:

- drawn in pencil
- ruled the axes
- labelled the axes
- used small dots plotted accurately
- shown a line of best fit
- included a clear title
- identified and communicated key features such as the relationship to the line of best fit.

Skills questions

1. Scattergraphs are used to show:
   a. the distribution of people across the world
   b. the shape of the land between two places
   c. the interconnection between two factors
   d. the dots representing a set of data.
2. A scattergraph includes information about:
   a. a single set of information
   b. a mass of non-related information
   c. no factors, but points
   d. two or more sets of information being compared.
3. Why and how do you look for a line of best fit?
4. Explain the difference between a positive correlation and a negative correlation. Refer to figure 6 if necessary.

19.7 SkillBuilder: Interpreting a cartogram

19.7.1 Tell me

What is a cartogram?

A cartogram is a diagrammatic map; that is, it looks like a map but is not a map as we usually know it. These maps use a single feature, such as population, to work out the shape and size of a country. Therefore, a country is shown in its relative location but its shape and size may be distorted. Cartograms are usually used to show information about populations and social and economic features.

Why is a cartogram useful?

Cartograms show value by area, allowing patterns to become obvious that are not identifiable on traditional maps. Computers have made the development of cartograms easy. Programs such as Worldmapper provide a range of cartograms. You will find these diagrammatic maps fascinating, and each readily signifies the importance of a feature in a country.

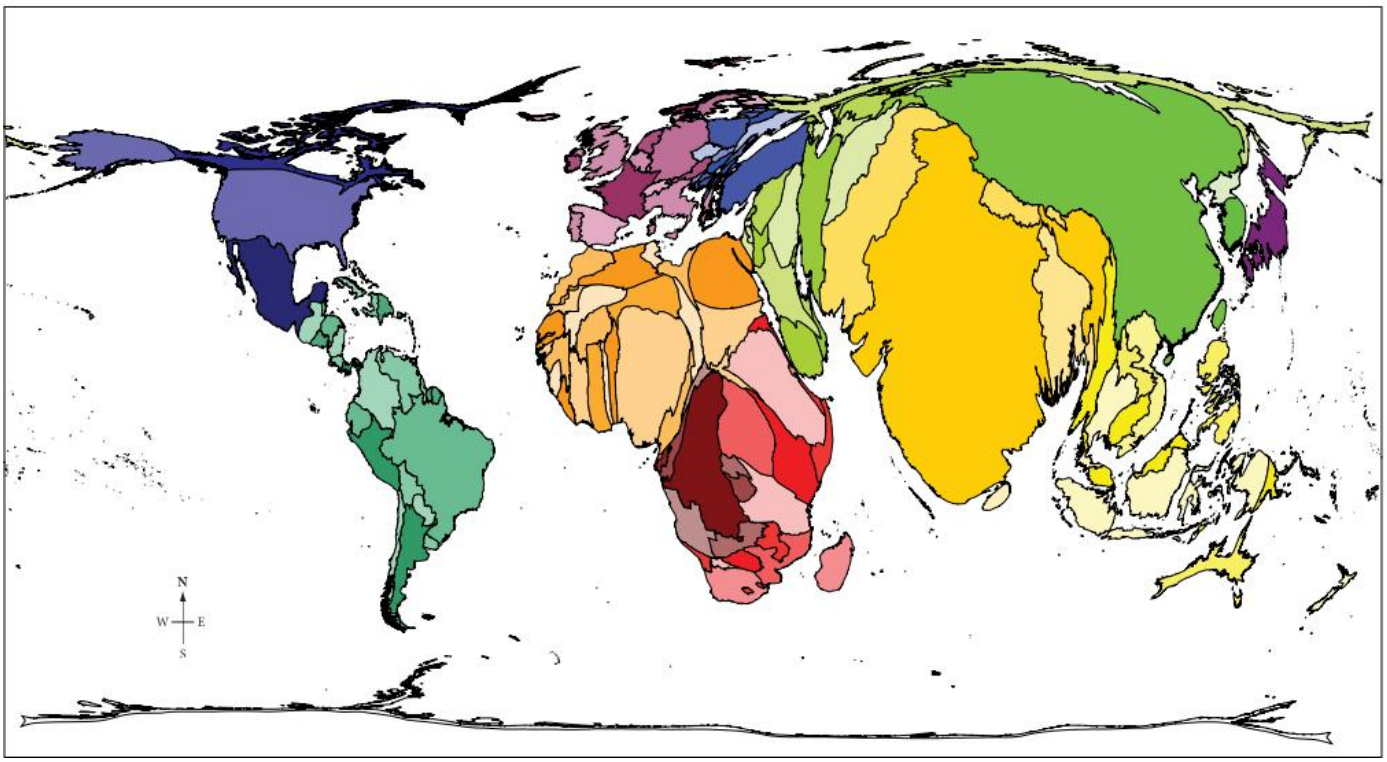
Cartograms are useful for:

- comparing statistical country data quickly and easily
- representing the proportion of a feature in a country
- identifying regional differences
- identifying global differences.

Model

The figure 1 cartogram or proportional map shows the estimated distribution of the world's population in 2050. It is evident that the greatest proportion of the world's population is expected to live in Africa and Asia as these mapped countries are distorted larger than their size on a standard world map. It is also evident that regions in South America, North America and South-East Asia are not expected to see massive population growth. Australia is distorted to be smaller than it is on a standard world map, indicating that population is not expected to grow too much here.

FIGURE 1 Cartogram showing estimated world population, 2050



Source: Spatial Vision

A good interpretation of a cartogram:

- identifies patterns
- identifies the countries that appear largest and those that appear smallest
- clearly represents and communicates the data.

19.7.2 Show me

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eLesson
Interpreting a cartogram
Searchlight ID: eles-1757

How to interpret a cartogram

You will need:

- a cartogram
- an atlas.

Procedure:

To interpret a cartogram, you need a computer-drawn cartogram like figure 1. These can be found on the internet at sites such as Worldmapper.

STEP 1

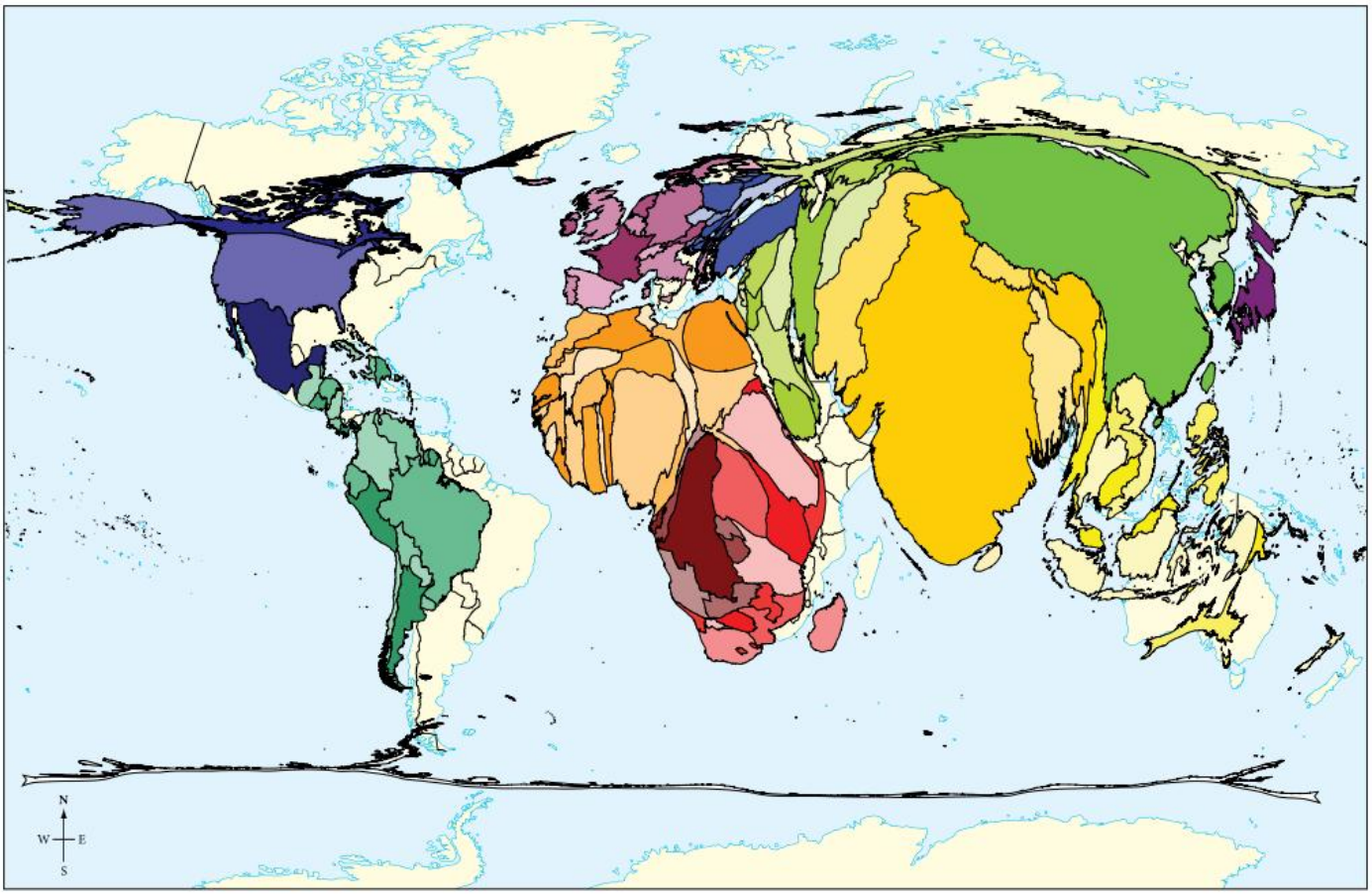
Read the title and make sure that the meaning of the terms is clear to you. In figure 1, the world's population in 2050 is mapped.

STEP 2

Study the cartogram, looking for the largest and the smallest shapes on it. With your knowledge of the world map, or by using an atlas, identify those countries and continents that are distorted in size and shape. For example, in figure 1, Africa and Asia are expanded, indicating a large estimated growth in population, but Australia has almost disappeared, indicating a small expected growth in population.

Figure 2 shows an ordinary map of the world with a cartogram superimposed on it.

FIGURE 2 Cartogram of the world's population in 2050 superimposed on a world map



Source: Spatial Vision

STEP 3

Interpreting the cartogram requires a description of the interconnection between the feature that has been mapped and the proportional size of a country.

Look for these aspects:

- countries that appear larger
- countries that appear smaller
- countries and continents whose shapes have been distorted.

Write a few sentences describing the feature mapped, as has been done above figure 1.

19.7.3 Let me do it

Developing my skills

Study the cartogram showing the proportion of the world's population living on less than US$1.25 per day in subtopic 19.4 (figure 2). Write a description of the countries in which people live on less than a dollar a day.

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Interactivity
Interpreting a cartogram
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Questions

1. Which continent is the enlarged shape at the centre of the map?
2. How has the shape of Australia been distorted? What does this tell us about the number of people living on less than a dollar a day in Australia?
3. Which other continents have been reduced in size by the cartogram?
4. Which continents have the most countries that have been enlarged by the cartogram? What does this say about the poverty levels in those countries?
5. How do you think this map might be changed by 2030?

Checklist

I have:

- identified patterns
- identified the countries that appear largest and those that appear smallest
- clearly represented and communicated the data.

Skills questions

1. Cartograms are used to:
   a. show where something occurs
   b. distort country shapes
   c. represent a feature proportionally
   d. show the area of a country.
2. Cartograms include information about:
   a. one feature
   b. cause and effect
   c. ideas
   d. relationships between several features.
3. Why is it useful to map such data in a proportional format?
4. Why would you not use a cartogram to show topography across the world?

19.12 Review

19.12.1 Review

1. How would you define the term *wellbeing*?
2. Define *living standards* in your own words.
3. Consider the data regarding life expectancy provided in table 1.
   a. Draw a bar chart to represent the information, or annotate a world map using an appropriate legend and data labels.
   b. Does the region in which these countries reside and their corresponding results surprise you? Why or why not?
   c. Why is life expectancy typically higher in more developed countries than in less developed countries? Draw two mind maps, one for each type of country, to illustrate the differences.

TABLE 1 Life expectancy at birth

Top countries	Life expectancy (years)	Bottom countries	Life expectancy (years)
Hong Kong	84	Swaziland	49
Japan	84	Lesotho	50
Spain	83	Central African Republic	51
Switzerland	83	Sierra Leone	51
Italy	83	Chad	52
Liechtenstein	82	Cote d'Ivoire	52
Singapore	83	Angola	52
France	82	Nigeria	53
Australia	82	Mozambique	55
Iceland	82	Guinea-Bissau	55
Israel	82	Somalia	55
Sweden	82	Cameroon	55
Luxembourg	82	South Sudan	56

Source: World Bank Population Data (2014).

4. Qualitative and quantitative indicators allow us to gain very different perspectives on a country's wellbeing.
   a. Why might one be more useful than the other in particular situations?
   b. Despite their shortcomings, how do indicators allow us to address global inequalities?
5. The use of child soldiers poses grave risks to the world's young citizens, particularly in some war-torn countries. Using up-to-date information about where children are currently engaged in conflict (use the **Child soldiers** weblink in the Resources tab), create a world map with an appropriate legend for showing where child soldiers are still used.
6. Write a short paragraph to explain ways in which aid is provided to less developed countries.
7. Which type of aid is more effective: top-down or bottom-up? Explain why they may result in different outcomes.
8. In what other ways does the provision of aid by more developed to less developed countries help to promote harmony and goodwill in the global community?

19.12.2 Reflect

9. Consider the various types of aid provided to less developed countries. Which do you think is the most effective? Justify your answer with some real-life examples.
10. In small groups, discuss how you or your school has been involved in a project supporting less developed communities (here in Australia or abroad).

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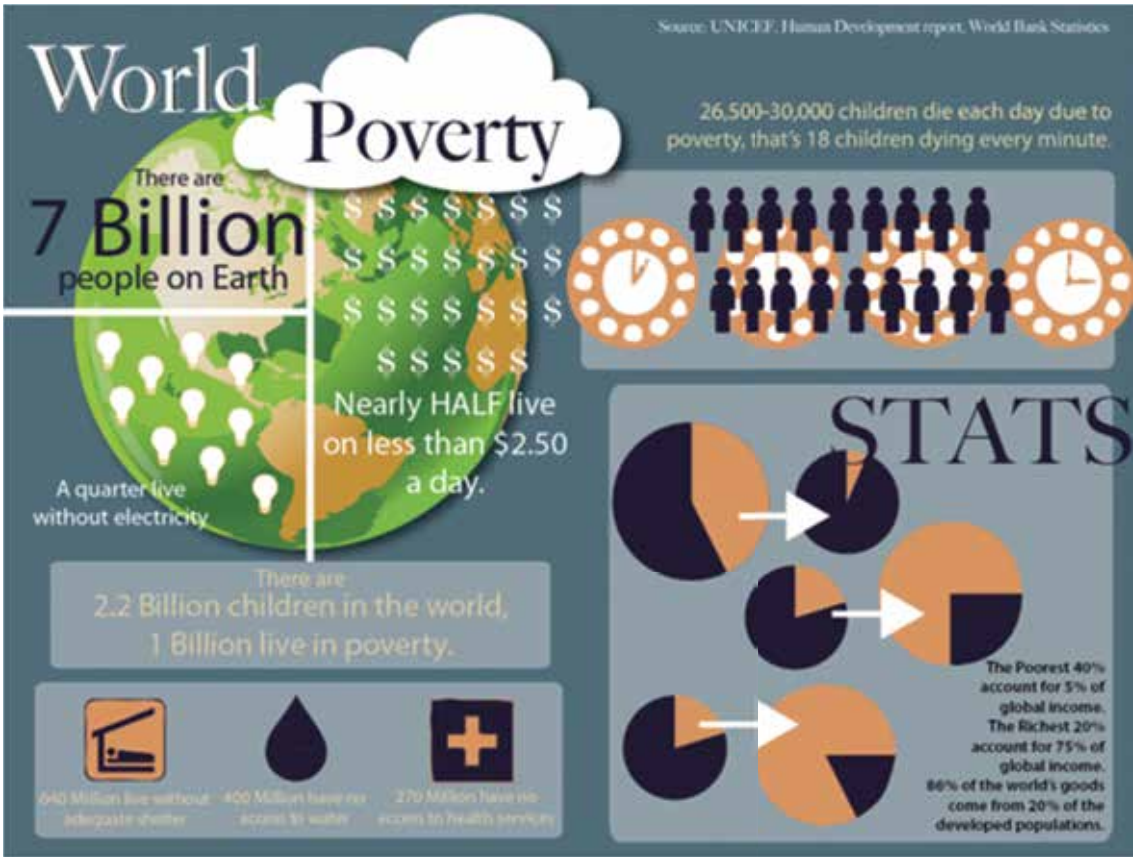
Weblink
Child soldiers

11. What do you think schools in less developed countries need most? In a small group, make a list of 10 items you think would be most sought after. Do some research to find an aid organisation that works to build schools and improve education in another country. What do they say they need most? Find out if someone who has volunteered in a school in a less developed country (a teacher, parent or ex-student) could speak with your class about their experiences.
12. In pairs, design and conduct a survey to find out about people's level of awareness of poverty in the world and what is being, or can be, done about it. Canvass a wide range of topics such as:
    - Do they know the number of people living in poverty worldwide?
    - What is their understanding of poverty in less developed countries?
    - Have they been personally involved in helping people in developing countries, and in what ways?
    - What would encourage them to become more involved?

    Use ICT tools to develop your survey questionnaire, to document your data and to interpret the results (e.g. use spreadsheets to document your data and generate a graph of the results). Prepare a short report on your findings using Word or a similar program, adding your data analyses as appendices. An alternative activity would be to develop an A3-sized myth-busting infographic (see figure 2 for an example) that would help dispel some of the myths and create greater awareness about poverty facts and figures.

FIGURE 2 UNICEF and World Bank statistics infographic



Source: © Sonia Pantoja.

13. Consider figure 3.
    a. What does this photograph tell you about the living conditions of the family shown?
    b. Do you think this photograph was taken in a less developed or more developed country? Justify your answer.
    c. Using the internet, find another photograph of a family somewhere in the world and provide annotations evaluating their living conditions.

FIGURE 3 A picture can be worth a thousand words for an observant geographer.

14. Civil and international wars cost a country in more ways than one — not just economically, but also in terms of devastation to the population, infrastructure, security and arable land. How can conflict impact on poverty? Select a country in sub-Saharan Africa and conduct some additional research online about the historical impacts of conflict on the wellbeing of its people.
15. Is the world getting better or worse? Is the world a very different ***place*** for adults than it is for children? In light of your studies on wellbeing, what do you think is happening?

Global population diversity

CHAPTER 20

Spatial variations in human wellbeing

20.1 Overview

20.1.1 Introduction

Human wellbeing is different right across the globe. In some nations the reality of not having two cars may be seen as a problem, whilst in others it may be not having enough to eat. There are many reasons for differences in wellbeing between and within countries. In 2050, it is estimated that the world's population will be between 8 and 11 billion. It is not just a matter of how many people we can fit in a particular place, but also the manner in which we live that affects our wellbeing.

Starter questions

1 Why would the estimates for the world population for 2050 vary so widely?
2 Think back to the definition of wellbeing you covered in chapter 15.
   a How might the number of people in a given ***place*** be ***interconnected*** with their wellbeing?
   b How could the wellbeing of a particular ***place*** have an impact on the number of people living at that location?

Inquiry sequence

		Syllabus outcomes
20.1 Overview		
20.2 What are the spatial variations between countries?		GE5-6
20.3 What are the spatial variations within countries?		GE5-6
20.4 SkillBuilder: Using Excel to construct population profiles	eBook plus ONLINE ONLY	GE5-7
20.5 What are the internal reasons for variations?		GE5-6, GE5-7, GE5-8
20.6 What are the external reasons for variations?		GE5-6, GE5-7, GE5-8
20.7 What are the consequences of spatial variations for the middle class?		GE5-6, GE5-7, GE5-8
20.8 How does population affect development and wellbeing?		GE5-6, GE5-7, GE5-8
20.9 How does gender affect wellbeing?		GE5-6, GE5-7, GE5-8
20.10 SkillBuilder: How to develop a structured and ethical approach to research	eBook plus ONLINE ONLY	GE5-7
20.11 Investigating topographic maps: What is wellbeing like in Japan and Kenya?		GE5-7
20.12 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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A long life
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20.2 What are the spatial variations between countries?

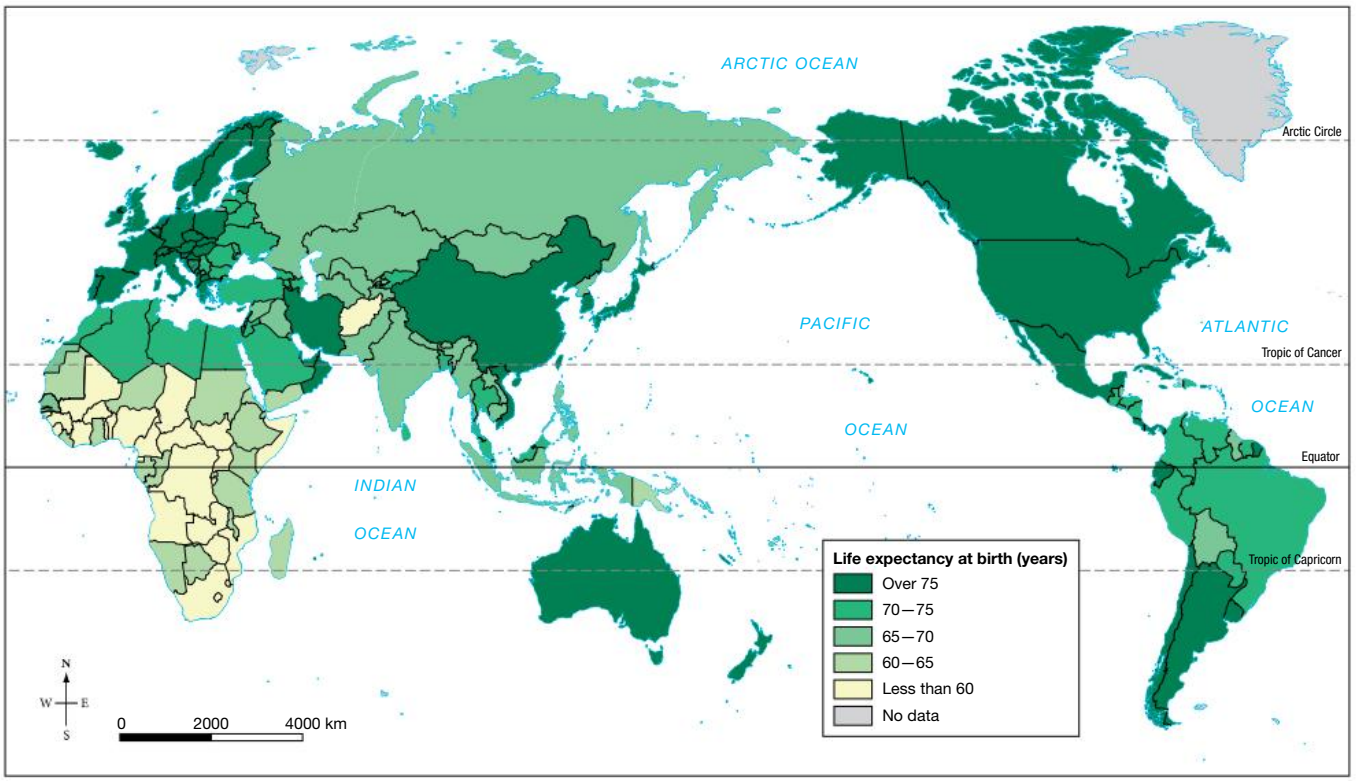
20.2.1 Life expectancy

Spatial variations exist across the globe for a range of wellbeing indicators. One of the major indicators of wellbeing is life expectancy. On average across the globe people are now expected to live longer than any time in history. This has a significant impact on current and future population levels. This increased life expectancy is linked to a fall in child mortality rates across the world.

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

How long we can expect to live when we are born is referred to as our **life expectancy** and is calculated according to the conditions in a particular country in that year. A child born in Japan in 2015 can expect to live 83 years, while one born in the African country of Sierra Leone can expect to live only 49 years. Figure 1 shows variation in life expectancy worldwide.

FIGURE 1 Global life expectancy



Source: © United Nations Publications

Life expectancy around the world started to increase in the mid-1700s due to improvements in farming techniques, working conditions, nutrition, medicine and hygiene. There is a clear interconnection between wealth and life expectancy: wealthier people in all countries can expect to live longer than poorer people. In general, women outlive men. A higher income enables people to have better access to education, food, clean water and health care. One region where life expectancy is decreasing rather than increasing is sub-Saharan Africa, where many countries have been affected by HIV and AIDS.

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Interactivity
Long life, short life
Use this interactivity to look at differences in life expectancy around the world.
Searchlight ID: int-3307

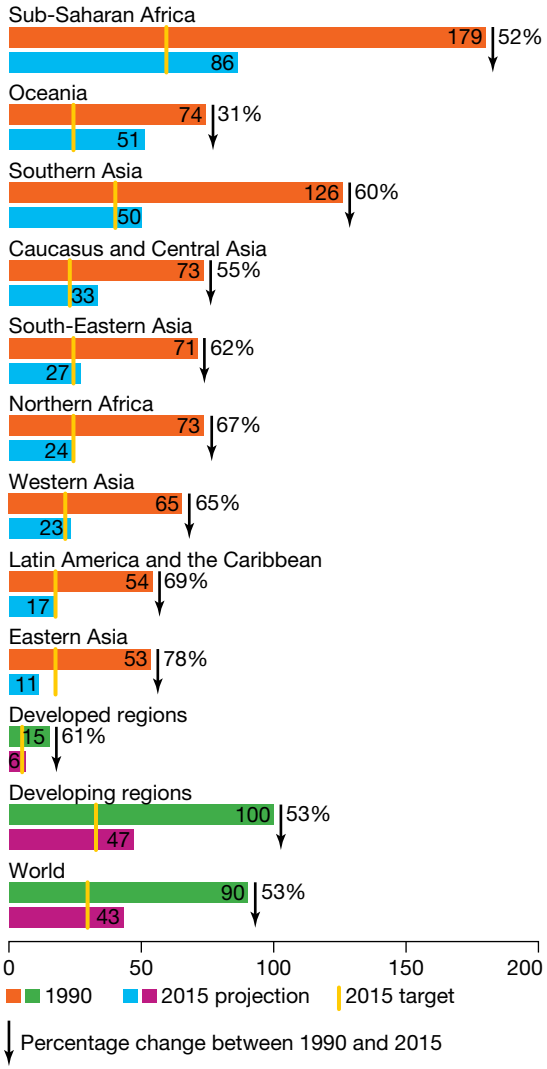
20.2.2 Child mortality

Life expectancy is closely interconnected to child mortality: countries with high death rates for children under five years of age have low life expectancy. Young children are particularly vulnerable to infectious diseases due to their lower levels of immunity. Major causes of death include pneumonia, diarrhoea, measles and malnutrition. In wealthier households, child deaths are lower as these children are likely to have better nutrition and be immunised, and parents are more likely to be educated and aware of how to prevent disease.

Under the United Nations' MDGs action, child mortality has been reduced considerably. The number of deaths of children under the age of five declined from 12.7 million in 1990 to 6 million in 2015, the equivalent of nearly 12 000 fewer children dying each day. Greatest success has been in northern Africa and eastern Asia, with respective declines in under-five mortality of 68 per cent and 58 per cent. The highest levels of under-five mortality continue to be found in sub-Saharan Africa, where one in eight children die before the age of five, 18 times the average in developed regions. However, substantial improvements are being made in this region, with four of these countries reducing child deaths by more than 50 per cent between 1990 and 2015. For example, increased measles vaccination coverage has been a relatively simple but effective way of reducing child deaths.

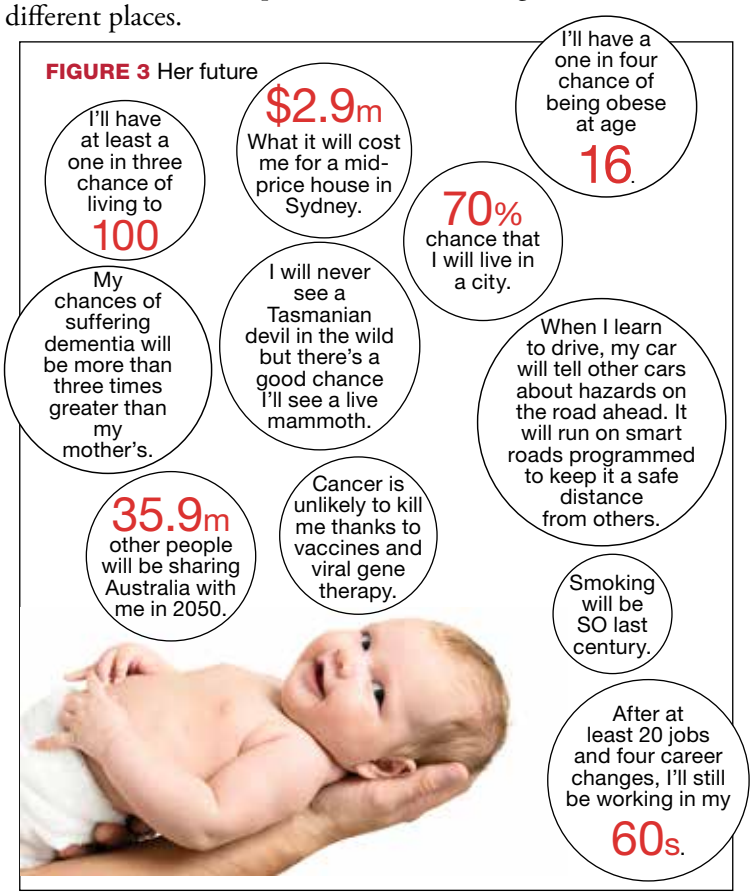
Life expectancy and child mortality allow us to measure and compare human wellbeing in different places.

FIGURE 2 Under-five mortality rate, 1990–2015 (deaths per 1000 live births)



Note: Percentage change calculations are based on unrounded numbers.

FIGURE 3 Her future



ACTIVITIES

IDENTIFY

1 Describe the distribution of life expectancy shown in figure 1.
2 What age groups are likely to have the highest mortality rates? Why?

INVESTIGATE

3 Refer to the **MDGs** weblink in your eBookPLUS. Construct a table showing the differences between the SDGs and MDGs. What is the same and what has been added?
4 Use the **Demographic indicators** weblink in your eBookPLUS to examine interactive maps on life expectancy and other demographic indicators.
5 Use the **Gauging interconnections** weblink in your eBookPLUS to examine the correlation between life expectancy and other indicators such as infant mortality. What do you find?

PREDICT

6 Predict how life expectancies in Sub-Saharan Africa may ***change*** if a cure for HIV/AIDS is discovered.
7 Will increased incomes always lead to increased life expectancy? Justify your answer.

APPLY

8 Write your own version of 'Her future' (figure 3), imagining what your life will be like when you are 35 years old.
9 What implications does an increase in life expectancy have on the provision of health care?

eBookplus

Weblinks
- MDGs
- Demographic indicators
- Gauging interconnections

20.3 What are the spatial variations within countries?

20.3.1 How and why is India's population changing?

You probably know that China has the biggest population in the world with a population of 1.37 billion. With some 1.26 billion people in 2016, India is set to surpass China's population by 2025, when its population will reach an estimated 1.4 billion. With a predicted 1.6 billion by 2050, what happens to India's population will have major implications in terms of the wellbeing of the people in that country.

FIGURE 1 Indian children assisting with rice planting

India's population was growing at a rate of 1.2 per cent in 2014. Improvements in water supply, a decrease in infectious diseases and an increase in education levels have resulted in a reduced death rate since the 1950s, while the birth rate has not declined to the same extent. Infant mortality remains high as over two-thirds of the population are rural dwellers who may not have ready access to health and reproductive services. Children remain a vital part of the family's labour force both on farms (as shown in figure 1) and for old age support, so it is essential for families to have more children to improve the chance of them surviving to adulthood. Thirty-one per cent of the population is under 15 years of age, creating huge momentum for future growth (see figure 2).

