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JACARANDA

GEOGRAPHY ALIVE 10

AUSTRALIAN CURRICULUM | THIRD EDITION

AUSTRALIAN CURRICULUM v9.0

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

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

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

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

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About this resource

NEW FOR

AUSTRALIAN CURRICULUM V9.0

JACARANDA

GEOGRAPHY ALIVE 10

AUSTRALIAN CURRICULUM
THIRD EDITION

Developed by teachers for students

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

Because both *what* and *how* students learn matter

Learning is personal

Whether students need a challenge or a helping hand, you'll find what you need to create engaging lessons.

Whether in class or at home, students can access carefully scaffolded lessons with in-depth skills development while engaging with multi-modal content designed to spark curiosity. Automatically marked, differentiated question sets are all supported by detailed sample responses — so students can get unstuck and progress!

Learning is effortful

Learning happens when students push themselves. With learnON, Australia's most powerful online learning platform, students can challenge themselves, build confidence and ultimately achieve success.

Learning is rewarding

Through real-time results data, students can track and monitor their own progress and easily identify areas of strength and weakness.

And for teachers, Learning Analytics provide valuable insights to support student growth and drive informed intervention strategies.

Learn online with Australia's most

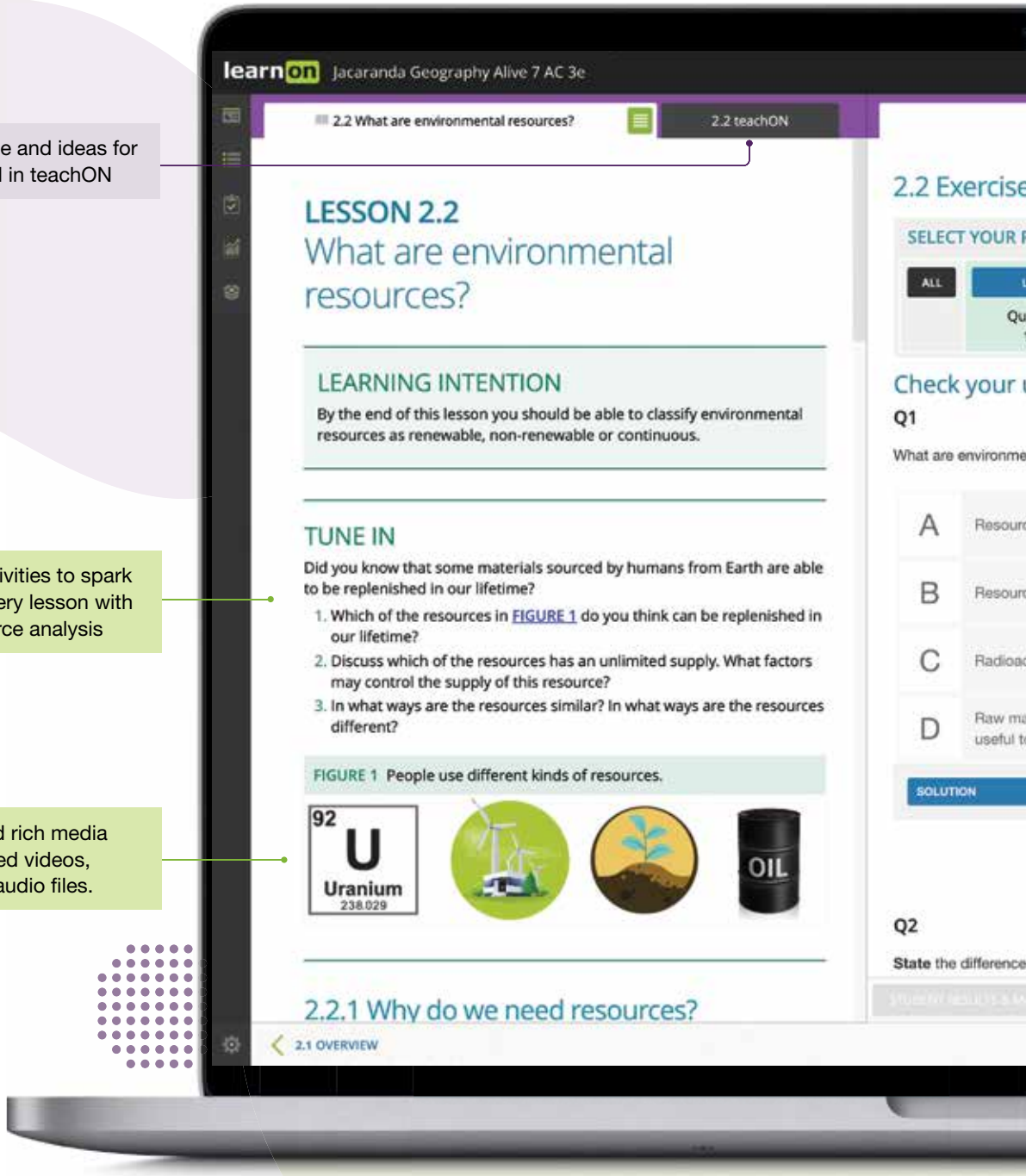
Everything you need for each of your lessons in one simple view

- **Trusted, curriculum-aligned content**
- **Engaging, rich multimedia**
- **All the teaching-support resources you need**
- **Deep insights into progress**
- **Immediate feedback for students**
- **Create custom assignments in just a few clicks.**

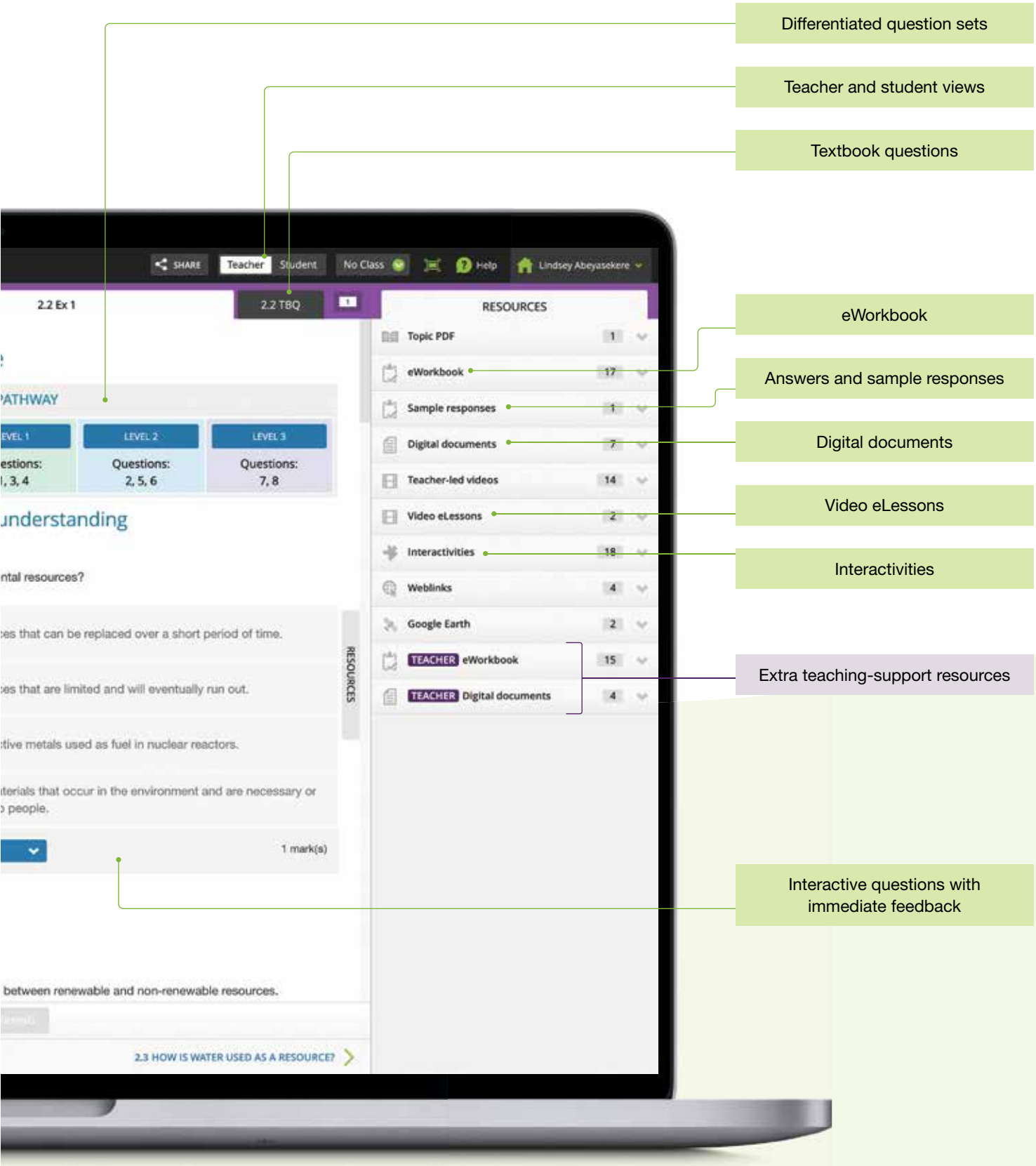
Practical teaching advice and ideas for each lesson provided in teachON

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

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



powerful learning tool, learnON

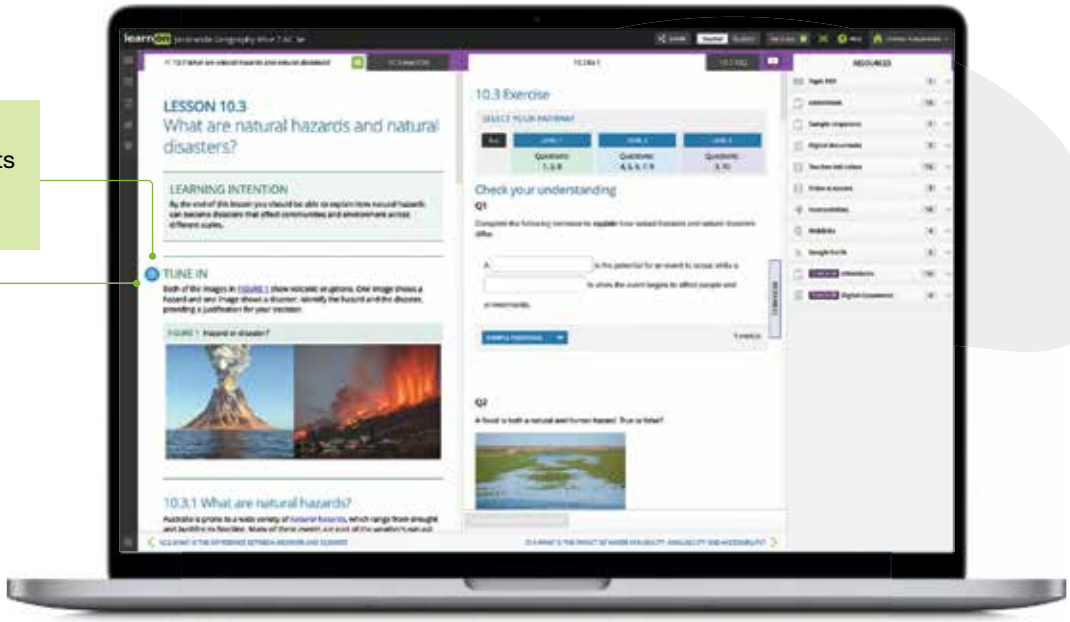


Get the most from your online resources

Online, these new editions are the complete package

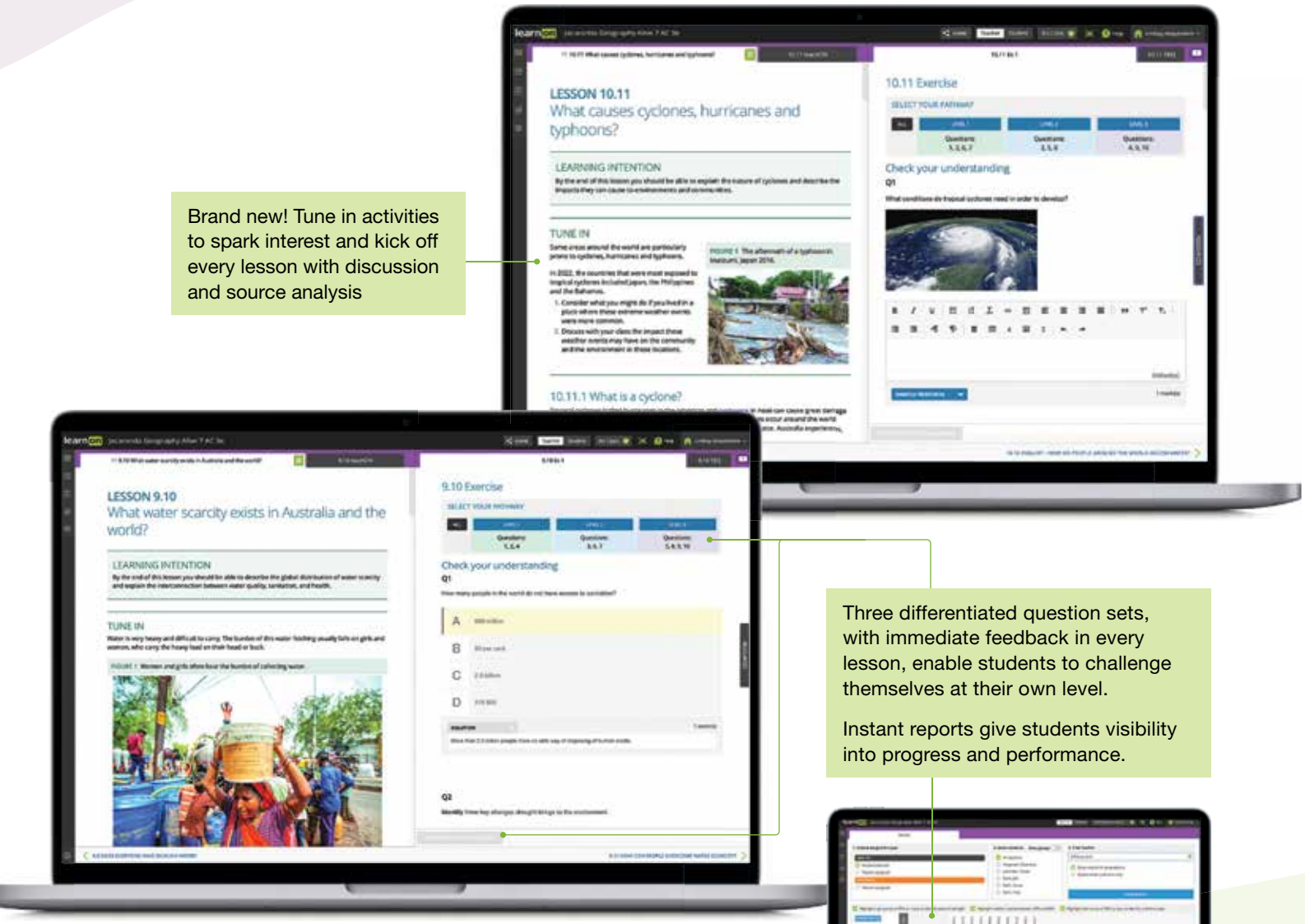
Trusted Jacaranda theory, plus tools to support teaching and make learning more engaging, personalised and visible.

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



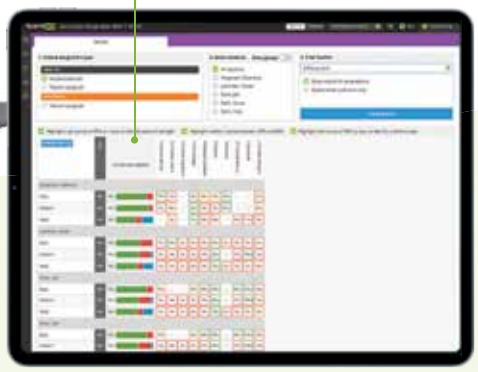
New teaching videos are designed to help students learn concepts by having a 'teacher at home', and are flexible enough to be used for pre-and post-learning, flipped classrooms, class discussions, remediation and more.

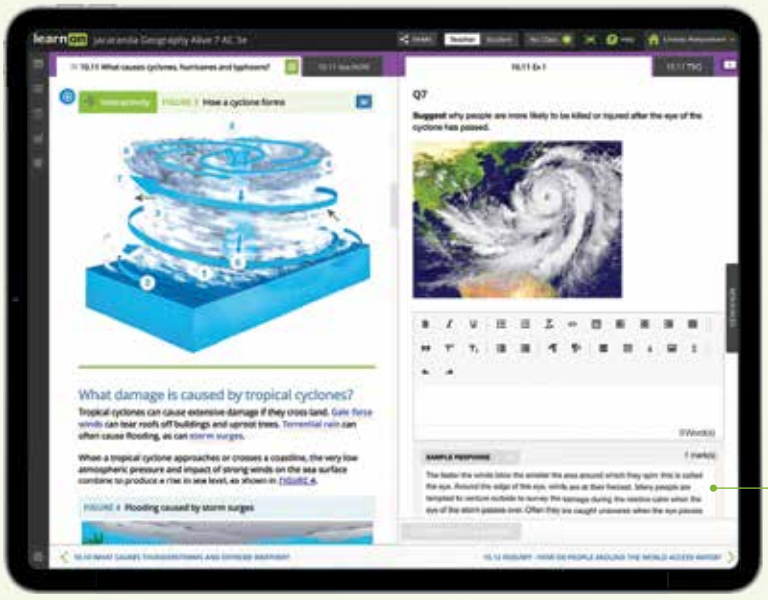
Brand new! Tune in activities to spark interest and kick off every lesson with discussion and source analysis



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

Instant reports give students visibility into progress and performance.





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

TUNE IN lesson starters

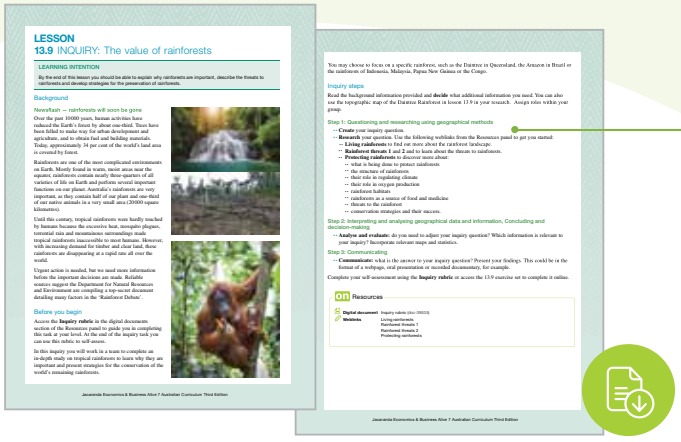
New Tune In activities spark interest and kick off every lesson with discussion and source analysis.

Skill development

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

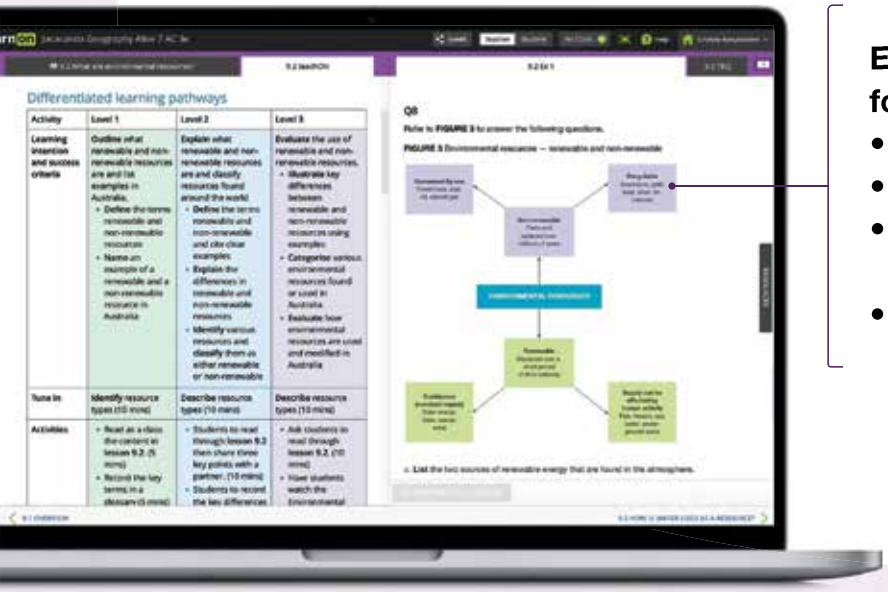
SkillBuilders support and strengthen skill development using our Tell me, Show me, Let me do it approach.

Inquiry projects



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

A wealth of teacher resources

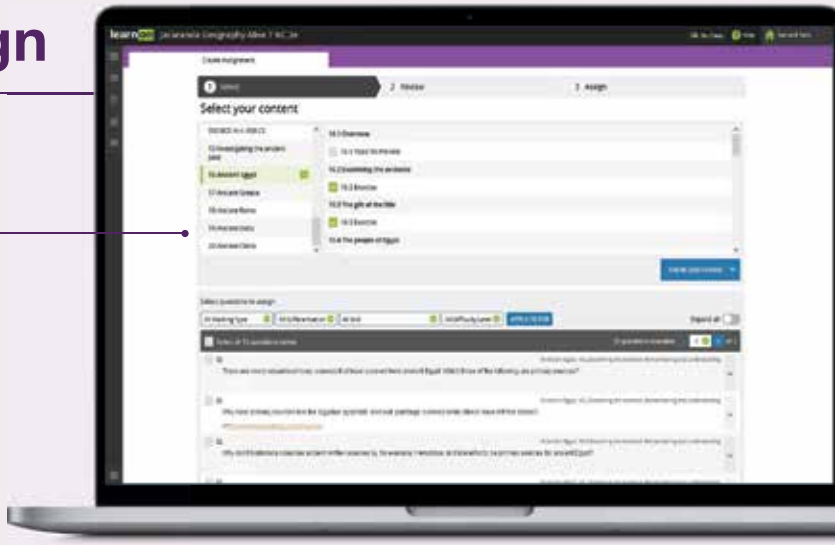


Enhanced teaching-support resources for every lesson, including:

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

Customise and assign

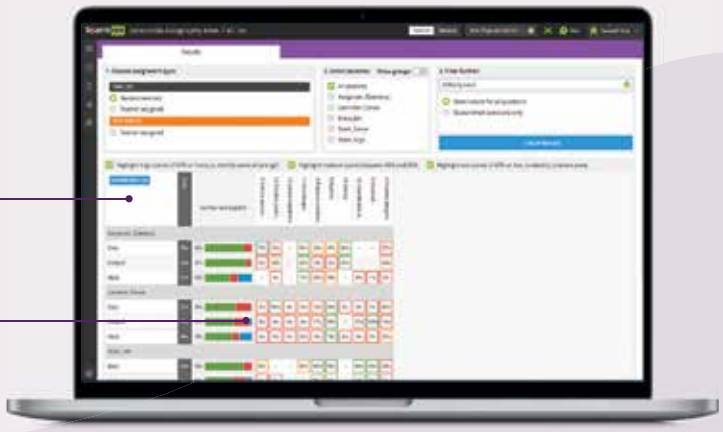
An inbuilt testmaker enables you to create custom assignments and tests from the complete bank of thousands of questions for immediate, spaced and mixed practice.