20.3.2 Regional variation in wellbeing and population

The number of children per woman in India has declined substantially from 5 in the 1970s to 2.5 in 2015. There is considerable regional variation. Levels of literacy and poverty shown in figures 4 and 5 reflect a varying distribution of wellbeing in India. For information about the Indian government's moves to reduce poverty and improve wellbeing across the country, use the **Poverty challenge** weblink in your eBookPLUS.

eBookplus

Weblink
Poverty challenge

FIGURE 2 (a) Population pyramid for India, 2014 and (b) Population pyramid for India, 2050

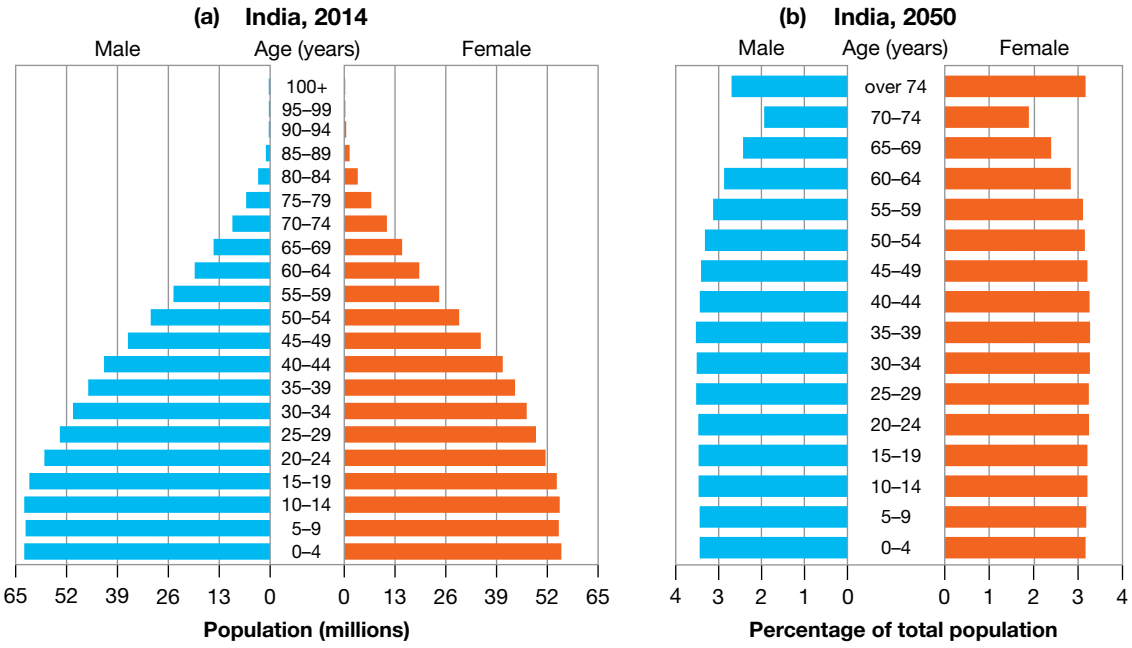


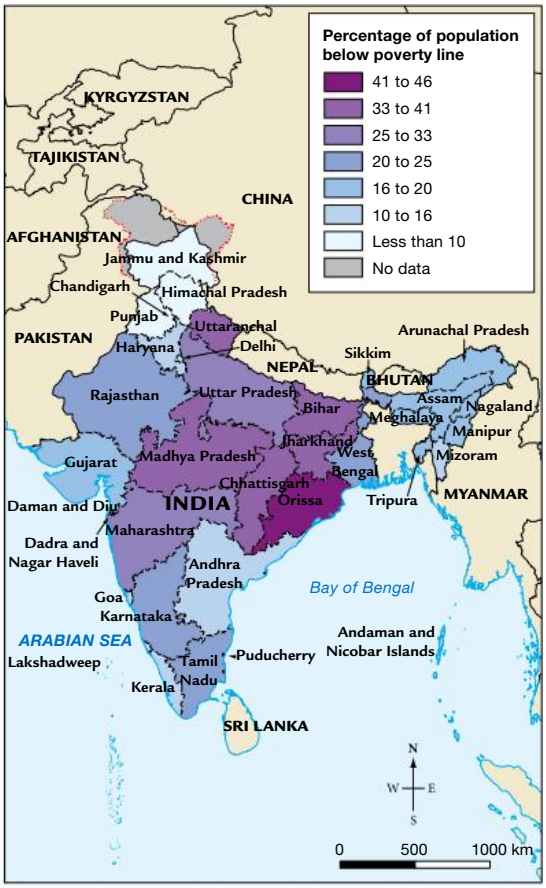
FIGURE 3 Proportion of children 0–6 years to total population, India, 2011

Source: Spatial Vision.

FIGURE 4 Literacy rates (percentage) in India, 2011

Source: Government of India, Ministry of Home Affairs, Office of Registrar General

FIGURE 5 Poverty levels in India



Source: Spatial Vision

ACTIVITIES

IDENTIFY

1 With reference to the population pyramids shown in figure 2, account for India's ***changing*** population growth.

EXPLAIN

2 Explain why India is set to overtake China in terms of total population.

3 Using the data provided in this section, describe and account for the variation in wellbeing in India. You can also use the **India: contrasting wellbeing** weblink in your eBookPLUS to learn more about the contrasting conditions in wellbeing within the country.

INVESTIGATE

4 a Using figure 5, pick two states that fall into different categories on the map. Use the **Census India** weblink in your eBookPLUS to compare the 2011 demographic characteristics for those two states.

b Share your findings with other members of your class who selected different states.

eBookplus

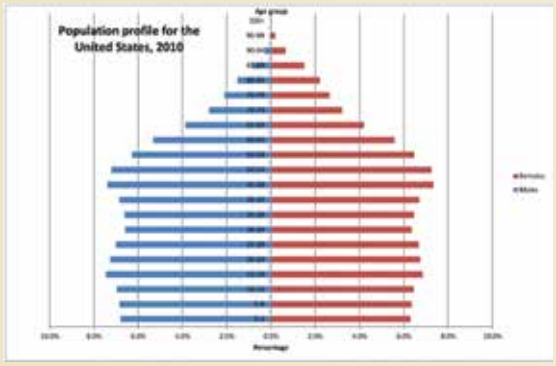
Weblink
- India: contrasting wellbeing
- Census India

eBook*plus* ONLINE ONLY

20.4 SkillBuilder: Using Excel to construct population profiles

Why do we use Excel to construct population profiles?

When constructing population profiles, there is a large amount of data and large numbers to handle. Excel allows actual population figures, which are generally large numbers, to be handled simply. Once the data is placed in the spreadsheet, the computer can create the graph.



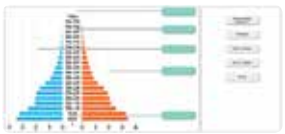
eLesson

Watch this video to learn how to construct population profiles using Excel.

Searchlight ID: eles-1758

Interactivity

Try this interactivity to learn how to construct population profiles using Excel.



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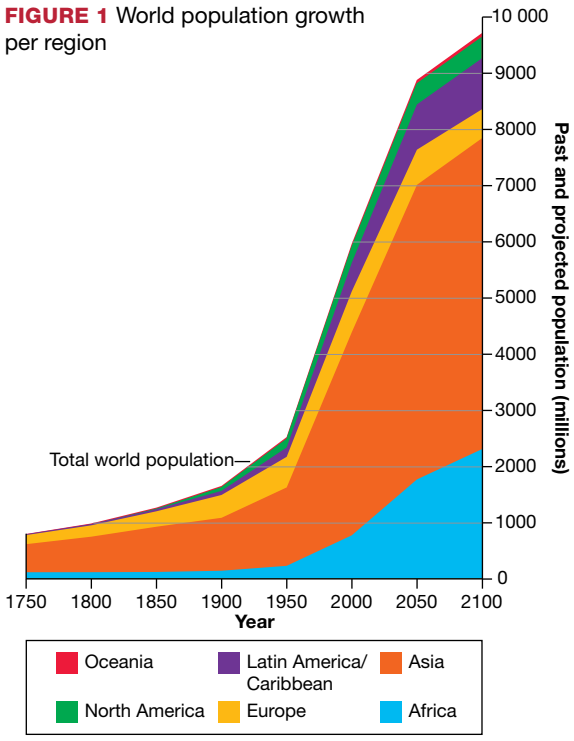
20.5 What are the internal reasons for variations?

fertility the birthrate of a population

FIGURE 1 World population growth per region



20.5.1 Population growth

Internal factors are those which take place within a country and are seen to have a greater degree of influence over its citizens and government. Factors such as the number of people, whether it is landlocked or located in the tropics and political systems all contribute to a country's level of development and the wellbeing of its people.

Most of the global population growth is taking place in developing countries, particularly the poorest nations (see figure 1). By 2050, with an estimated nine billion people in the world, some eight billion people (86 per cent) will be in developing countries, with two billion of those in the least developed nations. Despite continued global population growth, global fertility rates are falling. Declines in **fertility** have coincided with improvements in living conditions, greater access to education (particularly for women), improved health care and access to contraception. It is anticipated that fertility rates in developing regions will continue to fall, particularly with increasing rural–urban migration. In the cities, a child is more likely to be an economic burden than an asset, and there is better access to health services and family planning programs.

20.5.2 Resources

Variations occur between nations as their access to natural resources is uneven. A nation's biophysical environment will determine how well

it can undertake agriculture and if it can produce excess amounts and then export the surplus. However, other nations, such as Japan, cannot produce sufficient agricultural products to sustain its population, so it is a net importer of food products. Natural resources like gas and coal can be exploited in order to make significant economic gain, as can be seen in Qatar in the Middle East which has a GDP of $133 580. Then there are countries, such as those in Sub-Saharan Africa, which do not have access to any significant resources. Landlocked countries are particularly affected.

FIGURE 2 India's population is growing

Geographic isolation from coastal regions leads to additional transportation costs and fewer economic opportunities to access higher market share of world markets. Botswana is an exception to this after investing the money made during a mining boom into infrastructure and inland services. Another factor that leads to spatial variations is for those countries located in the tropics. These countries are more prone to infectious disease and natural disasters reducing wellbeing and quality of life.

20.5.3 Political instability

War and civil unrest have a major impact on wellbeing and development of countries. Those nations that experience higher levels of political instability find it much harder to develop. The need to support police and military forces can often see funds diverted away from much needed development and infrastructure projects that would directly enhance wellbeing. Much of a nation's infrastructure can be destroyed through conflict, either indirectly, as was the case with the Syrian conflict in 2015 (figure 3), or directly, such as when Indonesia withdrew from Timor Leste in 1999.

FIGURE 3 Conflict in Syria

FIGURE 4 Environmental degradation

Environmental degradation

As nations continue to degrade the stock of the environment as a result of a continued push for development, the environment can be degraded. Researchers say that of the nine processes needed to sustain life on Earth, four have exceeded 'safe' levels (refer to figure 4). According to the United Nations, 130 000 square kilometres of forests are cut down or burned every year — equivalent to three times the area of Denmark. As a result of this, the wellbeing of citizens is compromised with a reduction in areas such as biodiversity, air and water quality, increased erosion and runoff, as well as salinisation and desertification occurring. This is an issue being addressed by all nations at different levels as its importance is significant. In 2015, Pope Francis said on this issue 'The ecological crisis, and the large-scale destruction of biodiversity, can threaten the very existence of the human species'.

eBook*plus*

Weblink
- Gapminder
- Displacement

ACTIVITIES

IDENTIFY

1 Describe how world population growth has ***changed*** over time.
2 What else has been happening as fertility rates have fallen?

EXPLAIN

3 What is meant by the phrase 'in cities a child is more likely to be an economic burden than an asset'?
4 How does the biophysical ***environment*** determine natural resources?

INVESTIGATE

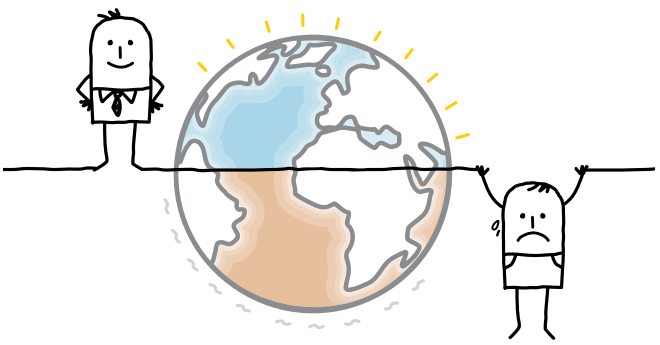
5 Select a country located within in the tropics and use the **Gapminder** weblink in your eBookPLUS to create a table showing its score/rank in the areas of health and education. How do these compare with Australia?
6 Use the **Displacement** weblink in your eBookPLUS to view a video about displacement in the Central African Republic. What problems do these people face?
7 Choose one nation or region currently involved in a conflict. What has been the cause of the political instability?

20.6 What are the external reasons for variations?

20.6.1 Colonisation

External factors refer to those that take place outside the control of a country. Many of these are historical and have played a significant role in determining the level of development experienced by different countries in certain parts of the world. Colonisation was one of the major influences in the past.

FIGURE 1 Effects of colonisation



European empires expanded throughout the world in the sixteenth, seventeenth, eighteenth and nineteenth centuries. This saw them take control over, what are today, some of the least-developed countries on Earth. Often this was to benefit the colonial powers by acquiring a source of raw materials as well as a potential market for their products.

20.6.2 Trade

Trade

Poorer and less-developed nations have a far greater proportion of their economy based in primary production, often centered on raw materials. These agricultural commodities have a far lower value than high-cost manufactured goods that are required within the country. Countries can find themselves in debt as the cost of the goods they import is more than what they receive for the goods they export. To fund this shortfall they must borrow funds and go into debt. As time passes, this debt can increase and takes a greater proportion of the nation's income to pay it off.

Subsistence farming is increasingly under threat, not only from farmers looking to grow cash crops rather than produce food, but also TNCs and other more developed nations attempting to secure land and agricultural production in these poorer areas (figure 2).

FIGURE 2 Subsistence agriculture in India

20.6.3 TNCs

Transnational corporations (TNCs) are large commercial enterprises operating in more than one country. They are attracted to less-developed nations because of their cheaper labour and often more relaxed or less regulated rules governing working conditions, such as minimum and maximum hours of work, rates of pay, penalty rates and other conditions. The irony is that in many of these developing nations the workers are producing goods that they would be unable to afford themselves.

20.6.4 Aid

Less-developed countries are offered aid from other countries as a means of helping their citizens. However there is the possibility of countries becoming aid dependant. Aid is usually delivered as either bilateral, multilateral or non-government organisation (NGO)/charity aid (figure 4). Bilateral aid is given by governments to donor countries. Multilateral aid is provided through international institutions, such as UNICEF. Non-government organisations or charity aid is voluntary, private, individual donations collected by organisations such as the Red Cross. Aid takes many forms: money, food, medicine, equipment, expertise, scholarships, training, clothing or military assistance.

There is always the threat that corruption amongst politicians and officials will prevent aid from reaching the people who need it most. If aid does not provide for and empower citizens, then wellbeing will not be improved.

FIGURE 3 The Friendship Bridge built with bilateral funding across the Mekong River

FIGURE 4 Advantages and disadvantages of aid

Bilateral aid	Multilateral aid	NGO/charity aid
+ Helps expand infrastructure: roads, railways, ports, power generation.	+ The organisations have clear aims around what they are trying to achieve (e.g. WHO combats disease and promotes health).	+ Usually targeted at long-term development within a country.
+ Aid which directly supports economic, social or environmental policies can result in successful programs.	+ Leading experts in their field work to help achieve multilateral aid program objectives.	+ Raises awareness of specific situations in a country or region.
– 'Tied aid' obliges the country receiving aid to spend it on goods and services from the donor country (may be expensive).	– Sometimes directed only towards specific areas or organisations, leaving many without benefit.	– The greatest source of need may not be prioritised (e.g. the 2006 tsunami devastation received many donations, but areas in Sub-Saharan Africa on a daily basis were just as much in need).
– Inappropriate technology may be given (e.g. tractors are of little use if there are no spare parts or fuel).	– May come with conditions to make big changes to structures, which can be difficult to manage once aid has 'finished'.	– Up to 30% of donations may be 'eaten up' by administration costs.

FIGURE 5 Multilateral aid involvement helps these primary school students in north-western Laos.

TABLE 1 Breakdown of economies by sectors

		GDP ($US millions)	Agriculture	Industrial	Services
	World	**74 699 258**	**5.9%**	**30.5%**	**63.6%**
1	United States	17 418 925	1.12%	19.1%	79.7%
2	China	10 380 380	9.1%	42.6%	48.3%
3	Japan	4 616 335	1.2%	27.5%	71.4%
28	United Arab Emirates	416 444	0.7%	59.4%	39.8%
31	Thailand	380 491	13.3%	34%	52.7%
35	Venezuela	209 226	4.7%	34.9%	60.4%

Source: CIAFactbook 2015

ACTIVITIES

IDENTIFY

1 How do external factors differ from internal factors?

APPLY

2 With the aid of a map, determine which European nations had ties to various countries within Africa.

3 Refer to table 1. Plot the listed countries onto a ternary graph.

EXPLAIN

4 How does trade influence economic development within a country?

5 How can trade improve wellbeing within a country?

6 Explain the difference between the three types of aid.

INVESTIGATE

7 Select a TNC and create a table showing where their goods or services are manufactured (made) and consumed (sold).

20.7 What are the consequences of spatial variations for the middle class?

20.7.1 Who are the middle class?

Much has been said about the 1 per cent vs 99 per cent or the wealthy and the poor or the haves and have nots. Variations across the globe in terms of access to resources as well as improvements in standards of living have seen development rates and overall wellbeing improve markedly. As a result of this we are now seeing the emergence of the middle class not only in the developed but also the developing world.

FIGURE 1 Is this how we see the middle class?

The middle class can be a very difficult concept to define. It is somewhere between struggling or poor and well-off or rich. It can be determined by a number of different means including income, wealth, consumption, aspiration or demographics. Depending on which definition we use to determine the size of the middle class, it will have significant impacts on the well-being of those individuals and families as well as businesses and governments.

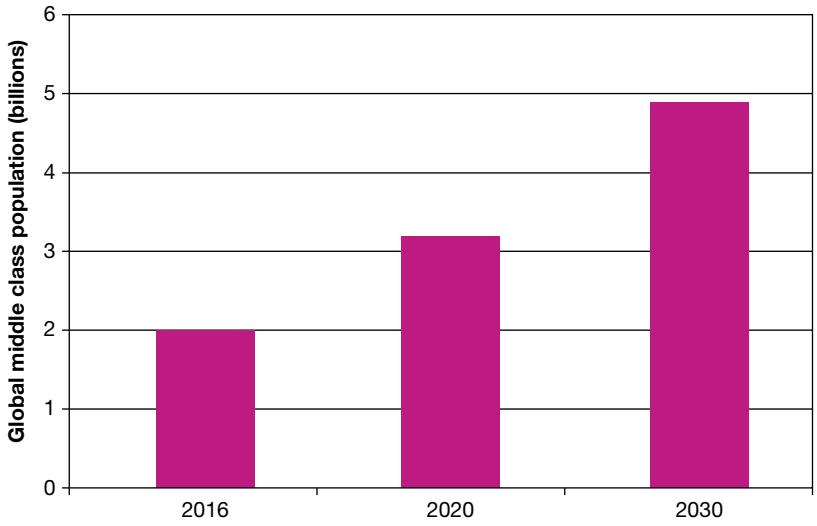
Developed nations (such as Australia and the US) may consider those earning between $18 000 and $125 000 a year as middle class; this measure of income essentially includes everyone who is not in either the bottom or top **quintile** of income earners. In developing countries this may be closer to

quintile any of five equal groupings used to measure and compare values

between $4000 and $40 000 a year. In either situation we are looking at those people that have risen above subsistence living and who have some money to spare and can start looking towards the future.

The size of the global middle class is predicted to grow from 2 billion in 2016 to 3.2 billion in 2020 and 4.9 billion by 2030. This is most apparent in the large populations of CHINDIA (CHINA and INDIA). These two nations have projected middle-class populations that are expected to be 856 million in China in 2030 and 547 million in India by 2025. This has specific consequences for households, businesses and government.

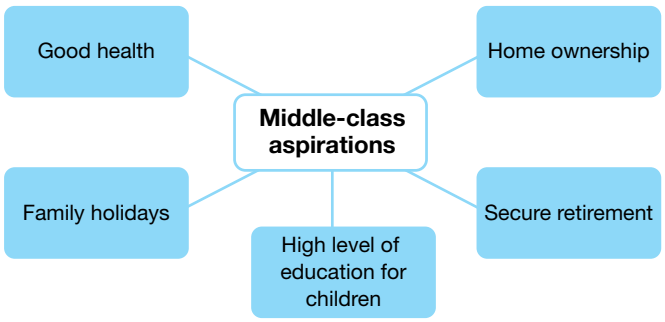
FIGURE 2 The growth of the middle class



Increased middle class — increased disposable income

As mentioned previously, one of the key measures of what is the middle class is consumption. Those people that have risen above subsistence living and have extra income are in a position to be able to spend it (figure 3). This creates huge demand for products from both domestic and international markets. Car manufacturer BMW sold over 450 000 cars in China in 2015, making China its largest market. Whilst this is still a small number relative to the population of China (one BMW for every 2900 people) it shows the potential for many other goods that are able to be sold in these markets. Powdered baby formula from Australia has become increasingly popular with Chinese buyers paying up to $100 a tin compared to $20 in Australian supermarkets. The Marxist perspective states that the middle class are the salaried socio-economic group that supervises the waged working class on behalf of the ruling class. They manage wealth and resources, but don't own them.

FIGURE 3 Aspirations of the middle class



Some benefits associated with growth in the middle class, particularly within developing nations, are the potential to stimulate domestic consumption, economic growth, employment opportunities and revenue for governments to provide more services to help citizens out of poverty and improve wellbeing. On the other hand, some nations may experience a 'tunnel effect' in which they are no longer satisfied with having access to basic services and want them to be of a higher quality.

One clearly negative impact faced by this consumption is its effect on the environment. The resources required to meet the needs of the world's current population far outstrips its long-term capacity. As both the middle class and demand for goods and services grows, so will the pressure on the environment.

ACTIVITIES

IDENTIFY

1 What are the different methods that can be used to determine the middle class?

EXPLAIN

2 What does figure 2 suggest about the role of age, of education, and of race in determining class systems.

APPLY

3 The Marxist perspective states the middle class are the salaried socio-economic group that supervises the waged working class on behalf of the ruling class. They manage wealth and resources, but don't own them. How does this fit with your perspective of the middle class? Can you think of people who may consider themselves middle class, but don't fit Marx's description?

INVESTIGATE

4 The OECD has found that while middle classes are expanding in developing countries they are shrinking in developed countries. Visit the OECD website to see a list of countries and compare the middle classes of one country from the list to a country not on the list. Focus on the size, the change in size and the impacts on the citizens.

eBook*plus*

Interactivity
Helping others
Use this interactivity to learn more about different types of aid.
Searchlight ID: int-3305

20.8 How does population affect development and wellbeing?

20.8.1 Population

The size of a family can directly affect everyone's wellbeing. In Australia we may be concerned with the cost of raising children. In other countries, children may make a contribution to family income by completing simple jobs such as collecting firewood. At a national scale, the numbers of children also affect the wellbeing of the country as a whole.

FIGURE 1 Youthful population in Kenya

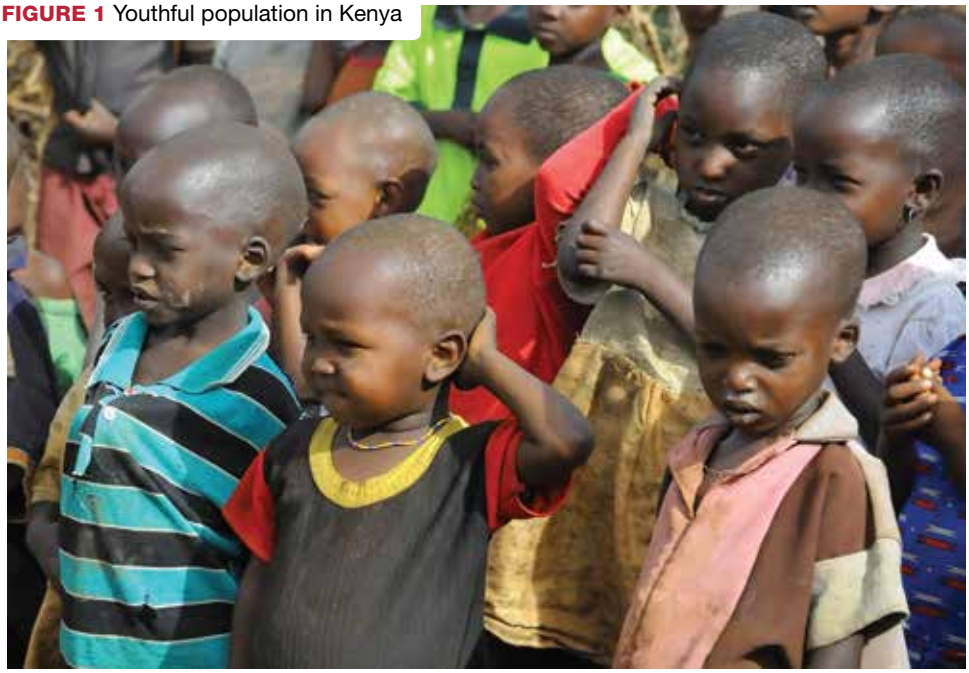


TABLE 1 Selected demographic characteristics for Japan and Kenya

Demographic	Japan	Kenya
Population (2015)	126 958 472	46 050 302
GNI per capita (US$)	36 680	1340
Population aged 0–14	13%	42%
Population aged 15–64	61%	55%
Population aged 65+	26%	3%
Annual population growth	–0.1%	2.6%
Life expectancy	83	62
Fertility rate	1.4	4.3
Infant mortality	2 per 1000	36 per 1000
Long term unemployed (% of labour force)	3.7%	9.2%

Source: Worldbank

20.8.2 Kenya: response to a youthful population

While Kenya's fertility rate has fallen substantially in the last 30 plus years from over seven children to just under four, the country still has a relatively high rate of population growth. Its population structure has a high proportion of young people (see table 1 and figure 3(a) and (b)), so by 2030 it is estimated that there will be over 65 million people. This increase will put pressure on Kenya's resources in terms of providing food, services and employment. With a predominantly rural population, the amount of arable land per person is falling.

Under Kenya's Vision 2030, a national framework for development, population management is an essential component of achieving wellbeing goals for health, poverty reduction, gender equality and environmental sustainability. The United Nations Population Fund (UNFPA), has been working with the Kenyan government since the 1970s to help improve wellbeing in the country. Between 2014–2018 it plans to contribute $32.5 million. This will finance a range of services including family planning with free contraceptives provided, increased availability of maternal and newborn health services, services to prevent the contraction of HIV and sexually transmitted infections, advocation for the education of girls and elimination of gender-based violence. Unfortunately, despite this work, there is still a huge unmet need for family planning in Kenya, particularly among the poorest women, where almost half report they have unplanned pregnancies.

20.8.3 Japan: response to an ageing population

Japan has one of the highest life expectancies in the world, and this, combined with a very low fertility rate, has led to an ageing population, with over one-quarter of Japan's population in the 65-plus age group (see table 1 and figure 4(a) and (b)). Fertility in Japan has been consistently below replacement level since the 1970s. A high standard of living, increased participation of women in the workforce, high costs of raising children and lack of supporting childcare facilities have all contributed

to this. Japan's total population is expected to decline from its current 126 million to an estimated 117 million in 2030.

The workforce is expected to fall 15 per cent over the next 20 years and halve in the next 50 years. That means that in 2025, three working people will have to support two retirees. The Japanese government also faces rising pension and healthcare costs. These economic concerns led to the Japanese government implementing a number of measures in 1994 such as subsidised child care and bonus payments for childbirth via a policy known as the Angel Plan (revised in 1999) as well as the Plus One policy aimed at encouraging parents to have one extra child. The policy has been largely ineffective: although the fertility rate rose slightly initially, it has remained well below replacement level. The Japanese government has historically been reluctant to use immigration to fill labour shortages, and solutions may include increased female workforce participation, increased **automation** of the workforce and more working by older people.

automation the use or introduction of automatic equipment in a manufacturing or other process or facility

FIGURE 2 Ageing population, Japan

FIGURE 3 Population pyramid for Kenya, (a) 2014 and (b) 2050

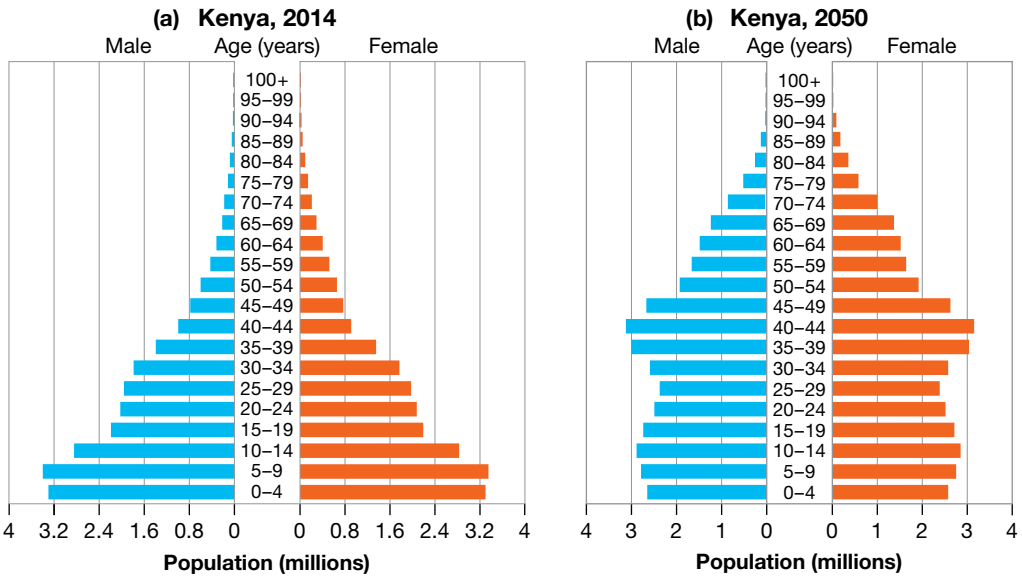
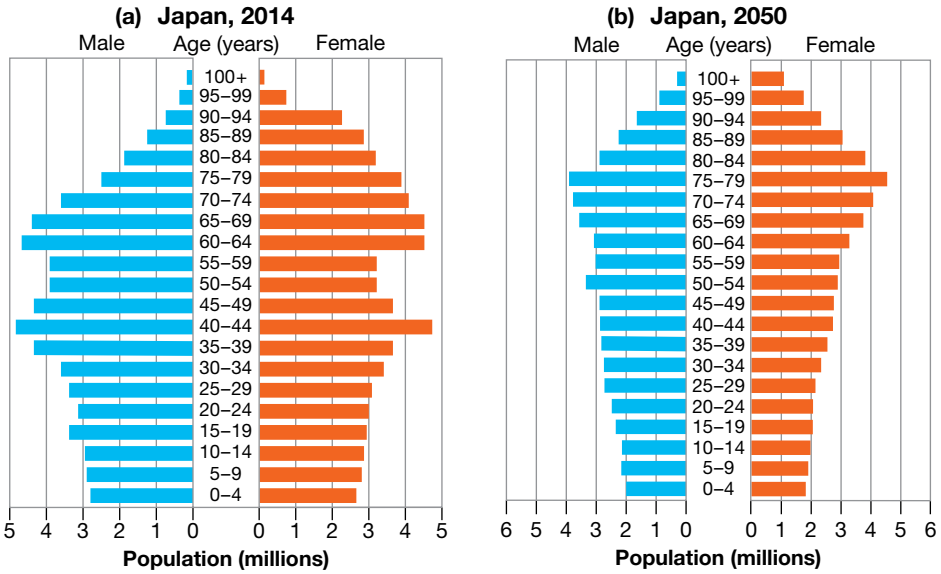


FIGURE 4 Population pyramid for Japan, (a) 2014 and (b) 2050



eBook*plus*

Interactivity
Revealing population pyramids
Use this interactivity to explore the relationship between birth and death rates in different places around the world.
Searchlight ID: int-3309

Weblink
Aging population Japan

ACTIVITIES

IDENTIFY
1 How has an improvement in living conditions led to a ***change*** in population structure?

EXPLAIN
2 Account for (give reasons for) the variation in shape of the population pyramids for Japan and Kenya in 2014 and 2050.
3 Describe the ***changing*** percentage of aged population between 2014 and 2050 in both Kenya and Japan.

PREDICT
4 What problems does the Kenyan government face with a large proportion of young population?
5 Use the **Aging population Japan** weblink in your eBookPLUS to determine what problems Japan faces with a large proportion of aged population.
6 How do these issues affect the wellbeing of people in those countries?

APPLY
7 Of the problems you listed (question 5), which do you consider more serious? Why?

20.9 How does gender affect wellbeing?

20.9.1 Women's health and wellbeing

Approximately every 90 seconds a woman dies from complications in relation to pregnancy or childbirth. Most of these deaths are from preventable complications such as severe bleeding, infections and complications from unsafe abortions. The incidence of **maternal mortality** and related illness is interconnected to poverty and lack of accessible and affordable quality health care.

maternal mortality the death of a woman while pregnant or within 42 days of termination of pregnancy

Eighty-five per cent of maternal deaths are in sub-Saharan Africa and southern Asia, with the former accounting for over half of all these deaths. Highest maternal mortality rates are recorded in Chad and Somalia where mothers have a 1 in 16 and 1 in 15 risk of dying. At a national scale, two countries account for one-third of global maternal deaths: India at 19 per cent (56 000) followed by Nigeria at 14 per cent (40 000).

Sustainable Development Goal (SDG) 3 set targets for 2030:

- reducing the global maternal mortality ratio to less than 70 per 100 000 live births and;
- ensuring universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.

Maternal mortality fell by 45 per cent between 1990 and 2015, with 10 countries meeting the MDG target of a three quarter reduction. However, globally the target was not met, particularly in countries in southern Africa where AIDS has had a major impact.

20.9.2 Maternal mortality in India

Rarely would women in Australia consider that pregnancy and giving birth could be one of the most life-threatening activities in which they could engage. For the large majority, having children is something that fits into our busy lifestyles without health complications to either mother or baby. Sadly, this is not the case for a huge number of women worldwide, for whom child-bearing has a negative impact on their wellbeing.

India accounts for the single biggest percentage of global maternal deaths. On average, maternal mortality rates have declined by over 15 per cent in the five-year period from 2011–2015. In 2015, the maternal mortality rate fell to 174 deaths per 100 000 births. However, there is substantial variation within India, as figure 1 indicates.

Maternal mortality is strongly interconnected with poverty in both rural areas and urban slums: places with poor provision of sanitation and a lack of affordable health services are associated with high levels of maternal mortality. In addition, women are likely to be less well-nourished than males in a household. According to the 2011 Indian Census, women also have much lower literacy levels — 65 per cent literacy rate compared to 82 per cent for men — so they are less likely to be able to access information on health and contraception.