Reports and results

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

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



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Understanding cognitive verbs

Cognitive verbs in the Australian Curriculum

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

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

Questions within Jacaranda resources use these cognitive verbs to support students in cognitive verb 'thinking'. The following list describes the cognitive verbs that are frequently used in Years 9 and 10.

Cognitive verb	Description
analyse	considering something in detail, finding meaning or relationships and identifying patterns. In an analysis you may reorganise ideas and find similarities and differences.
apply	using knowledge and understanding in order to solve a problem or complete an activity; activities and problems may be familiar or unfamiliar; applying knowledge and understanding can require recalling previous experiences.
compare	recognising how things are similar and dissimilar. Concepts or items are generally grouped before a comparison is made.
decide	selecting from available options. This may involve considering criteria on which to base your selection.
describe	giving an account of a situation, event, pattern or process. A description may require a sequence or order.
develop	bringing something to a more advanced state. Processing and understanding are required to develop an idea or opinion. Developing an idea or opinion may also involve considering feedback or the collective thoughts of a group.
evaluate	making a judgement using a set of criteria. This may include considering strengths and limitations of something in order to make a judgement on a preferred option.
examine	considering the information given and recognising key features. This might require making a decision, which involves gathering more information.
explain	making an idea, concept or relationship between two things clear by giving in-depth information. Explanations may include details of who, what, when, where, why and how in a step-by-step format.
identify	recognising and showing particular features of something. This might also include showing what or who something or someone is.
interpret	gaining meaning from text, graphs, data or other visuals. An interpretation includes stating what something might mean and drawing a conclusion.
select	choosing the most suitable option from a number of alternatives. This might require some consideration of context.
investigate	planning, collecting and interpreting data and information, and drawing conclusions.
synthesise	combining elements (information, ideas and components) into a connected or coherent whole.

Source: Adapted from the QCAA Cognitive Verbs.

1 Geography concepts and skills

LESSON SEQUENCE

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1.4 SkillBuilder: Interpreting a complex block diagram ..... online only
1.5 SkillBuilder: Creating a fishbone diagram ..... online only
1.6 SkillBuilder: Reading topographic maps at an advanced level ..... online only
1.7 SkillBuilder: Comparing an aerial photograph and a topographic map ..... online only
1.8 SkillBuilder: Using geographic information systems (GIS) ..... online only
1.9 SkillBuilder: Constructing and interpreting a scattergraph ..... online only
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LESSON
1.1 Overview

Hey students! Bring these pages to life online

Watch videos

Engage with interactivities

Answer questions and check results

Find all this and MORE in jacPLUS

1.1.1 Introduction

As a student of Geography, you are building knowledge and skills that will be needed by you and your community now and into the future. The concepts and skills that you use in Geography can also be applied to everyday situations, such as finding your way from one place to another. Studying Geography may even help you in a future career here in Australia or somewhere overseas.

Throughout your study of Geography, you will cover topics that will give you a better understanding of the social and physical aspects of the world around you, on both the local and global scale. You will investigate issues that need to be addressed now, and for the future.

FIGURE 1 Geography helps you understand and explore the amazing world we live in.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11496)

Video eLesson Geography concepts and skills (eles-6133)

LESSON
1.2 Concepts in Geography

LEARNING INTENTION

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

1.2.1 SPICESS

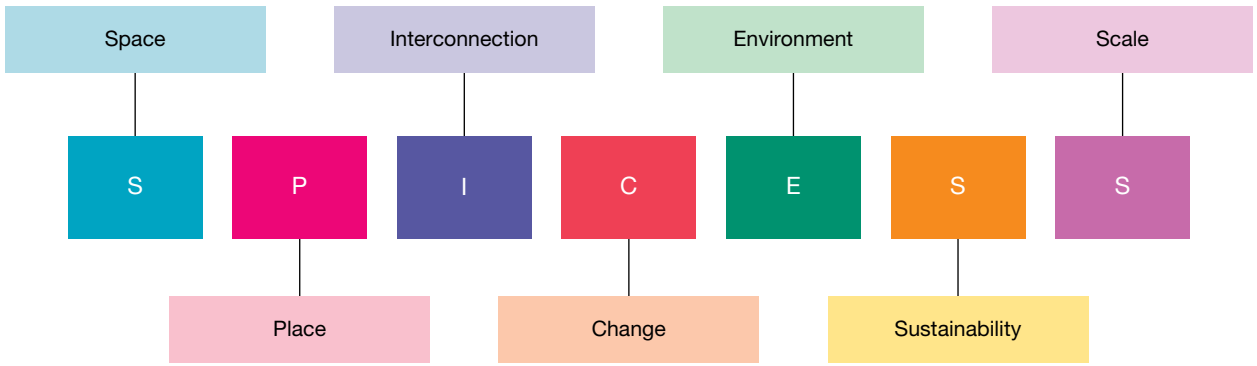
As you work through each of the topics in this title, you'll complete a range of exercises to check and apply your understanding of concepts covered. This year, you will build on your understanding of the key Geography concepts.

- Space
- Place
- Interconnection
- Change
- Environment
- Sustainability
- Scale

The easiest way to remember these concepts is the acronym SPICESS.

Geographical concepts help you make sense of your world. By using these concepts you can 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. We will explore each of the Geography concepts in detail in the following sections and through the activities and exercises for this lesson.

FIGURE 1 A way to remember the seven Geography concepts is to think of the term SPICESS.



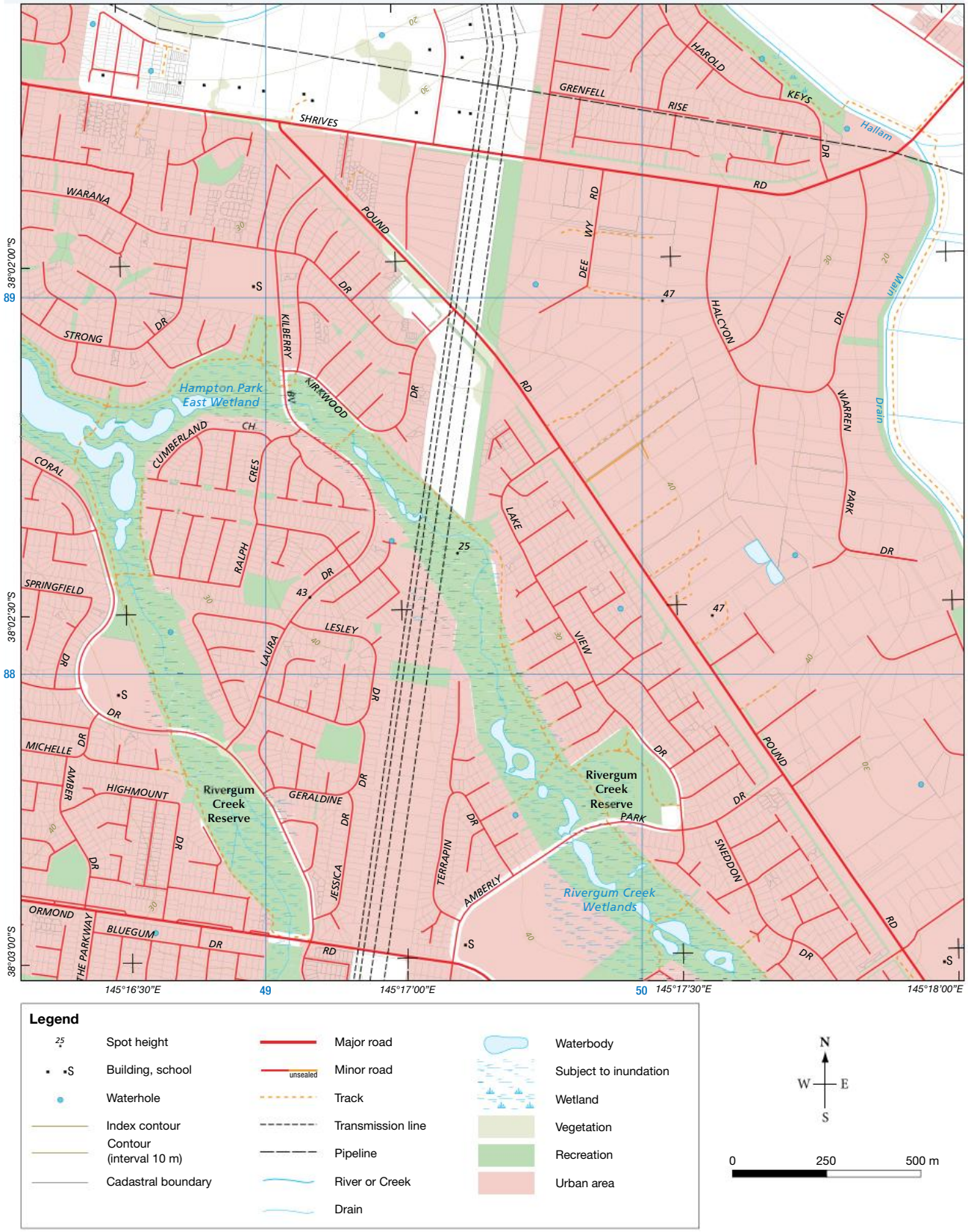
1.2.2 What is space?

The concept of **space** is about where things are located and distributed on the surface of the Earth.

When referring to space in Geography we can have absolute or relative location. Absolute location is the unique location of a site or geographical feature. For example, the absolute location of Broken Hill is at 31°57' South and 141°28' East. Relative location is the location of a place or feature in relation to other places. It can be described by direction and distance from other places and features.

space where things are located and distributed on the surface of the Earth

FIGURE 2 A topographic map extract of Narre Warren in 2013, a suburb on the rural–urban fringe of Melbourne



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

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.

Explore more with myWorldAtlas

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

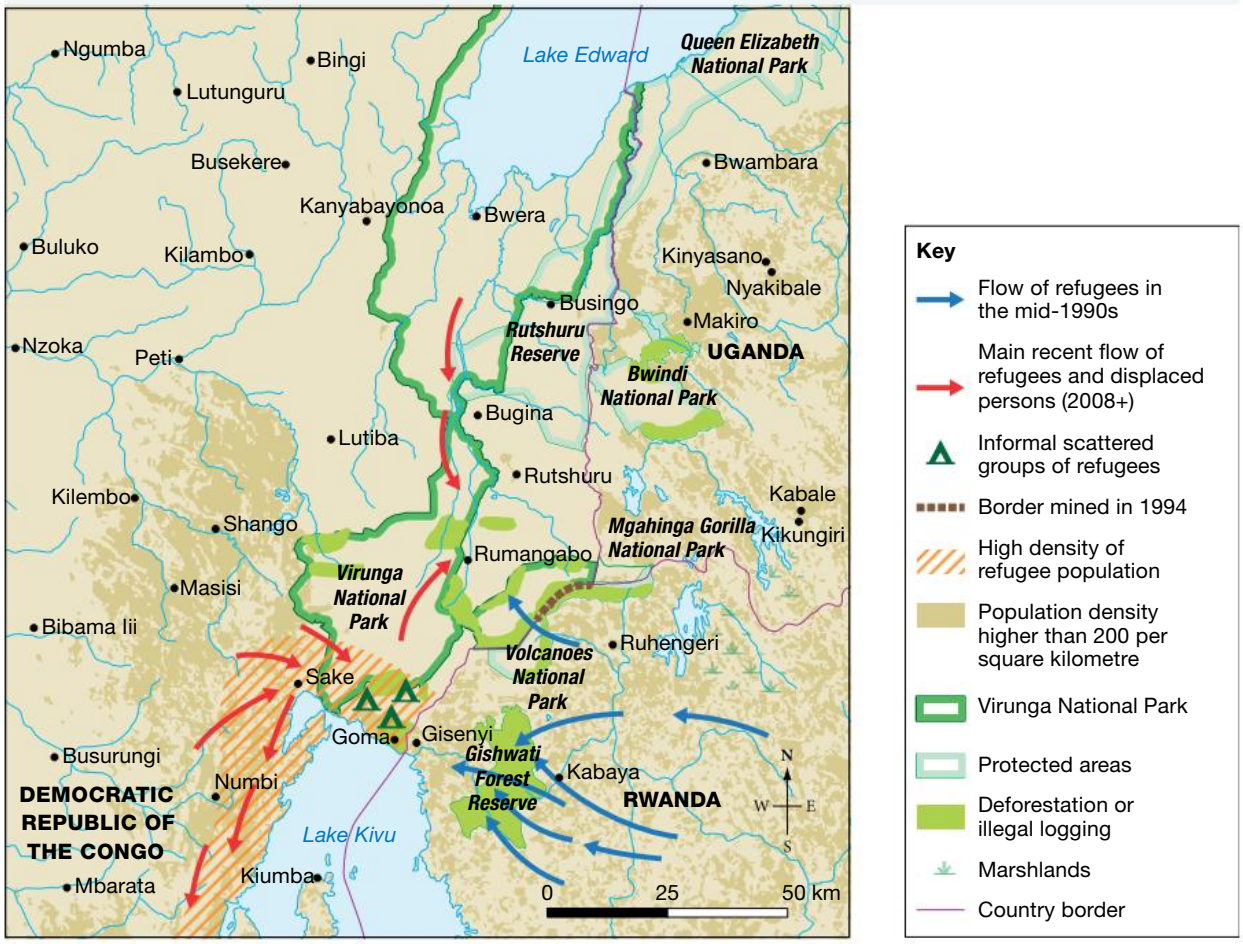
- Developing Australian Curriculum concepts > **Space**

1.2.3 What is place?

Place is an area on the Earth's surface which is identified and has meaning for people. 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.

place an area on the Earth's surface which is identified and has meaning for people

FIGURE 3 The Democratic Republic of the Congo (DRC) has for years been subject to raids by militia groups and the influx of refugees from neighbouring countries. Forests in the country are important places for wildlife habitats and shelter for soldiers. Forests also provide the valuable resources of timber for fuel and building materials for refugees, and cleared land can be planted for food crops.



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Places may be natural (such as an undisturbed wetland) or highly modified (like a large urban **conurbation**). Places provide us with the services and facilities we need in our everyday life. The physical and human characteristics of places, their location and their environmental quality can influence the quality of life and wellbeing of people living there.

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

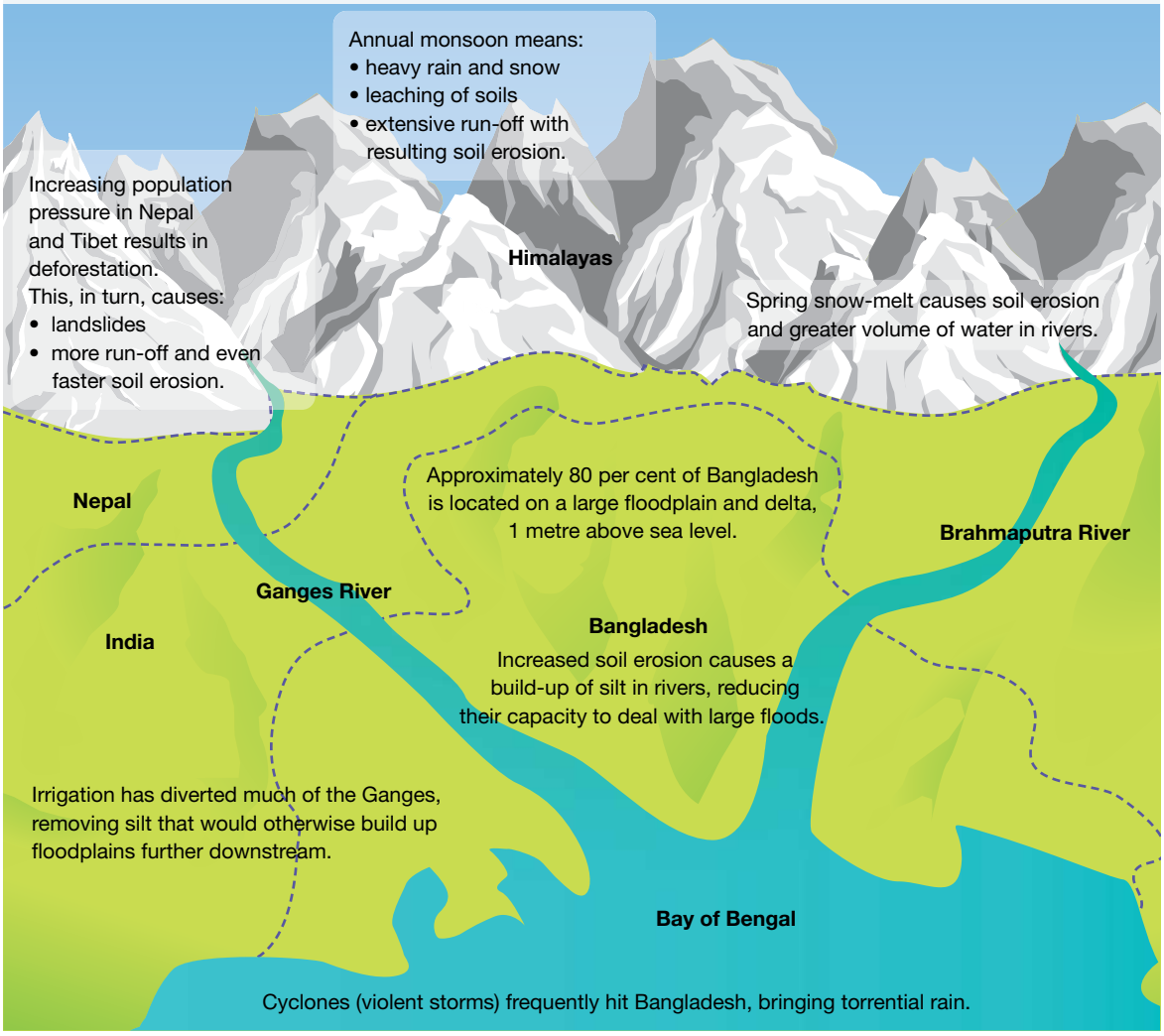
Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.
- Developing Australian Curriculum concepts > **Place**

1.2.4 What is interconnection?

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.

FIGURE 4 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.



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.

Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.
- Developing Australian Curriculum concepts > **Interconnection**

1.2.5 What is change?

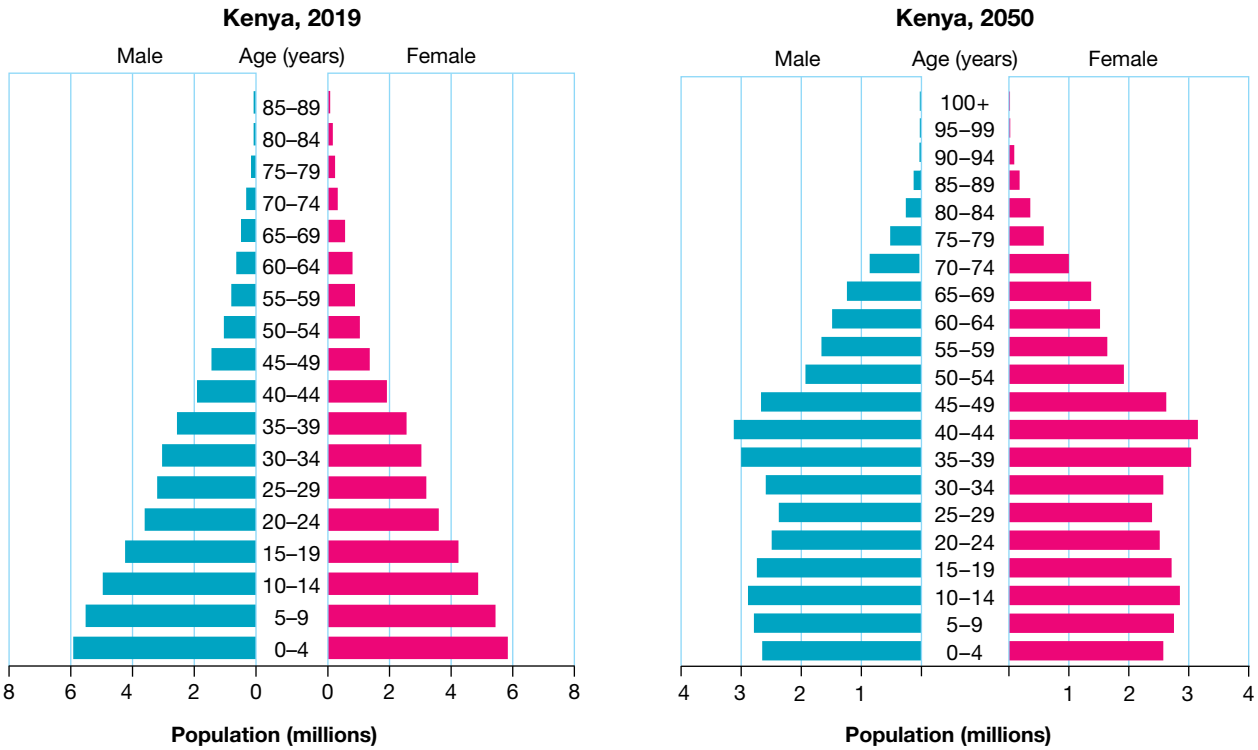
The concept of **change** is about using time to better understand a place, an environment, a spatial pattern or a geographical problem.

Topics that are studied in Geography are in a constant process of change over time. The scale of time may be a short time period, such as the issue of traffic congestion in peak hour or the erosion of a beach during a storm. Other changes can take place over a longer period, such as changes in the population structure of a country or revegetation of degraded lands.

interconnection the fact that people and things are connected to other people and things in their own and other places around the world

change refers to using time to better understand a place, an environment, a spatial pattern or a geographical problem. The concept of change involves both time and space — change can take place over a period of time, or over an area.

FIGURE 5 Population pyramids for Kenya, showing the predicted changes from 2019 to 2050. The graphs represent the number of males and females in five-year age groups.



Explore more with myWorldAtlas

Deepen your understanding of this topic with related case studies and questions.
- Developing Australian Curriculum concepts > **Change**

1.2.6 What is environment?

People live and depend on the **environment**, so it has an important influence on our lives. The environment, defined as the physical and biological world around us, supports and enriches human and other life by providing raw materials and food, absorbing and recycling wastes, and being a source of enjoyment and inspiration to people.

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, having both positive and negative impacts. 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 can potentially have a negative impact on quality of life for many people.

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

FIGURE 6 Lake Urmia is the largest lake in the Middle East and one of the largest landlocked saltwater lakes in the world. Between 2005 and 2017, the lake 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.

Explore more with myWorldAtlas

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

- Developing Australian Curriculum concepts > **Environment**

1.2.7 What is sustainability?

Sustainability is about maintaining the capacity of the environment to support our lives and the lives of other living creatures, both now and into the future.

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. 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.

sustainability refers to maintaining the capacity of the environment to support our lives and those of other living creatures now and into the future

FIGURE 7 Dust storms are an extreme form of land degradation.

Explore more with myWorldAtlas

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

- Developing Australian Curriculum concepts > **Sustainability**

1.2.8 What is scale?

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

Scale 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 on a national or even global scale.

scale the way that geographical phenomena and processes can be examined at different spatial levels. Scale can be applied from personal and local levels to regional, national or global levels.

FIGURE 8 A map of India showing the distribution of literacy levels (percentage) for 2011

Source: Government of India, Ministry of Home Affairs, Office of Registrar General. (***Note:*** Most recent data available)

Explore more with myWorldAtlas

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

- Developing Australian Curriculum concepts > **Scale**

LESSON
1.3 Skills used in Geography

LEARNING INTENTION

By the end of this lesson you should be able to explain what geographers do.

1.3.1 Careers that will help the Earth

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 population are just three environmental challenges that will be the focus for many occupations in the future. Which careers will be helpful in managing environmental change?

TABLE 1 Careers that will manage environmental change

Conservationists 	Conservationists will work to find solutions to land degradation. They will work for governments, in national parks and on policy development, and 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 suggest and implement plans for cleaning up the oceans.
Agricultural scientists 	Agricultural scientists will be employed by the government, and agricultural and horticultural producers. They will work with farmer groups and agribusiness to carry out research, and with mining companies, working on regeneration projects.

1.3.2 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
- Curiosity and adaptability
- Active listening
- Good communication
- Critical thinking
- Time management
- Problem solving

You can develop your skills and work attributes by undertaking work experience or volunteering activities while you are still at school.

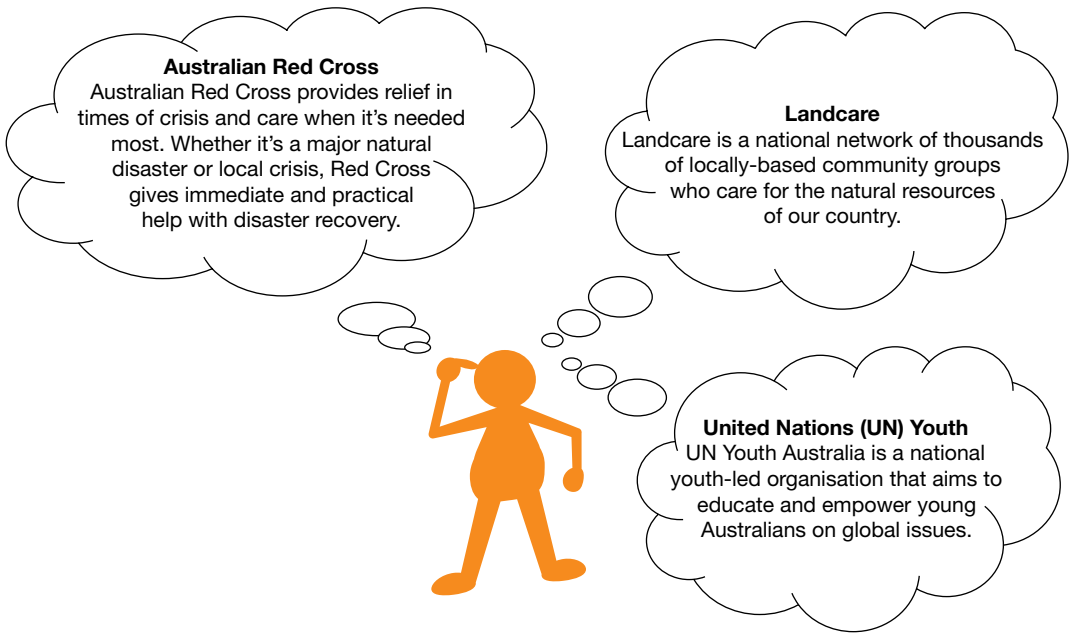
1.3.3 The importance of work experience

The activities you undertake and skills you develop in Geography will be useful to you in many aspects of your life and career. In building and managing your career options, it is also helpful to have an understanding of the interconnections between various careers. One way of building your knowledge of these interconnections, particularly in relation to 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 involved in various roles and the training required to specialise in a particular area. You can gain first-hand experience through observation of and participation 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 the things that affect the delivery of the services or programs. Volunteering your time to support local communities and businesses also demonstrates your willingness to learn and support others, and it can provide a great boost to your self-confidence, as well as important skill development. **FIGURE 1** provides some ideas to get you thinking.

FIGURE 1 Some options for volunteering



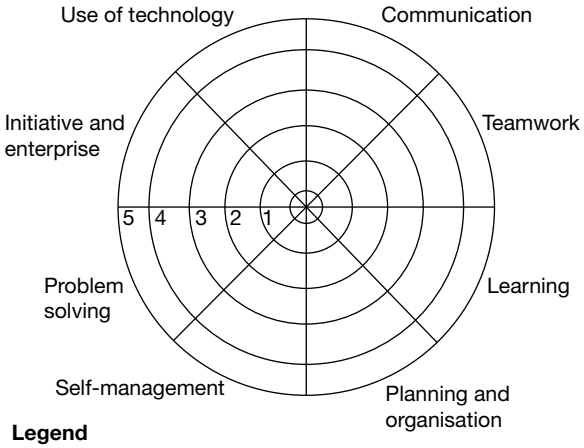
Learning directly from industry experts through volunteering can help you to consolidate your interests while also picking up valuable core skills for work (refer to **TABLE 2**). These core skills are considered the most important component of a career portfolio. The study of Geography also assists in the development of these skills.

TABLE 2 The core skills for work

Communication	Ability to use effective listening and speaking skills
Teamwork	Ability to connect and work with others
Learning	Ability to recognise and utilise diverse perspectives
Planning and organisation	Ability to develop plans and see things through to completion
Self-management	Ability to make decisions
Problem solving	Ability to identify and solve problems
Initiative and enterprise	Ability to create and innovate through new ideas
Use of technology	Ability to work in a digital world

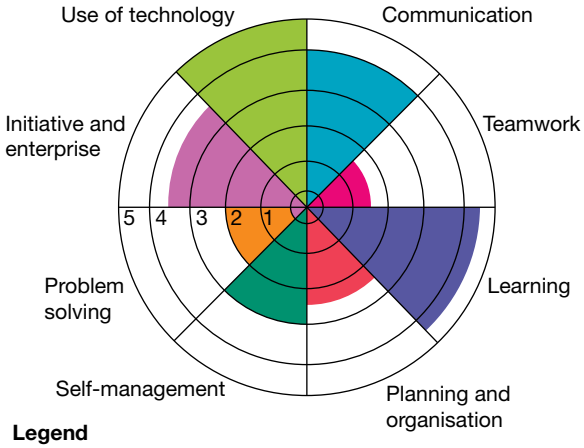
How many of the core skills for work have you developed? Use the **FIGURE 2** chart to help you think about your own skills. You may find you have particular strengths and other areas you need to improve upon. If you do this periodically, you can monitor your progress in this area. **FIGURE 3** is an example of a completed chart.

FIGURE 2 Evaluating my core skills for work



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

FIGURE 3 Core skills analysis — March 2023



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

1.3.4 Future careers and Geography

Studies in Geography, along with other Humanities 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 of this century are yet to be created, while others have been imagined and offer a glimpse into the future.

The hypothetical job advertisement in **FIGURE 4** outlines some of the skills that will be needed to tackle these future roles.

FIGURE 4 Agroecologist — a career of the future

Seeking an agroecologist…	Job requirements/skills
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 also work with Ecosystem Managers to reintroduce native species and biodiversity to repair the damage done by the ecosystem-disruptive farming techniques of the past.	You will need an undergraduate degree in Agroecology, in which you'll have learned 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 also have learned about the technologies and methods involved in growing food in a sustainable way. To be successful in this role, you will need to be responsive to change, demonstrate adaptability by working as part of a global team, and be creative and enterprising in all elements of the business to ensure that business growth is sustainable.

FIGURE 5 An agroecologist works on growing food in a sustainable way.

1.3 SKILL ACTIVITY: Questioning and researching using geographical methods

1. Part-time, casual or vacation work are all useful ways to build your core skills for work. Use the **ACTU Worksite** weblink in your online Resources to locate information on work experience, volunteering and being ready for your first job.
2. Over the coming decades, new careers in Geography will emerge. Ecosystem auditors, localisers and rewilders will 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 undertake to ensure that you are ready for the workforce of tomorrow.
   a. Use the internet to **research** one of the following careers: ecosystem auditor, localiser or rewilder.
   b. **Develop** a career profile for this emerging career. Include the following details in your profile:
      i. a definition for this occupation
      ii. the core skills needed in this field
      iii. the study or training required to successfully carry out the tasks of the role
      iv. the industries that will employ these occupations.

1.3.5 Skills used in studying Geography

In addition to these concepts, there is a range of essential practical skills that you will learn, practise and master as you study Geography. These skills can be categorised into the four core skills areas you already know from your study of Geography.

Questioning and researching using geographical methods

Questioning and researching using geographical methods involves applying geographical concepts to develop questions and using primary research or fieldwork to gain a greater understanding of a concept or issue. This year your research and fieldwork should involve gathering information from both primary sources and a range of secondary sources, while evaluating them for relevance, reliability and bias. In Geography we look at information from a range of perspectives, and use ethical protocols to assess reliability and worth. In Year 10 you will be investigating global, national and local differences in human wellbeing and how people's actions influence the sustainability of places and environments.

The SkillBuilders related to this skill that you'll use at Year 10 level are:

- how to develop a structured and ethical approach to research
- understanding policies and strategies.

Interpreting and analysing geographical data and information

In Geography this year you will interpret data by using both quantitative methods (measurable information) and qualitative methods (observations and descriptions) to find similarities, patterns and differences in sources studied. You will also be expected to predict trends and discuss relationships by identifying the key aspects of data presented to you in a variety of forms (for example, a range of different types of maps, tables, graphs and charts). In Year 10 Geography this may include analysing data on environmental change and the impact of people on places around the world. It will also be important to examine issues of wellbeing from a variety of economic and cultural perspectives.

The SkillBuilders related to this skill that you'll use at Year 10 level are:

- constructing and interpreting a scattergraph
- constructing and describing complex choropleth maps
- interpreting a complex block diagram
- reading topographic maps at an advanced level
- using geographic information systems (GIS)
- building a map with geographic information systems (GIS)
- using Excel to construct population pyramids
- interpreting a cartogram.

Concluding and decision-making

In Geography you will learn to justify conclusions and propose strategies by analysing data, information and perspectives from a variety of sources. By considering environmental, economic and social factors you will make assessments about questions relating to the way interconnections in our world affect the life of every living thing. Interpreting data in Year 10 will also enable you to predict trends and discuss relationships by identifying the key aspects of information presented to you in a variety of tables, graphs, maps, online resources and textbooks. There is a particular focus in Year 10 on physical and environmental geography and conclusions you make need to keep in mind the long-term sustainability of human interactions with the natural world.

The SkillBuilders related to this skill that you'll use at Year 10 level are:

- comparing an aerial photograph and a topographic map
- constructing and interpreting a scattergraph
- using multiple data formats
- constructing and describing complex choropleth maps
- creating a fishbone diagram
- comparing an aerial photograph and a topographic map
- using geographic information systems (GIS)
- evaluating alternative responses
- drawing a futures wheel
- comparing aerial photographs to investigate spatial change over time.

Communicating

Communicating your ideas and justifying your conclusions are key skills you will develop in Geography. Using geographical concepts and knowledge and digital and non-digital formats you will seek to express your thoughts and ideas on a wide range of concepts and issues. When communicating in Geography you need to ensure that you consider your audience, acknowledge your sources and choose appropriate methods of communication to ensure your message is clear and well presented. In Year 10 you will be expected to explore new ways of presenting information and further develop skills acquired in earlier years.

The SkillBuilders related to this skill that you'll use at Year 10 level are:

- writing a geographical essay
- drawing a futures wheel
- describing change over time
- debating like a geographer
- constructing and describing complex choropleth maps.

on Resources

Weblink ACTU Worksite

LESSON
1.4 SkillBuilder: Interpreting a complex block diagram

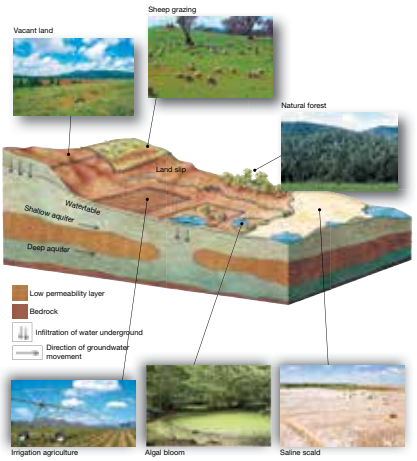
online only

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.

Go online to access:

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



on Resources

Video eLesson Interpreting a complex block diagram (eles-1746)

Interactivity Interpreting a complex block diagram (int-3364)

LESSON
1.5 SkillBuilder: Creating a fishbone diagram

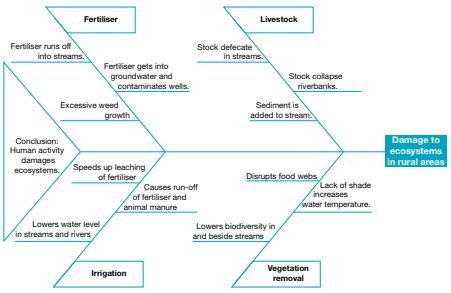
online only

What is a fishbone diagram?

Fishbone diagrams are useful to help visualise a problem or effect, and to show 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 flows to other causes and even sub-causes. These are all linked to convey the interconnection of ideas.

Go online to access:

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



on Resources

Video eLesson Creating a fishbone diagram (eles-1748)

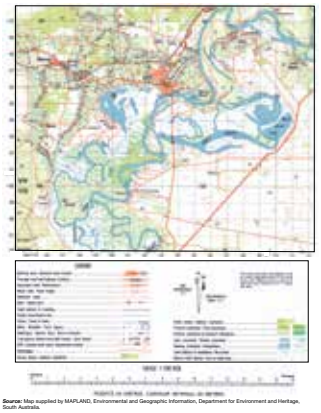
Interactivity Creating a fishbone diagram (int-3366)

LESSON
1.6 SkillBuilder: Reading topographic maps at an advanced level

online only

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.



Source: Map supplied by MAPLAND, Environmental and Geographic Information, Department for Environment and Heritage, South Australia.

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

on Resources

Video eLesson	Reading topographic maps at an advanced level	(eles-1749)
Interactivity	Reading topographic maps at an advanced level	(int-3367)

LESSON
7.7 SkillBuilder: Comparing an aerial photograph and a topographic map

online only

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.

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.

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

on Resources

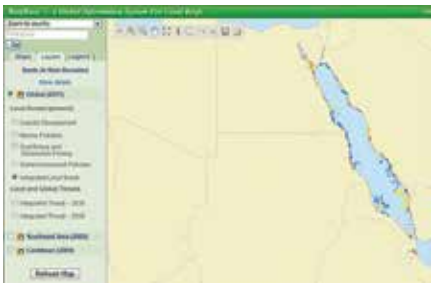
Digital documents	Topographic map of Mossman and the Daintree River National Park, Queensland	(doc-11572)
	Topographic map extract of Merimbula, New South Wales	(doc-11571)
Video eLesson	Comparing an aerial photograph and a topographic map	(eles-1751)
Interactivity	Comparing an aerial photograph and a topographic map	(int-3369)
Google Earth	Mossman	(gogl-0076)

LESSON
1.8 SkillBuilder: Using geographic information systems (GIS)

online only

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.



Go online to access:

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

on Resources

Video eLesson Using geographic information systems (GIS) (eles-1752)

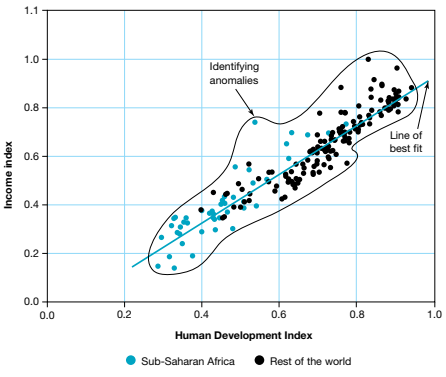
Interactivity Using geographic information systems (GIS) (int-3370)

LESSON
1.9 SkillBuilder: Constructing and interpreting a scattergraph

online only

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.



Source: © United Nations Development Programme.

Go online to access:

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

on Resources

Video eLesson Constructing and interpreting a scattergraph (eles-1756)

Interactivity Constructing and interpreting a scattergraph (int-3374)

LESSON
1.10 SkillBuilder: Interpreting a cartogram

online only

What is a cartogram?

A cartogram is a diagrammatic map. 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.

Go online to access:

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

on Resources

Video eLesson Interpreting a cartogram (eles-1757)

Interactivity Interpreting a cartogram (int-3375)

LESSON
1.11 SkillBuilder: Using multiple data formats

online only

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.

Go online to access:

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

on Resources

Video eLesson Using multiple data formats (eles-1761)

Interactivity Using multiple data formats (int-3379)

LESSON
1.12 SkillBuilder: Constructing and describing complex choropleth maps

online only

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 collected 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 most dense 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.

Go online to access:

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

on Resources

Digital document	Blackline master: Map of Africa (doc-12012)
Video eLesson	Constructing and describing complex choropleth maps (eles-1732)
Interactivity	Constructing and describing complex choropleth maps (int-3350)

LESSON
1.13 SkillBuilder: Evaluating alternative responses

online only

What are alternative responses?

Alternative responses are a range of different ideas/opinions on an issue. Evaluating ideas involves weighing up and interpreting your research to reach a judgement or a decision based on the information.

Go online to access:

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

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 islan'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 dun es 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 swinning 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.

on Resources

Video eLesson	Evaluating alternative responses (eles-1744)
Interactivity	Evaluating alternative responses (int-3362)

LESSON
1.14 SkillBuilder: Drawing a futures wheel

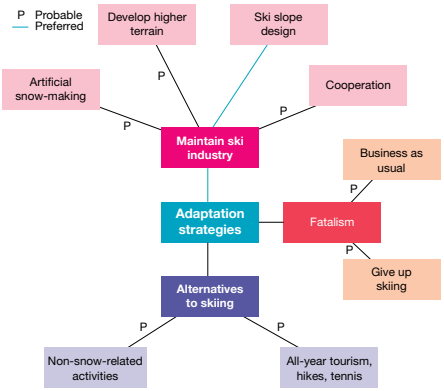
online only

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.

Go online to access:

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



on Resources

Video eLesson Drawing a futures wheel (eles-1745)

Interactivity Drawing a futures wheel (int-3363)

LESSON
1.15 SkillBuilder: Comparing aerial photographs to investigate spatial change over time

online only

What is an aerial photo?

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.

Go online to access:

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

on Resources

Video eLesson Comparing aerial photographs to investigate spatial change over time (eles-1750)

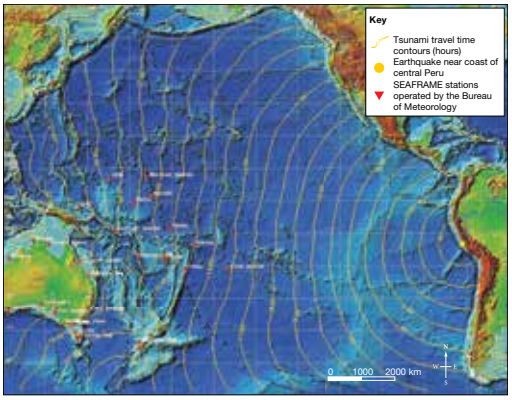
Interactivity Comparing aerial photographs to investigate spatial change over time (int-3368)

LESSON
1.16 SkillBuilder: Describing change over time

online only

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 period.



Go online to access:

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

on Resources

Video eLesson Describing change over time (eles-1753)

Interactivity Describing change over time (int-3371)

LESSON
1.17 SkillBuilder: Building a map with geographic information systems (GIS)

online only

What is GIS?

A geographic information system (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.

Go online to access:

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

on Resources

Video eLesson Building a map with geographic information systems (eles-1754)

Interactivity Building a map with geographic information systems (int-3372)

LESSON
1.18 SkillBuilder: Using Excel to construct population pyramids

online only

Why do we use Excel to construct population pyramids?

When constructing population pyramids, there is a large amount of data and large numbers to handle. The use of an Excel spreadsheet simplifies the process.

Go online to access:

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

on Resources

Video eLesson Using Excel to construct population profiles (eles-1758)

Interactivity Using Excel to construct population profiles (int-3376)

LESSON
1.19 SkillBuilder: How to develop a structured and ethical approach to research

online only

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.