The government of India launched the National Rural Health Mission in 2005, with a specific focus on maternal health. Efforts have been focused on those districts that account for 70 per cent of all infant and maternal deaths. Under this program, community workers have been trained to deliver babies, and 10 million women have been provided with a cash incentive to enable them

FIGURE 1 Maternal mortality rates in India

Source: Published and issued by Office of the Registrar General, India, Ministry of Home Affairs http://www.censusindia.gov.in/vital_statistics/SRS_Bulletins/MMR_Bulletin-2010-12.pdf

FIGURE 2 This Indian mother survived childbirth.

FIGURE 3 Rural pregnancy clinic in India

to give birth in clinics rather than at home. Maternal mortality has fallen, but Human Rights Watch reports that many women are being charged for services as they are unaware of these entitlements.

A related issue for pregnant women in India is the pressure to produce a son. Census data in 2011 revealed the number of female children (0–6 years) has decreased from 927 to 914 girls per 1000 boys in the past decade, despite some overall improvement in the sex ratio across all age groups (see figure 5). Males are traditionally preferred over female children: sons are seen as the breadwinners who carry the family name, while daughters are often perceived as an economic burden. Although **female infanticide** is illegal, use of ultrasound for sex-determination tests has led to sex-selective abortions, with 500 000 more girls than boys aborted each year out of a total of 6.7 million abortions. The pressure to produce a son means that many Indian women have multiple pregnancies, thereby increasing their risk of maternal mortality over their reproductive years. Figures 1 and 5 indicate a strong interconnection between the places of high maternal mortality and those with a large imbalance in the **sex ratio**.

female infanticide the killing of female babies, either via abortion or after birth

sex ratio the number of males per 1000 females

FIGURE 4 Son preference has resulted in an imbalance in India's sex ratio

FIGURE 5 Variation in sex ratio within India

Source: Government of India, Ministry of Home Affairs, Office of Registrar General.

FIGURE 6 The government of India launched the National Rural Health Mission in 2005, with a focus on maternal health, to particularly assist the large rural population.

ACTIVITIES

IDENTIFY
1 Define *maternal mortality*.
2 On a blank world map indicate the regions that account for 85 per cent of maternal deaths. Label the countries that have:
   a the highest risk of maternal mortality
   b the greatest number of total deaths.
3 Describe the variations in maternal mortality in different parts of India as shown in figure 1.

EXPLAIN
4 Refer to figure 5 in subtopic 20.3. To what extent is the ***interconnection*** between poverty and maternal mortality (as shown in figure 1 in this section) evident?

INVESTIGATE
5 Use the **Women's health** weblink in your eBookPLUS to learn more about the UN Global Strategy for women and children's health. Note any key information provided.

PREDICT
6 Predict the shape of India's population pyramid if the trends in India's sex ratio continue.

APPLY
7 Suggest measures that could be introduced by the Indian government to help Indian parents see the value of female babies as equal to that of males.

eBookplus

Interactivity
His and hers
Use this interactivity to explore differences between the sexes in India.
Searchlight ID: int-3310

Weblink
Women's health

eBookplus ONLINE ONLY

20.10 SkillBuilder: How to develop a structured and ethical approach to research

What is a structured and ethical approach to research?

A structured and ethical approach to research involves organising your work clearly and meeting research standards without pressuring anyone into providing material and without destroying environments while gathering the data. Your work must also be your own, and anything that is someone else's work must be referenced in the text and included in the reference list.

Preliminary data	Population at end Sept. quarter 2012 '000	Change over previous year '000	Change over previous year %
New South Wales	7 314.1	86.0	1.2
Victoria	5 649.1	94.8	1.7
Queensland	4 584.6	91.4	2.0
South Australia	1 658.1	16.4	1.0
Western Australia	2 451.4	81.7	3.4
Tasmania	512.2	0.5	0.1
Northern Territory	236.3	4.2	1.8
Australian Capital Territory	376.5	7.4	2.0
Australia	**22 785.5**	**382.5**	**1.7**

Source: Australian Bureau of Statistics, www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0.

eLesson
Watch this video to learn how to develop a structured and ethical approach to research.

Searchlight ID: eles-1759

Interactivity
Try this interactivity to learn how to develop a structured and ethical approach to research.

Searchlight ID: int-3377

20.11 What is wellbeing like in Japan and Kenya?

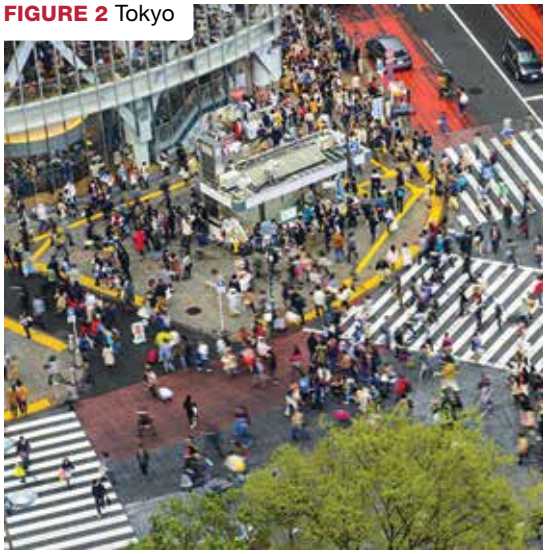
20.11.1 Japan and Kenya

As we have seen, Japan and Kenya are at opposite ends of the development scale and as such face very different sets of issues pertaining to development and wellbeing.

Tokyo–Yokohama is the largest urban area in the world with a population of 37.8 million people in 2015. On the other hand Nairobi, the capital of Kenya had a population of 3.5 million in 2014. These contrasts are illustrated in figures 1 and 2.

FIGURE 1 Nairobi

FIGURE 2 Tokyo



ACTIVITIES

IDENTIFY

1. What is the natural feature in the water south of Funabashi in AR4094?
2. What does the yellow portion of the map indicate in the south–west quadrant?
3. Estimate the size of this yellow area. (*Hint:* 1 square on the map represents 6.25 square kilometres.)
4. What is the distance by road from Noda in AR3997 to the centre of Ichikawa in AR4095?
5. What is the bearing of the landing area in AR4196 from Noda?

EXPLAIN

6. From table 1 in subtopic 20.8, what proportion of the Japanese population is involved in the labour force? How does this differ from the situation in Kenya?
7. What are the potential impacts on each of these societies?
8. What factors do you consider to be important for wellbeing?

INVESTIGATE

9. How do Tokyo and Nairobi OR Japan and Kenya fare in terms of meeting the wellbeing factors you listed in question 8?

PREDICT

10. Would wellbeing be greater for you in Tokyo or Nairobi? Justify your answer by using reasons from the indicators you identified previously, supported with data from the tables you have been using.

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20.12 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

FIGURE 3 Topographic map of Tokyo

Source: Army Map Service, Corps of Engineers, U.S. Army

20.4 SkillBuilder: Using Excel to construct population profiles

20.4.1 Tell me

Why do we use Excel to construct population profiles?

When constructing population profiles, there is a large amount of data and large numbers to handle. The use of an Excel spreadsheet simplifies the process.

Why is drawing population profiles with Excel useful?

Excel allows actual population figures, which are generally large numbers, to be handled simply. Once the data is placed in the spreadsheet, the computer can create the graph.

Excel is useful in creating population profiles because it:

- improves the time taken to create a population profile
- allows you to work with numbers rather than percentages
- plots the information accurately
- makes comparisons between population profiles reliable.

Model

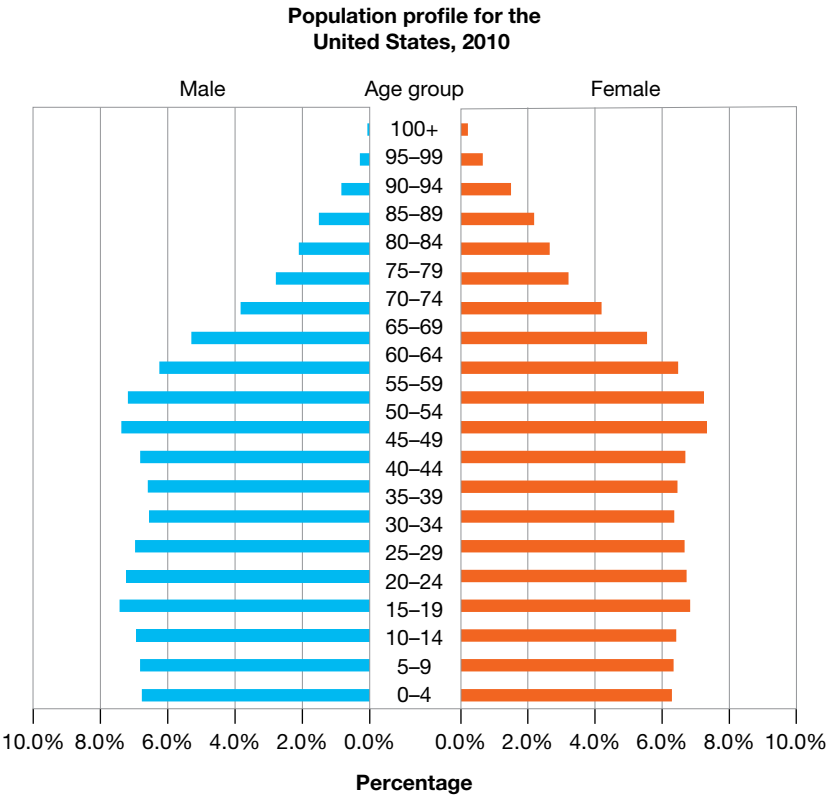
A good population profile created with Excel:

- includes carefully entered data
- meets geographic standards; for example, the bars are aligned
- has labelled axes
- has a clear title.

TABLE 1 Population table of the United States, 2010

Age	Male	Female
0–4	10,319,427	9,881,935
5–9	10,389,638	9,959,019
10–14	10,579,862	10,097,332
15–19	11,303,666	10,736,677
20–24	11,014,176	10,571,823
25–29	10,635,591	10,466,258
30–34	9,996,500	9,965,599
35–39	10,042,022	10,137,620
40–44	10,393,977	10,496,987
45–49	11,209,085	11,499,506
50–54	10,933,274	11,364,851
55–59	9,523,648	10,141,157
60–64	8,077,500	8,740,424
65–69	5,852,547	6,582,716
70–74	4,243,972	5,034,194
75–79	3,182,388	4,135,407
80–84	2,294,374	3,448,953
85–89	1,273,867	2,346,592
90–94	424,387	1,023,979
95–99	82,263	288,981
100+	9,162	44,202
All ages	**151,781,326**	**156,964,212**

FIGURE 1 Population pyramid, or profile, created from the Excel spreadsheet of population statistics for the United States, 2010



20.4.2 Show me

How to draw a population profile using Excel

You will need:

- a set of population statistics
- the Excel program on your computer.

eBookplus

eLesson
Using Excel to construct population profiles
Searchlight ID: eles-1758

Procedure:

STEP 1

Open an Excel spreadsheet and create a layout. Do this by having five columns:

- column 1 (A) is for the age groups
- column 2 (B) is for the raw population figures for each age group of males
- column 3 (C) is for a percentage calculation
- column 4 (D) is for the raw population figure for each age group of females
- column 5 (E) is for a percentage calculation.

The number of rows required is one for the column titles and one for each age group. (This should come to 22 rows.) Figure 2 shows what this will look like before the data is entered.

FIGURE 2 Part of the spreadsheet layout for the population profile

	A	B	C	D	E
1	Age group	Number of males	Males	Number of females	Females
2	0-4				
3	5-9				
4	10-14				
5	15-19				
6	20-24				
7	25-29				
8	30-34				
9	35-39				
10	40-44				
11	45-49				
12	50-54				
13	55-59				
14	60-64				

STEP 2

Into columns B and D, carefully enter the raw numbers of males and females in each age group.

FIGURE 3 The spreadsheet with raw data added

	A	B	C	D	E
1	Age group	Number of males	Males	Number of females	Females
2	0-4	10,319,427		9,881,935	
3	5-9	10,389,638		9,959,019	
4	10-14	10,579,862		10,097,332	
5	15-19	11,303,666		10,736,677	
6	20-24	11,014,176		10,571,823	
7	25-29	10,635,591		10,466,258	
8	30-34	9,996,500		9,965,599	
9	35-39	10,042,022		10,137,620	
10	40-44	10,393,977		10,496,987	
11	45-49	11,209,085		11,499,506	
12	50-54	10,933,274		11,364,851	
13	55-59	9,523,648		10,141,157	
14	60-64	8,077,500		8,740,424	
15	65-69	5,852,547		6,582,716	
16	70-74	4,243,972		5,034,194	

STEP 3

Click on cell A23 and type 'Total'. Then, use the computer to total the numbers in column B and column D. Your raw data in the table may have included this number but it is a good idea to practise this skill in Excel. Click on cell B23 and click on the Greek letter ∑ (AutoSum) found in the toolbar on your screen. This command will produce a display that asks you to check if these are the row numbers that you wish to total. If it is correct then press Enter and the total will appear. Do the same for the Column D. (Alternatively, select cells D2 to D22 and click ∑ AutoSum. The total should appear in cell D23. Do the same for B2 to B22. Ensure that all the numbers appear either *with* commas or *without* spaces. Spaces may cause AutoSum to not work correctly.)

FIGURE 4 The spreadsheet showing the totals completed

	A	B	C	D
10	40-44	10,393,977		10,496,987
11	45-49	11,209,085		11,499,506
12	50-54	10,933,274		11,364,851
13	55-59	9,523,648		10,141,157
14	60-64	8,077,500		8,740,424
15	65-69	5,852,547		6,582,716
16	70-74	4,243,972		5,034,194
17	75-79	3,182,388		4,135,407
18	80-84	2,294,374		3,448,953
19	85-89	1,273,867		2,346,592
20	90-94	424,387		1,023,979
21	95-99	82,263		288,981
22	100+	9,162		44,202
23	Total	151,781,326		156,964,212

STEP 4

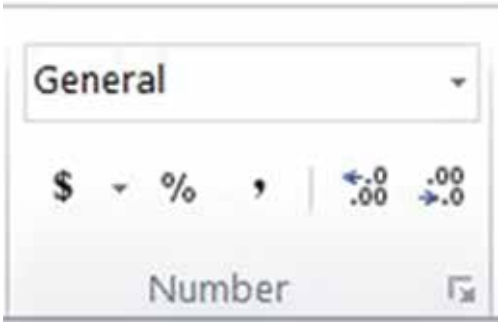
Now you need to calculate percentages. Allow Excel to do this for you. You are going to fill columns C and E with the results. Calculate the first percentage for males aged 0–4 years by clicking on the cell in column C, row 2. In the space you need to type = and then move the cursor to the cell with the male population of 0–4 year olds (cell B2). You will then see =B2 appear in the calculation cell. After that, insert a division symbol (/) and click on the cell that shows the total number of males (C23) and press Enter. A figure will appear as a decimal number, but you need to make this into a percentage. Your version of Excel may do this for you, but if not, you need to complete this task by finding the % symbol in the toolbar and clicking on it; you will see a percentage number appear in your place in column C. This will usually appear as a whole number. To select the number of decimal places for your calculation, click on the symbol .0/.00 in the toolbar (see figure 6). One button shifts the decimal place to the right, the other to the left.

At this point you will need to convert your percentage for males to a negative number. This is because we want to line up males and females opposite each other on a population pyramid — males on the left, females on the right — and a negative number tricks Excel into doing this. Simply type a minus sign in your formula (in the formula bar above your column headings), which now becomes =-B2/B23. Do this only for the males. (If you find that putting a minus sign in the formula doesn't work, click on cell C2, for example, and type 6.8. Repeat this for all other cells.)

FIGURE 5 Calculating percentage using Excel

	A	B	C	D	E
1	Age group	Number of males	Males	Number of females	Females
2	0-4	10,319,427	-6.8%	9,881,935	6.3%
3	5-9	10,389,638		9,959,019	
4	10-14	10,579,862		10,097,332	
5	15-19	11,303,666		10,736,677	
6	20-24	11,014,176		10,571,823	

FIGURE 6 Symbols in the toolbar



To complete the column, you can now save time by copying your newly created formula. First you need to change some parts of your formula from a relative address to a fixed address. A relative address is B23, which your spreadsheet interprets to mean 'one column back and 21 rows down'. A fixed address adds a dollar sign in front of the row and/or column: $B$23. The spreadsheet interprets this as 'the specific cell B23 only'. This addressing becomes important when you are copying formulas and want to keep reference to a particular cell, like the total population of males in this case.

Change your formula for the C2 cell now so that the address SUM reads as =-B2/$B$23.

Now select all the cells in Row C for each age crowd (excluding the 'Total' row). Click on the Fill button in the Editing group on the toolbar and select Down.

All the percentages figures will now appear.

(If this process does not work for you, add the minus signs manually.)

Repeat the whole process for females, remembering that this time you no longer need the minus sign.

Now you are ready to let the computer create the population profile.

FIGURE 7 The spreadsheet showing the application of a 'fixed' address. The headings of columns C and E have now been changed, so that this wording appears in the legend of the graph.

C2 f_x =-B2/$B$23

	A	B	C	D	E
1	Age group	Number of males	Males	Number of females	Females
2	0-4	10,319,427	-6.8%	9,881,935	
3	5-9	10,389,638		9,959,019	
4	10-14	10,579,862		10,097,332	
5	15-19	11,303,666		10,736,677	
6	20-24	11,014,176		10,571,823	

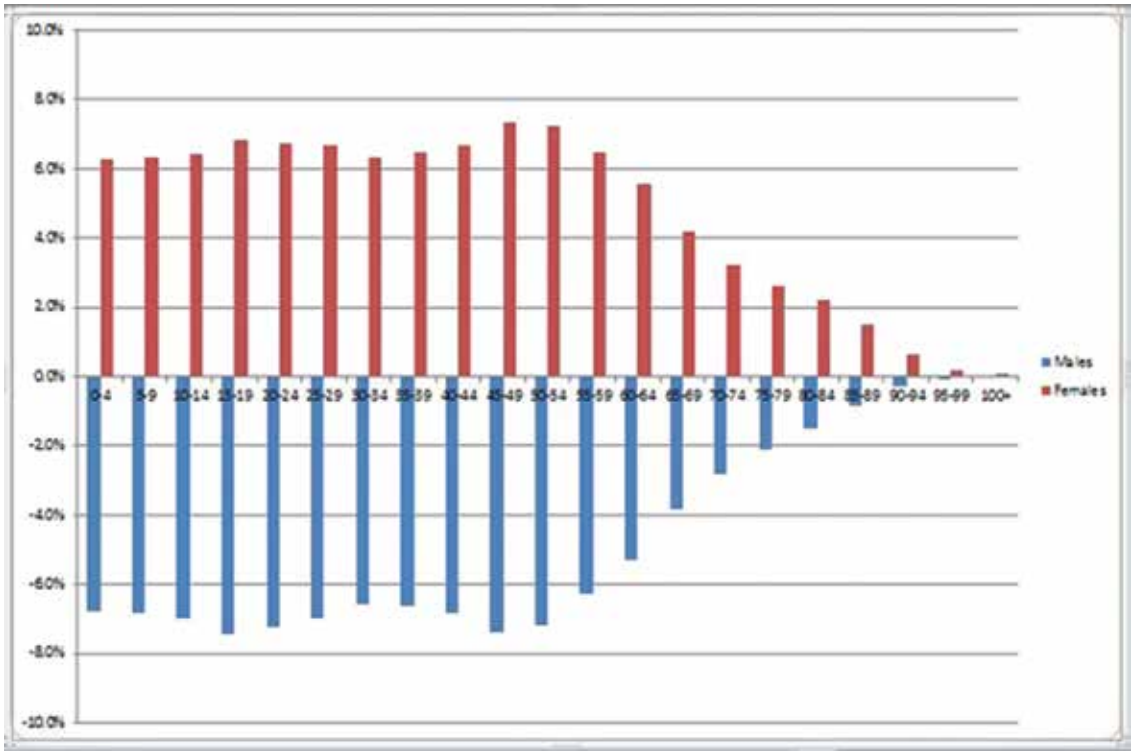
STEP 5

Making the bar chart for the country requires you to select the appropriate information. You require:

- the data in the column with age groupings (these will be your labels on the vertical axis)
- the percentage column for males
- and the percentage column for females (do not include the totals).

Select the data in column A and hold down the Control key; select the data in column C (including its heading, 'Males') and, keeping the control key down, select the data in column E (including its heading, 'Females'). Now let go of the Control key and press F11. The graph should come out a bit like figure 8.

FIGURE 8 The bar graph that Excel generates

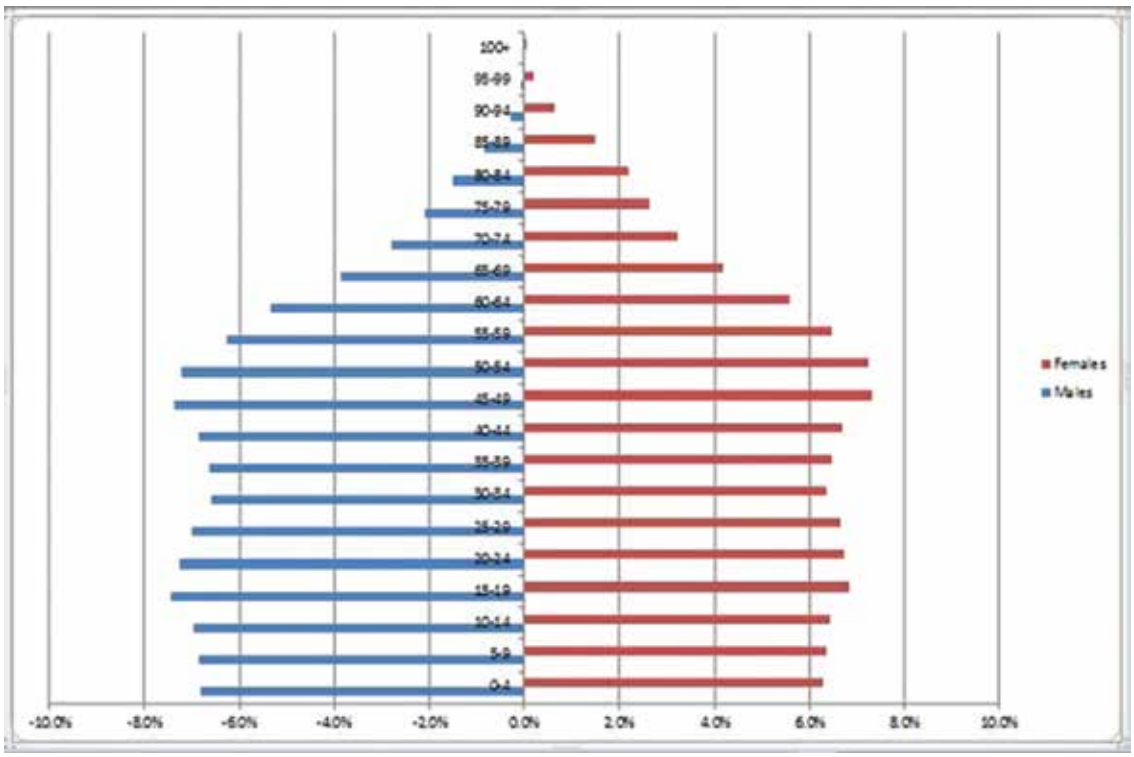


The next step is to change it. All versions of Excel are slightly different as to how this part is achieved and you may need to work your way through this by trial and error.

STEP 6

You now need to change this graph to suit geographic conventions. In the toolbar, go to Design and then Change Chart Type, on the far left of the toolbar. There you will find a horizontal bar graph. Click on this, and now your two bars should be horizontal. You should get something like figure 9. It is close to a population pyramid, but the male and female bars are not lined up and our axis labels have yet to be sorted out.

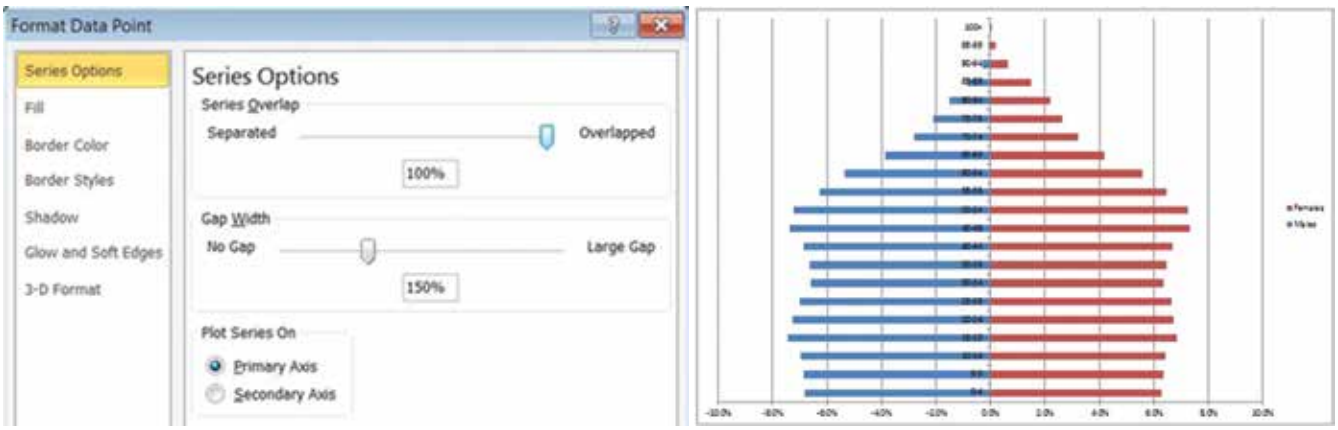
FIGURE 9 The graph now



STEP 7

It is now time to line up the bars. Click on any bar, and highlight just one bar. Then right-click your mouse, select Format Data Point… from the pop-up menu, and you should get a menu like the one shown in figure 10. Select the slider under Series Overlap and move it right until the window reads 100% and click Close. Your male and female bars should now be aligned.

FIGURE 10 Aligning the profile bars



STEP 8

You are nearly finished. All you need to do is remove the negative signs in the formatting of the male column (which was just a tool) and make a chart title.

First, click on the horizontal (%) axis at the bottom of the graph so that the axis is highlighted. Then right-click and a pop-up menu like the one shown in figure 11 will appear. Click on Format Axis… and then select Number. You will see a little Format Code window displaying 0.0%. Change this to #0.0%;#0.0% as shown in figure 12, then click Add and then Close. This ensures that the Excel graph ignores any sign in front of the % figure.

FIGURE 11 The Format Axis menu

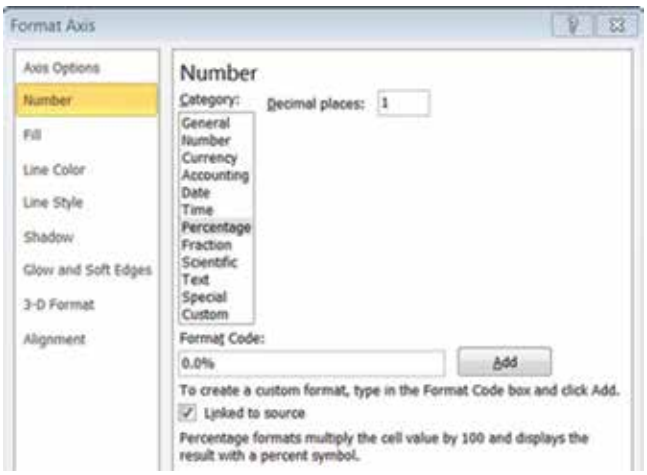
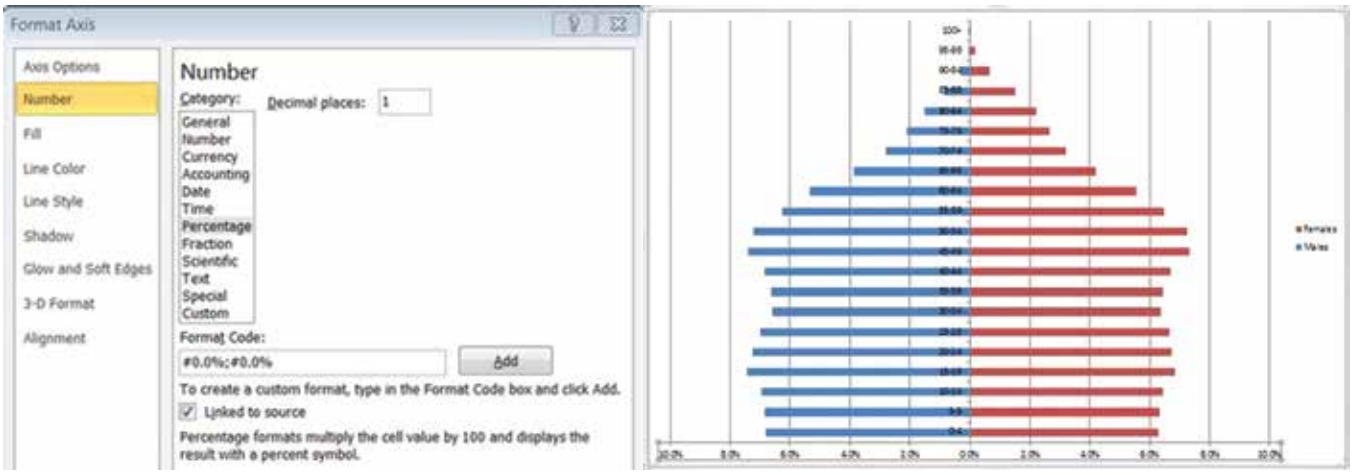


FIGURE 12 Removing the negative signs



STEP 9

Close this window and go back to the Excel main menu bar, click on the Layout tab and click on Chart Title to add your title (figure 13).

STEP 10

Label the horizontal axis 'Percentage' and the vertical axis 'Age group'. Go to Chart Tools, select Layout tab and click on the Axis Titles button. Select Primary Horizontal Axis Title, and Title Below Axis. Type the word 'Percentage' into the box that appears below the horizontal axis. Click on the Axis Titles button and then select Primary Vertical Axis Title and Horizontal Title. Type the words 'Age group' into the box that appears beside the vertical axis. Manually move the vertical axis title to sit above the population profile. You may also need to manually adjust the position of the chart title.

Before you save your graph, check that you have:

- included a clear title — the place name and date of the data
- made the *x*-axis the percentage of the population
- made the *y*-axis the age groups
- put the male category on the left and the female category on the right.

FIGURE 13 Adding the chart title

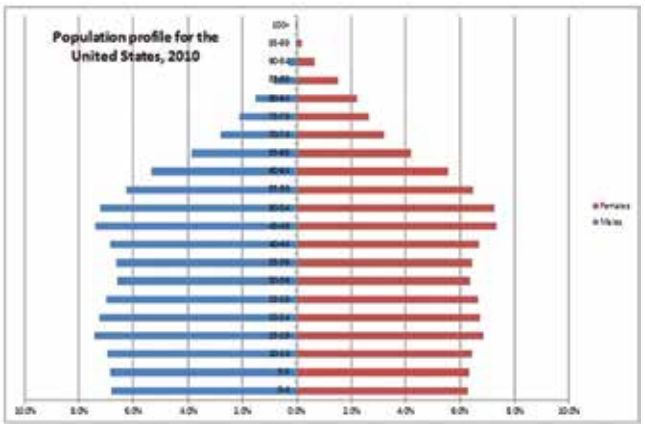
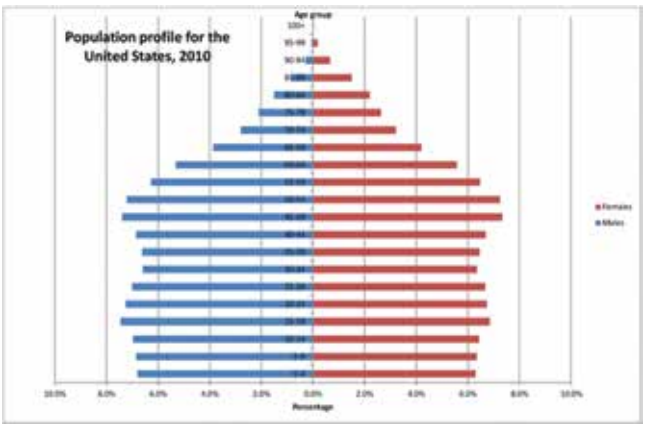


FIGURE 14 Population profile for the United States, 2010



20.4.3 Let me do it

Developing my skills

Using the Singapore Census data below, complete a population profile using Excel.

TABLE 2 Singapore residents by age group and sex, end June 2012

	Total	0–4 years	5–9 years	10–14 years	15–19 years	20–24 years	25–29 years	30–34 years	35–39 years
Total	3818.2	186.7	206.3	233.3	258.9	264.5	254.6	295.4	314.0
Males	1880.0	94.9	105.0	119.7	132.1	132.7	123.1	140.7	152.3
Females	1938.2	91.7	101.3	113.6	126.8	131.8	131.5	154.7	161.7

	40–44 years	45–49 years	50–54 years	55–59 years	60–64 years	65–69 years	70–74 years	75–79 years	80–84 years	85 + years
Total	308.8	320.9	310.4	271.8	214.0	128.9	104.4	67.7	44.1	33.6
Males	151.2	161.1	156.6	136.4	105.8	62.4	47.9	29.7	17.5	11.1
Females	157.6	159.8	153.8	135.4	108.2	66.5	56.5	38.0	26.6	22.5

Questions

1. Is your population profile that of a young population or an aged population?
2. Which age group has the largest number of people?
3. What percentage of the population is made up of children aged under 15?
4. What percentage of the population is made up of people aged over 65 years?
5. List two factors that the planners in this country need to take into consideration for the future wellbeing of the people.