Go online to access:

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

on Resources

Video eLesson How to develop a structured and ethical approach to research (eles-1759)

Interactivity How to develop a structured and ethical approach to research (int-3377)

LESSON
1.20 SkillBuilder: Understanding policies and strategies

online only

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.

Go online to access:

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

on Resources

Video eLesson Understanding policies and strategies (eles-1760)

Interactivity Understanding policies and strategies (int-3378)

LESSON
1.21 SkillBuilder: Debating like a geographer

online only

What does debating like a geographer mean?

Debating like a geographer is 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.

Go online to access:

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

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

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

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 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

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

Negative speaker 3
(Negates affirmative speaker 3 and expands on key ideas)
- Emphasises the resource is being degraded and conflict is rife

on Resources

Video eLesson Debating like a geographer (eles-1762)

Interactivity Debating like a geographer (int-3380)

LESSON
1.22 SkillBuilder: Writing a geographical essay

online only

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.

Go online to access:

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

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.

on Resources

Video eLesson Writing a geographical essay (eles-1763)

Interactivity Writing a geographical essay (int-3381)

LESSON
1.23 Review

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

Review your results

Watch teacher-led videos

Practise questions with immediate feedback

Find all this and MORE in jacPLUS

1.23.1 Key knowledge summary

1.2 Concepts in Geography

- The acronym SPICESS helps you remember the seven Geography concepts:
  - space
  - place
  - interconnection
  - change
  - environment
  - sustainability
  - scale.

1.3 Skills used in Geography

- Many occupations are linked to the study of geography.
- Careers that will be involved in the management of environmental change include conservationists, oceanographers and agricultural scientists.
- Work experience provides an important opportunity to explore career options, to learn what you enjoy and to gain valuable understanding of different careers and work roles.
- Volunteering in the community demonstrates your willingness to learn and to contribute, as well as providing opportunities for skills development.
- There are a number of core skills for work, which you can work on developing over time.
- Future careers will evolve in response to our ever-changing world.

1.23.2 Key terms

change refers to using time to better understand a place, an environment, a spatial pattern or a geographical problem. The concept of change involves both time and space — change can take place over a period of time, or over an area.

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

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

interconnection the fact that people and things are connected to other people and things in their own and other places around the world

place an area on the Earth's surface which is identified and has meaning for people

scale the way that geographical phenomena and processes can be examined at different spatial levels. Scale can be applied from personal and local levels to regional, national or global levels.

space where things are located and distributed on the surface of the Earth

sustainability refers to maintaining the capacity of the environment to support our lives and those of other living creatures now and into the future

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-11496)

Interactivity Geographical concepts and skills crossword (int-9109)

Hey teachers! Create custom assignments for this topic

Create and assign unique tests and exams

Access quarantined tests and assessments

Track your students' results

Find all this and MORE in jacPLUS

LESSON
1.4 SkillBuilder: Interpreting a complex block diagram

LEARNING INTENTION

By the end of this lesson you should be able to interpret a complex block diagram.

1.4.1 Tell me

What is a complex block diagram?

A complex block diagram is a diagram 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:

- 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.

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.

1.4.2 Show me

How to interpret a complex block diagram

You will need:

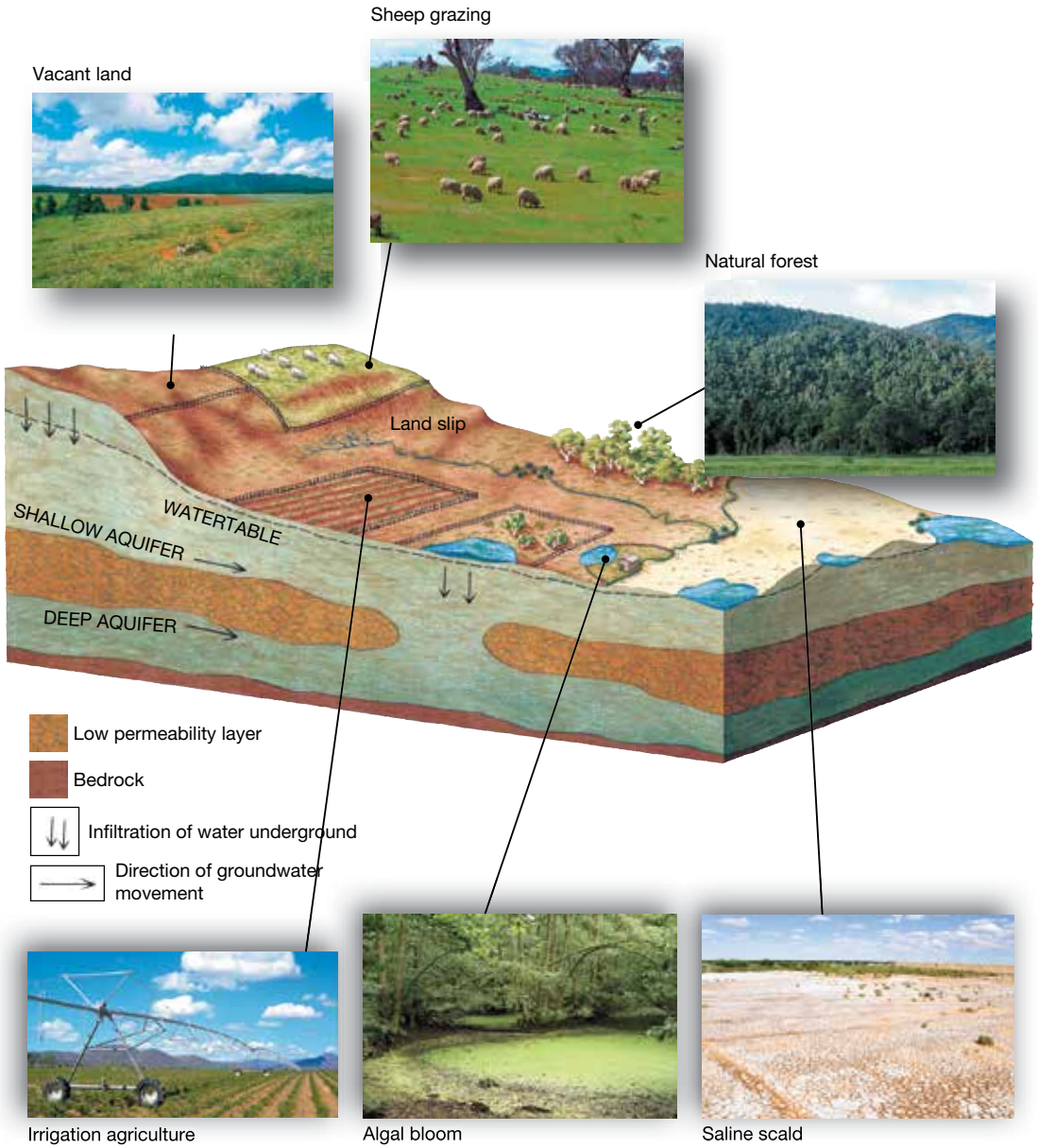
- a complex block diagram
- a geographic dictionary or internet access.

Model

The designer of the block diagram in **FIGURE 1** 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.

FIGURE 1 Saltbush Farm, land audit, 2012. Saltbush Farm is in the catchment of the Naangi River, a tributary of the Murray.



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

This 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 Model text 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'.

on Resources

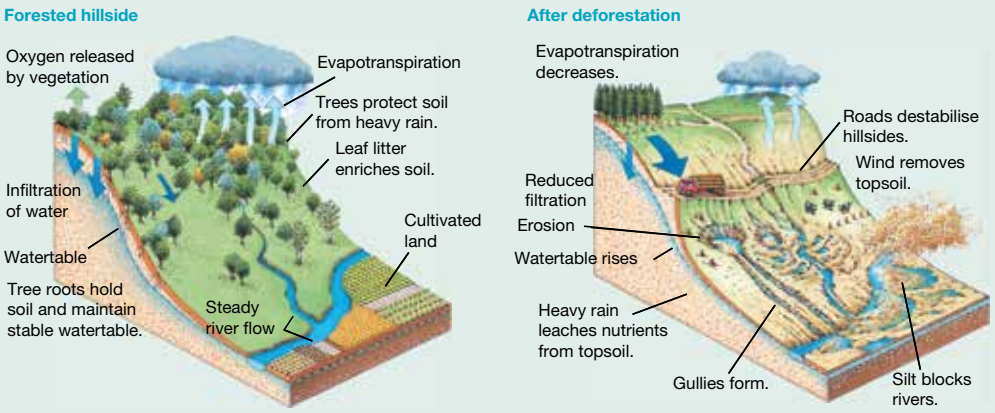
Video eLesson	Interpreting a complex block diagram (eles-1746)
Interactivity	Interpreting a complex block diagram (int-3364)

1.4.3 Let me do it

Complete the following activities to practise this skill.

1.4 ACTIVITIES

1. Using the following complex block diagrams (**FIGURE 5** from subtopic 12.2), write a short paragraph explaining how an area is ***changed*** by deforestation. Use the checklist to ensure you have covered all aspects of the task.
2. Apply your skills in interpreting a complex block diagram to answer the following questions.
   a. How is the water cycle affected by deforestation of an area?
   b. How can roads destabilise a hill slope?
   c. Why does erosion and land slippage occur?
   d. How can a dust storm pick up topsoil?
   e. Where does the silt that blocks rivers come from?



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***.

LESSON
1.5 SkillBuilder: Creating a fishbone diagram

LEARNING INTENTION

By the end of this lesson you should be able to create a fishbone diagram.

1.5.1 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 to help visualise a problem or effect, and to show 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 flows to other 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.

A good fishbone diagram:

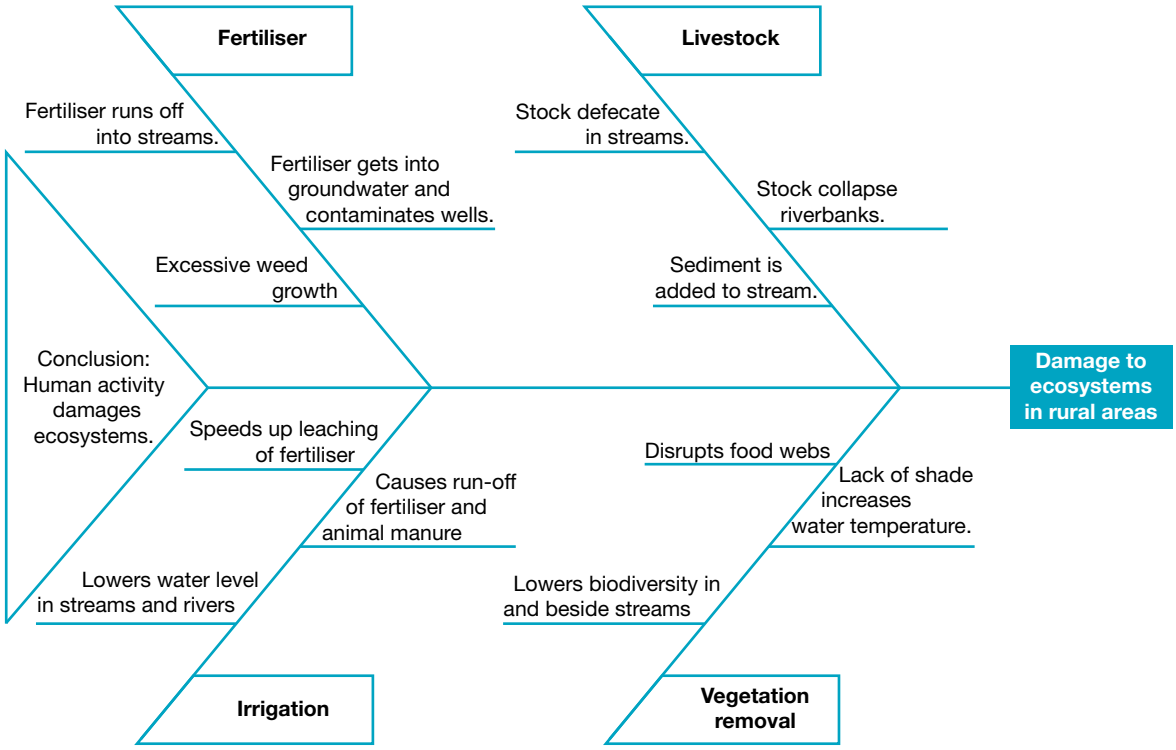
- is drawn in pencil
- has ruled lines
- identifies and labels causes and sub-causes
- identifies and labels the effect
- includes a clear title.

1.5.2 Show me

How to create a fishbone diagram

Model

FIGURE 1 Fishbone diagram that examines the causes of damage to ecosystems in rural areas



You will need:

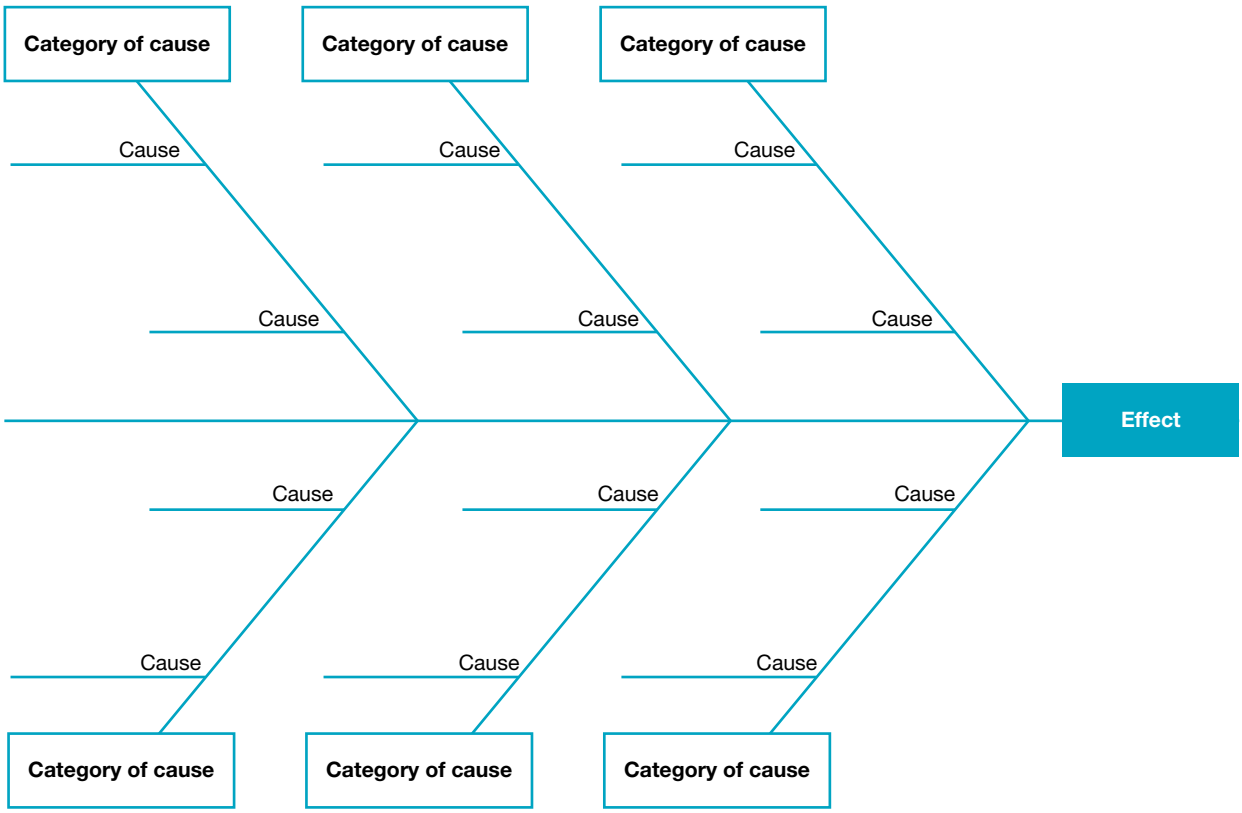
- a template of a fishbone diagram
- a piece of paper
- a ruler
- a light-grey pencil.

Procedure

Step 1

To complete a fishbone diagram, obtain a template to work on (see **FIGURE 2**). 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'.

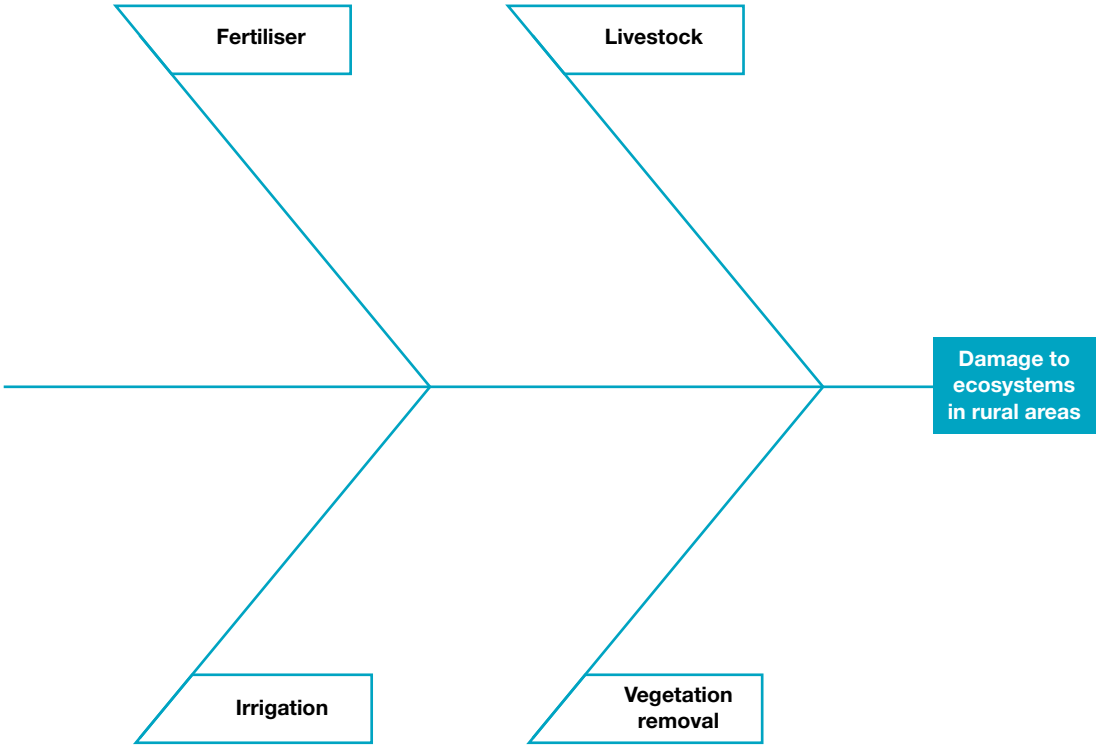
FIGURE 2 Fishbone diagram template



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.

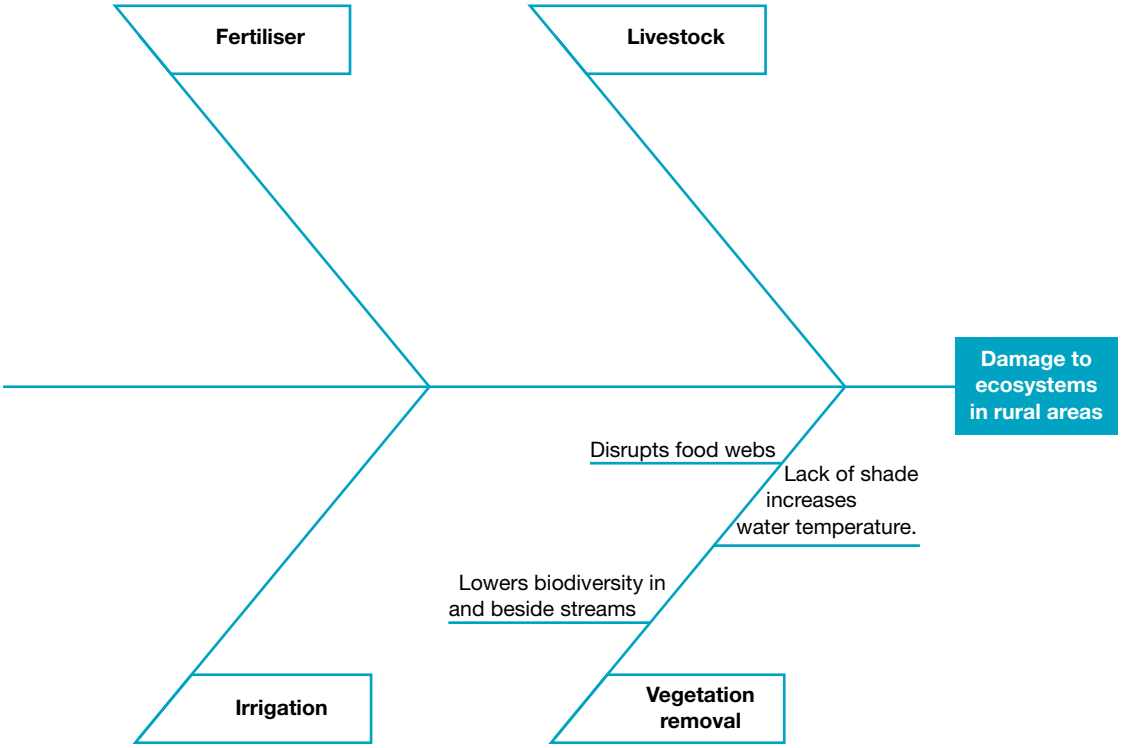
FIGURE 3 A fishbone diagram showing categories of causes



Step 3

For each category of causes, now brainstorm a number of effects 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'.

FIGURE 4 A fishbone diagram and some effects



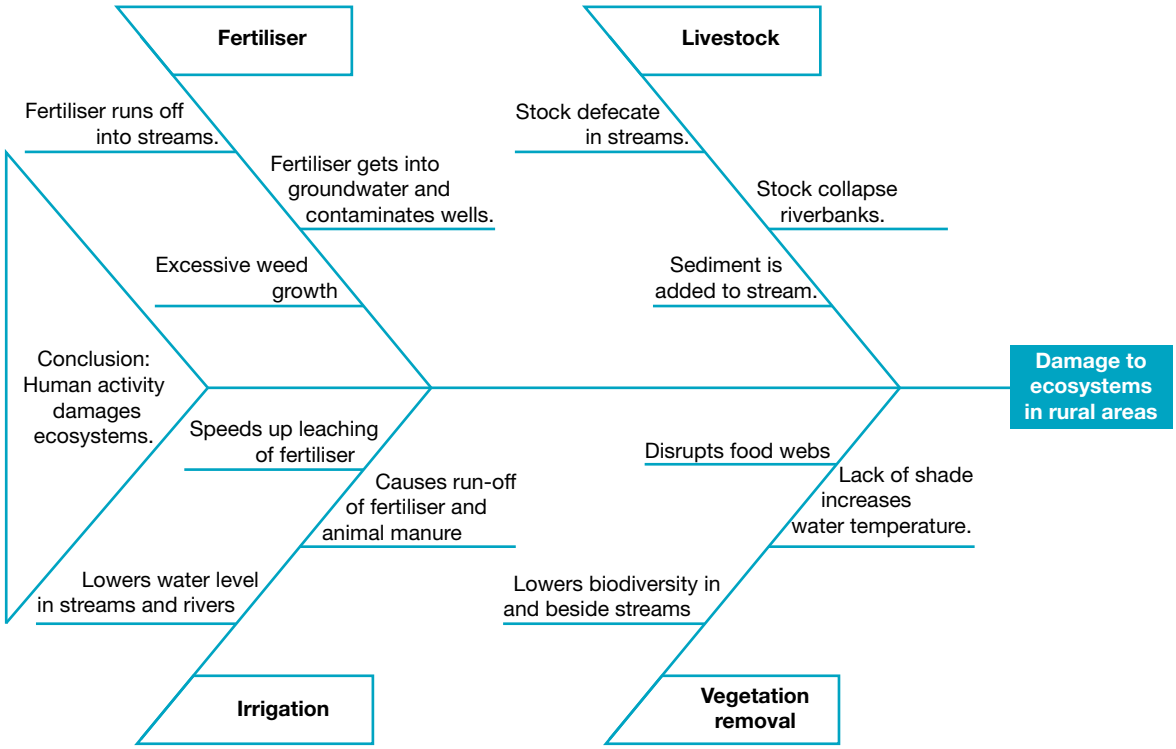
Step 4

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. How do you assess the causes of damage to rural ecosystems, given the four categories you considered?

FIGURE 5 Conclusion shown on fishbone diagram



on Resources

- **Video eLesson** Creating a fishbone diagram (eles-1748)
- **Interactivity** Creating a fishbone diagram (int-3366)

1.5.3 Let me do it

Complete the following activities to practise this skill.

1.5 ACTIVITIES

1. Referring to subtopics 15.2, 15.3 and 15.4, complete a fishbone diagram on the causes of damage to inland water resources. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions.
   a. What were the four main categories you used? Were your categories the same as those used by others in the class?
   b. Could you think of more causes than the lines provided?
   c. Did you share your ideas about possible causes with other class members to build up your responses?
   d. What did you conclude about the damage to inland water resources?
   e. 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.

LESSON
1.6 SkillBuilder: Reading topographic maps at an advanced level

LEARNING INTENTION

By the end of this lesson you should be able to read a topographic map at an advanced level.

1.6.1 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. Using advanced skills in map reading, you can make inferences 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.

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.

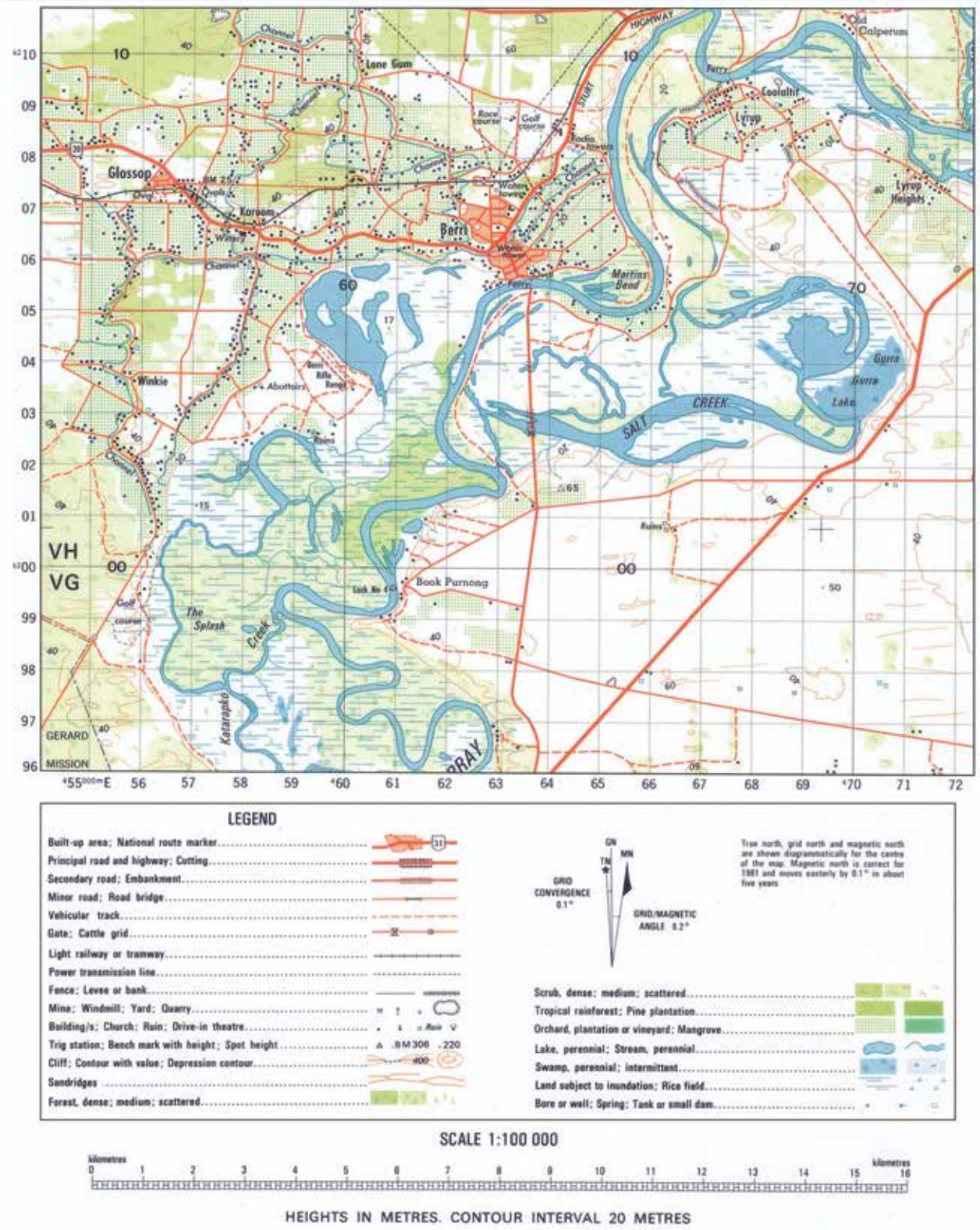
1.6.2 Show me

How to read a topographic map at an advanced level

Model

The local relief between Berri township and the village of Lone Gum (602098) is 20 metres. 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.

FIGURE 1 Topographic map of Berri, South Australia



Source: Map supplied by MAPLAND, Environmental and Geographic Information, Department for Environment and Heritage, South Australia.

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.

$$\frac{\text{Vertical interval rise}}{\text{Horizontal distance run}}$$
$$= \frac{20}{2000}$$
$$= \frac{1}{500}$$
$$= \text{The land rises one metre in height for every 100 metres in distance.}$$

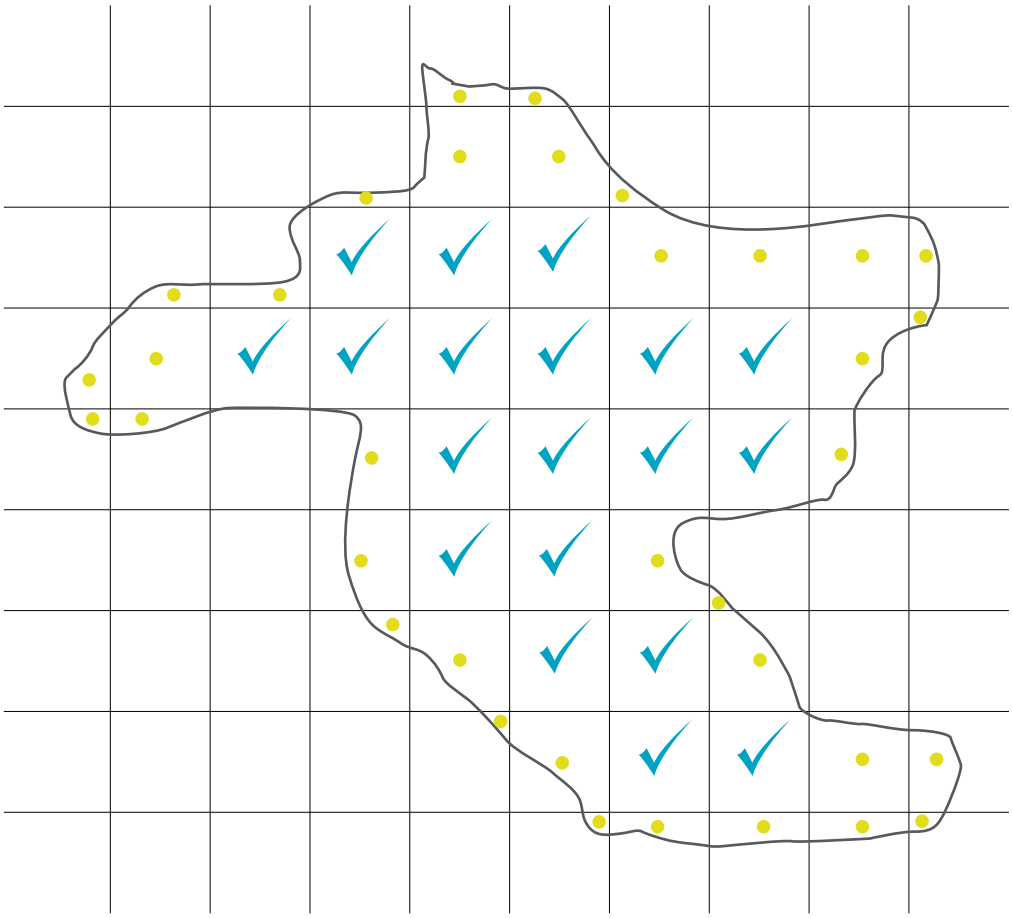
Step 6

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 square kilometre. If the scale is 1:500 000, 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.

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 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.

on Resources

Digital document	Topographic map of Berri, South Australia (doc-11570) Topographic map of Wentworth, New South Wales (doc-11569)
Video eLesson	Reading topographic maps at an advanced level (eles-1749)
Interactivity	Reading topographic maps at an advanced level (int-3367)
Google Earth	Berri

1.6.3 Let me do it

Complete the following activities to practise this skill.

1.6 ACTIVITIES

1. Use the topographic map for the region west of Wentworth provided in the Resources panel to complete the following calculations. Use the checklist to ensure you cover all aspects of the task.
   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.
2. Apply your skills to answer the following questions.
3. How would you describe the topography of the mapped area? Refer to local relief.
4. Using your understanding of gradient, explain why it is necessary to control Frenchmans Creek with levees.
5. Calculate the area that is prone to inundation and shown as wetland.
6. What time of year would be the best time to drive on the road network of this region? Explain your answer.
7. 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.

LESSON
1.7 SkillBuilder: Comparing an aerial photograph and a topographic map

LEARNING INTENTION

By the end of this lesson you should be able to compare an aerial photograph and a topographic map.

1.7.1 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.

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.

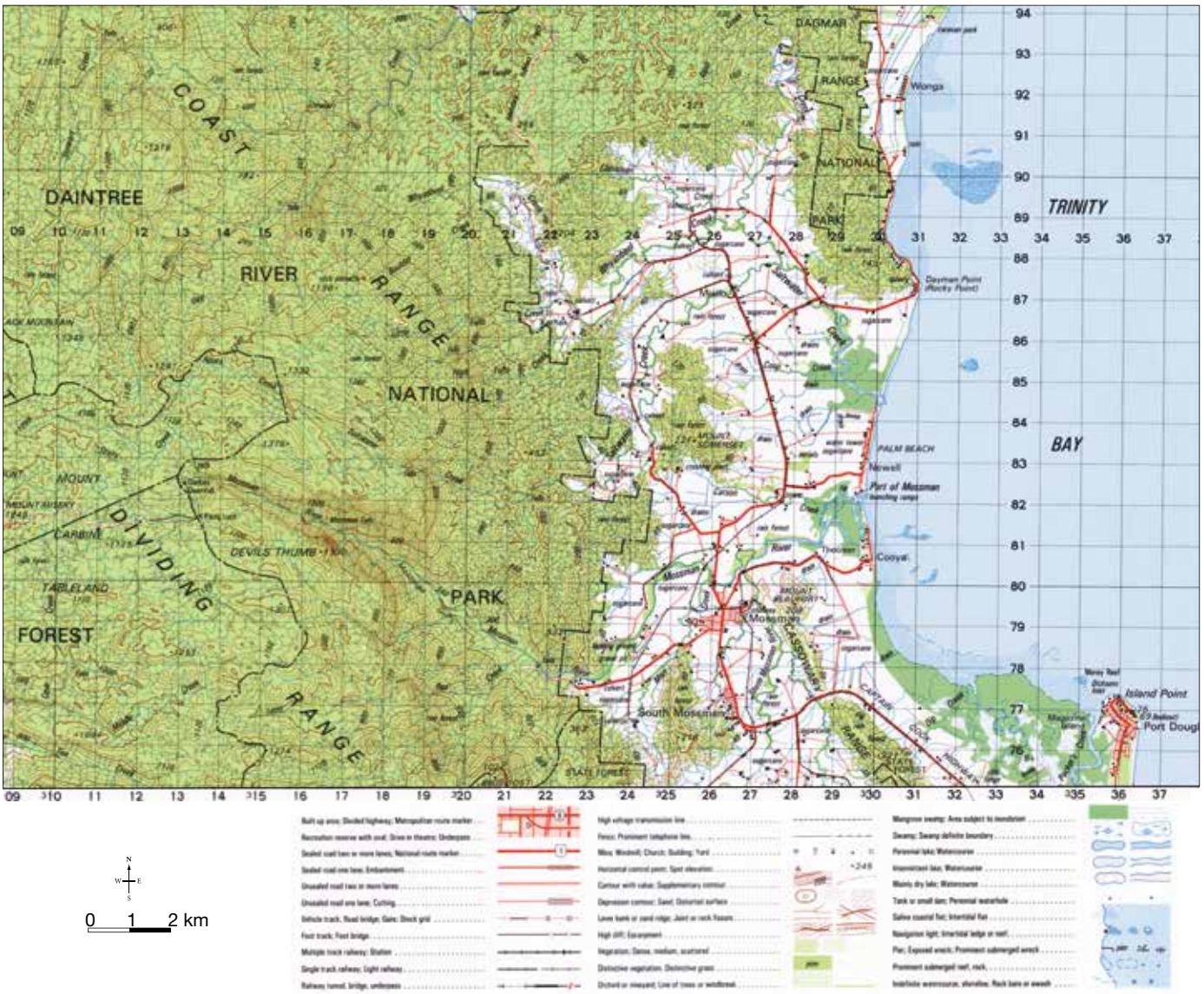
1.7.2 Show me

Model

Use Google Earth or Google Maps to locate an aerial photograph view of the same area shown in the **FIGURE 1** topographic map. You can download a higher resolution copy of this map from the Resources tab (doc-11572).

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 and 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.

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.

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 30 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'.

on Resources

Digital documents	Topographic map of Mossman and the Daintree River National Park, Queensland (doc-11572) Topographic map extract of Merimbula, New South Wales (doc-11571)
Video eLesson	Comparing an aerial photograph and a topographic map (eles-1751)
Interactivity	Comparing an aerial photograph and a topographic map (int-3369)
Google Earth	Mossman

1.7.3 Let me do it

Complete the following activities to practise this skill.

1.7 ACTIVITIES

1. Using the topographic map and the aerial photograph of Merimbula in subtopic 13.4, write a paragraph comparing the information gained about Merimbula from both data sources. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions.
   a. List three features within Merimbula that can be identified on the map but not on the aerial photograph.
   b. What information does the aerial photograph give you about boating in the area that is not available on the topographic map?
   c. 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?
   d. What information does the map provide about the airport that cannot be gained from the aerial photograph?
   e. 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***.

LESSON
1.8 SkillBuilder: Using geographic information systems (GIS)

LEARNING INTENTION

By the end of this lesson you should be able to use a geographic information systems.

1.8.1 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
- when you want to best locate a business; for example, retailers and fast-food chains use GIS to determine the best location for a new store
- you want to predict risk situations; for example, emergency services can use it to study the spread of bushfires and flood waters
- you need to map global trends, such as the movement of refugees between countries.

Using GIS involves:

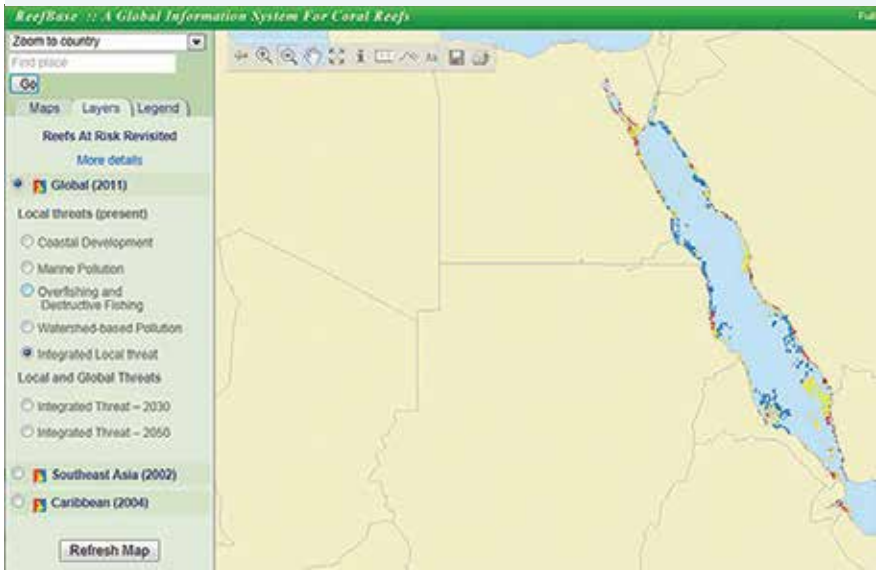
- using GIS-mapped geographic data
- interpreting map legends
- interpreting map layers
- looking for interconnections between map layers
- clearly representing and communicating data.

1.8.2 Show me

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.

FIGURE 1 Studying marine reefs using GIS on the Red Sea



You will need:

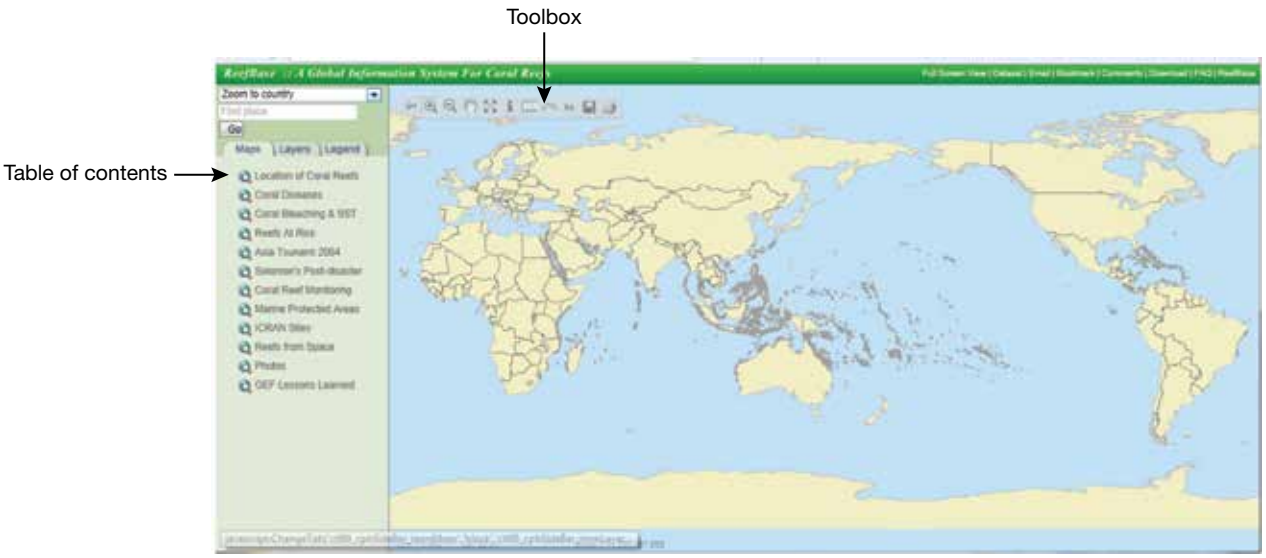
- a computer or tablet connected to the internet
- a website developed with GIS techniques
- an atlas.