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Interactivity
Using Excel to construct population profiles
Searchlight ID: int-3376

Checklist

I have:

- carefully entered data
- met geographic standards; for example, the bars are aligned
- labelled the axes
- included a clear title.

Skills questions

1. Excel-constructed population profiles are used to show:
   a. males in a population
   b. total number of people in a population
   c. females in a population
   d. total population numbers in an age–sex structure.
2. An Excel-constructed population profile includes information about:
   a. animals
   b. children
   c. wealth
   d. rainfall.
3. What are the key advantages of using an Excel spreadsheet to construct a population profile?
4. Why is it important to continue to subdivide the population into age groupings until 100 years of age on the graph?

20.10 SkillBuilder: How to develop a structured and ethical approach to research

20.10.1 Tell me

What is a structured and ethical approach to research?

A structured and ethical approach to research involves organising your work clearly and meeting research standards without pressuring anyone into providing material and without destroying environments while gathering the data. Your work must also be your own, and anything that is someone else's work must be referenced in the text and included in the reference list.

Why is a structured and ethical approach to research useful?

A structured and ethical approach to research ensures that the material:

- is gathered appropriately
- causes no harm
- avoids plagiarism, which means using someone else's words or ideas without acknowledgement
- avoids dispute over the ownership of material.

A structured approach involves understanding an issue, gathering the facts, and developing and presenting the research, including any recommendations.

An ethical approach avoids plagiarism, or using someone else's words or ideas. You must be able to say that a piece of work is all your own, unless you acknowledge input from others by referencing and footnoting. An ethical approach means that you have not coerced anyone or used deception to get them involved in your research; that you respect the privacy of those providing information; and that you will ensure no-one comes to harm through your research. In fieldwork activities, you must seek permission to enter private property, minimise damage to the environment and be safe in gathering your data. If your research is sensitive to an individual's or organisation's wellbeing, you must ensure the security of any data gathered or provided.

A structured and ethical approach to research is useful for:

- developing skills that will serve you well into the future in whatever occupation you take up
- ensuring a report is honest
- providing reports for an audience such as a consultancy group, legal company or planning authority
- undertaking authentic university research in future.

Model

A good structured and ethical approach to research:

- uses primary data as its basis
- acknowledges secondary data appropriately
- contains text that is all your own work — it does not plagiarise
- clearly identifies the data to be collected
- includes facts that support the idea
- develops a reasoned response.

FIGURE 1 A sample of a contribution form

Name:

School:

The research that I have undertaken has contributed to my understanding of the topic. At all times I have acted in such a way as to not harm the feelings of people or destroy the environment. This research is presented in my own words and is my understanding of the topic.

I, _____[name], certify the accuracy of this statement of contribution.

Signature: **Date:**

TABLE 1 A table of Australia's population, September 2012, with a source line at its foot

Preliminary data	Population at end Sept. quarter 2012 '000	Change over previous year '000	Change over previous year %
New South Wales	7 314.1	86.0	1.2
Victoria	5 649.1	94.8	1.7
Queensland	4 584.6	91.4	2.0
South Australia	1 658.1	16.4	1.0
Western Australia	2 451.4	81.7	3.4
Tasmania	512.2	0.5	0.1
Northern Territory	236.3	4.2	1.8
Australian Capital Territory	376.5	7.4	2.0
Australia	**22 785.5**	**382.5**	**1.7**

Source: Australian Bureau of Statistics, www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0.

20.10.2 Show me

How to develop a structured and ethical approach to research

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How to develop a structured and ethical approach to research
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You will need:

- to gather data
- to present the data.

Procedure:

STEP 1

Determine the features that you are going to explore in the community (your primary data) or to research (your secondary data). Set up an inquiry question to explore, such as 'Does our neighbourhood need a skateboard park?' or 'Does public transport service our community well?'

Primary data will need to be collected by you. Use of secondary data is when you refer to someone else's work, such as a newspaper report, historical account or planning document. You must make sure you acknowledge the source of your information.

STEP 2

You will need to undertake fieldwork to gather primary data on the factors. This is likely to mean that you will have to survey the community. A range of survey techniques is available:

- observation
- questionnaires
- interviews
- judgement surveys — agree, disagree, strongly disagree
- perspective surveys — 3 to minus 3
- attitudinal surveys — strongly agree, agree, neutral, disagree, strongly disagree.

Photographs and sketches may be needed to support ideas. At all times, the work must be completed with an ethical approach. You must maintain privacy of the sources, and cannot coerce anyone to provide responses or cause any harm in acquiring the information.

STEP 3

Data gathered in the field will need to be analysed and presented as text, tables, graphs and annotated photographs or sketches.

STEP 4

Any secondary data will need to be summarised or attributed appropriately to avoid plagiarism.

STEP 5

A report needs to be presented with the following structure and parts.

- The statement of the report's aim or purpose should identify an issue or problem and develop a geographical question that will investigate the issue and find an answer to the problem. At this stage, you are observing, questioning and planning (step 1).
- The collection, recording, evaluation and representation of primary and secondary data should be checked for reliability and bias (step 2).
- The analysis should make sense of the information gathered. It identifies order, diversity, trends, patterns, anomalies, generalisations and cause-and-effect relationships. Both quantitative and

qualitative data should be provided. The results should be interpreted to provide conclusions (steps 3 and 4).
- The information should be communicated by a variety of methods, such as written, oral, audio, visual and mapping, as appropriate to the topic, purpose and audience.
- The reflection on and response to the research is important. Reflect on what you have learned, the processes you have undertaken (and their effectiveness) and any actions that have been or should be undertaken (step 6).
- The reference list is crucial (step 7).

STEP 6

Conclusions need to be drawn. Conclusions should come from the data presented without allowing any bias you might have on a topic to be apparent.

STEP 7

If secondary sources are used, a list of references should be provided. Your teacher will guide you on the most appropriate style to adopt.

STEP 8

Write a brief statement, or complete a form provided by your school, to verify that your report is all your own work.

20.10.3 Let me do it

Developing my skills

Undertake an investigation into the wellbeing of your local community, and write a report on it. This may be undertaken as fieldwork using primary data, or by using secondary data from the Australian Bureau of Statistics to show differences between two places — both urban, both rural, or one urban and one rural.

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Interactivity
How to develop a structured and ethical approach to research
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Questions

1. By your assessment, which place has the higher level of wellbeing?
2. List three factors that you have used to come to this conclusion.
3. Which factor would you hope to see improvement in? Why did you choose this factor?
4. What changes in this factor would result in improvements to the community's wellbeing?
5. Has your data been gathered with an ethical approach? Explain your answer.

Checklist

I have:
- clearly identified the data to be collected
- found facts that support the idea
- developed a reasoned response
- used primary data as the basis of my report
- acknowledged secondary data appropriately
- written text that is all my own work and does not plagiarise.

Skills questions

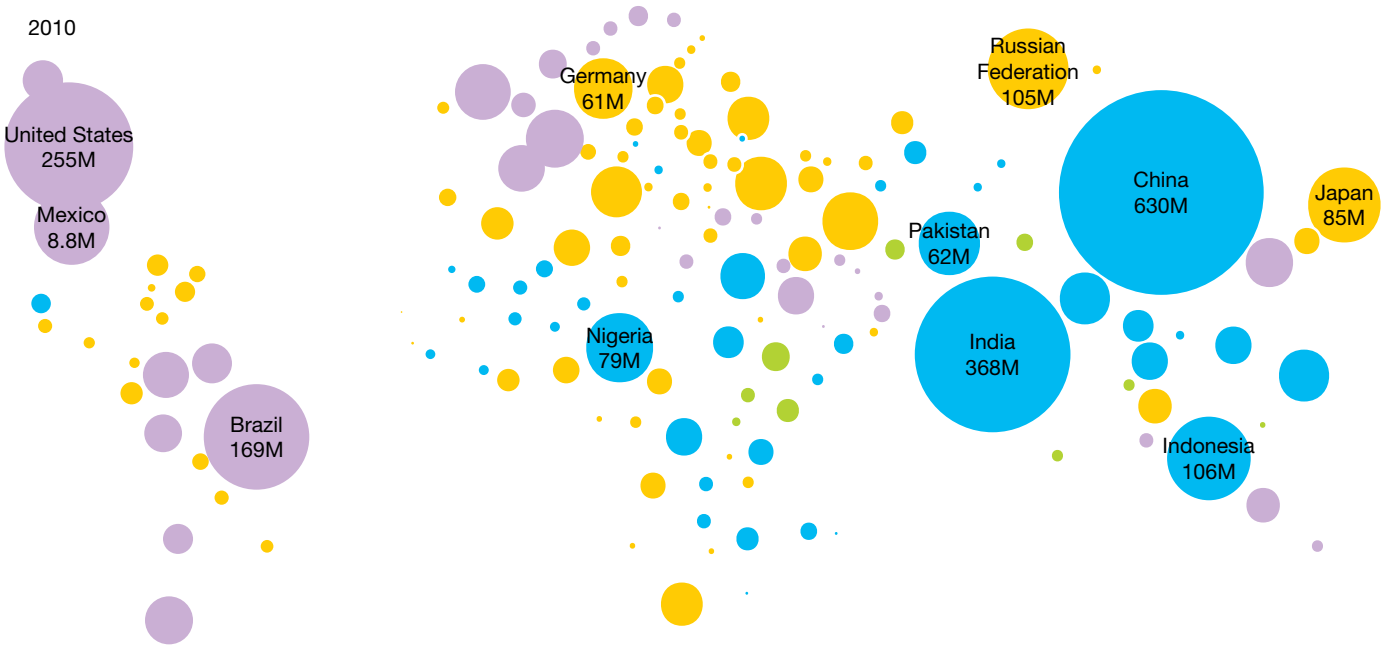
1. A structured and ethical approach to research is used to show:
   a. everything you know about a topic
   b. a factual response to a topic that is unbiased
   c. one point of view on a topic
   d. someone else's opinion on a topic.
2. A structured and ethical approach to research includes information other than:
   a. from libraries
   b. someone else's findings
   c. from newspapers
   d. primary data.
3. How and why should you ensure the ethical standards of research are maintained?
4. Why is it important to avoid plagiarism?

20.12 Review

20.12.1 Review

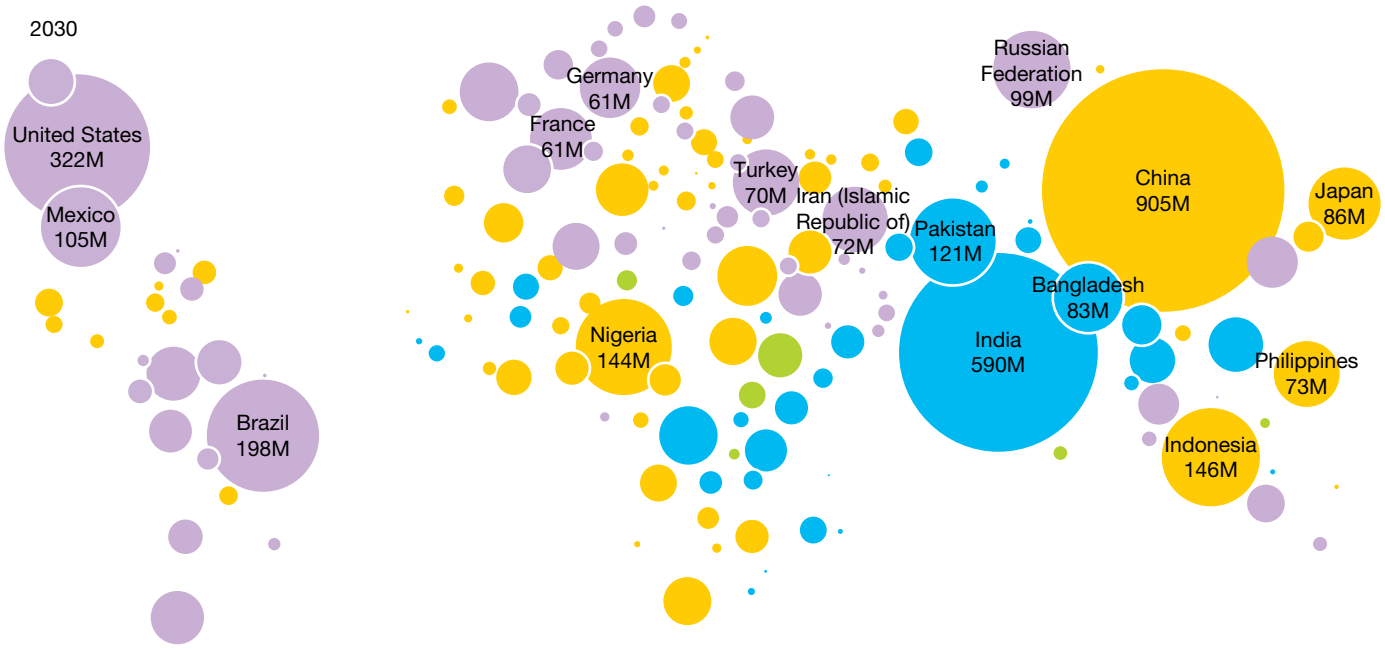
1. How does the physical ***environment*** affect the distribution of population?
2. Refer to figures 1 and 2. Describe the ***changing*** distribution of urban population globally between 2010 and 2030.

FIGURE 1 Urban world, 2010



M = 1 million
Source: © UNICEF.

FIGURE 2 Urban world, 2030



M = 1 million
Source: © UNICEF.

3. Account for the ***changing*** distribution of population from rural to urban ***places***.
4. Which regions of the world experience the highest and lowest life expectancy?
5. Draw a sketch of a population pyramid for a country with a low life expectancy and one for a country with a high life expectancy. Annotate their main features and account for their difference in shape.
6. Compare the distribution of birth and death rates between the regions of Asia, Africa and Europe.
7. What term is given to the difference between the birth and death rates?
8. Draw a rough sketch of the demographic transition model, annotating each of the five stages to indicate ***changes*** to births, deaths and population growth.
9. Compare the problems faced in the long term by Kenya and Japan in terms of the countries' fertility rates.
10. How do population characteristics vary across India?
11. Refer to table 1. Describe the ***changing*** characteristics of Australia's population indicated here. Account for this variation.

TABLE 1 Changes in Australia's demographic grouping

Region		2001 (millions)	2011 (millions)	2001–11 (millions)	2001–11 (%)
5 km radius	The inner city elite	1.0	1.3	0.3	24.4
Balance metro	The suburbanistas	11.4	13.0	1.9	16.4
Coastal	The seachangers	2.1	2.6	0.5	25.1
Regional	The rural heartlanders	4.7	5.3	0.5	11.5
Remote	Outbackistan	0.2	0.2	0.0	10.4
Australia		19.4	22.4	3.2	16.5

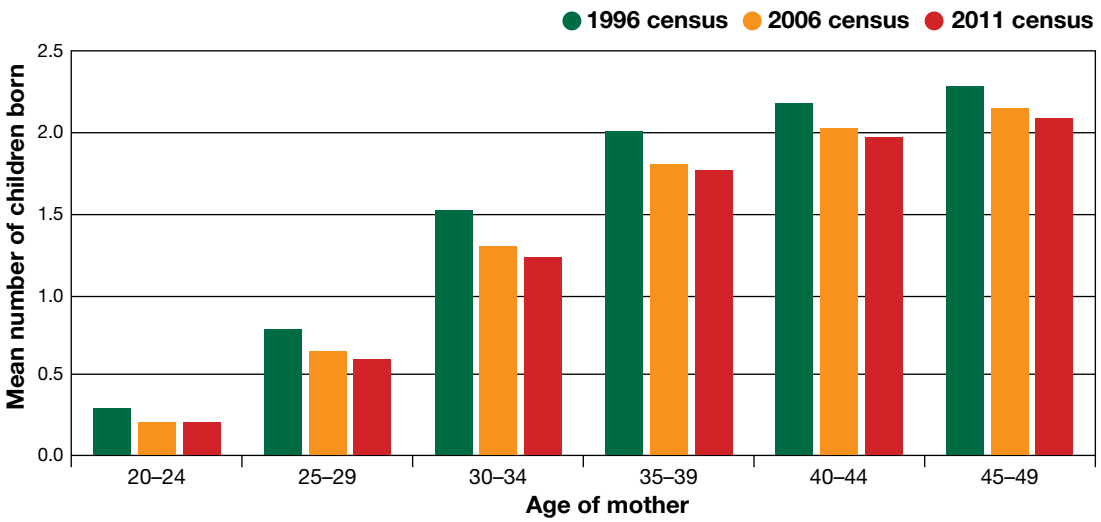
Source: © Newspix table, 'Changes in Australia's demographic grouping', Bernard Salt, *The Australian*, page 17, 23 June 2012.

12. Explain why India faces a significant gender imbalance.
13. What measures are being undertaken to prevent the spread of malaria?
14. How is HIV spread?
15. a. Why has the incidence of HIV/AIDS fallen?
    b. In what regions does HIV/AIDS remain a concern? Why?

20.12.2 Reflect

16. Consider how global population distribution might ***change*** in the future if:
    a. barriers to movement are removed by governments
    b. people become better educated.
17. How have improvements in technology led to an increase in life expectancy?
18. What factors might cause some ***places*** to experience a decrease in life expectancy?
19. There is a clear ***interconnection*** between women's education and fertility levels. Explain why this is the case. You may find it helpful to consider the information shown in figure 3.

FIGURE 3 Careers before babies



Source: © Australian Bureau of Statistics.

20. What are the long-term impacts of a low rate of natural increase in population?
21. Access to sanitation has a major impact on death rates. In what way might access to sanitation be considered a human right?
22. Do you think Kenya or Japan has a more difficult fertility problem to deal with? Justify your answer.
23. India and China both have a population of over one billion, yet both have vastly different population growth rates. Why?
24. Suggest how the issue of gender imbalance in India could be solved.
25. 'Australia's population distribution is likely to remain concentrated in the south-east.' To what extent do you agree with this statement?
26. a. How might the distribution of malaria on a global ***scale change*** in the future?
    b. Account for your answer.
27. Why is HIV/AIDS considered to be a pandemic?
28. What measures can be put in place to ensure people who contract HIV continue to live healthy, productive lives?
29. Research the Japanese Government's Angel Plan, designed to help increase the country's falling birth rate.
    a. What aspects of the Government's beliefs and values led to the development of the Angel Plan?
    b. What aspects of the Japanese culture, values and beliefs have prevented the plan from achieving success?
30. Australia is one of the world's most multicultural nations. Identify some of the challenges and benefits of living and working in our multicultural society.

Contrast between two places in Queensland: Thargomindah (inset) and Brisbane (main image)

CHAPTER 21

Human wellbeing in Australia

21.1 Overview

21.1.1 Introduction

All of us have travelled to different places during our lives. These places may be within our own suburb, within our town or city, in another state of Australia, or, if we are very fortunate, in another country. While we tend to be more conscious of differences between our own country and others, variations also occur at local and regional scales. Variation may be between urban and rural environments or even within the one city or town. Think about how the various spaces near where you live might reflect differences or similarities in wellbeing and the reasons for these characteristics.

Starter questions

1. What are the characteristics of the particular rural or urban ***environment*** in which you live (your suburb)?
2. In what ways do these characteristics vary from those of the neighbouring ***environment***, whether it is a farm, town or suburb?
3. What ***interconnection*** is there between these characteristics and the wellbeing of the people in these ***places***?
4. Why do similarities or variations in wellbeing occur at a local or regional ***scale***?

Inquiry sequence

		Syllabus outcomes
21.1 Overview		
21.2 What are Australia's population characteristics?		GE5-1
21.3 What are some rural–urban variations within Australia?		GE5-1, GE5-6
21.4 What are some variations in wellbeing in Sydney?		GE5-1, GE5-6
21.5 SkillBuilder: Using multiple data formats	eBook plus ONLINE ONLY	GE5-7, GE5-8
21.6 Is everybody equal?		GE5-6
21.7 SkillBuilder: Understanding policies and strategies	eBook plus ONLINE ONLY	GE5-7, GE5-8
21.8 What influences wellbeing for people with disabilities?		GE5-6
21.9 Investigating topographic maps: What influences wellbeing in Darwin?		GE5-7, GE5-8
21.10 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

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The other side of life
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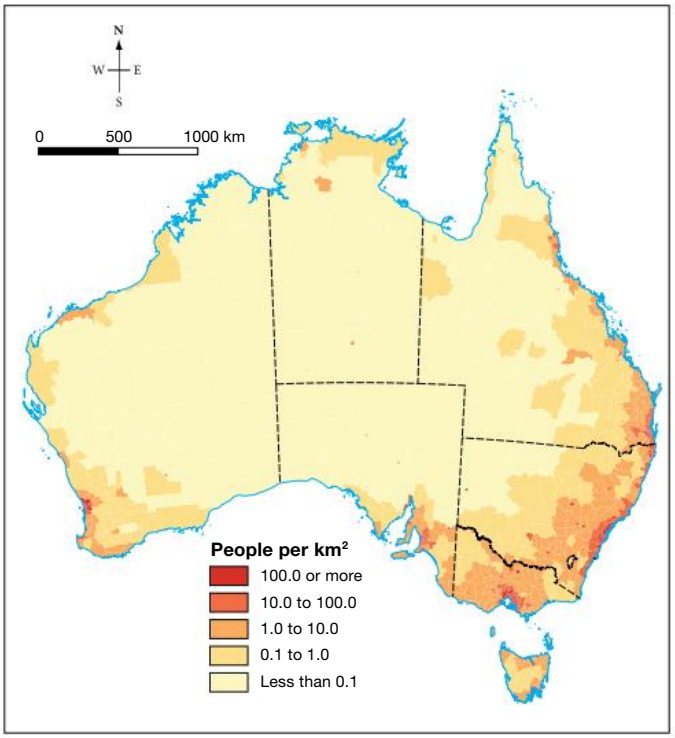
21.2 What are Australia's population characteristics?

21.2.1 Australia's population

FIGURE 1 Australia's population distribution



Source: Spatial Vision

According to the 2011 census, Australia's population in that year was 21 507 710. Statistically speaking, a typical Australian in that year would be female, born in Australia, aged 37 years, living in a household consisting of a couple and children (although the average household size was only 2.6 people). Of course, Australia's demographic characteristics are much more diverse than this. To what extent do you fit the 'typical' profile?

Most of Australia's population is concentrated in coastal regions in the south-east and east and, to a lesser extent, in the south-west. The population within these regions is concentrated in urban centres, particularly the capital cities (see figure 1).

Australia's population has increased considerably over time and is continuing to grow. Between 2006 and 2011, the population increased by 1 652 432 people, or 8.3 per cent (see figure 4).

Our population growth is due to immigration rather than natural increase. The level of migration is set annually by the Federal Government and is currently around 170 000 per year.

Our rate of fertility has declined steadily since the 1970s and is now well below replacement rate. Despite attempts to increase the number of children via a Federal Government

FIGURE 2 Brisbane, a typical Australian urban environment

baby bonus of approximately $5000 per baby, which was in place between 2003 and 2013, our fertility rate was 1.8 in 2011.

The decline in fertility and increased life expectancy has resulted in an ageing population (see figure 5). The proportion of the population aged 65 years and over increased from 11.8 per cent to 14.7 per cent between 1994 and 2014.

FIGURE 3 Innamincka: an outback town

FIGURE 4 Australia's changing population growth

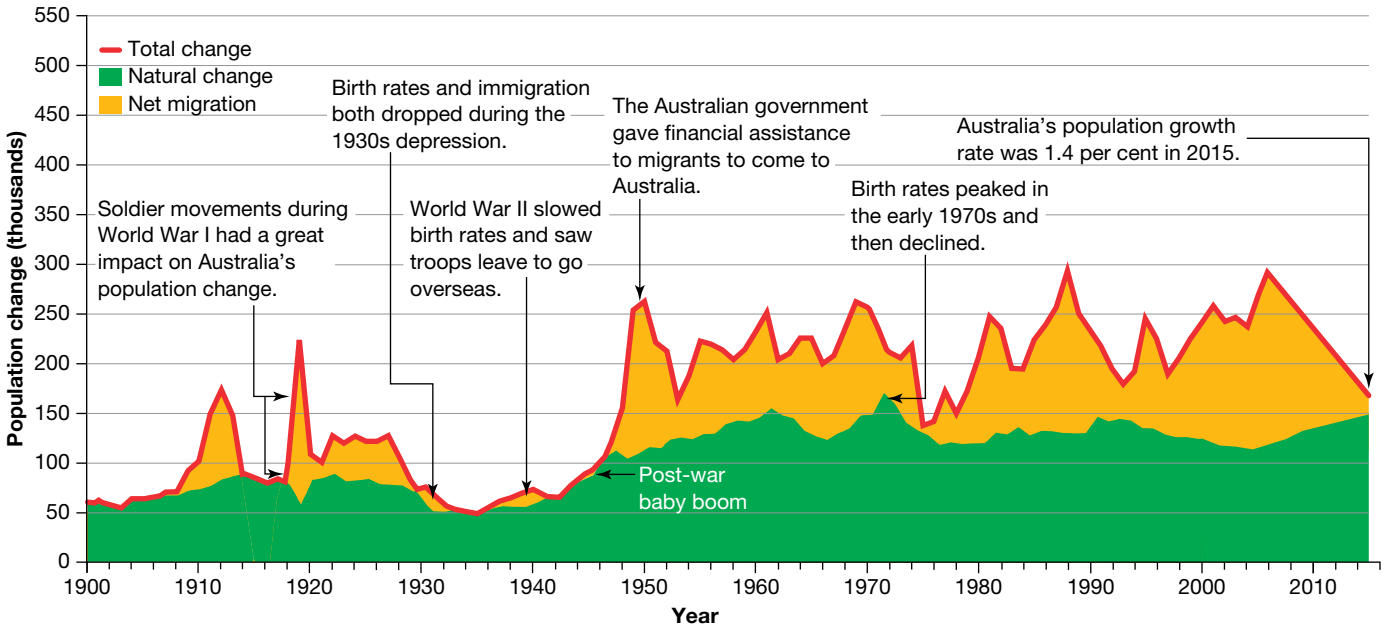


FIGURE 5 Australia's changing population structure

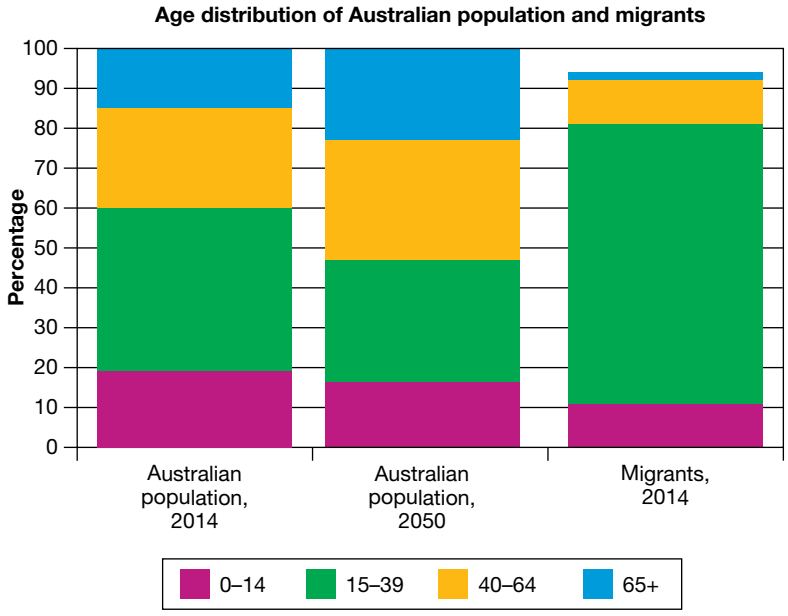
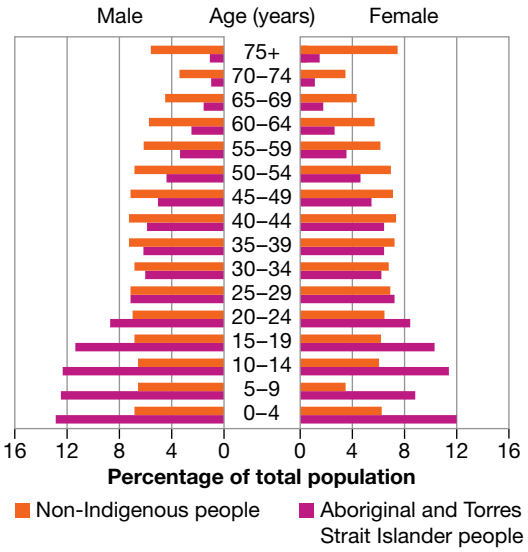


FIGURE 6 Population pyramid for Indigenous and non-Indigenous Australians



ACTIVITIES

IDENTIFY

1 What factors have accounted for Australia's ***changing*** population growth over time?

2 How is Australia's population structure expected to ***change*** in the future?

EXPLAIN

3 Account for the variation in Australia's population distribution.

PREDICT

4 Predict the impact of Australia's ageing population on our demand for different facilities. Use the **Lateline** weblink in your eBookPLUS to assist you with this answer.

5 Sketch the shape of how you think Australia's population pyramid will look in 50 years' time. Justify your drawing.

APPLY

6 What other methods could the Australian government use in order to encourage population growth in Australia?

7 What are the advantages and disadvantages of a 'big Australia' and a projected future population of 35 million? Use the **Population puzzle** weblink in your eBookPLUS to find out about one side of the argument.

INVESTIGATE

8 a Use the Australian Bureau of Statistics website to access statistics on four demographic characteristics of your Local Government Area.

b How do the statistics for your Local Government Area compare to those for Australia as a whole and those of your state?

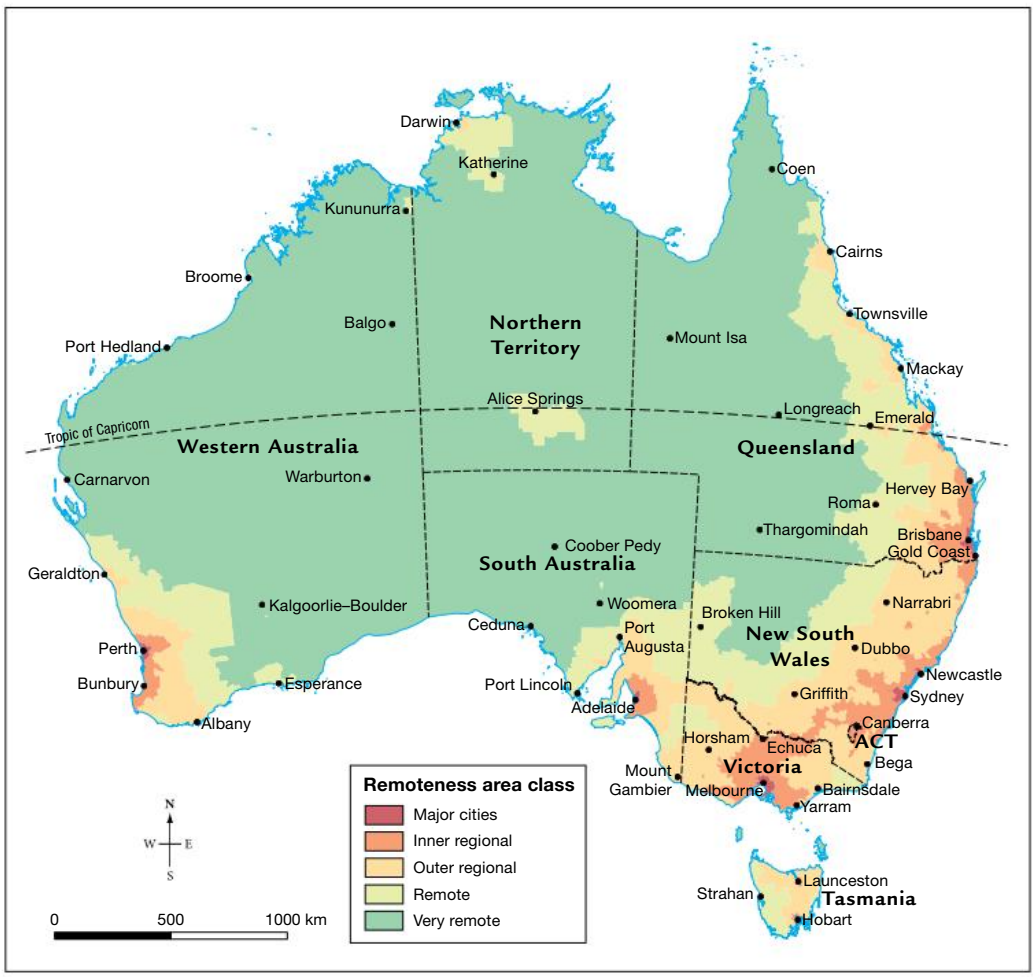
eBookplus

Weblinks
- Lateline
- Population puzzle

regional and remote areas areas classified by their distance and accessibility from major population centres

21.3 What are some rural–urban variations within Australia?

FIGURE 1 Australia's population by remoteness classification



Source: Australian Bureau of Statistics

21.3.1 Rural–urban variation in Australia

Wellbeing varies considerably from one place to another within the one country and also within urban and rural environments. Sometimes these variations are quite distinct, but at other times they may be quite minor. As you will have seen in earlier chapters, the particular indicators used may give a different picture of these places.