Procedure

You need to identify a GIS website. Use the **ReefBase GIS** weblink in the Resources panel, 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



Step 1

As with any map you explore, you need to begin by checking the information provided to assist you to interpret 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

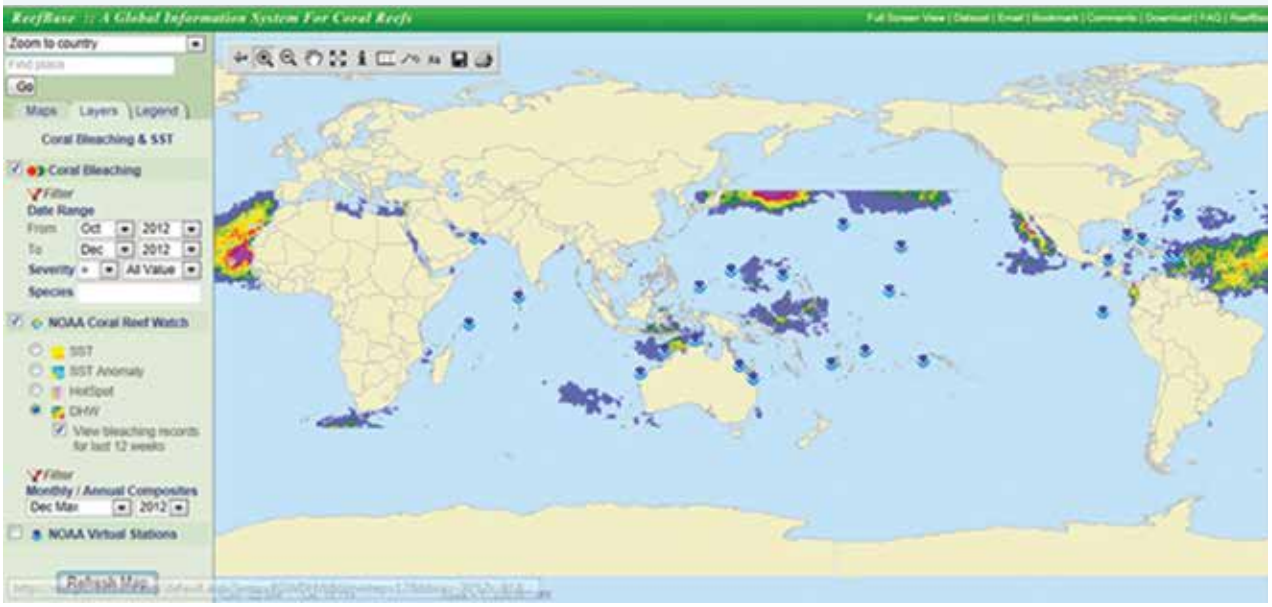
In the same table of contents, once you open a map, the program lists the different layers available for that map. Choose a map and explore some of these layers. Select one of the circles or boxes to apply an aspect of the layer, and then select Refresh Map at the bottom of the layers panel, so that 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

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.

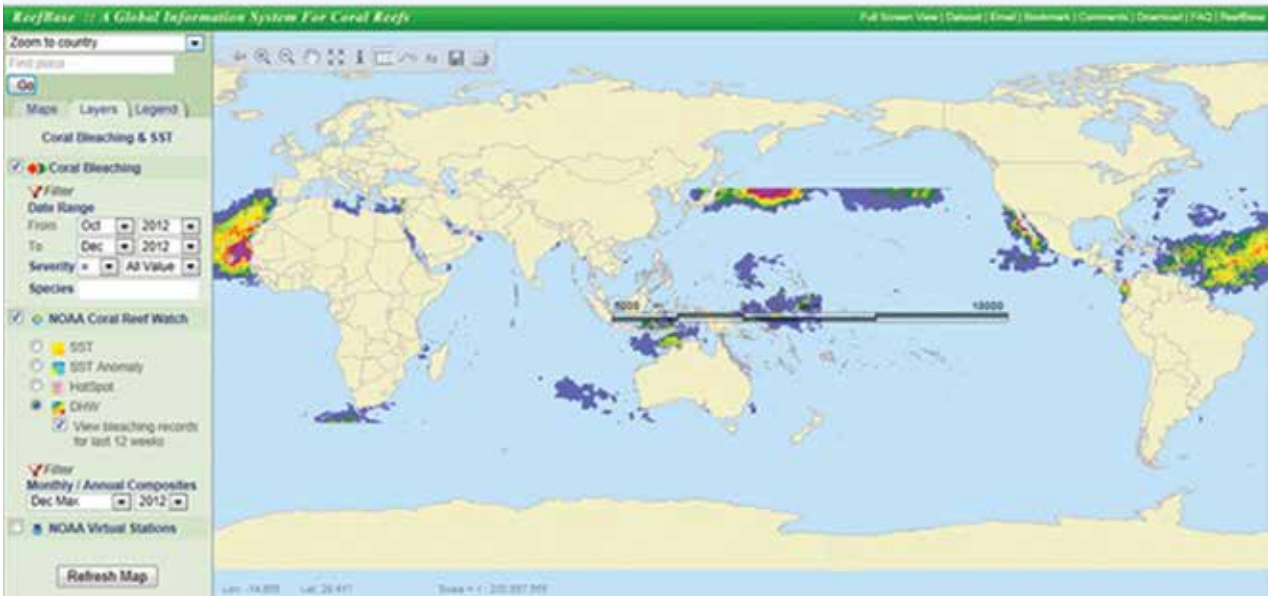
FIGURE 4 Coral bleaching, October to December 2012



Step 3

Along the top of the map, there is also a tool bar to explore (see **FIGURE 5**). Hovering over each symbol, will give you an explanation of its use. 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.

FIGURE 5 Applying the distance tool on the coral bleaching map



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 (see **FIGURE 6**). 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

Step 5

You can now develop a description of the natural and human impacts on the Red Sea coral reefs. Then you can discuss the management processes that are in place to ensure the sustainability of the environment. 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 Model paragraph for an example.

on Resources

Video eLesson	Using geographic information systems (GIS) (eles-1752)
Interactivity	Using geographic information systems (GIS) (int-3370)
Weblink	ReefBase GIS

1.8.3 Let me do it

Complete the following activities to practise this skill.

1.8 ACTIVITIES

1. 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***. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions. Each question requires you to change maps, layers and legend.
   a. Name three diseases that have affected the Great Barrier Reef.
   b. Which part of the Australian coastline has experienced the worst coral bleaching since 2000?
   c. 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.
   d. With the aid of an atlas, name the coastal places where the reef is at greatest risk.
   e. What types of management programs are used on the Great Barrier Reef?
   f. 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.

LESSON
1.9 SkillBuilder: Constructing and interpreting a scattergraph

LEARNING INTENTION

By the end of this lesson you should be able to construct and interpret a scattergraph.

1.9.1 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.

How 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.

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:

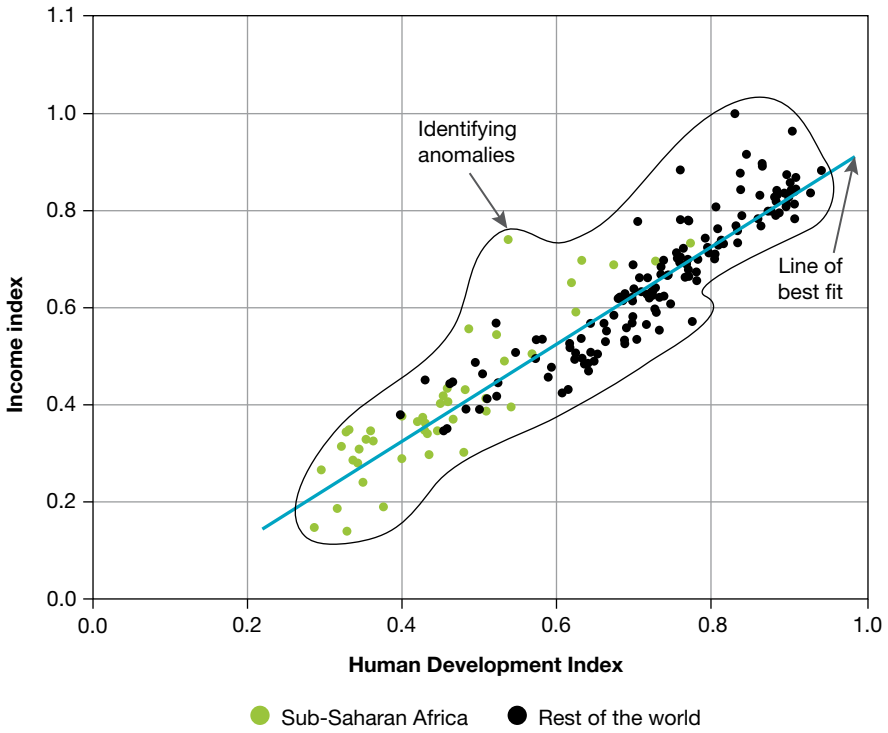
- identifies and communicates key features such as the levels of each feature on each axis and the relationship to the line of best fit.

1.9.2 Show me

Model

Interpretation of this scattergraph shows a positive correlation between income and the Human Development Index (HDI). 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 HDI. Most of these countries fall at less than 0.4 on both axes — the HDI 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 HDI for sub-Saharan Africa and the rest of the world, 2011



Source: © United Nations Development Programme.

You will need:

- two sets of data
- a piece of graph paper
- a light-grey pencil
- a ruler.

Procedure

To complete a scattergraph, you must have two sets of information about which you want to test the interconnection. In the following example, we use the data on food supply and road network density from the 2012 Human Development 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, kilocalories 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	2.80
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
Sao Tomé and Príncipe	3407.8	2.3
Senegal	1168.4	1.3
Seychelles	–	5.9

(continued)

TABLE 1 Food supply and road density in Africa *(continued)*

Countries	Food supply, kilocalories per capita per day, 2005–2007	Road density network, metres per capital, 1999–2008
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

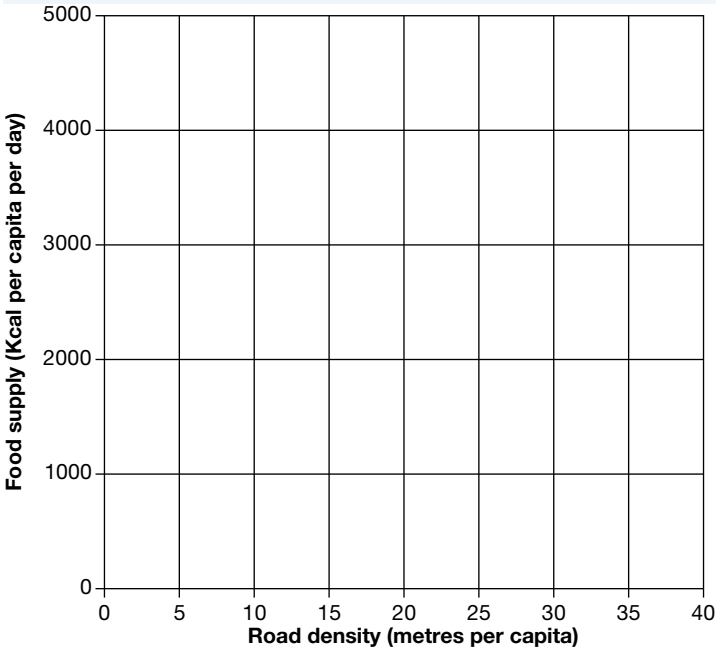
Step 2

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 (see **FIGURE 2**).

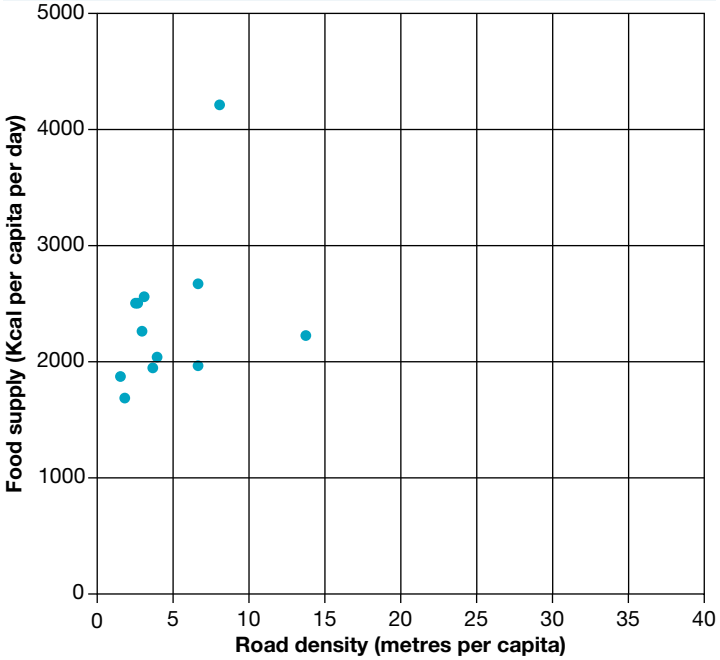
FIGURE 2 The graph base



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.

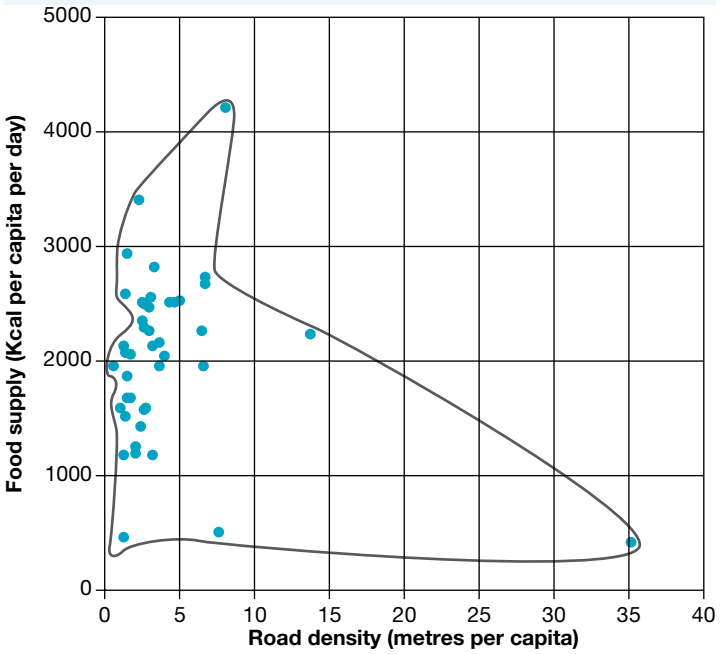
FIGURE 3 Starting to plot the data



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.

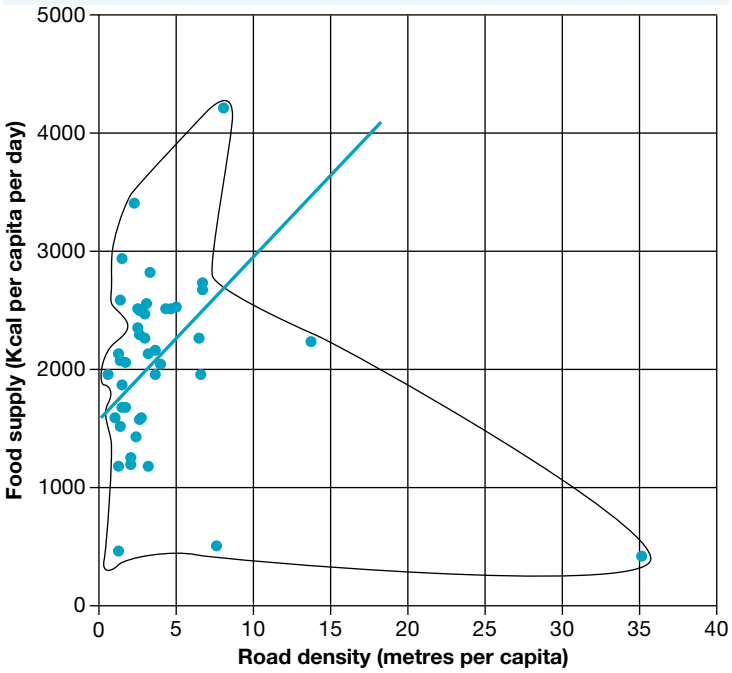
FIGURE 4 Identifying the trend



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.

FIGURE 5 Drawing the line of best fit



Step 7

Using the models in **FIGURE 6**, 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.

Step 8

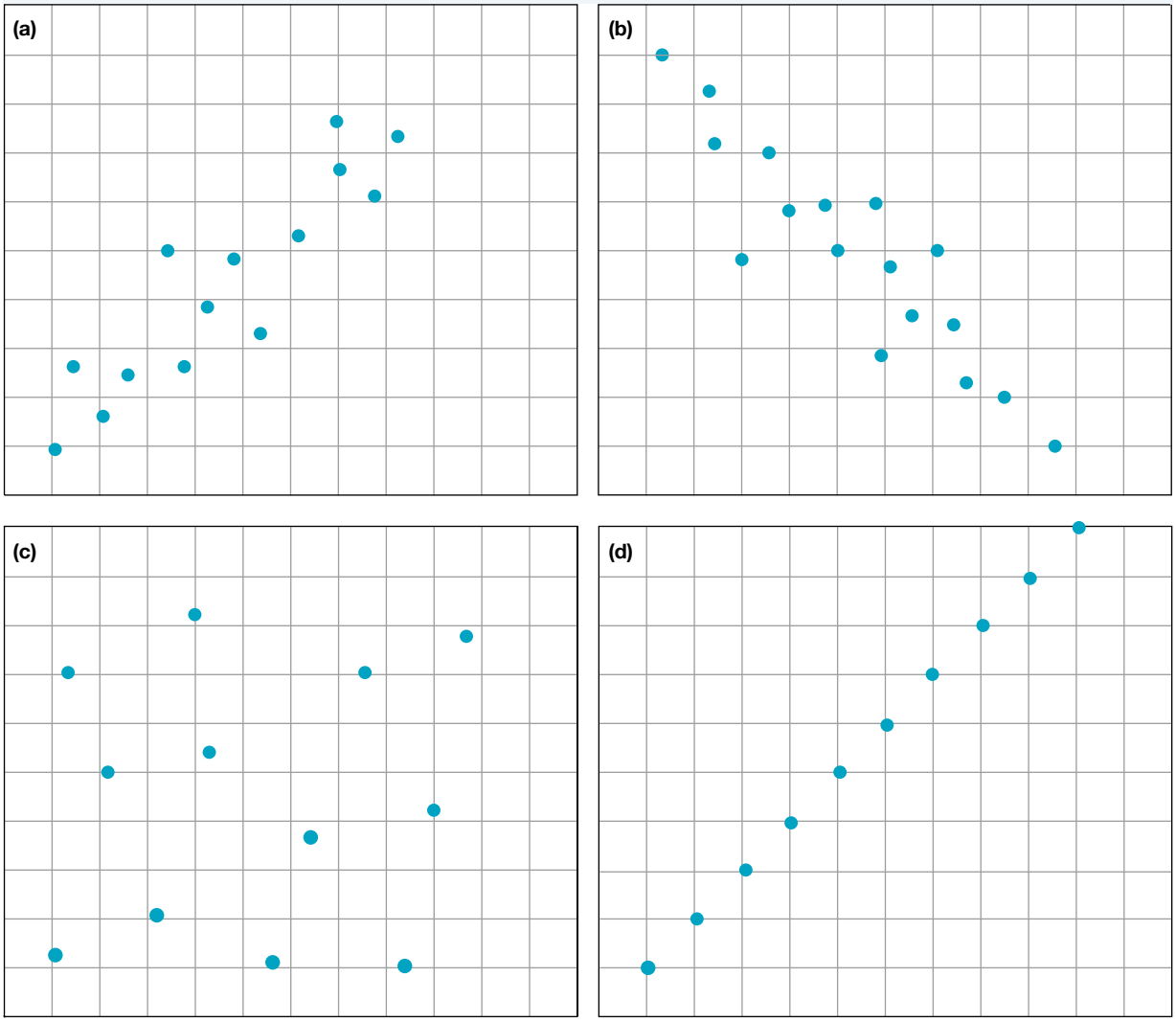
Give your graph a title.

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.

FIGURE 6 Correlation patterns: (a) positive correlation, (b) negative correlation, (c) no correlation, (d) perfect correlation



on Resources

Video eLesson Constructing and interpreting a scattergraph (eles-1756)
Interactivity Constructing and interpreting a scattergraph (int-3374)

1.9.3 Let me do it

Complete the following activities to practise this skill.

1.9 ACTIVITIES

1. Using the data in **TABLE 2**, 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. Use the checklist to ensure you have covered all aspects of the task.

TABLE 2 Life expectancy and years of schooling, selected countries, 2019

Country	Life expectancy (years), HDI Report 2019	Years of schooling, HDI Report 2019
Australia	83.3	12.7
China	76.7	7.9
Democratic Republic of the Congo	60.4	6.8
Egypt	71.8	7.3
India	69.4	6.5
Japan	84.5	12.8
Kenya	66.3	6.6
Norway	82.3	12.6
Syria	71.8	5.1
United States	78.9	13.4

2. Apply your skills to answer the following questions.
- **a.** Is there a correlation between life expectancy and years of schooling?
- **b.** What type of correlation can you identify?
- **c.** In your scattergraph, are there any anomalies?
- **d.** What type of relationship between the two factors would result in an anomaly?
- **e.** From this correlation pattern, where would you expect the following countries to fit on the graph?
  - **i.** United Kingdom
  - **ii.** Indonesia
  - **iii.** New Zealand
  - **iv.** 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.

LESSON
1.10 SkillBuilder: Interpreting a cartogram

LEARNING INTENTION

By the end of this lesson you should be able to interpret a cartogram.

1.10.1 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.

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.

Cartograms are useful for:

- comparing statistical country data quickly and easily
- representing the proportion of a feature in a country
- identifying regional or global differences.

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.

1.10.2 Show me

You will need:

- a cartogram
- an atlas.

Procedure

To interpret a cartogram, you need a computer-drawn cartogram such as **FIGURE 1**.