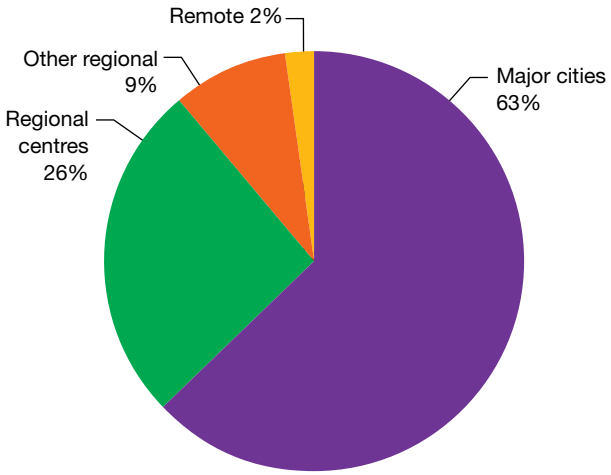
According to the Australian Institute of Health and Welfare (AIHW), people living in rural places tend to have shorter lives and higher levels of some illnesses than those in major cities. The level of health of Australians is much lower in **regional and remote areas** than in major cities. The location of these categories is shown in figure 1. People

from regional and remote areas tend to be more likely than their major cities counterparts to smoke and drink alcohol in harmful or hazardous quantities. This is reflected in higher mortality rates than for those living in major cities.

These higher death rates may relate to differences in access to services, increased risk factors and the regional/remote environment. More physically dangerous occupations in rural areas lead to higher accident rates. Factors associated with driving such as long distances, greater speed and animals on roads contribute to elevated road accident rates in country areas.

People with disability living outside major cities are significantly less likely to access disability support services. Where health services are provided, regional and remote residents also face higher out-of-pocket expenses. Use the **100 people** weblink in your eBookPLUS to find out more about the health of the Australian population.

FIGURE 2 Percentage of Australia's population by remoteness classification



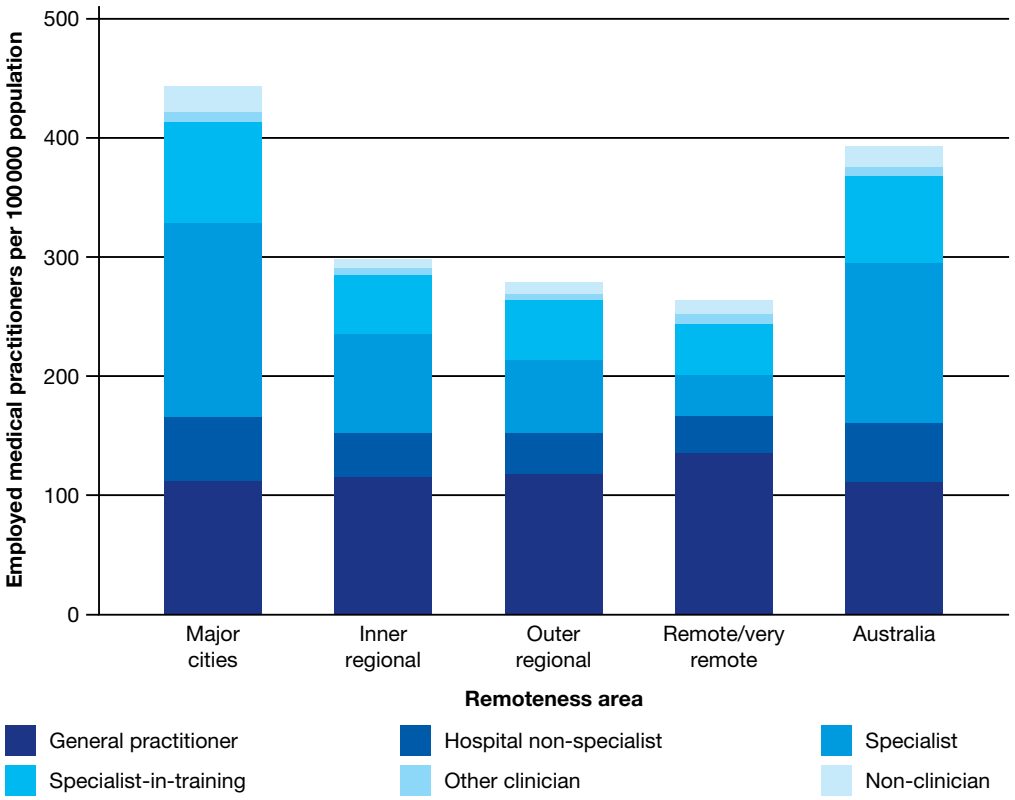
In general, people living in rural Australia do not always have the same opportunities for good health as those living in major cities. Residents of more inaccessible areas of Australia are generally disadvantaged in their access to health facilities with skilled personnel. Figures 3 and 4 show access to services is at least partially affected by the number of available health workers per population. Medical personnel in rural areas have a higher average age and face longer hours than their city counterparts. Recruitment difficulties in rural areas also affect the sustainability of such services.

Higher costs and more limited availability of products such as fresh fruit and vegetables also impacts on health and wellbeing. A government survey found that absence of competition in remote areas led to mark-ups of up to 500 per cent on some foods, particularly fresh fruit and vegetables, which took up to two weeks to reach their destination. A typical packet of pasta cost approximately five times more than in metropolitan stores. Fewer educational and employment opportunities are other challenges faced by those in regional and remote places.

eBookplus

Weblink
100 people

FIGURE 3 Distribution of medical practitioners, Australia, 2009



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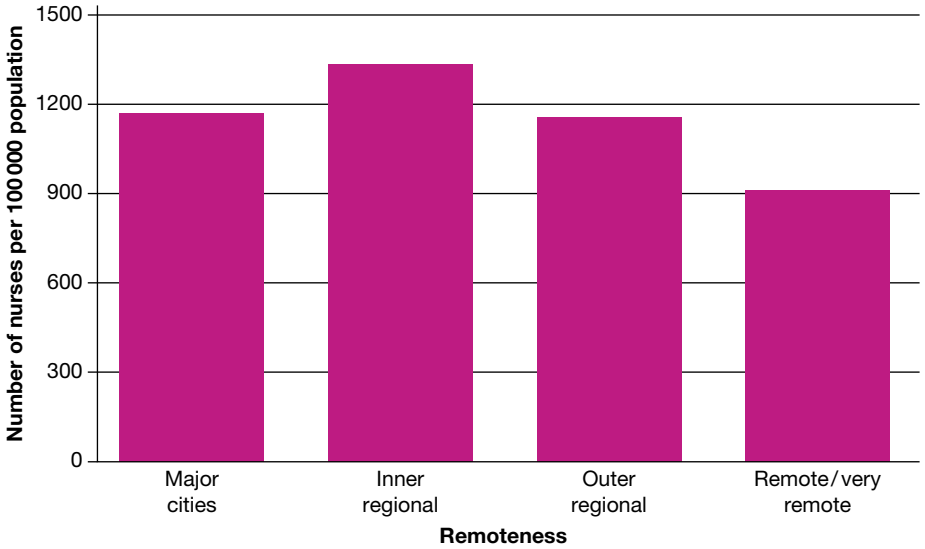
Interactivity
Call the doctor!
Call the nurse!
Use this interactivity to compare differences in access to medical services across Australia.
Searchlight ID: int-3311

FIGURE 4 Distribution of nurses, Australia, 2011



On the positive side, in terms of wellbeing, rural Australians tend to have higher levels of social cohesiveness, as reflected in higher rates of participation in volunteer work and feelings of safety in their community. The Country Women's Association is one such volunteer organisation (see figure 6).

FIGURE 5 The Royal Flying Doctor Service provides vital health care for remote areas of Australia.

FIGURE 6 Members of the Canberra Evening Branch of the Country Women's Association held a charity bake-off for the Women's Refuge of the ACT.

ACTIVITIES

IDENTIFY

1 Draw a table to show the advantages and disadvantages of rural versus urban areas in terms of wellbeing in Australia.
2 Which suburbs of Sydney are considered to be the most advantageous?
3 Which suburbs of Sydney are considered to be the least advantageous?

EXPLAIN

4 Compare the graphs showing the distribution of doctors and nurses within Australia. Suggest reasons to account for this variation.

APPLY

5 What is the long-term potential outcome of the contrast in wellbeing as shown in:
a the housing affordability graphs?
b the distribution of medical practitioners and nurses?

PREDICT

6 Suggest an alternative measure of wellbeing not mentioned in this section that could highlight the variation in wellbeing within an urban area.

21.4 What are some variations in wellbeing in Sydney?

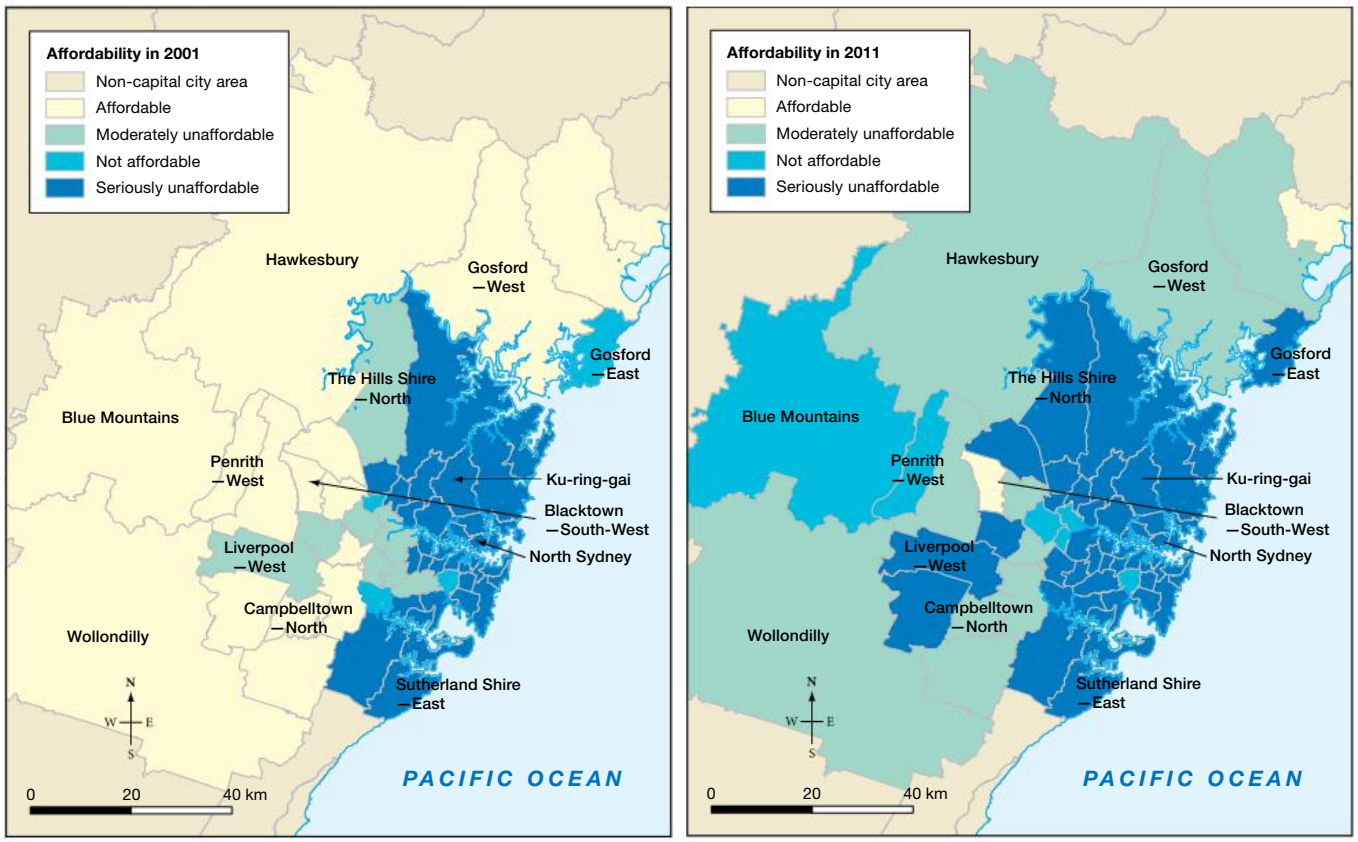
21.4.1 Variation in wellbeing within cities

Although, according to many measures, people in urban places generally have a higher standard of wellbeing than those living in rural areas, levels of wellbeing are not uniform across towns and cities. If you live in a town or city yourself, you would be aware that not all parts of that location have the same access to facilities or the same types of housing. Variations in wellbeing occur on a local scale as well as at national and global scales.

Figure 1 shows **housing affordability** as a measure of wellbeing in Sydney. The cost of housing is a major expenditure for people so its affordability directly impacts on people's living standards. Based on this information, it would appear that most of Sydney's population is not in a comfortable position, particularly those in the eastern and northern suburbs.

housing affordability relates to a person's ability to pay for their housing; in Australia, those spending more than 30 per cent of their income on housing, while earning in the bottom 40 per cent of the income range, are considered to be in housing affordability stress

FIGURE 1 Changing housing affordability in Sydney: (left) 2001 and (right) 2011



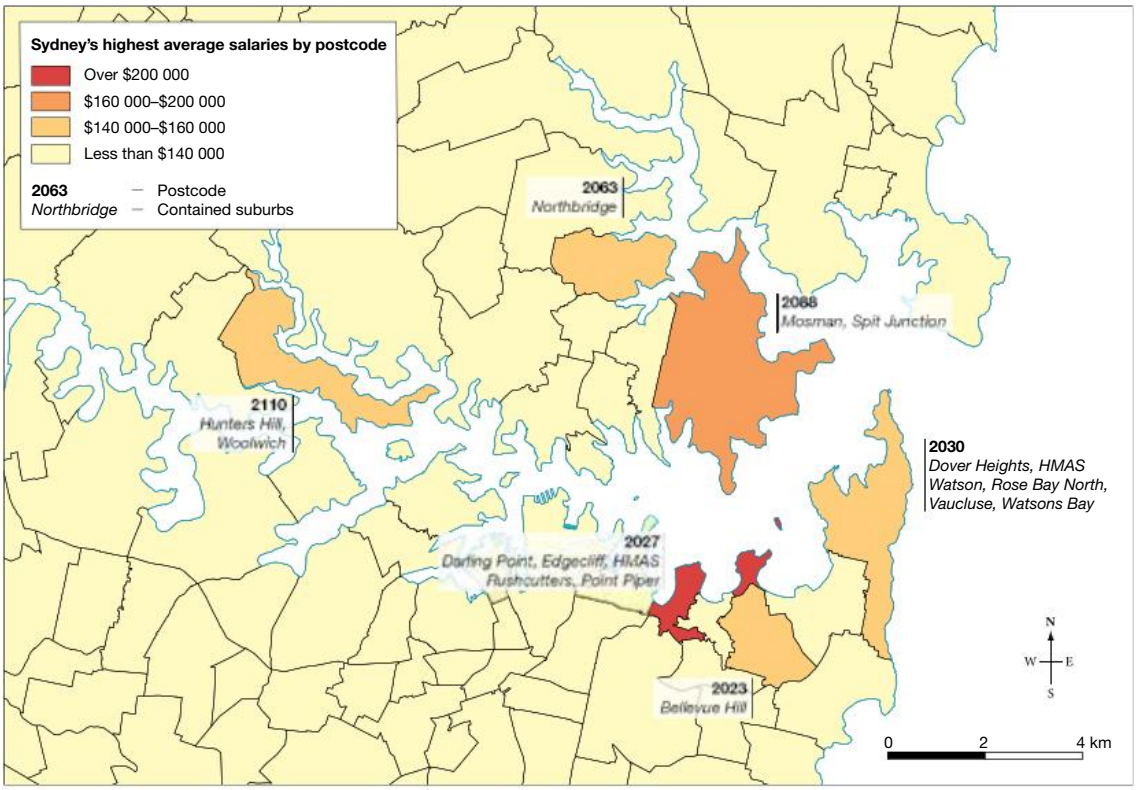
Source: Spatial Vision

Source: Spatial Vision

Figure 2 shows the average salary increase per municipality between 2003 and 2008. The percentage increase varies greatly across Greater Metropolitan Sydney. Housing affordability is a key driver of the growing income divide in Sydney. Rising house prices are pushing low-income workers out of inner-city harbourside areas.

There are significant spatial variations within Sydney, as indicated in figure 1, which reflect the varying level of human wellbeing among Sydney-siders. Some suburbs are more affordable than others. Residents of some suburbs earn higher taxable incomes. The relationship between housing affordability and taxable income affects the way people can improve their own wellbeing. The role of the New South Wales government is to allocate funding to allow people to gain access to adequate housing, healthcare and education without being disadvantaged by their income.

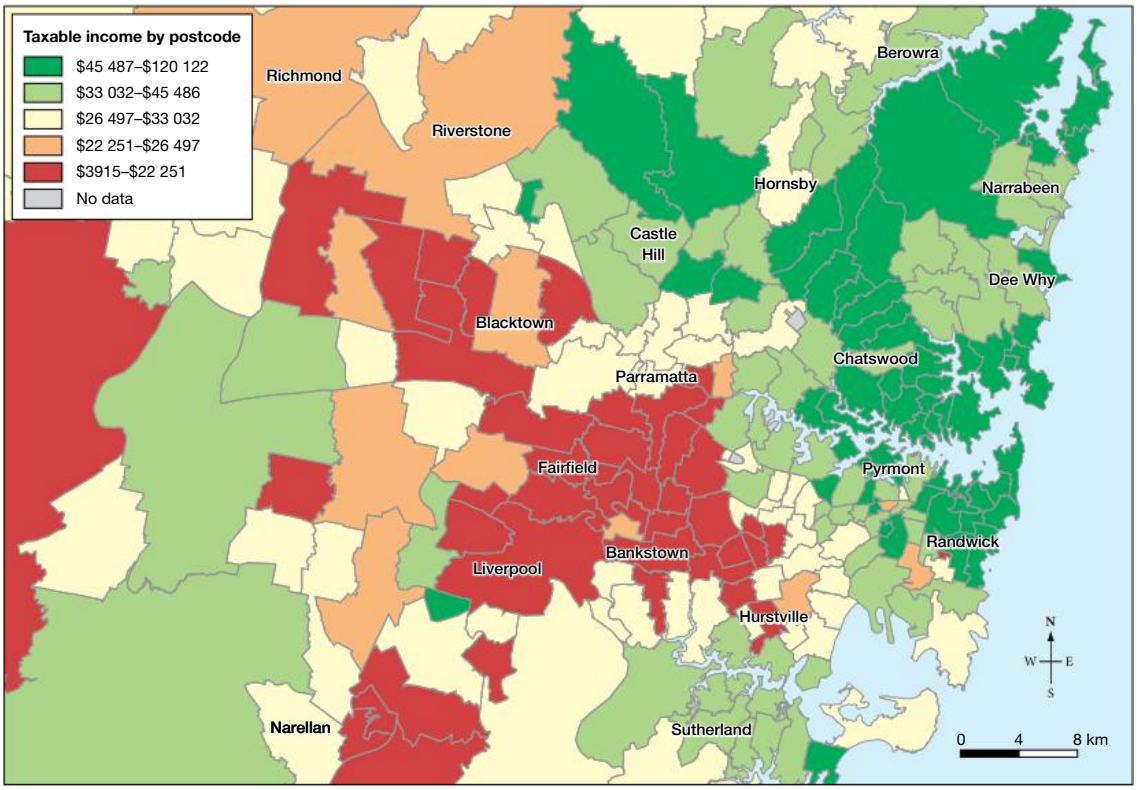
FIGURE 2 Sydney's growth in average wage and salary income, 2007–2008



Source: Australian Tax Office, Australian Bureau of Statistics

Figure 3 shows the average salaries within municipalities of Sydney. There are very large differences, which would affect a person's ability to purchase a house and to have access to education and healthcare.

FIGURE 3 Sydney's taxable income by postcode



Source: Australian Tax Office, Australian Bureau of Statistics

ACTIVITIES

IDENTIFY
1 Describe the change in housing affordability shown in figure 1.
2 State the wealthiest suburbs of Sydney.
3 State the disadvantaged suburbs of Sydney.

EXPLAIN
4 Why do variations in wellbeing exist?
5 Explain why the information shown in figures 1, 2 and 3 is considered to be a measure of wellbeing.

APPLY
6 Provide reasons why housing became less affordable between 2001 and 2011.
7 Use figures 1, 2 and 3 to recommend ways an individual could improve their income.

INVESTIGATE
8 Suggest an alternative measure of wellbeing not mentioned in this section. Highlight the variation in wellbeing within an urban area.

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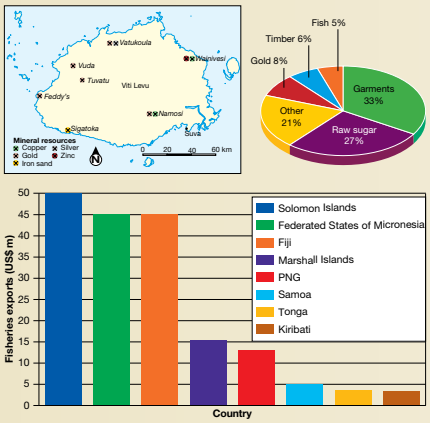
21.5 SkillBuilder: Using multiple data formats

What are multiple data formats?

Multiple data formats are varied forms of data presentation, used when a range of data needs to be shown. All the information must be read before the data can be interpreted. Multiple data formats are useful in major reports when a range of ideas needs to be pulled together and presented as a united document.



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Watch this video to learn how to use multiple data formats.

Searchlight ID: eles-1761

Interactivity
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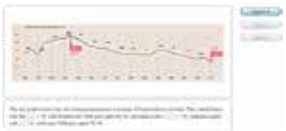

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21.6 Is everybody equal?

21.6.1 Are all Australians equal?

Aboriginal culture has often been acknowledged as the world's oldest surviving culture. Sixty thousand years of history has resulted in rich traditions, strong spiritual beliefs and complex social structures. Since European settlement much has changed, but culture and the bonds within **Indigenous** communities remain strong. Why then, do Aboriginal and Torres Strait Islander peoples not enjoy the level of wellbeing experienced by the wider Australian community?

In a just society like Australia, we would expect that everyone is able to experience a similar standard of living. It would be unfair for one sector of a community to experience significant disadvantage when the rest of the community enjoys the privileges of a 'good life'. Many Indigenous people consistently experience lower levels of health, education, employment and economic independence than those enjoyed by most Australians. These **socioeconomic** factors inhibit the ability of Indigenous Australians, who make up 2.5 per cent of the Australian population, to contribute to and benefit from all that Australia has to offer.

Indigenous
Australia's Indigenous peoples are made up of Aboriginal people (who live all around Australia) and Torres Strait Islanders (who settled the many small islands to the north of Cape York Peninsula in Queensland)

socioeconomic
relating to or involving a combination of social and economic factors

FIGURE 1 Closing the gap for Indigenous Australians will take generations of commitment.

21.6.2 Why does disadvantage exist?

The inequalities may be attributed to three main causes:

- the dispossession of land
- the displacement of people
- discrimination.

Many generations of Indigenous people have experienced difficulties in accessing the same services and opportunities as other Australians. Disadvantage in one area, for example, poor access to health services, may affect a student's ability to attend school, which may in turn alter their employment prospects. Compared with other Australians, Indigenous people (as a group) remain disadvantaged (see figure 3).

FIGURE 2 Better and more frequent access to health care will help close the gap. The Close the Gap Campaign is Australia's biggest ever public movement for health equality. Led by a coalition of leading Australian health and human rights organisations, it campaigns for long-term and sustainable change to close the gap in life expectancy and health standards for Indigenous Australians and aims to ensure that they are able to have direct control over their own health.

21.6.3 How can we measure Indigenous wellbeing?

Indigenous peoples are culturally and linguistically diverse, but Indigenous culture differs markedly from non-Indigenous Australian culture. Concepts of family structure and community obligation, language, obligations to country and the passing down of traditional knowledge are all viewed and practised very differently by Indigenous cultures in comparison to non-Indigenous cultures. These are important factors that contribute to both identity and wellbeing, yet as indicators, they may be difficult to measure.

The National Aboriginal and Torres Strait Islander Health Survey conducted by the government aimed to measure the emotional and social health of Indigenous adults. In this, more than half the adult Indigenous population reported being happy (71 per cent), calm and peaceful (56 per cent),

and/or full of life (55 per cent) all or most of the time. Just under half (47 per cent) said they had a lot of energy all or most of the time. Indigenous peoples in remote areas were more likely to report having had these positive feelings all or most of the time than Indigenous peoples living in non-remote areas.

A note on statistics: collecting data for Indigenous people in Australia can be difficult, and the Australian Bureau of Statistics concedes that it encounters many difficulties in getting accurate figures such as those shown in figure 3.

FIGURE 3 Indicators of Indigenous wellbeing

ACTIVITIES

IDENTIFY

1 What are some of the reasons why disadvantages exist for Indigenous Australians?
2 Refer to figure 3. What is the average life expectancy for Indigenous Australians and non-Indigenous Australians? What is the difference (in years) between these average life expectancies?

EXPLAIN

3 Explain how the National Aboriginal and Torres Strait Islander Health Survey might give us more insight into the wellbeing of Indigenous Australians.
4 Did any of the statistics about Australia's Indigenous people surprise you? Explain your reaction to them, and how they may have either ***changed*** or reinforced your own opinions or beliefs.

APPLY

5 Another factor contributing to disadvantage may be the remoteness of Indigenous communities. What innovative solutions can you come up with to try to solve these accessibility problems? Consider a range of socioeconomic areas.
6 *Social justice* means fair and equitable access to a community's resources. Do you think Indigenous people experience social justice in Australia? Explain your answer.

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21.7 SkillBuilder: Understanding policies and strategies

What are policies and strategies?

Policies are principles and guidelines that allow organisations to shape their behaviour and decisions, and to clarify future directions. Strategies ensure that the key components of a plan are implemented. Policies and strategies are particularly useful in large organisations, where information needs to be spread to all employees.

Policy
The Metcalfe Boys' High School must maximise student numbers in order to remain viable and to offer a broad range of subjects.

Strategies
Long term
- The Metcalfe Boys' High School is to become a co-educational school. It will do this over a six-year period, beginning with Year 7.
- It must achieve a gender balance in the classes within six years.
- Awards for girls should be developed.
- Associations for past students should be created.

Short term
- Design and create a uniform for the girls.
- Create facilities such as toilets and gymnasium change rooms.
- Consider school camp facilities.
- Consider the need to join other sporting organisations such as softball and girls' competitions.

eLesson
Watch this video to learn how to understand policies and strategies.

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Interactivity
Try this interactivity to learn how to understand policies and strategies.

Searchlight ID: int-3378

21.8 What influences wellbeing for people with disabilities?

21.8.1 Disability

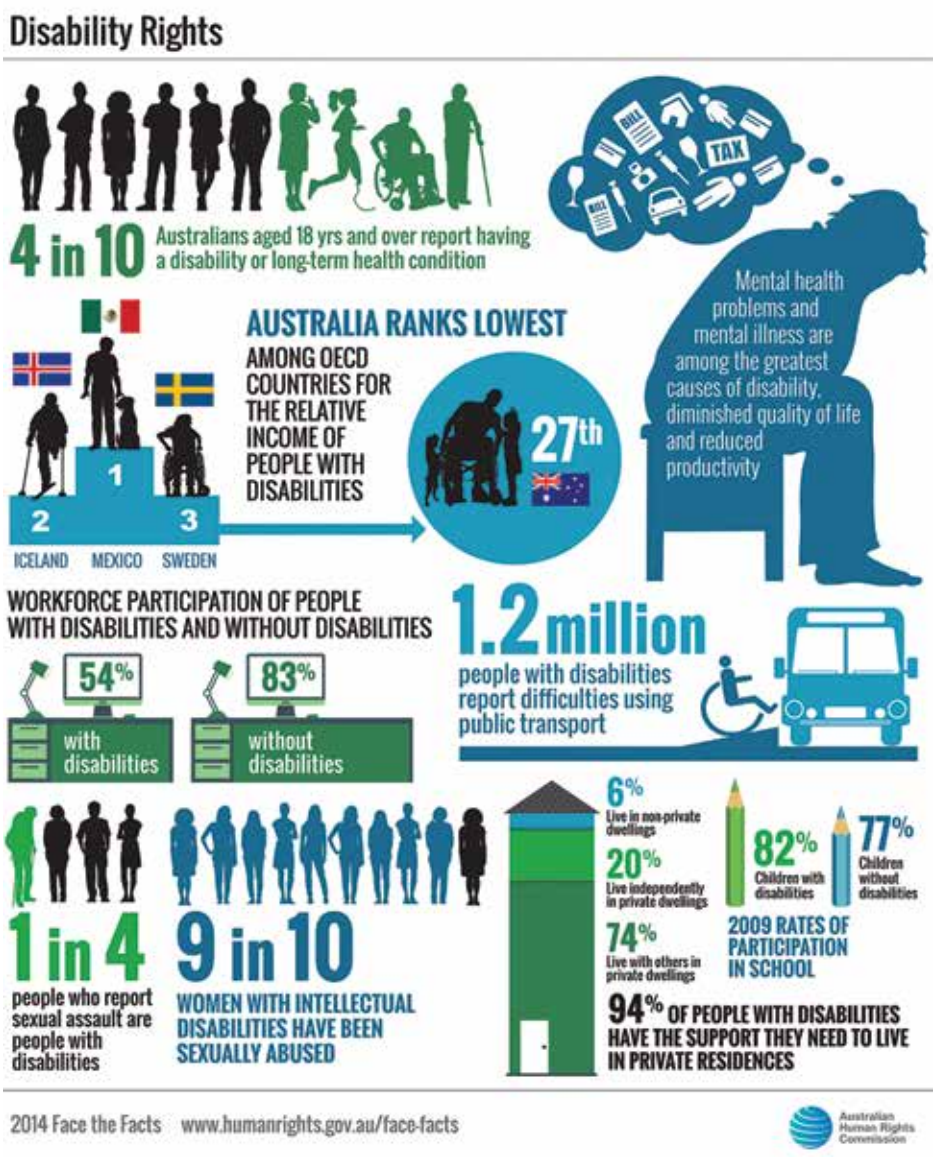
A disability is any condition that restricts a person's mental, sensory or mobility functions. It may be caused by accident, trauma, genetics or disease. A disability may be temporary or permanent, total or partial, lifelong or acquired, visible or invisible. Disabilities restrict or prevent a person from completing everyday activities, such as mobility, self-care or communication.

Causes of disability

A disability can result from any of the following:

- accident – includes loss of limbs and paralysis
- trauma – such as brain damage
- genetic conditions – such as cystic fibrosis and Down syndrome
- disease and disorders – including Alzheimer's, arthritis, diabetes and cancer.

FIGURE 1 As a consequence of a disability, wellbeing suffers



21.8.2 Disadvantage in Australia

Around 6.8 million Australians aged 18 years and over report having a disability or long-term health condition. As a direct result of their disability, people with disabilities are more likely to experience poverty, live in poor quality or insecure housing and have low levels of education reducing their level of wellbeing compared to other Australians. Daily activities become difficult to achieve. 1.2 million people with disabilities report difficulty using public transport. Mental health problems and illness are among the greatest cause of disability. They reduce a person's productivity and therefore their ability to maintain a job in the long term. Young Australians with mental health disorders are at least six times more likely to be in prison than counterparts without mental health disorders. Figure 1 illustrates many more of the issues that affect people with disabilities.

The Australian government enacted the Disability Discrimination Act in 1992 to protect Australians with disabilities from unfair treatment and allow them to have equal opportunities and access to education, employment and healthcare. More recently the government has implemented the National Disability Insurance Scheme (NDIS)

to assist people with disabilities and their families. The NDIS is a holistic approach to care which empowers the person with a disability to enjoy more opportunities and improve their wellbeing in a more inclusive community.

FIGURE 2 Wheelchair racing at the Paralympics

FOCUS ON FIELDWORK

Catering for the disabled in your community

You are going to collect primary data from your local community to illustrate the ways your community assists people with disability.

1. Explore a place in your community such as a train station, ferry wharf, bus terminal, school, shopping centre or sporting field to determine how accessible it is to people with disabilities.
2. Create a list of facilities provided for people with disabilities at your chosen location. You should also take notes on what the facilities are used for. For example, the disabled toilet cubicles are larger than regular cubicles to allow access for wheelchairs and walking aids.
3. Take photographs of the facilities available for people with disabilities.
4. Upload your photographs and provide annotations indicating how the pictured facilities assist people with disabilities.
5. Write a brief report outlining the following. What type of disabilities are the facilities used for? Are there enough facilities to meet the needs of a disabled person? Do you think there should be more facilities available?

ACTIVITIES

IDENTIFY

1. Study figure 1 and answer the following.
   - a What percentage of Australians aged 18 years and over report having a disability or long-term health condition?
   - b What is the workforce participation of people with disabilities compared to those without disabilities?
   - c How many people with disabilities live in a private dwelling?
2. How many different types of disabilities can you think of?

EXPLAIN

3. Give reasons to suggest what makes disabilities difficult.
4. Outline why it is difficult for some people with a disability to use public transport.
5. Explain why it is difficult for people with mental disabilities to maintain a steady job.

INVESTIGATE

6. How can our community and government better support people with disabilities?

21.9 What influences wellbeing in Darwin?

21.9.1 Darwin

With some of the most diverse landscapes in Australia, the Northern Territory has an abundance to offer locals and tourists. Covering an area of 1 350 000 square kilometres, the landscape is vast with only a small population of approximately 245 000. Most of the population lives in the more urbanised centres of Darwin, Katherine and Alice Springs. There are many rural towns with populations under 1000 people, such as Pine Creek (473), Adelaide River (237) and Noonamah (528).

Wellbeing can be difficult to manage in rural areas due to their remote location. According to the Australian Institute of Health and Welfare (AIHW), people in rural areas have lower life expectancies due to coronary heart disease, other circulatory diseases and motor vehicle accidents. These higher death rates may relate to the difference in access to services, risk factors and the remote environment. There are also lower rates of hospital surgical procedures, GP consultations and higher rates of hospital admissions.

In contrast, rural Australians generally have higher levels of social cohesiveness than their urban counterparts. People living in rural areas have higher rates of participation in volunteer work and feelings of safety in their community which contributes to an individual and community wellbeing.

FIGURE 1 Many people living in the Northern Territory have to travel vast distances for services.

ACTIVITIES

IDENTIFY

1 Give an approximate latitude and longitude for Darwin.
2 Calculate the approximate area of Litchfield National Park.
3 Give the direction of Adelaide River from Darwin.
4 Calculate the bearing of Pine Creek from Litchfield.
5 Calculate the distance between Darwin and Pine Creek along the main highway.
6 Calculate the population density of the Northern Territory.

EXPLAIN

7 Provide reasons why people in remote areas:
- **a** have lower life expectancies than those in urban areas
- **b** do more volunteer work than those who live in urban areas.

PREDICT

8 **a** List 10 services and facilities that would improve wellbeing in these communities.
- **b** How would these services and facilities improve wellbeing?

9 You are staying at the Emerald Springs Roadhouse and you need to get to the hospital located in Darwin.
- **a** What is the distance by road between the Emerald Springs Roadhouse and Darwin?
- **b** How long would it take you if you travelled at 60 kilometres per hour?
- **c** How long would it take you if you travelled at 80 kilometres per hour?
- **d** Do you think the hospital is accessible to service the wellbeing of the surrounding population? Justify your answer.
- **e** Suggest two potential locations for the Northern Territory government to build new hospitals. Explain your choices.

INVESTIGATE

10 Research one of the smaller communities in the north-east Northern Territory. Create a profile on the social, environmental and economic indicators of human wellbeing of your selected town.

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21.10 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

FIGURE 2 Topographic map of the Northern Territory

Source: Geoscience Australia

21.5 SkillBuilder: Using multiple data formats

21.5.1 Tell me

What are multiple data formats?

Multiple data formats are varied forms of data presentation, used when a range of data needs to be shown. All the information must be read before the data can be interpreted.

Why are multiple data formats useful?

Multiple data formats are useful in major reports when a range of ideas needs to be pulled together and presented as a united document. You will probably have used multiple data formats when presenting annotated visual displays, poster displays, PowerPoint presentations, brochures and so on.

Multiple data formats are useful for:

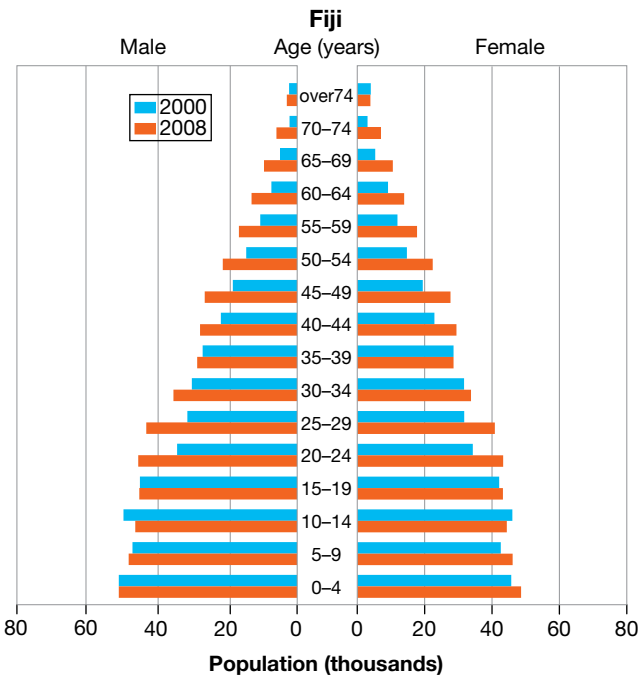
- bringing together a range of data on a topic
- providing the best opportunity to showcase a range of data in the most suitable formats
- drawing attention to data by having interesting presentation techniques
- providing material at a level of readability suited to a particular audience.

Model

Fiji is a group of Pacific islands where population growth and subsistence living go hand in hand. The population pyramid, figure 1(a), shows that Fiji has a young population, and that the largest age group is 0–4 years of age. The population in 2008 had become evenly distributed between the rural and the urban areas (figure 1(b)), whereas in the past rural living had dominated. Native Fijians are mostly involved in subsistence farming or fishing, while Indo-Fijians are employees (figure 1(c)). The pie graph, figure 1(e), shows that these businesses in which they might be employed include the garment industry, which is a third of Fiji's exports. Other resources include mining, timber, raw sugar and fishing. Table 1 indicates that 30 000 Fijians are involved in subsistence fishing, and figure 1(f) shows that fishing for export provides US$45 million. Fiji's growth and development is ongoing, and is supported by overseas aid.

FIGURE 1 (a)–(f) A range of data about Fiji

(a)



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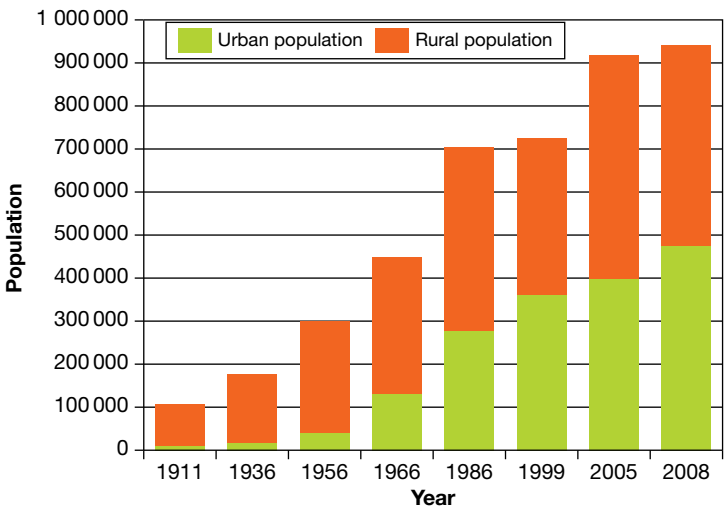

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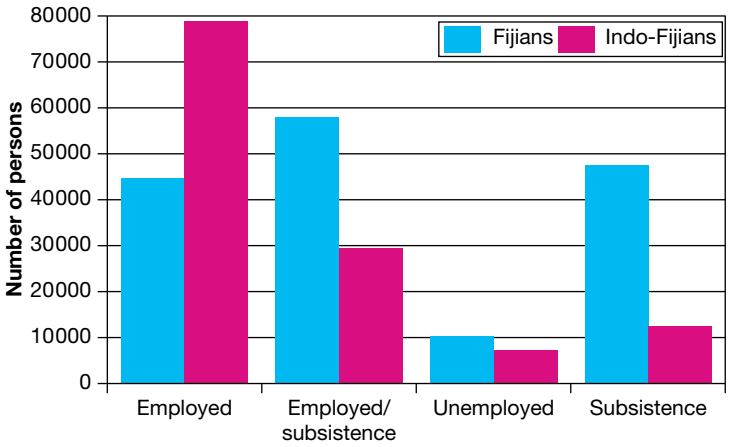

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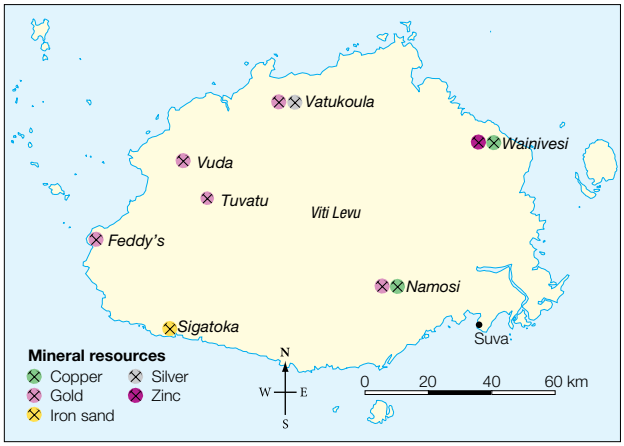
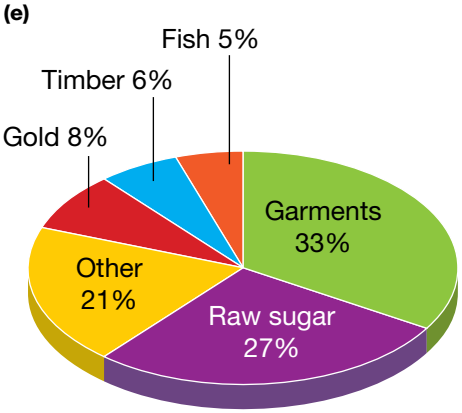


Source: MAPgraphics Pty Ltd, Brisbane

(e)



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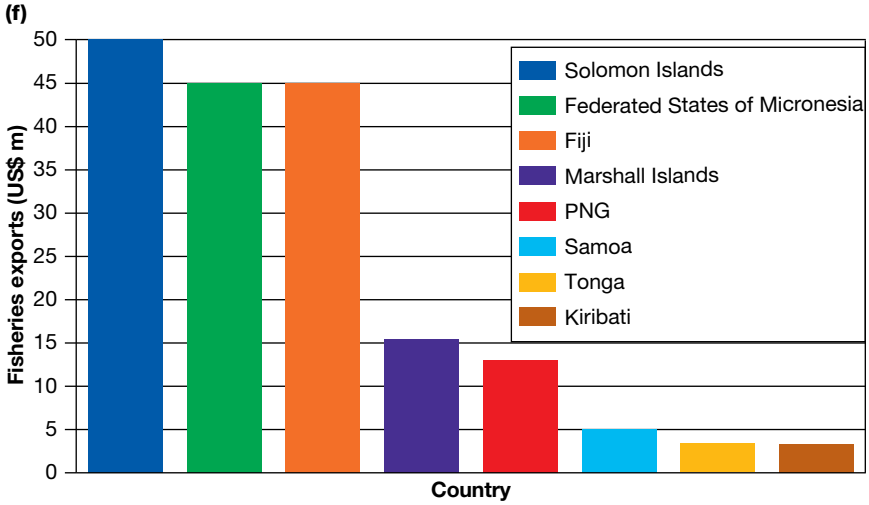

TABLE 1 Employment in subsistence fishing in selected Pacific countries

Pacific country	Number employed
Papua New Guinea	250 000–500 000
Solomon Islands	50 000
Fiji	30 000
Kiribati	20 000
Tonga	7500
Marshall Islands	4700

A good interpretation of multiple data formats:

- makes concise and accurate analysis of each data format
- includes all the information provided.

21.5.2 Show me

How to use multiple data formats

You will need:

- a range of data.

Procedure:

STEP 1

Study figure 1 carefully. You should have encountered all these formats — population profiles, bar graphs, cumulative bar graphs, tables, pie graphs and maps — in your study of Geography.

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Using multiple data formats
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Be systematic in your approach to the data. Read titles, labels, units of measurement, dates and legends, and then make your interpretations.

STEP 2

Consider an approach that allows you to link data in a logical flow of ideas about the topic. In this instance, the data in figure 1 is about Fiji's people and their work. Introduce your topic with a short sentence stating the intention of your writing. For example, the 'Model' paragraph in section 21.5.1 starts with an opening sentence about the location of Fiji.

STEP 3

Begin by finding the figures that are about population structure (population profile, bar graphs on urban and rural population growth, for example). The section 21.5.1 model includes the following statements: 'Fiji has a young population, and the largest age group is 0–4 years of age.' The population in 2008 had become evenly distributed between the rural and the urban areas, whereas in the past rural living had dominated.

STEP 4

To show the interconnection between people and work, the graph of economic activity works well. The model paragraph says 'Native Fijians are mostly involved in subsistence farming or fishing, while Indo-Fijians are employees'. Then you can consider the map on mining, the pie graph showing industries providing employment Fiji, and the graph and table on the role of fishing. See the remainder of figure 1 and the model paragraph.

STEP 5

When writing, end with a concluding statement. The model paragraph has the concluding statement: 'Fiji's growth and development is ongoing, and is supported by overseas aid.'

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Interactivity
Using multiple data formats
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21.5.3 Let me do it

Developing my skills

Discuss the wellbeing of the women in India. Use the maps and images from subtopic 20.9 (figures 1–5).

Questions

1. How does maternal mortality in India compare with other parts of the world?
2. In which parts of India would a woman prefer not to be when giving birth?
3. In which parts of India are there more females than males?

Checklist

I have:

- made concise and accurate interpretations of each data format
- included all the information provided.

Skills questions

1. Multiple data formats are used to show:
   a. a range of data about a topic
   b. the researcher's skills
   c. one point of view on a topic
   d. as many different mapping and graphing techniques as possible.
2. Multiple data formats do not include:
   a. data gathered during fieldwork
   b. hypotheses
   c. secondary data
   d. primary data.
3. What is a major benefit of using multiple data formats?
4. How does the use of multiple data formats attract the attention of an audience?

21.7 SkillBuilder: Understanding policies and strategies

21.7.1 Tell me

What are policies and strategies?

Policies are the guiding rules or broad aims of an organisation. They present the 'big picture' of what the organisation wants to achieve. Generally, policies are in place for long periods of time. For example, a school may have a policy that its students should be protected, as far as possible, from the effects of ultraviolet radiation during school hours, and this policy may have been in place for 20 years.

Strategies, on the other hand, are a range of steps and activities that ensure the policy is met. The strategies may be short term or long term; they may be modified or added to. In the above example, a short-term strategy might be that students should be involved in designing a new casual hat to be worn within the school grounds. Long-term strategies might include the involvement of teachers in checking that students are wearing hats during lunch hours, and a three-year construction program to create shaded areas within the school grounds.

Why are policies and strategies useful?

Policies are principles and guidelines that allow organisations to shape their behaviour and decisions, and to clarify future directions. Strategies ensure that the key components of a plan are implemented. Policies and strategies are particularly useful in large organisations, where information needs to be spread to all employees (see figure 1).

Policies and strategies are useful for:

- arranging the order of a range of initiatives to be developed
- keeping organisations on target
- bringing structure to an organisation's activities
- guiding future directions.

Model

A good understanding of policies and strategies:

- clearly identifies the difference between a policy and a strategy.

FIGURE 1 Metcalfe Boys' High School student numbers policy

Policy

The Metcalfe Boys' High School must maximise student numbers in order to remain viable and to offer a broad range of subjects.

Strategies

Long term

- The Metcalfe Boys' High School is to become a co-educational school. It will do this over a six-year period, beginning with Year 7.
- It must achieve a gender balance in the classes within six years.
- Awards for girls should be developed.
- Associations for past students should be created.

Short term

- Design and create a uniform for the girls.
- Create facilities such as toilets and gymnasium change rooms.
- Consider school camp facilities.
- Consider the need to join other sporting organisations such as softball and girls' competitions.

21.7.2 Show me

How to develop an understanding of policies and strategies

You will need:

- to show knowledge of a particular field of study.

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Procedure:

STEP 1

Seek out the general statement of an organisation's aims. These should be big picture guiding rules, aims or principles. Understand that a policy is not achieved without a set of strategies to make it become reality. In figure 1 the policy is stated as: 'The Metcalfe Boys' High School must maximise student numbers in order to remain viable and to offer a broad range of subjects.'

STEP 2

Look for a series of strategies or specific actions that can be taken to achieve a policy. Each strategy is likely to have a set of programs within it that help make the strategy successful. Discover these programs and assess whether they are making a difference; that is, are the programs supporting the change required by the policy? The policy shows the strategies to be:

- become a co-educational school over a six-year period, beginning with Year 7
- achieve a gender balance in the classes within six years
- develop awards for girls
- create associations for past students
- design and create a uniform for the girls
- create facilities such as toilets and gymnasium change rooms
- consider school camp facilities
- consider the need to join other sporting organisations such as softball and girls' competitions.

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21.7.3 Let me do it

Developing my skills

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Weblink
Indigenous education

Use the **Indigenous education** weblink in the Resources tab to research the government's policy in this area.

Write down the government's main policy on Indigenous schooling. This will be expressed as its broadest aim. Also list a number of short-term and long-term strategies that the government has put in place.

Questions

1. The policy on education for Indigenous children is part of a broader policy. What is that broader policy called?
2. Research to discover when this policy came into being.
3. List three strategies to support the education policy.
4. Which strategy do you find the most interesting? Why?
5. Suggest reasons why education is an important policy area for people's wellbeing.

Checklist

I have:

- clearly identified the difference between a policy and a strategy.

Skills questions

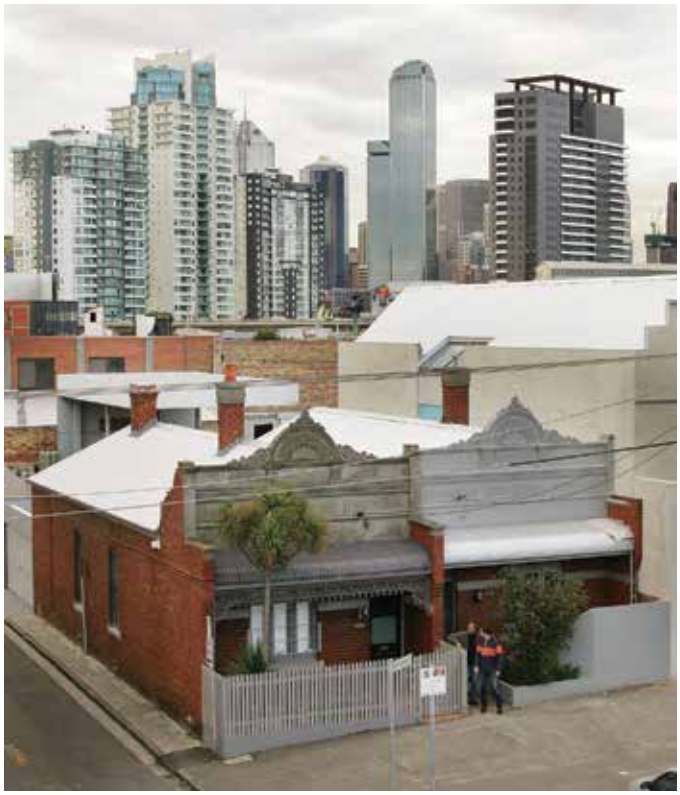
1. Policies are used to show:
   a. the past directions taken by an organisation
   b. the current opinions of an organisation
   c. the guiding rules or broad aims of an organisation
   d. the short-term targets an organisation is working on.
2. Strategies do not generally include information about:
   a. programs
   b. personnel to be used
   c. research
   d. past policies.
3. Why are there always many more strategies than there are policies for an organisation?
4. Are all policies achieved? What role do strategies play in achieving policy success?

21.10 Review

21.10.1 Review

1. Account for the rural–urban variation in Australia.
2. To what extent are there variations in human wellbeing in Sydney? Include statistics in your answer.
3. What contrasts in wellbeing are evident in the urban environment shown in figure 1?

FIGURE 1 Contrasts within the urban environment of Melbourne



4. Compare the characteristics of Australia's Indigenous and non-Indigenous populations as shown by the indicators in figure 3 in subtopic 21.6 'Is everybody equal?'.
5. Refer to table 1. Describe the variation in death numbers and percentage (a) between states and (b) between Indigenous and non-Indigenous populations.

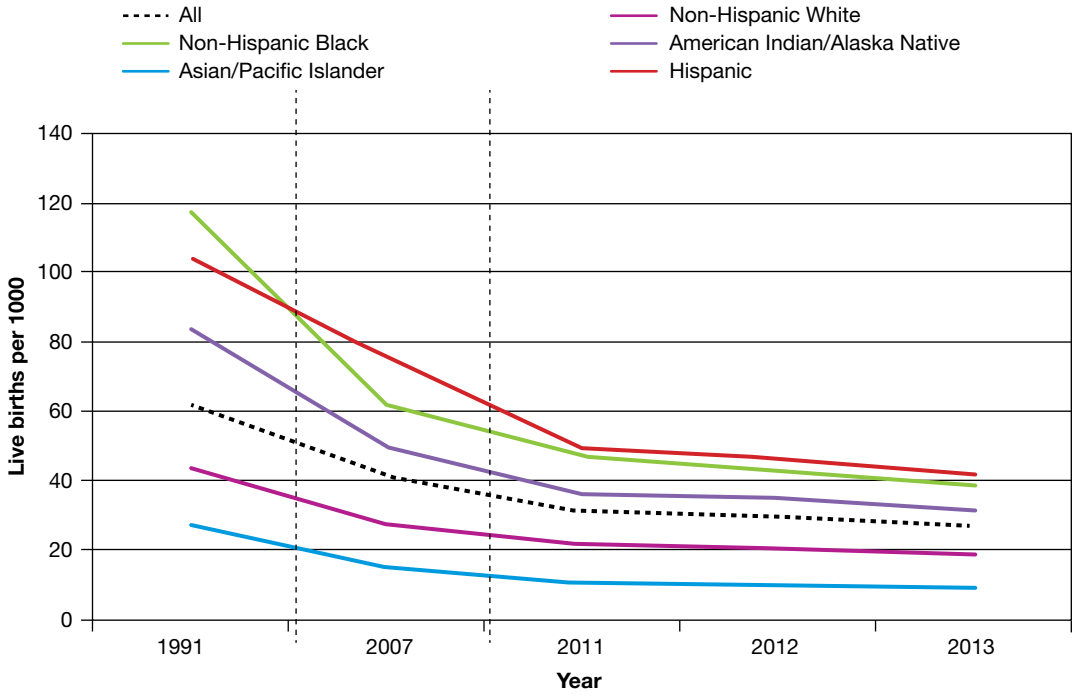
TABLE 1 Deaths among Indigenous and non-Indigenous populations, 2014

State or territory of usual residence	Aboriginal and Torres Strait Islander		Non-Indigenous		Not stated		Total
	no.	%	no.	%	no.	%	no.
NSW	794	1.5	51370	98.2	156	0.3	52320
VIC	139	0.4	37869	99.5	34	0.1	38042
QLD	688	2.4	27443	95.6	573	2.0	28704
SA	169	1.3	13080	98.6	13	0.1	13262
WA	517	3.7	13106	95.1	164	1.2	13787
TAS	31	0.7	4442	99.2	3	0.1	4476
NT	562	48.1	591	50.6	15	1.3	1168
ACT	13	0.7	1793	98.9	7	0.4	1813
AUST.[(a)]	**2914**	**1.9**	**149701**	**97.5**	**965**	**0.6**	**153580**

Source: © Australian Bureau of Statistics 2015.
Note: (a) Includes other Territories.

6. Give statistics to indicate the extent the problem of access to clean water and sanitation poses on health, and therefore life expectancy, worldwide.
7. a. Describe the trends shown in figure 2.
   b. Compare the teen birth rates for Hispanic females with one other ethnic group.

FIGURE 2 Teen birth rates by race, 1991–2013



21.10.2 Reflect

8. How might levels of maternal mortality ***change*** in future as an increasing percentage of the world's population lives in cities?
9. How will improving female literacy improve women's wellbeing in both the short and long term?
10. Use the **Sanitation solution** weblink in the Resources tab to read an article about a possible sanitation solution for urban slums. How could the invention of the Peepoo improve the level of wellbeing for people living in urban slums?
11. Explain why people in rural areas in Australia are likely to have a lower level of health than those in urban areas.
12. Use the **Carving a route to Indigenous wealth** weblink in the Resources tab to read an article on this topic. According to the article, what benefits has the mining industry provided for the wellbeing of the Indigenous population in Australia?
13. Use the **Aboriginal women in jail** weblink in the Resources tab to read an article on the subject. According to the article, what changes in wellbeing are ***interconnected*** with the increased numbers of Aboriginal women in jail?

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Weblinks
- Sanitation solution
- Carving a route to Indigenous wealth
- Aboriginal women in jail

CHAPTER 22

Improving human wellbeing

Families collecting water rations in South Sudan.

22.1 Overview

22.1.1 Introduction

Human wellbeing and quality of life can be improved with targeted programs by governments, non-government organisations and individuals. Societies pressure governments for change. Improvements are sought in living conditions, better access to services such as education and health care, and opportunities for jobs and economic advancements. You too can have an impact on the quality of life of people in your community.

Starter questions

1. Make a list of the best things in your life — those things that make you content.
2. In the media there is often reference to people whose wellbeing has been affected. In the past month, recall those places and people that you have heard or seen mentioned.
3. How can government improve wellbeing for a community?
4. What can you do to help others?

Inquiry sequence

		Syllabus outcomes
22.1 Overview		
22.2 What can governments do to improve human wellbeing?		GE5-2, GE5-6
22.3 What can non-government organisations do to improve human wellbeing?		GE5-2, GE5-6
22.4 What can I do to improve human wellbeing?		GE5-6, GE5-7
22.5 How can we improve wellbeing for Indigenous Australians?		GE5-6
22.6 SkillBuilder: Debating like a geographer	eBook plus ONLINE ONLY	GE5-7, GE5-8
22.7 How can wellbeing be improved in Brazil?	eBook plus ONLINE ONLY	GE5-1, GE5-6
22.8 Investigating topographic maps: How do people in Albury–Wodonga improve wellbeing?		GE5-1, GE5-7, GE5-8
22.9 SkillBuilder: Writing a geographical essay	eBook plus ONLINE ONLY	GE5-8
22.10 Review	eBook plus ONLINE ONLY	
Key terms	eBook plus ONLINE ONLY	

22.2 What can governments do to improve human wellbeing?

22.2.1 Why give aid?

Governments play a national and international role in improving the wellbeing of people. They have the ability to fund projects and facilities to improve health, happiness, prosperity and welfare not only in their own country but across the world.

humanitarianism concern for the welfare of other human beings

Humanitarianism is the most significant motivation for the giving of aid, but it may be motivated by other functions as well:

- as a sign of friendship between two countries
- to strengthen a military ally
- to reward a government for actions approved by the donor
- to extend the donor's cultural influence
- to gain some kind of business or commercial access to a country.

22.2.2 How does Australia help?

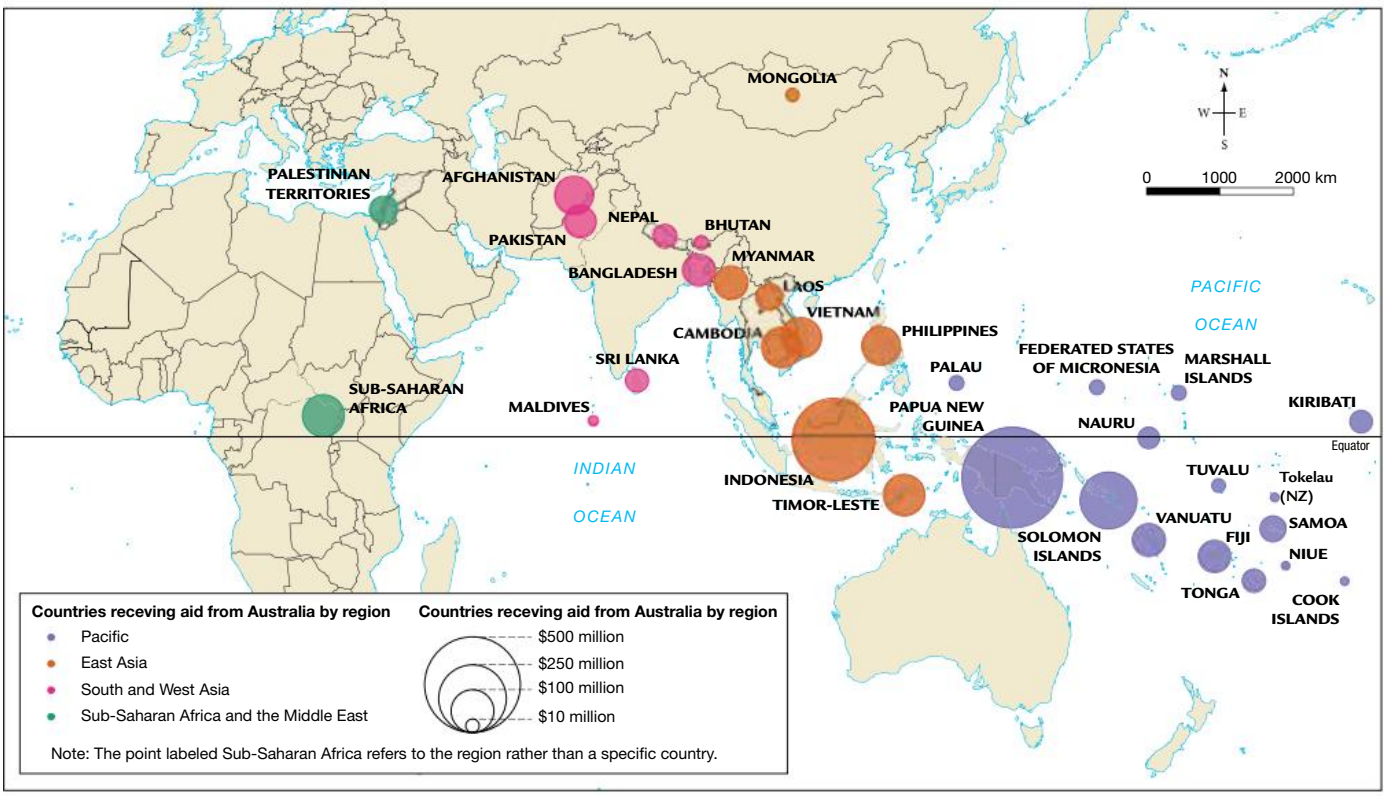
sustainable development development that meets the needs of the current generation without the depletion of resources

The Australian government will provide an estimated $4 billion between 2015 and 2016 to lots of regions in the world (see figure 1). Australian aid helps developing countries reduce poverty and achieve **sustainable development**. It focuses on:

- the Asia–Pacific region
- helping over 58 million people annually through various programs
- distributing funds through bilateral and multilateral aid programs as well as emergency relief, such as to the crisis in Syria.

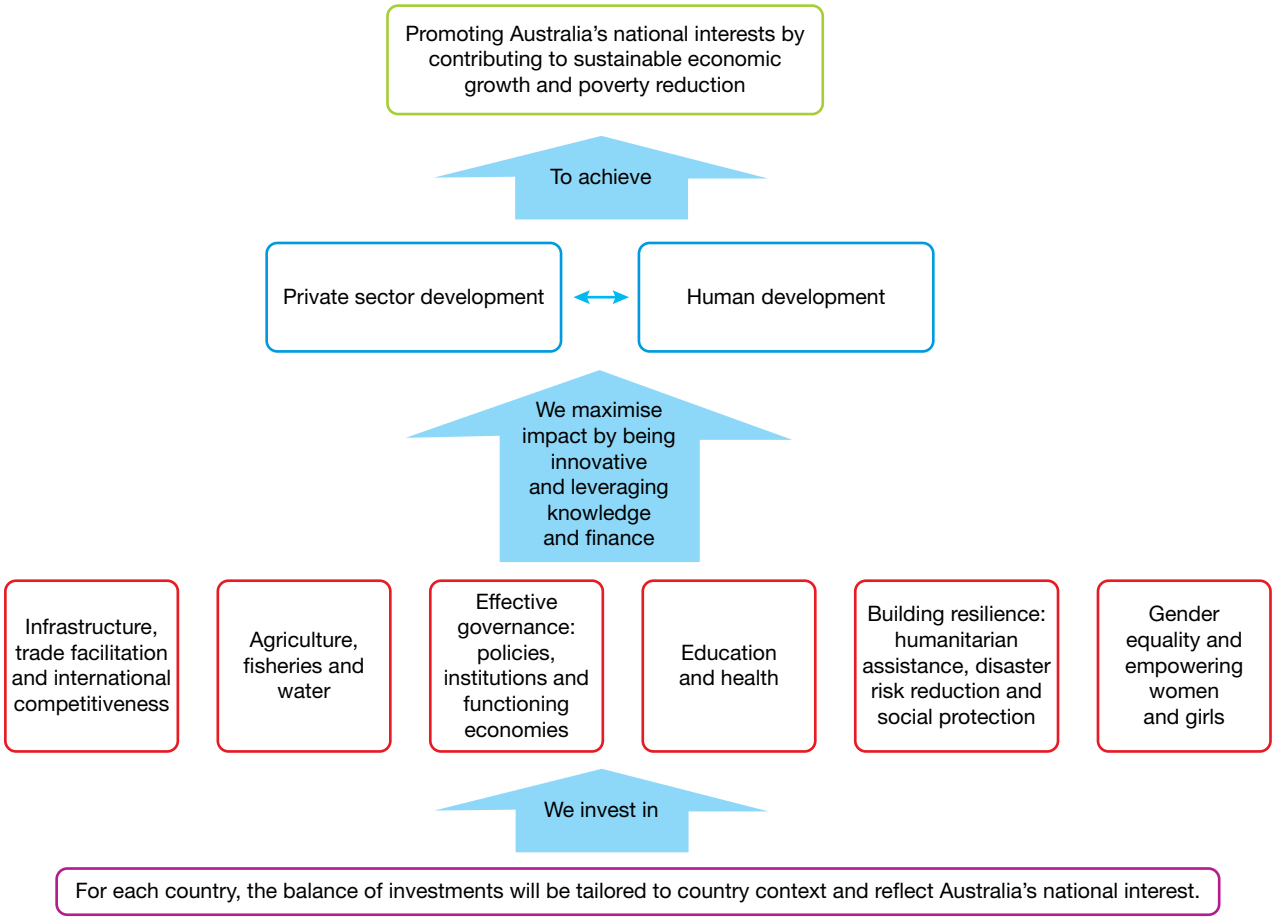
Aid is not always about giving large sums of cash to other governments. It is about investing in various industries to increase the number of jobs available, giving access to education and health services and setting up sustainable industries to improve all aspects of wellbeing (see figure 2).

FIGURE 1 A map showing the countries to which the Australian government gives aid. The size of the dot represents the quantity of aid given; so the larger the dot, the more aid.