Step 1

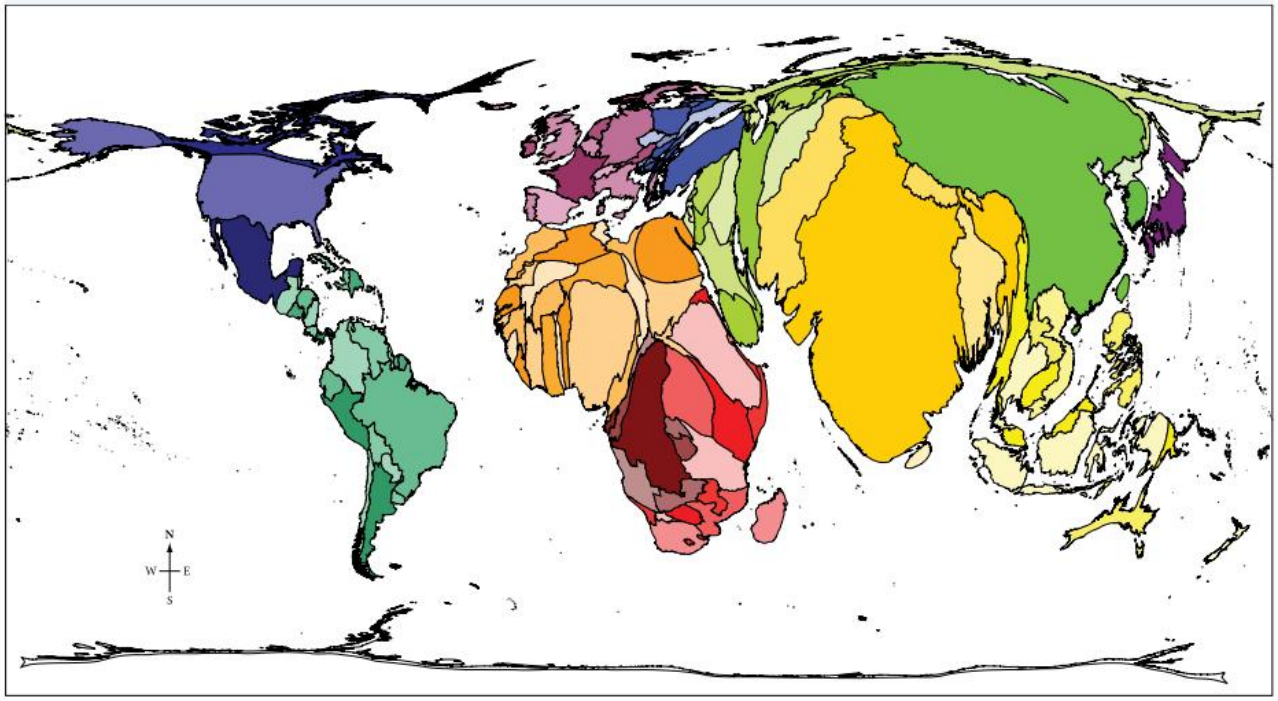
Read the title; check that the meaning is clear. In **FIGURE 1**, the world's population in 2050 is mapped.

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.

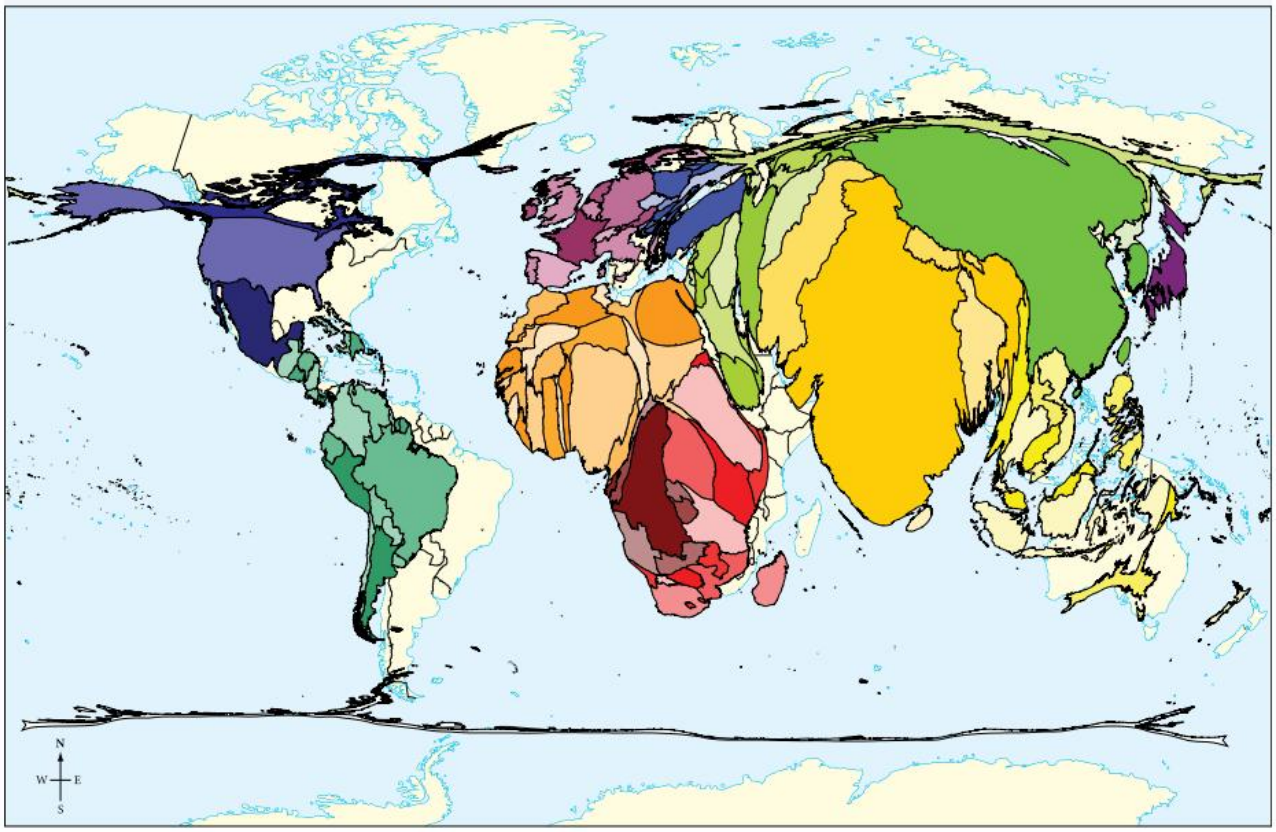
FIGURE 2 shows an ordinary map of the world with a cartogram superimposed on it.

FIGURE 1 Cartogram showing estimated world population, 2050



Source: Spatial Vision.

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 in the 'Model' paragraph.

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.

on Resources

Video eLesson Interpreting a cartogram (eles-1757)

Interactivity Interpreting a cartogram (int-3375)

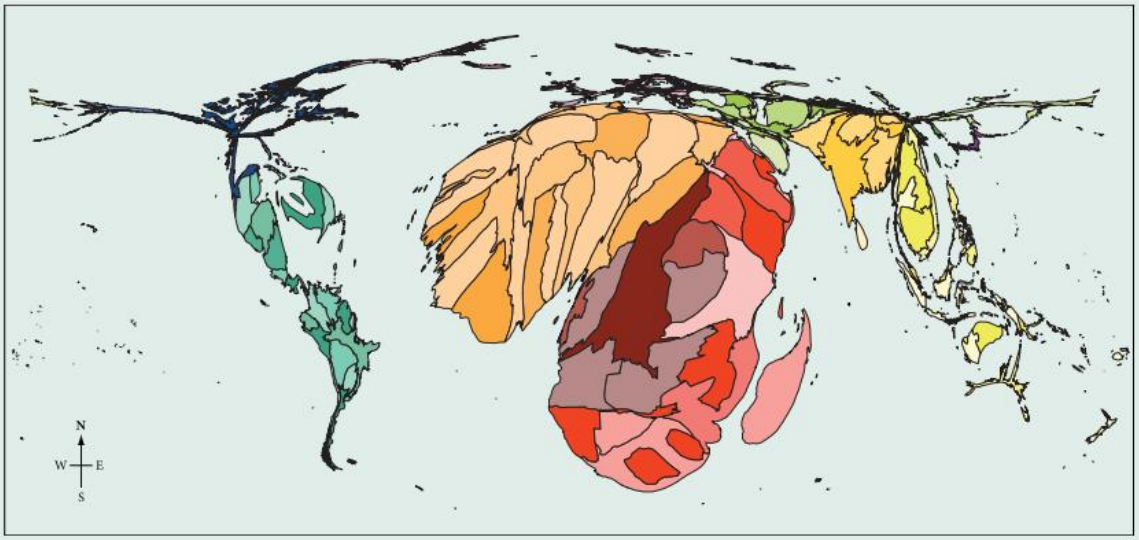
1.10.3 Let me do it

Complete the following activities to practise this skill.

1.10 ACTIVITIES

1. Study the **FIGURE 3** cartogram, which shows the proportion of the world's population living on less than US$1.25 per day. Write a description of the countries in which people live on less than a $1.25 a day. Use the checklist to ensure you have covered all aspects of the task.

FIGURE 3 The proportion of the world's population living on less than US$1.25 per day



Source: The World Bank: Poverty headcount ratio at $1.25 a day PPP % of population: World Development Indicators. Map by Spatial Vision.

2. Referring to **FIGURE 3**, apply your skills to answer the following questions.
   a. Which continent is the enlarged shape at the centre of the map?
   b. How has the shape of Australia been distorted? What does this tell us about the number of people living on less than US$1.25 a day in Australia?
   c. Which other continents have been reduced in size by the cartogram?
   d. Which continents have the most countries that have been enlarged by the cartogram? What does this say about the poverty levels in those countries?
   e. 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.

LESSON
1.11 SkillBuilder: Using multiple data formats

LEARNING INTENTION

By the end of this lesson you should be able to use multiple data formats

1.11.1 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, slide 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.

A good interpretation of multiple data formats:

- makes concise and accurate analysis of each data format
- includes all the information provided.

1.11.2 Show me

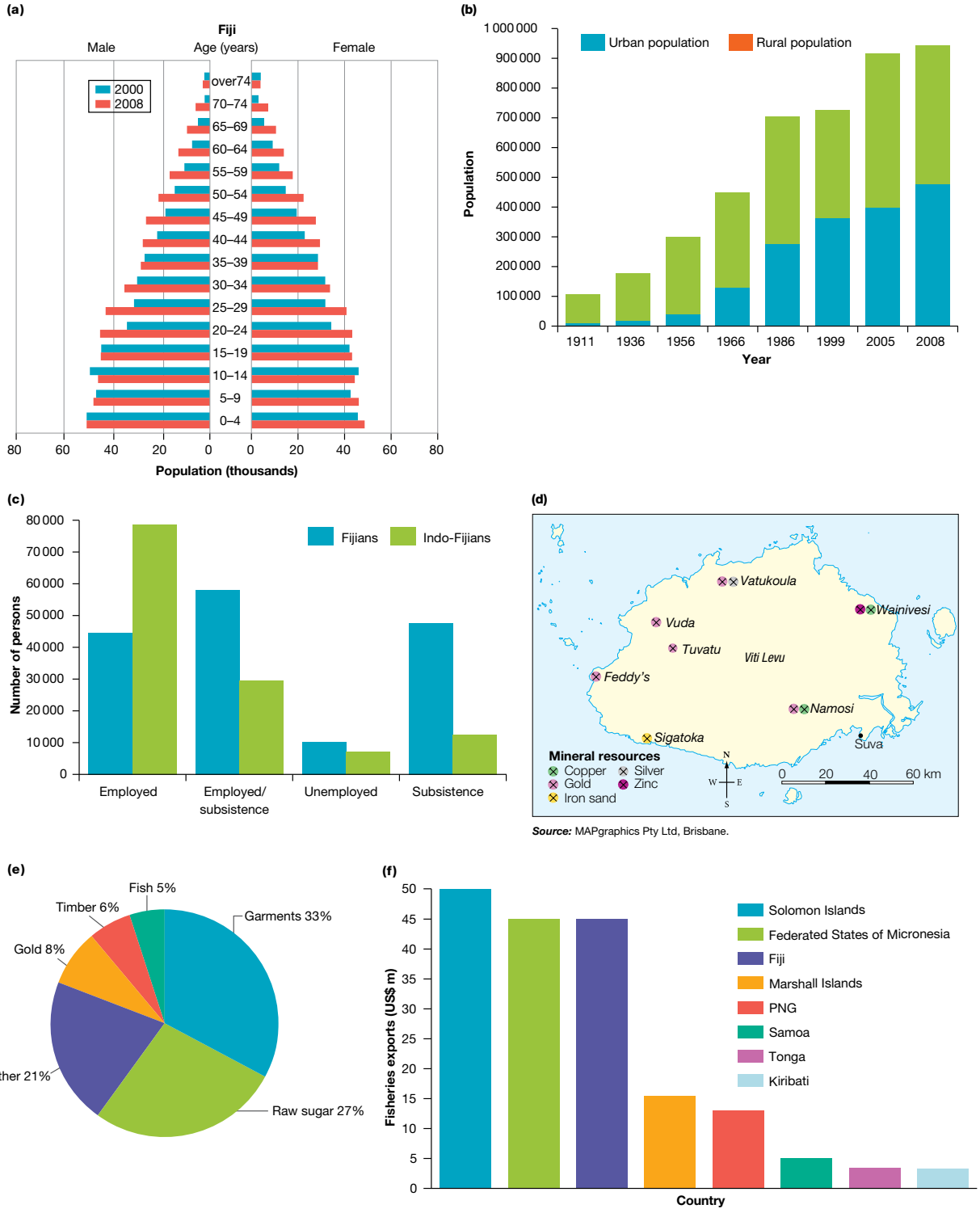
You will need:

- a range of data.

Model

In Fiji, a group of Pacific islands, population growth and subsistence living go hand in hand. The population pyramid, **FIGURE 1a**, 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 1b**), whereas in the past rural living had dominated. Native Fijians are mostly involved in subsistence farming or fishing, while Indo-Fijians are employees (**FIGURE 1c**). The pie graph, **FIGURE 1e**, 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 1f** 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



Source: MAPgraphics Pty Ltd, Brisbane.

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

Procedure

Step 1

Study **FIGURE 1** and **TABLE 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. 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** and **TABLE 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 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 model paragraph 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 and pie graph on mining 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'.

on Resources

Video eLesson Using multiple data formats (eles-1761)
Interactivity Using multiple data formats (int-3379)

1.11.3 Let me do it

Complete the following activities to practise this skill.

1.11 ACTIVITIES

1. Discuss the wellbeing of women in India. Use the maps, images and graphs from subtopic 8.4 (**FIGURES 8** and **9**) and subtopic 8.5 (**FIGURES 7** and **8**). Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions.
   a. How does maternal mortality in India compare with other parts of the world?
   b. In which parts of India would a woman prefer not to be when giving birth?
   c. In which parts of India are there more females than males?
   d. Using **FIGURE 9** in subtopic 8.4, describe how reproductive health indicators have ***changed*** since 1990.

Checklist

I have:

- made concise and accurate interpretations of each data format
- included all the information provided.

LESSON
1.12 SkillBuilder: Constructing and describing complex choropleth maps

LEARNING INTENTION

By the end of this lesson you should be able to construct and describe complex choropleth maps.

1.12.1 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 most dense 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.

How 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.

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.

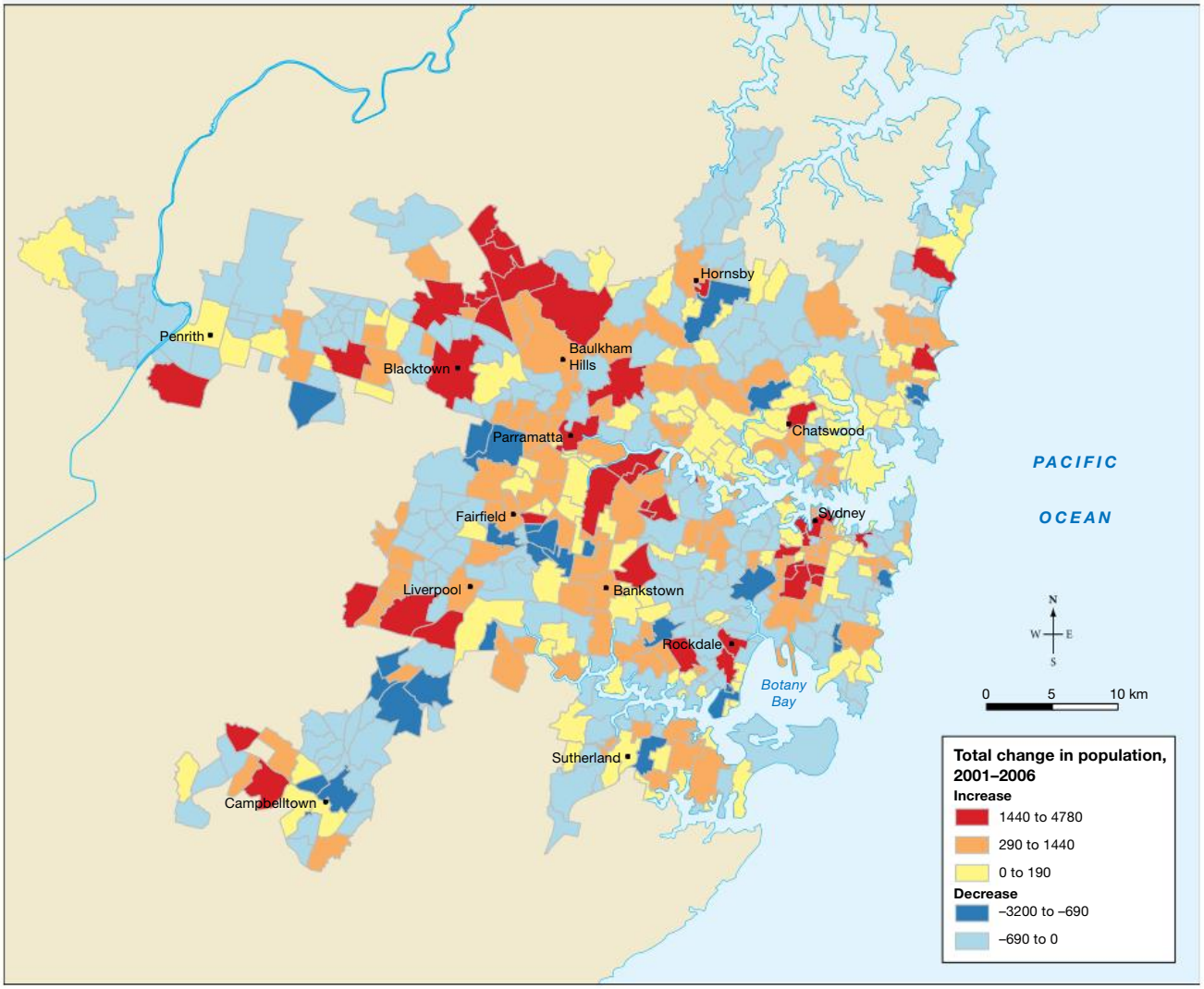
1.12.2 Show me

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.

Model

FIGURE 1 Population change in Sydney, 2001–06



Source: Spatial Vision.

The change in Sydney's population between 2001 and 2006 was very uneven. The areas of greatest increase (1440 to 4780) are scattered across the city, with most found on the urban fringes.

Most areas that 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.

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 are 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? That is, is there a colour among a mass of other colours 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.

on Resources

Digital document	Blackline master: Map of Africa (doc-12012)
Video eLesson	Constructing and describing complex choropleth maps (eles-1732)
Interactivity	Constructing and describing complex choropleth maps (int-3350)

1.12.3 Let me do it

Complete the following activities to practise this skill.

1.12 ACTIVITIES

1. Use the data from **TABLE 1** and a base map of Africa (use the **Blackline master: Map of Africa** digital document in the Resources panel) to construct a choropleth map, then describe what is shown on your map. Use the checklist to ensure you cover all aspects of the task.

TABLE 1 Official development assistance to agriculture in sub-Saharan Africa, 2010

Country	US$ million	Country	US$ million
Angola	27	Madagascar	19
Benin	21	Malawi	79
Botswana	1	Mali	223
Burkina Faso	71	Mauritania	11
Burundi	96	Mauritius	0
Cameroon	62	Mozambique	72
Cape Verde	3	Namibia	14
Central African Republic	3	Niger	43
Chad	9	Nigeria	69
Comoros	2	Rwanda	68
Congo	1	Sao Tome and Principe	3
Cote d'Ivoire	93	Senegal	256
Democratic Republic of Congo	100	Seychelles	1
Eritrea	13	Sierra Leone	75
Ethiopia	222	Somalia	1
Gabon	28	South Africa	20
Gambia	15	Sudan	145
Ghana	126	Swaziland	6
Guinea	8	Togo	36
Guinea-Bissau	10	Uganda	198
Kenya	323	United Republic of Tanzania	132
Lesotho	0	Zambia	36
Liberia	36	Zimbabwe	81

Source: Food and Agriculture Organization of the United Nations, 2012, FAO, *The State of Food and Agriculture 2012*, www.fao.org/docrep/017/i3028e/i3028e.pdf.

2. Based on what you have learned in this lesson, apply your skills to answer the following questions.
   a. Which regions of sub-Saharan Africa receive the most agricultural assistance?
   b. Which regions of sub-Saharan Africa receive the least agricultural assistance?
   c. Which countries within southern Africa (south of 10°S) received quite different agricultural aid from that of their neighbours?
   d. 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?
   e. Will aid make a difference to the food production 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.

LESSON
1.13 SkillBuilder: Evaluating alternative responses

LEARNING INTENTION

By the end of this lesson you should be able to evaluate alternative responses.

1.13.1 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.

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.

Consider the question 'Should tourist numbers on Fraser Island be limited?' 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.

1.13.2 Show me

Model

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. In the past, Fraser Island has not always been well managed but I believe restricting tourism numbers will allow this special environment to be sustained into the future.

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 islan'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.

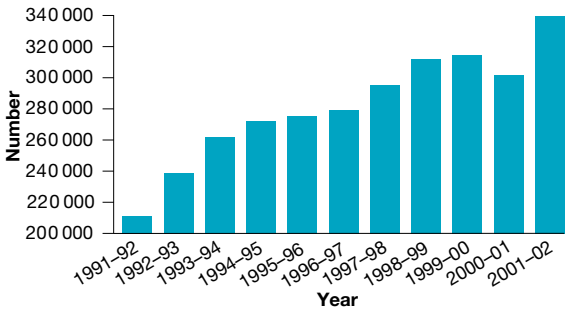
Managing four-wheel drive vehicles

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 dun es 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 swinning 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.

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** about 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 ecotourism, 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 to determine 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 the responses in **FIGURE 1** are based on. This is a considered opinion based on a range of alternative responses to the issue.

On Resources

Video eLesson	Evaluating alternative responses (eles-1744)
Interactivity	Evaluating alternative responses (int-3362)

1.13.3 Let me do it

Complete the following activity to practise this skill.

1.13 ACTIVITY

Our ecological footprint is one means of measuring human demand for ecological services. Using the information in **FIGURE 4** in subtopic 11.2 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).

Consider the following questions, and use the checklist to ensure you have covered all aspects of the task.

a. 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.
b. Which alternative response has the most advantages? Which has the fewest advantages?
c. In which response do the advantages outweigh the disadvantages?
d. What perspectives dominate a consideration of the ecological footprint?
e. 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.