Source: Department of Foreign Affairs and Trade

FIGURE 2 How Australia provides aid to other countries

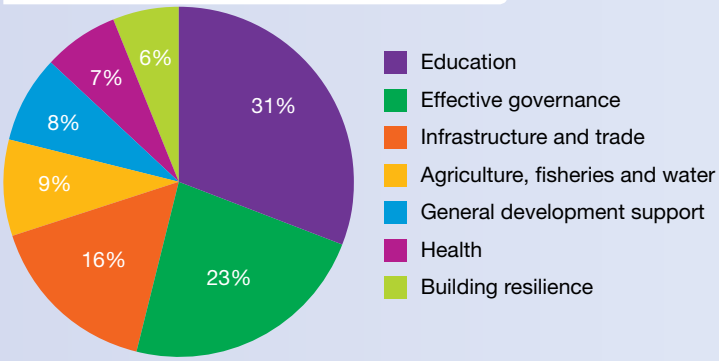


CASE STUDY

Australian aid to Indonesia

Indonesia is a close neighbour and an important partner in our bilateral, regional and global interests. A prosperous, stable and growing Indonesia is good for regional stability, security, trade and cooperation. Australia works with Indonesia to develop effective economic institutions and infrastructure, human development, effective governance and poverty reduction. Australia is pledging $375.7 million to the various sectors presented in the graph below.

FIGURE 3 Graph showing Australian aid to Indonesia by investment priorities, 2015–2016



Australia's aid program with Indonesia has resulted in improvements in wellbeing including the following:

- 866 Australian Awards for Indonesian students to study in Australia
- Connected 464 034 people in rural areas to water and sanitation services in 2014–2015
- Supported the formation of 950 local women's groups across Indonesia, which will help influence policy in areas such as access to jobs and reducing violence against women
- Funded skilled birth attendants to reduce maternal mortality by 40 per cent between 2009 and 2014.

ACTIVITIES

IDENTIFY

1 List the countries Australia gives aid to.
2 Provide reasons why Australia would give aid to other countries.
3 What is Australia's total aid contribution for 2015–2016?
4 a How much aid did Australia give to Indonesia in 2015–2016?
b In what sectors was the aid invested?
c How much money was given to develop the education sector?

EXPLAIN

5 Suggest reasons why aid is given in infrastructure and development and not cash.

APPLY

6 How does aid improve the wellbeing of people?
7 Do you think the Australian government does enough to assist countries in need? Justify your answer.

22.3 What can non-government organisations do to improve human wellbeing?

22.3.1 NGOs

Non-government organisations (NGOs), also known as charities, play a critical role in improving wellbeing for many different groups around the world. NGOs are not-for-profit organisations, which aim to improve the standard of living and quality of life for people, animals and the environment. Charity aid is voluntary; governmental, private and individual donations are collected by organisations such as the Red Cross, Greenpeace, Sea Shepherd and the World Wildlife Fund (WWF) to meet their aim.

22.3.2 How do NGOs give aid?

Aid takes many forms, including money, food, medicine, equipment, expertise, scholarships, training, clothing or military assistance. Aid received from NGOs is generally for small-scale aid projects (bottom-up aid) which target the people most in need of assistance. These small-scale projects help people directly without any government interference. UNICEF, UNHCR, Red Cross, Oxfam and OzHarvest are just some examples of NGOs who work domestically and internationally to improve people's wellbeing.

CASE STUDY

OzHarvest

OzHarvest is an Australian NGO that redistributes excess and unwanted food from supermarkets, bakeries, cafes and restaurants to people in need at refuge centres, homeless shelters, youth groups and other organisations that service people with addictions, people with mental health issues, people with disabilities and the elderly. OzHarvest focuses on rescuing food, educating people, engaging the community and innovation to combat food waste. With assistance from a large group of volunteers, they successfully rescue and redeliver approximately 56 tonnes of food each week. Food is an important component in a person's wellbeing. It contributes to good health and welfare of an individual. According to Foodbank, nearly one million Australian children go without breakfast or dinner.

Oxfam

Oxfam is an international NGO that focuses on fighting poverty through the provision of education, food, healthcare and infrastructure development. They have assisted approximately 25 million people in more than 85 countries around the world during 2014–2015. They also have partnerships with more than 138 fair trade and ethical producers, which contributes to the wellbeing of those producers.

Oxfam relies on donations to support its wellbeing projects and the majority of the money donated goes directly to the program (see figure 2). A $300 donation allows Oxfam to give a water harvesting system to supply clean water for 200 families in drought-stricken southern Africa. Clean water is essential in preventing diseases like cholera.

Water-poor communities are usually economically poor as well, because of the waterborne illnesses. Education levels also suffer because sick children are unable to attend school.

FIGURE 1 OzHarvest redistributes excess and unwanted food to people in need.

FIGURE 2 How Oxfam spends the money that is donated to its wellbeing projects.

ACTIVITIES

IDENTIFY

1 Identify at least three different types of aid that NGOs can give.
2 Outline the benefits of small-scale aid.
3 How are people assisted by OzHarvest and Oxfam?

EXPLAIN

4 How do NGOs help in your local area? What do they do for people?

APPLY

5 With the use of statistics and examples, write a paragraph to explain how OzHarvest and Oxfam improve human wellbeing.

PREDICT

6 Research the work of another NGO that works to improve human wellbeing. Write a paragraph outlining what they do and how and why they do it.

22.4 What can I do to improve human wellbeing?

22.4.1 What makes us happy?

Individuals have a role to play in their own state of wellbeing but also contribute to the wellbeing of others. All aspects of life influence a person's health, happiness, prosperity and welfare.

Happiness and contentment enhance a person's wellbeing. The Victorian Government published a list of factors that influence a positive state of wellbeing for individuals. The list includes:

- a close network of friends
- an enjoyable and fulfilling career
- regular exercise
- nutritional diet
- sufficient sleep
- fun hobbies and leisure pursuits
- a healthy self-esteem
- realistic and achievable goals
- a sense of belonging
- the ability to adapt to change
- living in a fair and democratic society
- enough money
- optimistic outlook
- spiritual or religious beliefs.

FIGURE 1 Factors that influence wellbeing are interconnected. For example, participating in regular exercise allows you to meet people to form a close network of friends.

22.4.2 What can I do for others?

Helping another not only makes you feel good, but it also contributes to the other person's wellbeing. There are many ways individuals can get involved in larger programs through governments and NGOs to assist other people and improve their wellbeing.

Volunteering

Volunteering your time in a project that interests you can be one of the most rewarding and eye-opening experiences. Lots of non-government organisations offer volunteer positions domestically and internationally. Getting involved in projects allows you to engage and connect with your

volunteer a person who offers to give up time to commit to an idea or organisation without being paid

FIGURE 2 (a) Localised volunteering includes activities such as serving food in homeless shelters. (b) Participating in overseas programs can involve teaching children how to read and write. (c) Juan Mann made it his mission to reach out and hug strangers to brighten up their day. He was often located in Pitt Street Shopping Mall, Sydney.

local community or even the international community. Doctors Without Borders (also known as Médecins Sans Frontières) are an international NGO who deliver emergency medical aid to people affected by conflict, epidemics, disasters or exclusion from healthcare. Regardless of the type of volunteering work and the time you have available, you are making a difference to a person or family. If you are interested in becoming involved, a good place to start is www.volunteeringaustralia.org.

FOCUS ON FIELDWORK

Wellbeing at school

Your task is to produce a fieldwork report that you could present to your school that outlines student wellbeing. You need to focus on what your school already does for student wellbeing and areas that could be improved. You also need to make suggestions how individuals and groups can get involved to improve wellbeing at your school.
Tip: A good way to measure wellbeing is to create a student satisfaction survey based on what makes them happy.

FIGURE 3 A sample satisfaction survey scale.

ACTIVITIES

IDENTIFY

1 Define *wellbeing*.
2 Create a list of what makes you happy.
3 What factors influence a person's wellbeing?
4 What is a volunteer? What do they do?

EXPLAIN

5 Why do people volunteer?
6 How can volunteering improve human wellbeing?

APPLY

7 What can you do to contribute to and improve:
- **a** your own wellbeing
- **b** someone else's wellbeing
- **c** community wellbeing?

8 What could your school do to improve:
- **a** student wellbeing
- **b** the wellbeing of other community groups?

22.5 How can we improve wellbeing for Indigenous Australians?

22.5.1 Recognising the divide

Recognising the divides that exist at home, Australian governments and other agencies such as Oxfam are continuing to push initiatives aimed at improving some of the problems that many Indigenous communities face. Ultimately, all Australians benefit from a united effort to address Aboriginal and Torres Strait Islander disadvantage. When disadvantage is overcome, the need for government expenditure is decreased. At the same time, Aboriginal and Torres Strait Islander peoples will be better placed to fulfil their cultural, social and economic aspirations.

22.5.2 Programs to close the gap

Under the Closing the Gap program, five specific targets were set relating to:

- Indigenous life expectancy
- infant mortality
- early childhood development
- education
- employment.

antenatal care the branch of medicine that deals with the care of women during pregnancy, childbirth and recovery after childbirth

neonatal intensive care the specialised nursing practice of caring for newborn infants

The two specifically relating to health are to close the life expectancy gap within a generation (by 2030) and to halve the gap in mortality rates for Indigenous children under 5 within a decade (by 2018). Child mortality rate targets are currently on track to be met due to improvements in **antenatal care**, sanitation and public health, better **neonatal intensive care**, and the development of immunisation programs. Meeting the life expectancy target will be challenging, particularly as overall life expectancy for the population as a whole is increasing. To meet the life expectancy target, average Indigenous life expectancy gains of 0.6 and 0.8 years per year are needed—that is almost 21 years by 2031 to close the gap.

22.5.3 Examples of programs to improve Indigenous wellbeing

The following initiatives provide examples as to how both government and non-government agencies are working to improve the health of the Indigenous population in Australia.

- *The National Partnership Agreement on Closing the Gap in Indigenous Health Outcomes*. For example, the Many Rivers Aboriginal Medical Service Alliance in northern New South Wales brings together 10 Aboriginal-controlled health organisations who share resources and programs servicing 35 000 people.

FIGURE 1 New food store at Ngukurr, Northern Territory

FIGURE 2 Location of Lombadina, Western Australia

Source: Spatial Vision GAT-45; © Commonwealth of Australia Geoscience Australia 2013. © Commonwealth of Australia Australian Bureau of Statistics 2013.

- *The Australian Government licensing scheme for community stores in the Northern Territory*. This scheme requires store managers to offer a range of healthy food and drinks and to make these attractive to customers. Prior to this, people in remote Indigenous communities often had little choice. Goods and food were of poor quality and basic consumer protection was lacking. In December 2011, 90 Northern Territory stores, such as that pictured in figure 1, were licensed, with reported improvements in management, hygiene and employment of Indigenous staff.
- *Oxfam's Indigenous Health and Wellbeing Program*. Oxfam works with Indigenous organisations to hold governments to account over the Closing the Gap program. It also supports the Fitzroy Stars Football club, which competes in Melbourne's Northern Football League. This club brings together 300 Indigenous men with the aim of nurturing a culture that promotes a healthy lifestyle, fitness, nutrition and self-esteem. It also aims to build bridges between Indigenous and non-Indigenous communities.

Lombadina Indigenous community program

Indigenous communities themselves are also working hard to improve their wellbeing. Lombadina is an Indigenous community inhabited by the Bardi people. It is located on the north-western coast of Western Australia (see figure 2). Lombadina and the neighbouring Djarindjin community are home to approximately 200 Indigenous people. The Lombadina community is working towards self-sufficiency through ventures that include tourism operations, a general store, an artefact and craft shop, a bakery and a garage. The tourist ventures centre on sharing knowledge of an Indigenous lifestyle. In addition to providing serviced accommodation, many tours are offered, including cultural tours, fishing charters, kayaking and bushwalking. Lombadina has received a number of tourism awards. The considerable success of these businesses has contributed substantially to the wellbeing of this community. Use the **Lombadina** weblink in your eBookPLUS to experience a kayaking tour led by a Lombadina community member.

Lombadina is also involved in the EON Thriving Communities Project. EON is a non-government

organisation operating by invitation in Indigenous communities in Western Australia. It aims to close the gap in terms of health; for example, via the provision of practical knowledge about growing and preparing healthy food in schools and communities. The project has community ownership and is designed to be sustainable, thus improving wellbeing in the long term.

ACTIVITIES

IDENTIFY

1 What areas are being addressed by the Federal Government's Close the Gap program?

EXPLAIN

2 Why is the Close the Gap program necessary?

INVESTIGATE

3 National Close the Gap Day is held in March each year to improve community awareness of the issue of Indigenous disadvantage and to publicise Federal Government action. Use the internet to find out what activities are taking place in your state and/or local area for Close the Gap Day.

4 Using the internet, research one of the following organisations that have experienced success in combating some of the health, social or educational disadvantages experienced by Indigenous Australians. Why have they been successful? What outcomes will be ***changed*** for Indigenous people?

- Aboriginal Women Against Violence (NSW)
- MPower — Family Income Management Plan (Qld)
- Indigenous Enabling Program at Monash University (Vic.)

APPLY

5 How might Indigenous tourism initiatives such as those run by the Lombadina community improve the wellbeing of people beyond that community?

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Weblink
Lombadina

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22.6 SkillBuilder: Debating like a geographer

What does debating like a geographer mean?

Debating like a geographer involves being able to give the points for and against any issue that has a geographical basis, and supporting the ideas with arguments and evidence of a geographical nature. Debating like a geographer is useful for showing the different points of view on a wide range of global, national and local issues that affect our lives.

Affirmative speaker 1
(Introduces key ideas)
- Where is the Southern Ocean?
- Who is whaling?
- Which countries are involved in the issue?
- How far is it from Japan?
- Whale species
- Uses of whale meat
- The role of tradition
- Scientific research

Negative speaker 1
(Negates affirmative speaker 1 and introduces key ideas)
- Southern Ocean is a whale sanctuary
- Why don't the trawlers work closer to home?
- What is so important about the whale hunting that the benefits outweigh the costs?
- Global food chains affected
- Animal cruelty

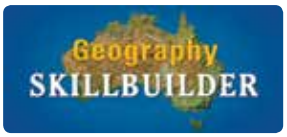
Affirmative speaker 2
(Negates negative speaker 1 and expands on key ideas—provides the facts, statistics, emotional argument)
- Whale numbers
- Scientific research: what is research achieving?
- Importance of tradition

Negative speaker 2
(Negates affirmative speaker 2 and expands on key ideas—provides the facts, statistics, emotional argument)
- Global food chains: facts
- How are whales caught? Is it humane?
- The work of Greenpeace, its actions, the conflict
- International Whaling Commission, its work, the global ban

Affirmative speaker 3
(Negates negative speaker 2 and sums up key ideas)
- Emphasises that resource is well managed: whaling is not the only threat to species

Negative speaker 3
(Negates affirmative speaker 3 and expands on key ideas)
- Emphasises the resource is being degraded and conflict is rife

eLesson
Watch this video to learn how to debate like a geographer.



Searchlight ID: eles-1762

Interactivity
Try this interactivity to learn how to debate like a geographer.

Searchlight ID: int-3380

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22.7 How can wellbeing be improved in Brazil?

To access this subtopic, go to your eBookPLUS at **www.jacPLUS.com.au**.

22.8 How do people in Albury–Wodonga improve wellbeing?

22.8.1 Albury–Wodonga

The Murray River is the natural boundary which separates the states of New South Wales and Victoria. Albury lies to the northeast of the river in New South Wales and Wodonga lies southwest of the river in Victoria.

Albury–Wodonga had a population of 83 328 at the 2011 census. Approximately 19 per cent of people living in the region are 60 years or older and 20 per cent are aged 0–15 years. The agricultural region is renowned for producing fruit, vegetables, cheese, honey, olive oil, meat and wine.

Albury–Wodonga boasts many volunteering opportunities that support the wellbeing of others and the community. Volunteers operate the Opportunity Shop, which sells recycled furniture and clothing, and assist with Pet Therapy at the hospitals. The Pink Ladies, who fundraise, and Ward Programs, which provide emotional and social support to patients at the hospitals, are also made up of volunteers.

FIGURE 1 The historic old railway at Albury

ACTIVITIES

IDENTIFY

1 What is the scale of the map in figure 2? Write your answer as a sentence.
2 What is the contour interval of the map?
3 Give the area reference for Albury Private Hospital.
4 Give the grid reference for the police station.
5 Calculate the straight-line distance between Albury ambulance (AR9207) and the fire station (AR9207).
6 What is the main type of vegetation that dominates this region?

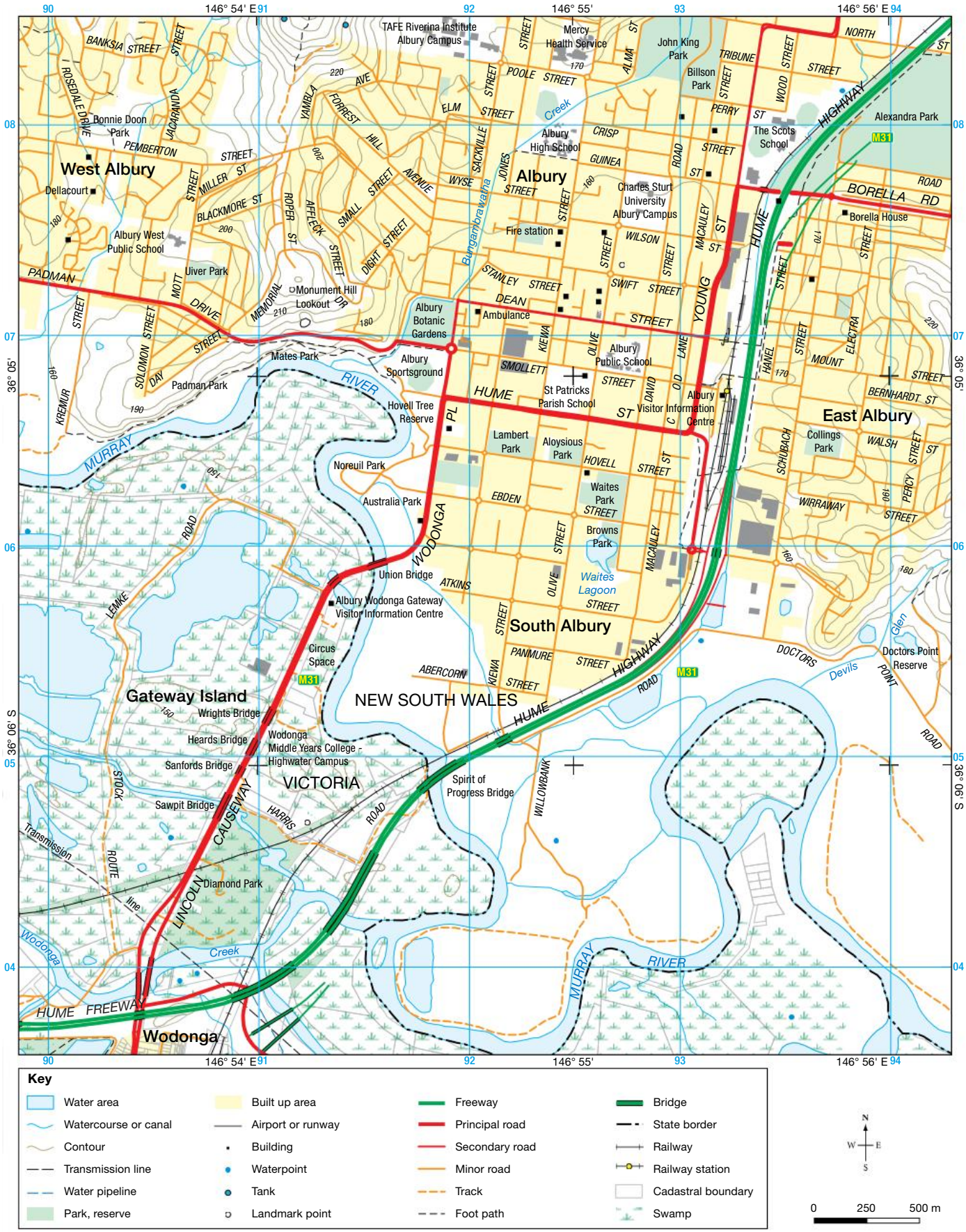
EXPLAIN

7 Give reasons why there is so much land around Albury–Wodonga that is subject to inundation.

APPLY

8 Suggest types of volunteering activities in which people could get involved:
a in Albury–Wodonga
b in your local area.

FIGURE 2 Topographic map of Albury–Wodonga



Source: Copyright © The State of Victoria, Department of Environment, Land, Water & Planning 2016.

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22.9 SkillBuilder: Writing a geographical essay

What is a geographical essay?

A geographical essay is an extended response structured like any essay, but it focuses on geographical facts and data, particularly data that can be mapped. A geographical essay may indicate change over time, refer to the scale of activities, or look to the future in discussing sustainability.

Introduction: A freeway should not go through the urban parkland. Three reasons, or themes, are listed.

Theme 1: Noise levels from traffic. Currently peaceful environment. Sound barriers don't work.

Theme 2: House and land prices will decrease. People will not buy property because of the noise. Lifestyle is changed; roads and pathways are divided by the freeway; many people can't get to the parkland.

Theme 3: Animals will lose habitat and movement routes. Currently the area is home to kangaroos, and the habitat will be diminished. Vegetation may not support the kangaroos, animals will suffer.

Conclusion: If a road has to go through this area, it must be a tunnel under the parkland.

eLesson

Watch this video to learn how to write a geographical essay.

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Interactivity

Try this interactivity to learn how to write a geographical essay.

Searchlight ID: int-3381

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22.10 Review

To access this resource, go to your eBookPLUS at **www.jacPLUS.com.au**.

People in Madagascar face poverty due to slow development in the country.

22.6 SkillBuilder: Debating like a geographer

22.6.1 Tell me

What does debating like a geographer mean?

Debating like a geographer involves being able to give the points for and against any issue that has a geographical basis, and supporting the ideas with arguments and evidence of a geographical nature. Geographic evidence uses skills that you have developed over years of studying Geography. You should use maps; discuss scale, direction and distance where appropriate; look for distribution patterns, anomalies, trends, relationships and interconnections; and support your viewpoints with quantitative and qualitative data.

Why is debating like a geographer useful?

Debating like a geographer is useful for showing the different points of view on a wide range of global, national and local issues that affect our lives. We are entitled to opinions on environmental, social and planning issues, provided we support our arguments with geographic evidence. Show your geographic understanding by using the concepts of place, space, environment, interconnection, sustainability, scale and change. At year 10, there is a focus on world views, so support your ideas with global examples. Change and management strategies are also an important part of the course, and these can be brought into the debate. The promotion of a sustainable future allows you to round off your line of argument.

Debates are also useful for:

- resolving planning decisions
- determining laws to protect the environment
- attracting attention to issues such as logging of forests
- making political decisions.

Model

A good geographic debate involves:

- presenting both sides of the argument
- providing evidence in the form of maps, statistics, graphs and data
- arguing points well
- presenting challenging arguments.

FIGURE 1 Palm cards for a debate on whaling in the Southern Ocean

Affirmative speaker 1
(Introduces key ideas)
- Where is the Southern Ocean?
- Who is whaling?
- Which countries are involved in the issue?
- How far is it from Japan?
- Whale species
- Uses of whale meat
- The role of tradition
- Scientific research

Negative speaker 1
(Negates affirmative speaker 1 and introduces key ideas)
- Southern Ocean is a whale sanctuary
- Why don't the trawlers work closer to home?
- What is so important about the whale hunting that the benefits outweigh the costs?
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- Animal cruelty

Affirmative speaker 2
(Negates negative speaker 1 and expands on key ideas—provides the facts, statistics, emotional argument)
- Whale numbers
- Scientific research: what is research achieving?
- Importance of tradition

Negative speaker 2
(Negates affirmative speaker 2 and expands on key ideas—provides the facts, statistics, emotional argument)
- Global food chains: facts
- How are whales caught? Is it humane?
- The work of Greenpeace, its actions, the conflict
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Affirmative speaker 3
(Negates negative speaker 2 and sums up key ideas)
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Negative speaker 3
(Negates affirmative speaker 3 and expands on key ideas)
- Emphasises the resource is being degraded and conflict is rife

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eLesson
Debating like a geographer
Searchlight ID: eles-1762

22.6.2 Show me

How to debate like a geographer

You will need:

- a topic of a geographic nature
- two teams of three debaters
- a chairperson
- a timekeeper
- a panel of judges
- an audience.

Procedure:

To complete a geographic debate, you need a topic, time to research and prepare arguments, a formal debate format, and an outcome that is adjudicated by judges.

STEP 1

Determine the topic to be debated. For example, 'Should Japan be whaling in the Southern Ocean?'

STEP 2

Create two teams of three debaters. One team must argue for the topic (the affirmative) and one team must argue against the topic (the negative). Select class members for each team.

STEP 3

Appoint the other members of the debating squad: the chairperson, judges and timekeeper. The chairperson introduces the speakers and keeps order during the debate. The judges (usually three of them) use a set of criteria to score the points made by each of the speakers. The timekeeper ensures that each speaker has equal time to convey their points.

STEP 4

Each debating team needs to be given time to research and prepare arguments — they might need as much as a week. Figure 1 shows some ideas that could be explored. To support these ideas, geographical information is required: maps, statistics, graphs and data.

STEP 5

Prepare the classroom for a formal debate. Chairperson and timekeeper sit facing the audience. The affirmative team is to their right, with first speaker closest to the chair. The negative team is to the left of the chairperson and timekeeper, with the first speaker closest to the chair. The judges sit almost in the audience, facing the debaters. The adjudicated outcome is given when the judges have considered three key aspects of the debate: geographical matter, method and manner.

22.6.3 Let me do it

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Interactivity
Debating like a geographer
Searchlight ID: int-3380

Developing my skills

Undertake further research on the arguments for and against Australia increasing its intake of asylum seekers. Organise a class debate on the topic. Listen to the debate and then answer the following questions.

Questions

1. What was the key argument for an increase in Australia's intake of asylum seekers?
2. What was the key argument against an increase in Australia's intake of asylum seekers?
3. Which team provided the most convincing arguments? Why?
4. Which argument did you not believe?
5. What is your personal response to the issue after listening to both sides of the debate? Has your viewpoint been altered?

Checklist

I have:

- either developed arguments or listened intently to the arguments
- considered my opinion on the issue and am now better informed.

Skills questions

1. Geographical debates are used to show:
   a. one side of an argument
   b. a mass of information
   c. the correct response to an issue
   d. both sides of an argument.
2. A geographical debate does not include arguments:
   a. for the topic
   b. against the topic
   c. that are emotional
   d. that are not based on fact.
3. Why should you listen attentively to each speaker in a debate?
4. Why should you congratulate each speaker in a debate?

22.7 How does poverty affect wellbeing?

22.7.1 Variations in wellbeing within a city

How would you like to live with spectacular views over one of the world's most beautiful coastlines? The only problem is that you could be living in a slum without running water and your only access in or out is via hundreds of stairs and laneways. This is the life in a typical **favela** in Rio de Janeiro.

In 2011, Brazil overtook the United Kingdom as the world's seventh largest economy in terms of **GDP**. Despite its development over the past 30 years, the benefits of economic growth have not trickled down to the poor, resulting in large differences in wellbeing across the nation.

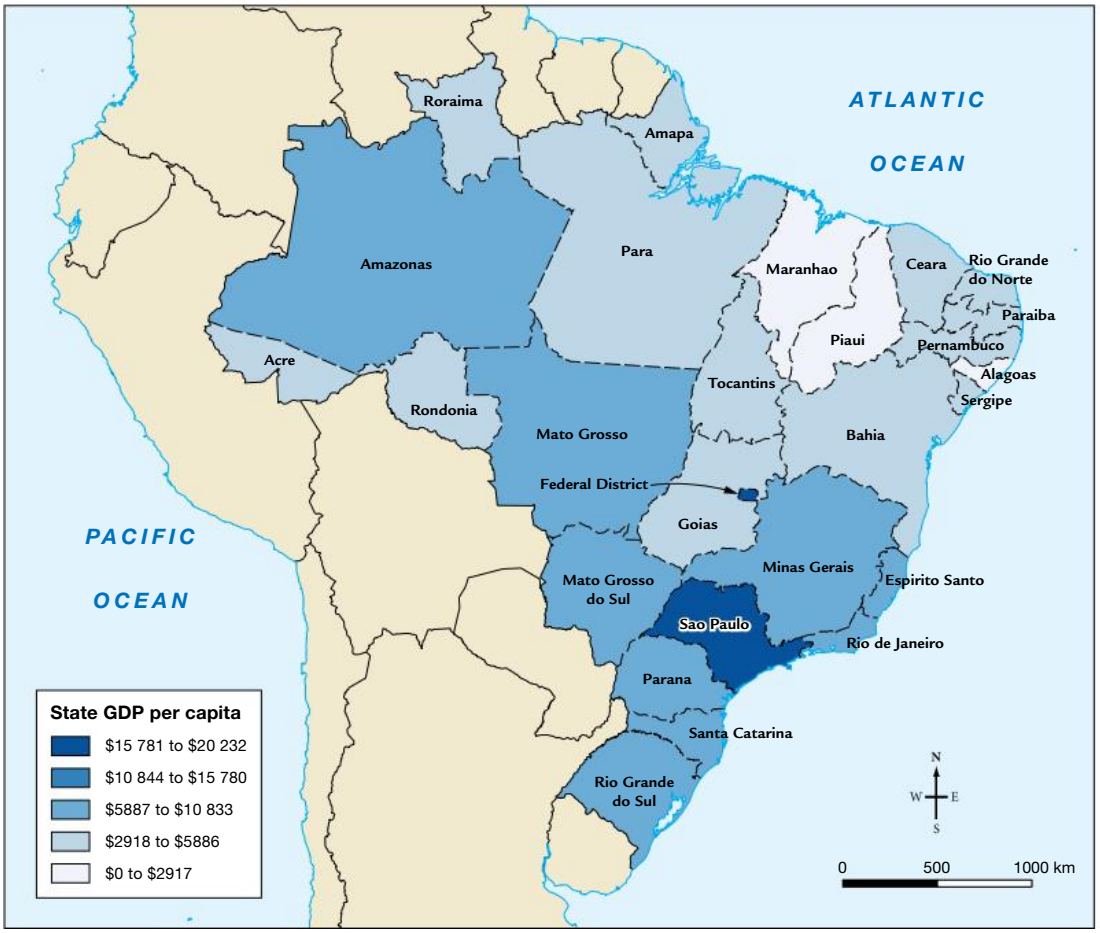
A relatively small group of Brazilians live extremely well, while 11 per cent of the approximate population of 202 million inhabitants remain in poverty. Of these, almost half continue to experience **extreme poverty** (see figure 1).

favela an area of informal housing usually located on the edge of many Brazilian cities. Residents occupy the land illegally and build their own housing. Dwellers often live without basic infrastructure such as running water, sewerage or garbage collection.

GDP (gross domestic product) the total value of all goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports minus the value of imports

extreme poverty under the United Nations' Millennium Development Goals, this is defined as living on less than AU$1.30 per day

FIGURE 1 Distribution of wealth per state of Brazil



Source: Instituto Brasileiro de Geografia e Estatística. Made with Natural Earth. Map by Spatial Vision.

There is considerable spatial variation in wellbeing between regions in Brazil. The majority of industrial development in Brazil has occurred in the south and south-east regions, generating more wealth there. This contrasts markedly with the agriculturally based north-east region, which has higher rates of poverty and infant mortality and lower rates of nutrition.

22.7.2 What impact has the development of Rio de Janeiro had on wellbeing?

Rio de Janeiro is a well-known tourist destination in Brazil, famous for its beautiful beaches, spectacular scenery and carnivals. However, for many local people, this is not the reality. Even within

FIGURE 2 A favela located on a steep slope in Rio de Janeiro

FIGURE 3 Street view of Rocinha favela, Rio de Janeiro

one of the wealthiest cities in the wealthiest region in Brazil, there is considerable variation in wellbeing and living conditions.

The city has experienced rapid growth, starting back in the eighteenth century when freed slaves who had originally worked on plantations came into the city in search of employment. This rural–urban migration still exists today, with thousands flocking to the city in search of opportunity and a new life. New settlers faced the dual problems of low wages and high housing costs, thus forcing them to construct illegal shanties on wasteland or vacant land. Over time, these have developed into full-blown suburbs, or favelas. Typically, these slums are located on steep slopes on the edges of the city, although, as the city has expanded, it has wrapped itself around the favelas.

Ironically, the poorest citizens live on unstable slopes with spectacular million-dollar views (see figure 2), while the wealthier tend to live on the more stable flatter land closer to the city centre.

According to Brazil's last census, 22 per cent of Rio de Janeiro's population of over 6.35 million people live in some 763 favelas. Rocinha (shown in figure 3) is considered Rio's largest favela, with its population estimated in the range of 150 000 to 300 000 people. It is located in the south zone of the city, in close proximity to the famous beaches of Rio's Ipanema and Copacabana districts.

22.7.3 How does living in a favela impact on people's wellbeing?

Living conditions in the favelas are extremely difficult as they have developed without any type of planning or government regulations and the housing is generally substandard. As a result, the issues that have arisen are affecting the development of the city as well as the wellbeing of its citizens.

Issues affecting wellbeing include:

- Lack of infrastructure such as sanitation and piped water; for example, almost one-third of favela households lack sanitation, leading to higher rates of disease. Garbage has to be put in sectioned-off dumping sites.
- Vulnerability to weather extremes; for example, heavy rainfall creates landslides and floods on steep slopes. Timber shacks are more vulnerable to collapse than houses built of concrete bricks.
- Lack of access: There is often only one main road, so movement around the favelas is via narrow lanes and steep staircases (see figure 3).
- Long commuting times: The average time to travel into the city centre of Rio is 1 1/2 hours by bus. The cost of public transport also takes a sizeable proportion of the average worker's salary. This in turn limits both educational and employment opportunities.
- Lower household income: The average household income for people living in the favelas is approximately half that of those people living in the inner suburbs.
- High crime rates such as homicide, particularly linked to the influence of drug trafficking and criminal gangs who have established themselves within the relative safety of the favelas. In 2013, an estimated 37 per cent of favelas were controlled by drug traffickers.
- A sense of inferiority and insecurity felt by residents — most people do not have legal title to their land or dwellings and can be moved by the government at any time.

22.7.4 How is wellbeing being improved in the favelas?

In order to reduce crime and the control of the favelas by drug traffickers, and to improve safety, in 2008 the government introduced Pacifying Police Units (UPP), installing 37 UPPs by 2014. These have been very successful in the places where they have been implemented.

To help improve access for favela residents, the government has installed cable cars to transport people up and down the steep hillsides quickly and effectively, with local residents entitled to one free round trip per day. It is also hoped that the cable cars will allow for expansion of tourism. However, one favela community criticised the government's priorities, maintaining that locals were not properly consulted and that basic services such as sewerage and education should have come first.

As Brazil hosted the 2016 Olympic Games and the 2014 World Cup, the city expanded infrastructure and built new facilities. Figure 4 highlights what was a major issue; that many of the planned Olympic Zones were located on current favela sites. Many residents were very unhappy at the prospect of being relocated to make way for new sporting venues. They claimed that the financial compensation offered was insufficient for a new home and that communities that have existed for generations were being destroyed. Over 3000 families were forcibly relocated and another 11 000 threatened with eviction. Use the **Favelas** weblink in the Resources tab to view a video clip about this issue.

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Weblink
Favelas

FIGURE 4 Location of Rio's favelas and Olympic venues

Source: UNEP-WCMC 2012. Made with Natural Earth.

Preventing the continued growth of favelas by providing adequate low-income housing is the most cost-effective means of improving wellbeing. The cost of upgrading a favela with basic infrastructure is estimated to be two to three times as much as the cost of providing new high-rise housing estates. However, with 65 per cent of Rio's population growth coming from rural–urban migration, it is difficult for authorities to keep up with demand for housing and space.

Nationally, the government aimed to eliminate extreme poverty by 2014 with its Brazil Without Misery Plan. It involved the expansion of cash transfer payments to low-income families in exchange for them keeping their children in school and following a health and vaccination program. Improved infrastructure, vocational training and **micro-credit** were also part of this plan. Although the plan reduced the numbers of those living in extreme poverty from 10 per cent in 2004 to 4 per cent by 2012, extreme poverty remains. Its strategies are continuing so the wellbeing of those living in favelas should also improve.

micro-credit the provision of small loans to borrowers who usually would not be eligible to obtain loans due to having few assets and/or irregular employment

ACTIVITIES

IDENTIFY

1 Outline the characteristics of a favela.
2 Refer to figure 1.
  a With the use of your atlas, describe the location of the city of Rio de Janeiro.
  b What is the average GDP for the state of Rio de Janeiro?
3 Refer to figure 1.
  a Describe the distribution of Brazilian states with an average GDP per capita of more than $12 000.
  b What reason can you give for this pattern?
4 With reference to figure 4, describe the ***spatial*** distribution of favelas in Brazil.
5 How has the development of Rio de Janeiro affected people's wellbeing?
6 Refer to figure 2. Describe how topography has influenced the development of favelas in Rio de Janeiro.

EXPLAIN

7 Explain the ***interconnection*** between the development of favelas and movement of people from rural areas into Rio de Janeiro.
8 Study figure 3.
  a What difficulties would exist for people of different ages living in this street?
  b Why would the government find it cheaper to build new high-rise housing rather than upgrading existing favelas?
  c Predict the changes people would face if they are moved from living in a favela like this to living in a high-rise housing estate.
9 Discuss the government action to improve wellbeing in favelas on two different ***scales***.

INVESTIGATE

10 a Visiting favelas is increasingly popular among tourists. Research the positive and negative impacts of tourist tours of favelas.
  b Formulate your own opinion: is such tourism exploiting or helping locals?

APPLY

11 Why would the estimated population of Rocinha (150 000 to 300 000) vary to such an extent?
12 How might hosting the Olympic Games and World Cup have affected the wellbeing of the residents of Rio?

22.9 SkillBuilder: Writing a geographical essay

22.9.1 Tell me

What is a geographical essay?

A geographical essay is an extended response structured like any essay, but it focuses on geographical facts and data, particularly data that can be mapped.

Why is writing a geographical essay useful?

A geographical essay is used to show the facts about a place, its environment, people and interconnections. A geographical essay may indicate change over time, refer to the scale of activities, or look to the future in discussing sustainability.

Geographical essays are useful for:

- students writing extended responses and presenting researched views on a topic
- environmental groups reporting on a hotly debated local topic
- planners presenting ideas for transport options
- researchers providing data on census analysis
- journalists writing about a community issue.

Model

A good geographical essay has:

- an introduction
- a number of paragraphs, each with a key geographic idea
- facts and figures of a geographic nature supporting each paragraph
- a conclusion
- a bibliography.

FIGURE 1 An essay plan

Introduction: A freeway should not go through the urban parkland. Three reasons, or themes, are listed.

Theme 1: Noise levels from traffic. Currently peaceful environment. Sound barriers don't work.

Theme 2: House and land prices will decrease. People will not buy property because of the noise. Lifestyle is changed; roads and pathways are divided by the freeway; many people can't get to the parkland.

Theme 3: Animals will lose habitat and movement routes. Currently the area is home to kangaroos, and the habitat will be diminished. Vegetation may not support the kangaroos, animals will suffer.

Conclusion: If a road has to go through this area, it must be a tunnel under the parkland.

22.9.2 Show me

How to write a geographical essay

You will need:

- a topic to write about
- a piece of paper for brainstorming
- a piece of paper for drafting the structure of your essay
- access to research materials in a library or on the internet.

Procedure:

STEP 1

On a piece of paper, brainstorm all the ideas you can think of for the topic. When you have finished, try to group the ideas into three or four themes. Connect ideas with a line. Even try a fishbone diagram or some other graphic organiser.

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eLesson
Writing a geographical essay
Searchlight ID: eles-1763

STEP 2

Figure 1 sets out a plan for your essay:

- introduction
- paragraph 1 is about key theme 1
- paragraph 2 is about key theme 2
- paragraph 3 is about key theme 3 etc.
- conclusion.

STEP 3

Having organised your key ideas, you now need to find some geographic facts and figures to support your ideas. Using case studies and giving examples of particular places add value to your writing. Quoting organisations gives authority to your work. Keep your work organised according to the key ideas so you can find information when writing.

STEP 4

Introduce your topic by stating a powerful fact that captures the reader's imagination. In the next sentence, outline the aspects that are going to be discussed in the following paragraphs. Make sure that you list these in the order in which you wish to present the paragraphs. Your last sentence should lead into your first paragraph.

FIGURE 2 An essay introduction

> A freeway should not go through the urban parkland of Sandy Bay. The increased traffic will cause noise levels from cars, small trucks and semi-trailers to soar. House and land prices will decrease by up to 10 per cent, as potential buyers will be concerned about the noise and pollution. Animals, such as the grey rock wallaby and echidna, will lose habitat, and their movement routes will be disrupted. If a road must go through this area, it should be a tunnel under the parkland.

STEP 5

Each paragraph that you write needs to have a distinct and powerful opening sentence that summarises the facts you are going to present in the following sentences. The factual sentences need to be presented in an organised manner. The last sentence should link clearly to the next paragraph.

In this instance, paragraph one will be on increased noise levels and will require data from other road developments to show the increase in noise levels. Paragraph two could include the results of a survey of local residents, showing their concerns about the roadwork and what they perceive will be the impact on the value of their houses. Paragraph three will highlight a species of animal in the parkland and show maps indicating that the animal often crosses the area of the planned roadway.

STEP 6

The conclusion should consist of only one or two sentences. It must contain no new data. It needs to leave the reader in no doubt about what your opinion on the topic is. For example: 'For the wellbeing of people and animals, the only viable roadway is one contained in a tunnel.'

STEP 7

Provide a list of the references you have used. Your school will have a preferred system for bibliographies and reference lists. You may have heard, for example, of the Harvard, Oxford, Chicago or Vancouver referencing systems.

22.9.3 Let me do it

Developing my skills

Plan a geographical essay on the following topic: 'The scenic/historic [select one] environment of _____ [put in a place near you] is being destroyed by degradation. Discuss.'

Questions

1. What are three key themes that you outlined in your plan?
2. List two facts that you would search for to support each theme.
3. What would be your opening sentence of the introduction?
4. What would be the final sentence of your essay?
5. Will this topic ever be resolved? Explain your answer.

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Interactivity
Writing a geographical essay
Searchlight ID: int-3381

Checklist

I have:

- an introduction
- a number of paragraphs, each with a key geographic idea
- facts and figures of a geographic nature supporting each paragraph
- a conclusion
- a bibliography.

Skills questions

1. Geographical essays are used to:
   a. briefly outline an idea
   b. show one point of view
   c. cause controversy
   d. provide an extended response to an idea.
2. A geographical essay includes:
   a. soil samples
   b. examples
   c. plagiarism
   d. outdated data.
3. Why should you have a very organised introduction?
4. Why might it be important to carefully consider your final sentence?

22.10 Review

22.10.1 Review

1. Create a table to compare and contrast the different ways governments, non-government organisations and individuals can improve human wellbeing.

Improving human wellbeing		
Governments	**Non-government organisations**	**Individuals**

2. Explain why human wellbeing for Indigenous Australians needs to improve.
3. Outline two issues that would make it difficult to improve human wellbeing in Brazil.
4. Describe the services available at your school that improve student wellbeing. Is it enough?

22.10.2 Reflect

5. Study the table below detailing homelessness in Sydney.

Type of homelessness	Region and number	Region and number	Region and number
Sleeping rough	Sydney Inner City **490**	Richmond Valley Coastal **211**	Wyong **69**
Refuges/special housing services	Sydney Inner City **677**	Wollongong **212**	Strathfield-Ashfield **188**
Boarding house	Sydney Inner City **1486**	Strathfield-Ashfield **786**	Marrickville-Petersham **670**
Couch surfing	Sydney Inner City **165**	Penrith **142**	Blue mountains south **142**
Severely over-crowded dwelling	Fairfield **1034**	Merrylands-Guilford **646**	Mount Druitt **542**
Other temporary accommodation	Sydney Inner City **31**	Parramatta **15**	Eastern Suburbs South **11**

Inner-city sydney Suburbs of sydney Out of sydney

a. Suggest two reasons why there are more people experiencing a type of homelessness in Sydney inner city than in other suburbs of Sydney or out of Sydney.
b. What do you know is currently being done to combat homelessness by (i) the government, (ii) non-government organisations and (iii) individuals?
c. What can be done to improve the human wellbeing for homeless people? Make a suggestion for the government, non-government organisations and also individuals.

CHAPTER 23

Fieldwork inquiry: Comparing wellbeing in the local area

23.1 Overview

23.1.1 Scenario and task

Task: Produce a fieldwork report you could present to your local council that outlines variations within your local area, reasons for the differences and strategies to improve the situation in the future.

You may have noticed that there are distinct variations across space in any city, suburb or regional community in terms of human wellbeing. Your council has asked for locals to inform them about differences in wellbeing they notice within their local areas, and what could or should be done about these in the future. Investigation of the topic will require you to undertake some fieldwork in order to make first-hand observations in the field, collect, process and analyse data.

Your task

The aim of the fieldwork is for you to explore some area variations by comparing two places at the local scale. The key inquiry questions the council wants to know answers to are:

- How does wellbeing vary between area X and area Y in the local area?
- What factors might explain the variations in wellbeing?
- How can wellbeing be improved in the local area?

23.2 Inquiry process

23.2.1 Process

Open the ProjectsPLUS application for this project located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start project' button and set up your class group. Save your settings and the project will be launched.

- **Planning:** As a class, discuss the types of indicators you would use as a basis for comparing wellbeing in your local area; for example, surveys. Decide on teams and allocate tasks, or different streets, to each team member. Download the fieldwork planning document from the Media Centre to help you plan your fieldwork. Navigate to your Research Forum. Use the research topics to provide a framework for your fieldwork.
- You will need to determine the features of the houses and streets that you wish to gain data about. How will you record this data on the day (per house block or per street block)? Think carefully and plan your data record sheet so it is easy to use and also easy to summarise. Download the sample street analysis template from the Media Centre to help you plan and to record your housing data.
- If you are planning to survey people, you will need to plan and prepare survey questions. Download the community sample survey template from your Media Centre to help you plan and to record your data. You may wish to refer to the relevant SkillBuilder to help you with this.

23.2.2 Collecting and recording data

Prior to going on your field trip, prepare a simple map to show the location of your fieldwork site(s) relative to key features such as your school or city centre. You will need a separate location map if your second site is not in the same area.

Prepare a more detailed map of your fieldwork site(s). Use a street directory, Google Earth or local council map as a guide. Include streets, street names, schools, preschools, shops and shopping centres, parks, public transport and other community facilities. Complete your map with BOLTSS.

During the field trip you may be required to survey houses whereby you record key features, take photographs (*Hint:* Keep a record of the location of photographs taken) and survey local residents in public places such as parks and shopping centres.

Download the fieldwork report document from your Media Centre to help you prepare your report.

23.2.3 Processing and analysing your information and data

An important skill is the ability to analyse the information you have collected on your field trip and any other supplementary data, in order to write the findings of your inquiry into a fieldwork report. A key part of your report is to determine any patterns or trends revealed in the data. At the same time, try to identify any anomalies (variations) from the patterns or trends. Download the analysis document from your Media Centre to help you further analyse the data you have collected.

23.2.4 Communicating your findings

Formally write your observations as a fieldwork report using these suggested sub-headings:

- Background and key inquiry question (include location descriptions and map(s))
- Conducting the fieldwork (planning and collection of data)
- Findings (results of data analysis)
- Future (How might wellbeing in the local community be improved upon? What could local councils and other community-based organisations do to improve living conditions? You might like to put forward a proposal to local council outlining your suggestions.)

You may wish to add your own headings.

23.3 Review

23.3.1 Reflecting on your work

Think about how you approached this fieldwork project and how you, personally, were able to organise yourself and contribute to the working of the team. Access and complete the reflection document in your Media Centre. Be honest in assessing your strengths and areas where you think you could do better next time.

Print out your Research Report from ProjectsPLUS and hand it in with your fieldwork report and reflection notes.

Your ProjectsPLUS application is available in this chapter's Resources tab in your eBookPLUS. Visit **www.jacplus.com.au** to locate your digital resources.

Suggested software

- ProjectsPLUS
- Microsoft Word

Media Centre

Your Media Centre contains:

- a fieldwork planning document
- a sample street analysis template
- a community sample survey template
- a fieldwork report document
- an analysis document
- a reflection document
- weblinks to research sites
- an assessment rubric.

GLOSSARY

active consumerism a movement that is opposed to the endless purchase of material possessions and the pursuit of economic goals at the expense of society or the environment

affordability the quality of being affordable — priced so that people can buy an item without inconvenience

agribusiness business set up to support, process and distribute agricultural products

algal bloom rapid growth of algae caused by high levels of nutrients (particularly phosphates and nitrates) in water

alluvial plain an area where rich sediments are deposited by flooding

alpha world city a city generally considered to be an important node in the global economic system

anabranch section of a river or stream that diverts from the main channel

antenatal care the branch of medicine that deals with the care of women during pregnancy, childbirth and recovery after childbirth

aquaculture the farming of aquatic plants and aquatic animals such as fish, crustaceans and molluscs; also called fish farming

aquaponics a sustainable food production system in which waste produced by fish or other aquatic animals supplies the nutrients for plants, which in turn purify the water

aquifer a body of permeable rock below the Earth's surface, which contains water, known as groundwater

arable describes land that is suitable for growing crops

atoll a coral island that encircles a lagoon

automation the use or introduction of automatic equipment in a manufacturing or other process or facility

base flow water entering a stream from groundwater seepage, usually through the banks and bed of the stream

basin the land area drained by a river and its tributaries; another name for a river catchment

bi-articulated bus an extension of an articulated bus, with three passenger sections instead of two

biocapacity the capacity of a biome or ecosystem to generate a renewable and ongoing supply of resources and to process or absorb its wastes

biodegradable capable of being decomposed through the actions of microorganisms

biodiversity the variety of living organisms (plant and animal life) within an area

biofuel fuel that has been produced from renewable resources, such as plants and vegetable oils, and treated municipal and industrial wastes

biophysical environment all elements or features of the natural or physical and the human or urban environment including the interaction of these elements; made up of the Earth's four spheres — the atmosphere, biosphere, lithosphere and hydrosphere

blowout a hollow or bare patch found in sand dunes caused by the removal of sand by the wind

by-catch marine species that are unintentionally caught while targeting/catching other marine species

carrying capacity the ability of the land to support livestock

clearfelling the removal of all trees in an area

climate the long-term precipitation and temperature patterns of an area

climate change any change in climate over time, whether due to natural processes or human activities

coastal dune vegetation succession the process of change in the plant types of a vegetation community over time — moving from pioneering plants in the high tide zone to fully developed inland area vegetation

commercial an activity that is concerned with buying and/or selling of goods or services

condensation the process in which water in the atmosphere cools and changes from a gaseous state into a liquid state; this occurs when the water vapour clusters around a solid particle (such as dust)

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

coral polyp a tube-shaped marine animal that lives in a colony and produces a stony skeleton. Polyps are the living part of a coral reef.

Coriolis effect force that results from the Earth's rotation. Moving bodies, such as wind and ocean currents, are deflected to the left in the Southern Hemisphere and to the right in the Northern Hemisphere.

country the area of land, river and sea that is the traditional land of each Aboriginal language group or community; the place where they live

crop rotation a procedure that involves the rotation of crops, so that no bed or plot contains the same crop in successive seasons

deforestation clearing forests to make way for housing or agricultural development

degradation deterioration in the quality of land and water resources caused by excessive exploitation

deltaic plain a flat area where a river empties into a basin

desertification the transformation of land once suitable for agriculture into desert by processes such as climate change or human practices such as deforestation and overgrazing

developing nation a country whose economy is not well developed or diversified, although it may be showing growth in key areas such as agriculture, industries, tourism or telecommunications

development according to the United Nations, defined as 'to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community'

development corridor area set aside for urban growth or development

diversion man-made project to divert the water from a river

downturn of the global economy a recession or downturn in a nation's economic activity which includes increased unemployment and also decreased consumer spending

dyke an embankment constructed to prevent flooding by the sea or a river

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; a measure of human demand on the Earth's natural systems in general and ecosystems in particular

ecological services any beneficial natural process arising from healthy ecosystems, such as purification of water and air, pollination of plants and decomposition of waste

edible fit to be eaten as food; eatable

endemic describes species that occur naturally in only one region

enhanced greenhouse effect the observable trend of rising world atmospheric temperatures over the past century, particularly during the last couple of decades

environmental ethics an individual's beliefs about what is right or wrong behaviour in relation to the Earth and its environments and communities

environmental flow the quantity, quality and timing of water flow required to sustain freshwater ecosystems

environmental impact assessment a tool used to identify the environmental, social and economic impacts, both positive and negative, of a project prior to decision-making and construction

environmental refugees people who are forced to flee their home region due to environmental changes (such as drought, desertification, sea-level rise or monsoons) that affect their wellbeing or livelihood

environmental worldview varying viewpoints of how the world works and where people fit into the world. The worldview will form the assumptions and values that guide an individual's actions towards the environment.

ephemeral describes a stream or river that flows only occasionally, usually after heavy rain (e.g. Todd River, Alice Springs)

erosion the wearing down of rocks and soils on the Earth's surface by the action of water, ice, wind, waves, glaciers and other processes

EU European Union — an economic and political union of 27 member states, mostly in Europe. (In 2016 Great Britain voted to exit the EU. At the time of publishing they were still officially a member.)

eutrophication a process in which water bodies receive excess nutrients that stimulate excessive plant growth

evaporation the process in which water contained in water bodies is heated by the sun, causing the liquid to change into a gaseous state and rise into the atmosphere

evapotranspiration the process including evaporation from water storage areas as well as evaporation from trees

exotic species species introduced from a foreign country

extensive farm farm that extends over a large area and requires only small inputs of labour, capital, fertiliser and pesticide

factory farming a highly-intensive system of farming that confines animals or poultry to small, confined, and strictly controlled spaces for the sole purpose of food production

family household two or more persons, one of whom is at least 15 years of age, who are related by blood, marriage (registered or de facto), adoption, step-relationship or fostering

famine a drastic, widespread food shortage

FAO Food and Agricultural Organization of the United Nations

female infanticide the killing of female babies, either via abortion or after birth

fertility the birthrate of a population

floating settlement anchored building that floats on water and is able to move up and down with the tides

flood mitigation managing the effects of floods rather than trying to prevent them altogether

fly-in, fly-out (FIFO) 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

fodder food such as hay or straw for cattle and other livestock

genetically modified describes seeds, crops or foods whose DNA has been altered by genetic engineering techniques

geographical factors reasons for spatial patterns, including patterns noticeable in the landscape, topography, climate and population

geographic processes the physical forces that form and transform our world

global warming increased ability of the Earth's atmosphere to trap heat

green energy sustainable or alternative energy (e.g. wind, solar and tidal)

greenhouse gas a gas that absorbs infrared radiation which contributes to the greenhouse effect

Green Revolution a significant increase in agricultural productivity resulting from the introduction of high-yield varieties of grains, the use of pesticides and improved management

gross domestic product (GDP) a measurement of the annual value of all the goods and services bought and sold within a country's borders; usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

gross national income (GNI) a measurement of the value of goods and services produced by citizens and firms of a specific country no matter where they take place, normally discussed as GNI per capita

groundwater water held underground within waterbearing rocks or aquifers

groundwater salinity presence of salty water that has replaced fresh water in the subsurface layers of soil

groyne a structure (e.g. a rock wall) that is built perpendicular to the shoreline to interrupt the flow of water and the movement of sediment

Gulf Stream a warm Atlantic ocean current; it originates at the Gulf of Mexico, follows the east coast of the United States, then divides to create the North Atlantic Drift, the Florida Current and the Gulf Stream itself

gyre swirling circular ocean current (similar to water swirling around a plug hole)

high-density housing residential developments with more than 50 dwellings per hectare

historical architecture urban environment that has significant value due to its unique form and history of development

horticulture the practice of growing fruit and vegetables

housing affordability relates to a person's ability to pay for their housing; in Australia, those spending more than 30 per cent of their income on housing, while earning in the bottom 40 per cent of the income range, are considered to be in housing affordability stress

Human Development Index (HDI) measures the standard of living and wellbeing in terms of life expectancy, education, literacy and income

human–environment systems thinking using thinking skills such as analysis and evaluation to understand the interaction of the human and biophysical or natural parts of the Earth's environment

humanitarian aid assistance provided in response to a human crisis caused by natural or man-made disasters, in order to save lives and alleviate suffering

humanitarianism concern for the welfare of other human beings

humus organic substance in the soil that is formed by the decomposition of leaves and other plant and animal material; rich in nutrients needed for plant growth

hunger the sensation felt when a person does not have enough to eat to meet their body's energy needs

hybrid plant or animal bred from two or more different species, sub-species, breeds or varieties, usually to attain the best features of the different stocks

hydroponic describes a method of growing plants using mineral nutrients, in water, without soil

icon sites six sites located in the Murray–Darling Basin that are earmarked for environmental flows; they were chosen for their environmental, cultural and international significance

impervious describes a rock layer that does not allow water to move through it due to a lack of cracks and fissures

improved pasture pasture that has been specially selected and sown, which is usually more productive than the local native pasture

incentive something that motivates or encourages a person to do something

indicator a value that informs us of a condition or progress; it can be defined as something that helps us to understand where we are, where we are going and how far we are from the goal

indigenous native to or belonging to a particular region or country; Australia's Indigenous peoples are made up of Aboriginal people (who live all around Australia) and Torres Strait Islanders (who settled the many small islands to the north of Cape York Peninsula in Queensland)

industrialised having developed a wide range of industries or having highly developed industries

Industrial Revolution the period from the late 1700s into the 1800s that saw the widespread introduction of mechanical processes in industry

infiltration water that is absorbed into the ground, flows downward and collects above an impermeable layer or rock

infrastructure the facilities, services and installations needed for a society to function, such as transportation and communications systems, water and power lines

innovation new and original improvement to something, such as a piece of technology or a variety of plant or seed

intensive farm farm that requires a lot of inputs, such as labour, capital, fertiliser and pesticide

invasive plant species commonly referred to as weeds; any plant species that dominates an area outside its normal region and requires action to control its spread

investment an item that is purchased or has money dedicated to it with the hope that it will generate income or be worth more in the future

irrigation the supply of water by artificial means to agricultural areas where there is a shortage

jatropha any plant of the genus *Jatropha*, but particularly *Jatropha curcas* which is used as a biofuel

kenaf plant in the hibiscus family that has long fibres useful for making paper, rope and coarse cloth

Kyoto Protocol an agreement negotiated in 1999 between 160 countries designed to bring about reductions in greenhouse gas emissions

lagoon a shallow body of water separated from the sea by a sand barrier or coral reef

land degradation a decline in the quality of land, which makes it less able to support agriculture or native vegetation

land grabs large-scale buying or leasing of land by governments or companies

leaching the process in which water runs through soil, dissolving minerals and carrying them into the subsoil

leeward describes the area behind a mountain range, away from the moist prevailing winds

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

livelihood job or skill that supports a person's existence, so that they can have the necessities of life

logging the cutting down, processing and removal of trees from an area

longshore drift a current that moves sediment parallel to the shoreline, created by the backward and forward motion of waves

low-density housing residential developments with around 12–15 dwellings per hectare; usually located in outer suburbs

mallee vegetation areas characterised by small, multitrunked eucalypts found in the semi-arid areas of southern Australia

malnourished describes someone who is not getting the right amount of vitamins, minerals and other nutrients to maintain healthy tissues and organ function

malnourishment a condition that results from not getting the right amount of vitamins, minerals and other nutrients needed to maintain healthy tissues and organ function

manufacturing and industrial base all factories or companies producing goods or related services on a large or medium scale in a country or region, considered in relation to the economy as a whole

maternal mortality the death of a woman while pregnant or within 42 days of termination of pregnancy

Mediterranean (climate) characterised by hot, dry summers and cool, wet winters

medium-density housing residential developments with around 20–50 dwellings per hectare

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

metropolitan region an urban area that consists of the inner urban zone and the surrounding built-up area and outer commuter zones of a city

micro hydro-dam dam that produces hydro-electric power on a scale serving a small community (less than 10 MW). They usually require minimal construction and have very little environmental impact.

migration the movement of people (or animals) from one location to another

monoculture the cultivation of a single crop on a farm or in a region or country

monsoon a wind system that brings heavy rainfall over large climatic regions and reverses direction seasonally

mulch organic matter such as grass clippings

nautical miles a unit of measurement used by sailors and/or navigators in shipping and aviation. It is the average length of one minute of one degree along a great circle of the Earth. One nautical mile corresponds to one minute of latitude; thus, degrees of latitude are approximately 60 nautical miles apart.

neonatal intensive care the specialised nursing practice of caring for newborn infants

nocturnal active during the night

nomadic describes a group of people who have no fixed home and move from place to place according to the seasons, in search of food, water and grazing land

old-growth forests natural forests that have developed over a long period of time, generally at least 120 years, and have had minimal unnatural disturbance such as logging or clearing

organic matter decomposing remains of plant or animal matter

pastoral run an area or tract of land for grazing livestock

per capita per person (literally 'by head')

per capita income average income per person; calculated as a country's total income (earned by all people) divided by the number of people in the country

perennial describes a stream or river that flows permanently

permaculture a view that farming should work with nature, not against it

permafrost permanently frozen ground

photodegradation action of sunlight breaking down plastic into minute particles

plantation an area in which trees or other large crops have been planted for commercial purposes

pneumatophores exposed root system of mangroves, which enable them to take in air when the tide is in

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 have high population densities and remote places such as deserts usually have low population densities

potable drinkable: safe to drink

prairie native grasslands of North America

precipitation water droplets or ice crystals become too heavy to be suspended in the air and fall to Earth as rain, snow, sleet or hail

prevailing wind the dominant direction a wind blows from

pull factor favourable quality or attribute that attracts people to a particular location

pulp the fibrous material extracted from wood or other plant material to be used for making paper

pulses plants that have nitrogen-fixing properties contributing to soil fertility

push factor unfavourable quality or attribute of a person's current location that drives them to move elsewhere

qualitative indicator usually consists of a complex set of indices that measure a particular aspect of quality of life or describe living conditions; useful in analysing features that are not easily calculated or measured, such as freedom or security

quality of life your personal satisfaction (or dissatisfaction) with the conditions under which you live

quantitative indicator easily measured and can be stated numerically, such as annual income or how many doctors there are in a country

quintile any of five equal groupings used to measure and compare values

rain shadow the dry area on the leeward side of a mountain range

rainwater harvesting the accumulating and storing of rainwater for re-use before it soaks into underground aquifers

Ramsar site a wetland of international importance, as defined by the Ramsar Convention — an intergovernmental treaty on the protection and sustainable use of wetlands

rebate a partial refund on something that has been bought or paid for

recharge the process by which groundwater is replenished by the slow movement of water down through soil and rock layers

regional and remote areas areas classified by their distance and accessibility from major population centres

reservoir large natural or artificial lake used to store water, created behind a barrier or dam wall

retrofitting adding a component or accessory to something that did not have it when it was originally built or manufactured

ringbark remove the bark from a tree in a ring that goes all the way around the trunk. The tree usually dies because the nutrient-carrying layer is destroyed in the process.

river delta a landform composed of deposited sediments at the mouth of a river where it flows into the sea

river fragmentation the interruption of a river's natural flow by dams, withdrawals or transfers

river regime the pattern of seasonal variation in the volume of a river

road intersection place where two or more roadways cross

runoff water that is unable to be absorbed into the ground, flows over its surface and collects in nearby waterways or reaches stormwater drains

salinity the presence of salt on the surface of the land, in soil or rocks, or dissolved in rivers and groundwater

salt scald the visible presence of salt crystals on the surface of the land, giving it a crust-like appearance

sanitation services provided to remove waste such as sewage and rubbish

sea change/tree change movement of people from major cities to live near the coast or forests, to achieve a change of lifestyle

seasonal crops crops that are harvested in a certain season of the year, rather than all year round

sex ratio the number of males per 1000 females

shifting agriculture system in which small parcels of land are used to produce food for a period and abandoned when they become less productive so they can recover naturally, while the farmers move to another plot of land

slum a run-down area of a city characterised by poor housing and poverty

socioeconomic relating to or involving a combination of social and economic factors

standard of living a level of material comfort in terms of goods and services available to someone or some group; often measured on a continuum, for example a 'high' or 'excellent' standard of living compared to a 'low' or 'poor' standard of living

staple an important food product or item that people eat or use regularly

stewardship an ethic that embodies the responsible planning and management of resources

storm surge a temporary increase in sea level from storm activity

subsidence the gradual sinking of landforms to a lower level as a result of earth movements, mining operations or over-withdrawal of water

subsistence describes farming that provides food only for the needs of the farmer's family, leaving little or none to sell

sustainable describes the use by people of the Earth's environmental resources at a rate such that the capacity for renewal is ensured

sustainable development development that meets the needs of the current generation without the depletion of resources

terminal lake a lake from which the water does not drain into a river or sea. Water can leave only through evaporation, which can increase salt levels in arid regions. Also known as an endorheic lake.

thermoline circulation refers to the flow of ocean water caused by changes in water density. Salt and temperature levels can change; for example, fresh water added by rain, snow melt or river run-off. Temperatures can change from contact with the atmosphere.

topsoil the top layers of soil that contain the nutrients necessary for healthy plant growth

training walls walls or jetties that are constructed to direct the flow of a river or tide

transpiration the process in which water contained in plants is heated, changes from a liquid into a gaseous state and rises into the atmosphere

tsunami a powerful ocean wave triggered by an earthquake or volcanic activity under the sea

turbid describes water that contains sediment and is cloudy rather than clear

undernourished describes someone who is not getting enough calories in their diet; that is, not enough to eat

undulating describes an area with gentle hills

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 environment the human-made or built structures and spaces in which people live, work and recreate on a day-to-day basis

urban expansion the increasing size of urban areas

urban infilling the division of larger house sites into multiple sites for new homes

urbanisation the social and economic processes whereby an increasing proportion of the population of a country or region live in urban areas

urban renewal redevelopment of old urban areas including the modernisation of household interiors

urban sprawl the spreading of urban areas into surrounding rural areas to accommodate an expanding population

volunteer a person who offers to give up time to commit to an idea or organisation without being paid

voucher a card or ticket that allows you to purchase goods and services to a set value

waterlogging saturation of the soil with groundwater so that it hinders plant growth

water rights the right through ownership to use water from a water source such as a river, stream, pond or groundwater source

water stress situation that occurs when water demand exceeds the amount available or when poor quality restricts its use

watertable upper level of groundwater, below which all pores in the soils and rock layers are saturated with water

weathering the breaking down of rocks

weeds any plant species that dominates an area outside its normal region and requires action to control its spread

weir wall or dam built across a river channel to raise the level of water behind. This can then be used for gravity-fed irrigation.

wellbeing a good or satisfactory condition of existence; a state characterised by health, happiness, prosperity and welfare

Western-style diet eating pattern common in developed countries, with high amounts of red meat, sugar, high-fat foods, refined grains, dairy products, high-sugar drinks and processed foods

wetland an area covered by water permanently, seasonally or ephemerally; includes fresh, salt and brackish waters such as rivers, lakes, rice paddies and areas of marine water, the depth of which at low tide does not exceed 6 metres

windward describes the side of the mountain that faces the prevailing winds

yield amount of agriculture produced or provided

yield gap the gap between a certain crop's average yield and its maximum potential yield

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