LESSON
1.14 SkillBuilder: Drawing a futures wheel

LEARNING INTENTION

By the end of this lesson you should be able to draw a futures wheel.

1.14.1 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.

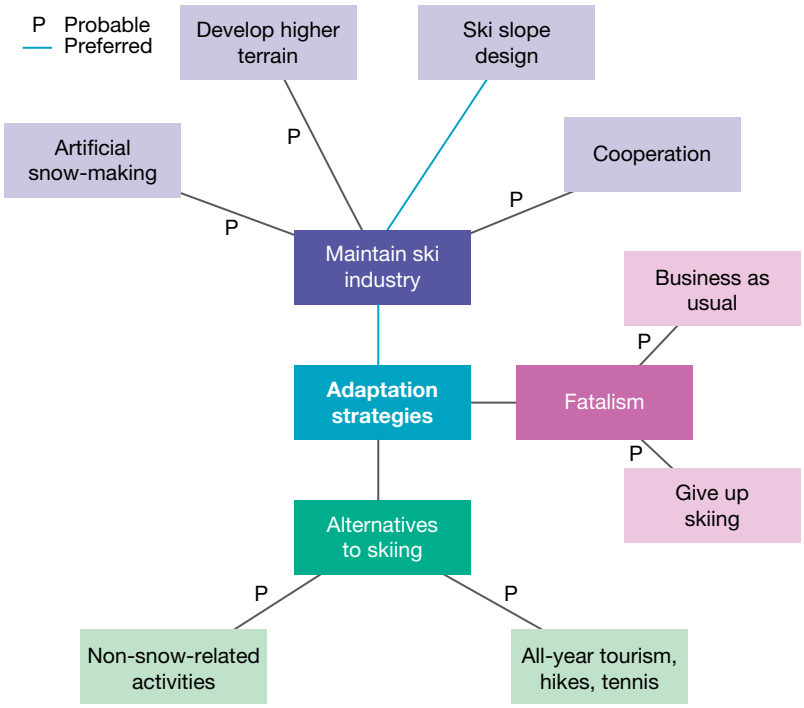
A good futures wheel has:

- 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.

1.14.2 Show me

Model

FIGURE 1 Possible responses by the ski and alpine resort industry to climate change



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.

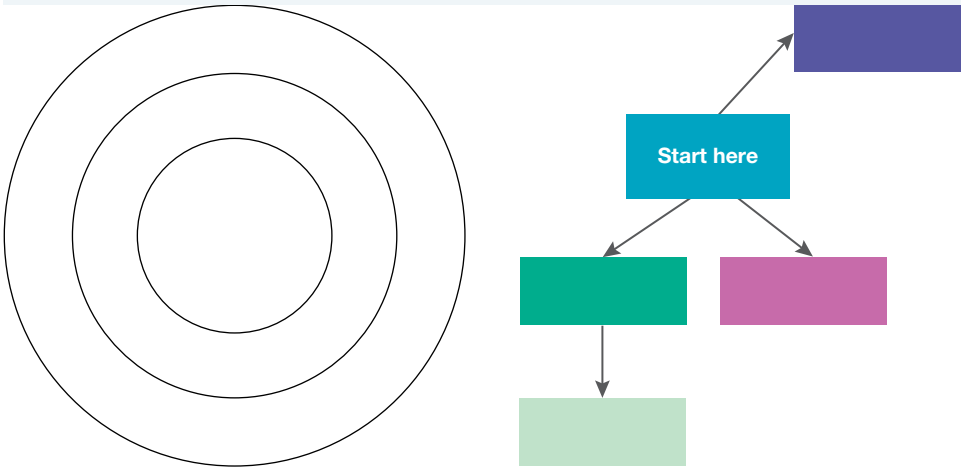
Procedure

To complete a futures wheel, first brainstorm a wide range of ideas in groups or while participating in a class discussion.

Step 1

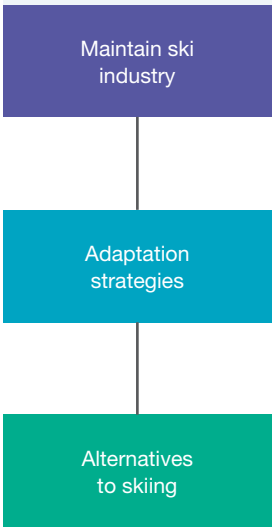
Draw a number of concentric rings — four is a good starting point. Make sure the inner circle is big enough to write in.

FIGURE 2 Examples of futures wheels



Step 2

FIGURE 3 Starting the futures wheel



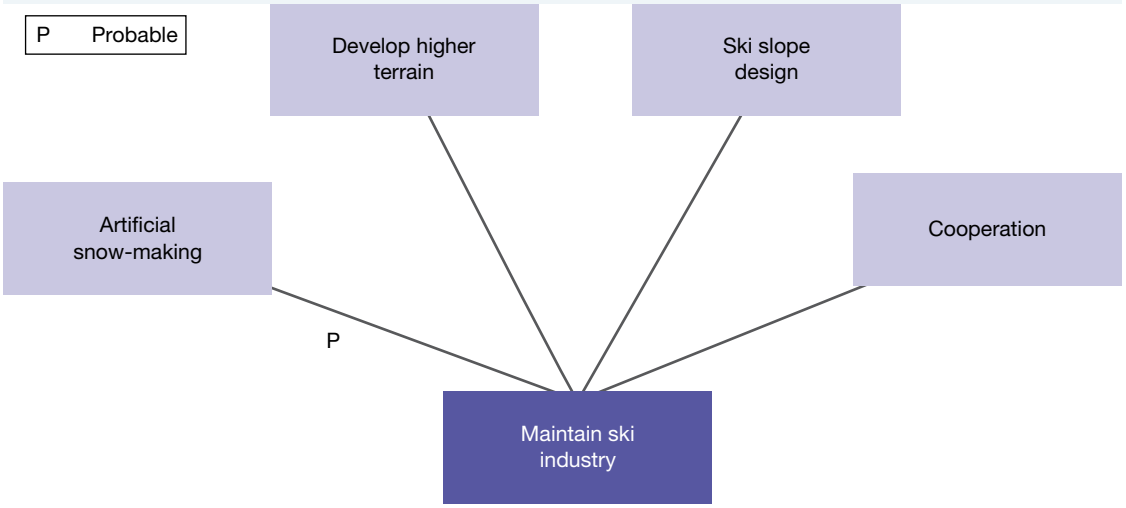
In the inner circle or bubble, write the issue that you are considering, such as possible responses by the ski and alpine resort industry to climate change (see **FIGURE 1**).

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.

Step 4

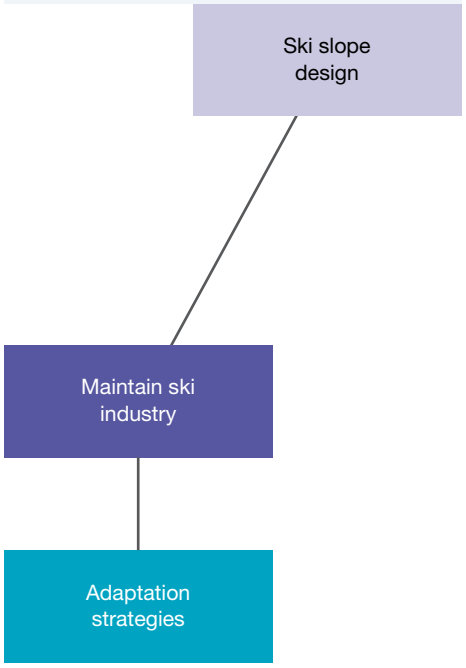
FIGURE 4 Some probable ideas on the futures wheel



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 involve. 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 the start of this level.

Step 5

FIGURE 5 Identifying a preferred option in the eyes of a ski-lift operator



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.

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 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'.

on Resources

Video eLesson	Drawing a futures wheel (eles-1745)
Interactivity	Drawing a futures wheel (int-3363)
Weblink	Bubbl.us

1.14.3 Let me do it

Complete the following activities to practise this skill.

1.14 ACTIVITIES

1. Using the information on climate ***change*** in topic 2, complete a futures wheel to show the consequences of climate ***change***. Identify layers as possible, probable and preferred. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions.
   a. Is the issue explored in the futures wheel a big picture issue or a more specific idea?
   b. What are two key consequences that you can see on the futures wheel?
   c. Which of the consequences has been developed in greater depth? Why might this be the case?
   d. Which of the consequences has been developed in the least depth? Why might this be the case?
   e. 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.

LESSON
1.15 SkillBuilder: Comparing aerial photographs to investigate spatial change over time

LEARNING INTENTION

By the end of this lesson you should be able to compare aerial photographs to investigate spatial change over time.

1.15.1 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.

FIGURE 1 Lake Urmia (a) in 1988 and (b) in 2016

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.

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.

1.15.2 Show me

How to compare aerial photographs

Model

Use the **Hurricane Sandy** weblink in the Resources panel 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 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.

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 panel, which also shows change over time in aerial imagery of other global disasters (such as the Japanese t sunami).

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 panel.

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 panel. 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'.

on Resources

Video eLesson	Comparing aerial photographs to investigate spatial change over time (eles-1750)
Interactivity	Comparing aerial photographs to investigate spatial change over time (int-3368)
Weblink	Hurricane Sandy

1.15.3 Let me do it

Complete the following activities to practise this skill.

1.15 ACTIVITIES

1. Use the **Hurricane Sandy** weblink in the Resources panel 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. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions.
   a. What happened to the bridge in the storm?
   b. How was the land ***changed*** by the storm?
   c. What happened to the houses on the ocean side of the land?
   d. Are the boat moorings still useful? Explain your answer.
   e. 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.

LESSON
1.16 SkillBuilder: Describing change over time

LEARNING INTENTION

By the end of this lesson you should be able to describe change over time.

1.16.1 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.

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.

1.16.2 Show me

How to describe change over time

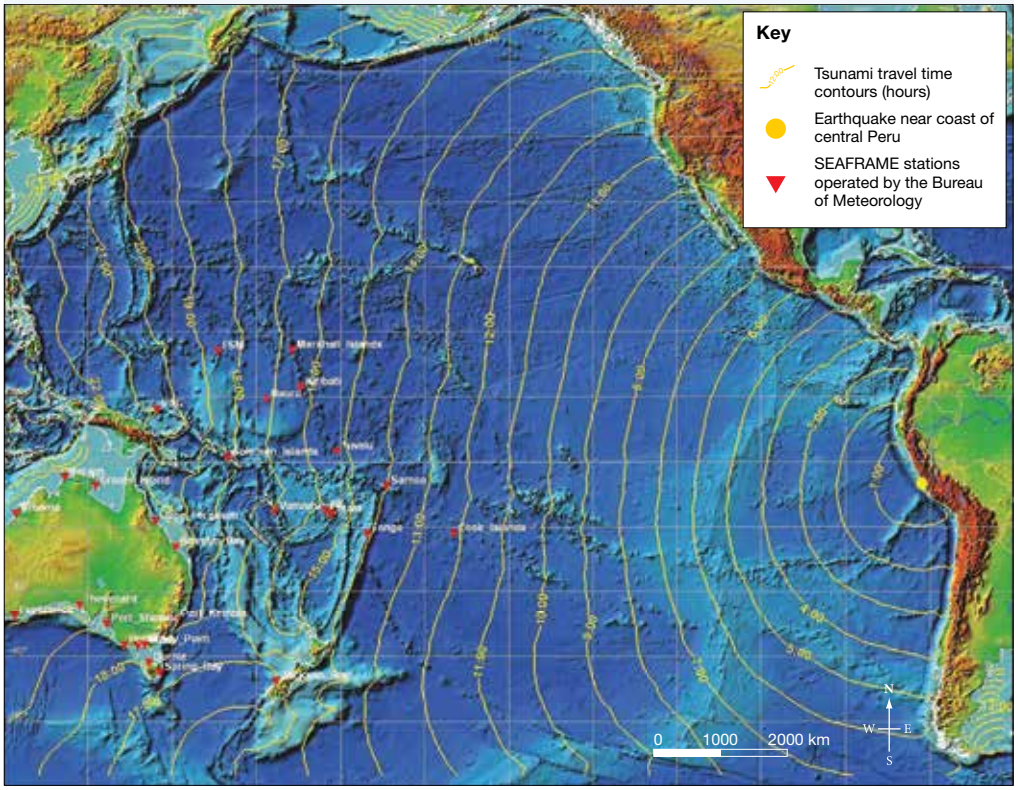
You will need:

- 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.

Model

The following paragraph describes change over time as detailed in the **FIGURE 1** map, showing tsunami mapping from Peru on 15 August 2007.

FIGURE 1 Tsunami mapping from Peru, 2007 showing the magnitude 8.0 earthquake that occurred on 15 August. SEAFRAME stations on Pacific Islands detected a tsunami.



On the 15th of August 2007, a magnitude 8.0 earthquake struck near the coast of Peru. The earthquake was monitored using advanced equipment from SEAFRAME (SEA Level Fine Resolution Acoustic Measuring Equipment) and a warning was sent across the Pacific, based on the timeframes of the tsunami's energy movement. 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.

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.

Step 1

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; f or 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 affected 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.

Step 6

Conclude your analysis with an overall statement about the level or magnitude of the event.

The Model text has this example: 'Although the world watched and waited for a tsunami, the impact was minimal'.

on Resources

Video eLesson	Describing change over time (eles-1753)
Interactivity	Describing change over time (int-3371)
Weblink	Oil spill

1.16.3 Let me do it

Complete the following activity to practise this skill.

1.16 ACTIVITY

Use the **Oil spill** weblink in the Resources panel to view interactive maps showing ***change*** over time, and write an analysis of the event. Answer the following questions to guide your analysis. Use the checklist to ensure you have covered all aspects of the task.

a. Which area of the United States was most affected by the oil spill?
b. What distance, and in which directions, did the oil spread?
c. How long did it take for the Gulf of Mexico to be clear of oil movement?
d. What role did ocean currents play in the movement of the oil?
e. 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.

LESSON
1.17 SkillBuilder: Building a map with geographic information systems (GIS)

LEARNING INTENTION

By the end of this lesson you should be able to build a map with geographic information systems.

1.17.1 Tell me

What is GIS?

A geographic information system (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, a GIS allows you to turn layers on and off to make comparisons between data.

Why is GIS useful?

A 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.

A GIS map 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.

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.

1.17.2 Show me

How to use GIS

View the 'Building a map with geographic information systems (GIS)' in the Resources panel.

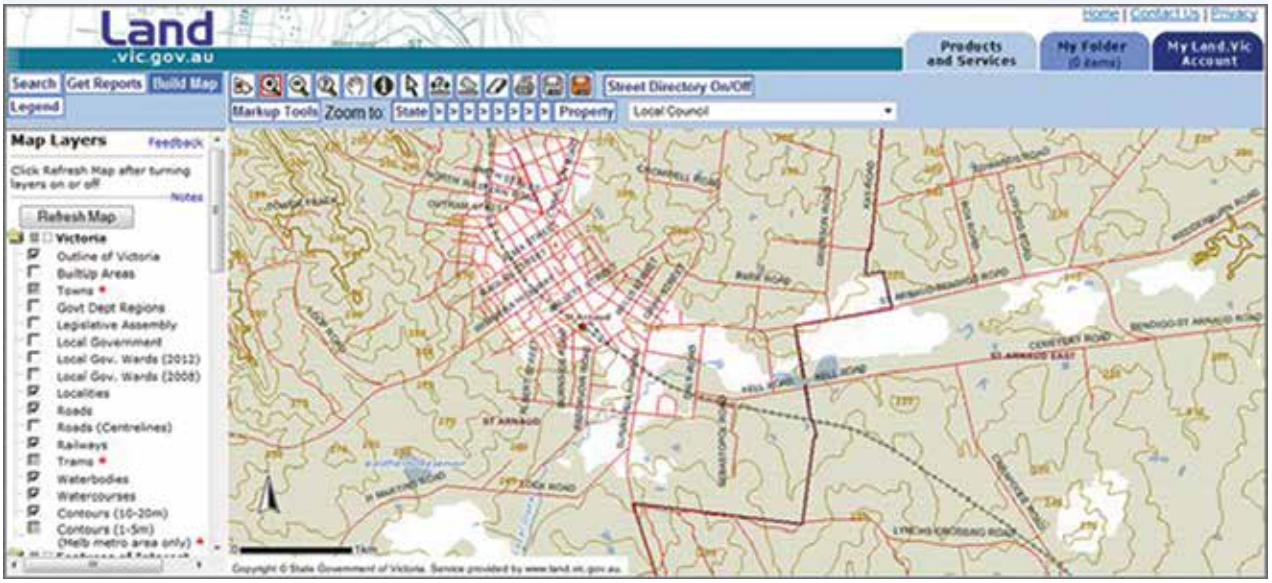
You will need:

- a computer or tablet connected to the internet
- a website developed with GIS techniques.

Model

The following paragraph describes St Arnaud and its environs, as depicted in the **FIGURE 1** GIS image.

FIGURE 1 St Arnaud and its environs



Source: © The State of Victoria, Department of Environment and Primary Industries, 2013. Reproduced by permission of the Department of Environment and Primary Industries.

St Arnaud 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.

Procedure

Use the **Land Victoria** weblink in the Resources tab to locate the map shown in **FIGURE 2**.

FIGURE 2 A base map of Victoria

Step 1

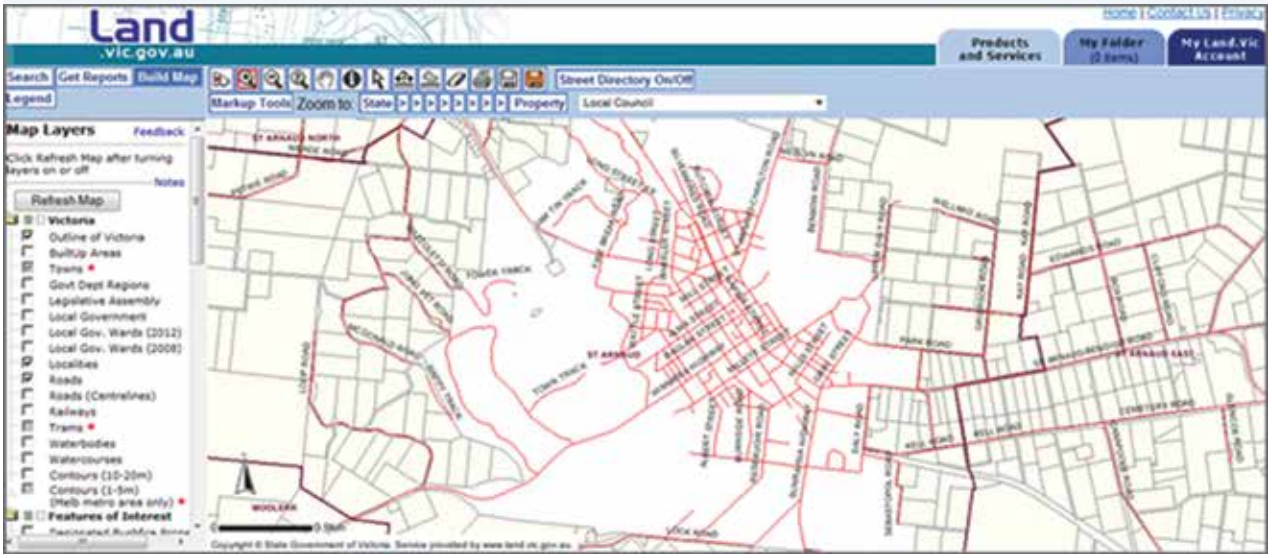
As with any map that you explore, you need to begin by checking the information that is provided. On the left of the screen you will find a list of the map layers (see **FIGURE 2**). Select the option of Build Map. Select any box to turn on a layer of the map. Note that some layers apply only at a specific scale; the cursor will tell you this when you try to turn on the layer.

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.

FIGURE 3 Beginning to build a map

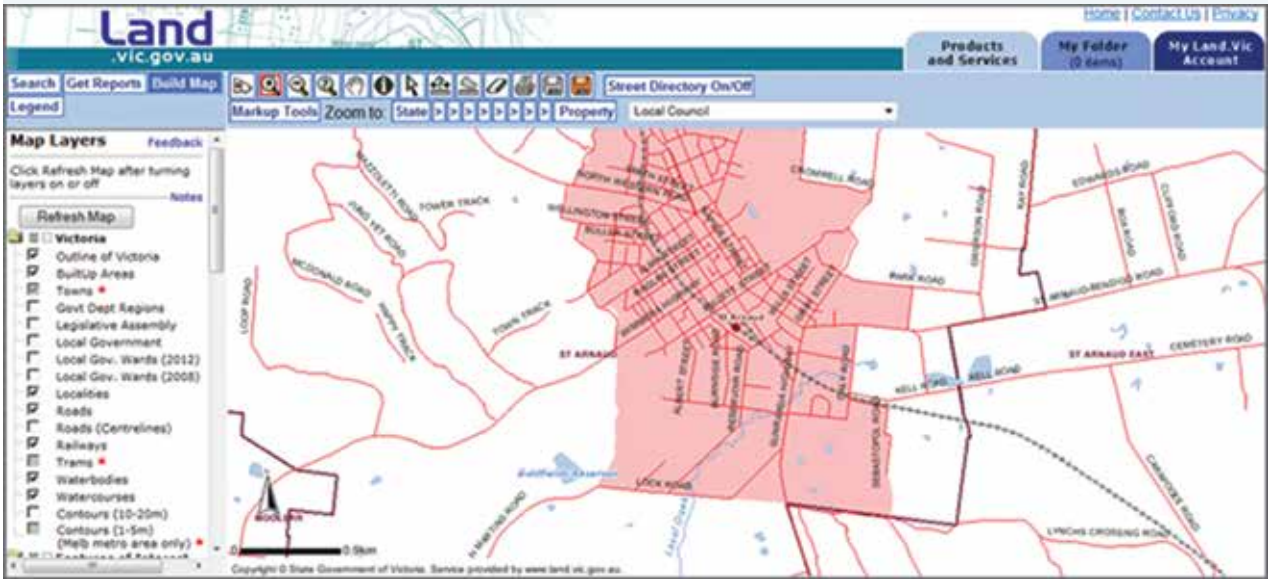
FIGURE 4 St Arnaud 1:25 000



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.

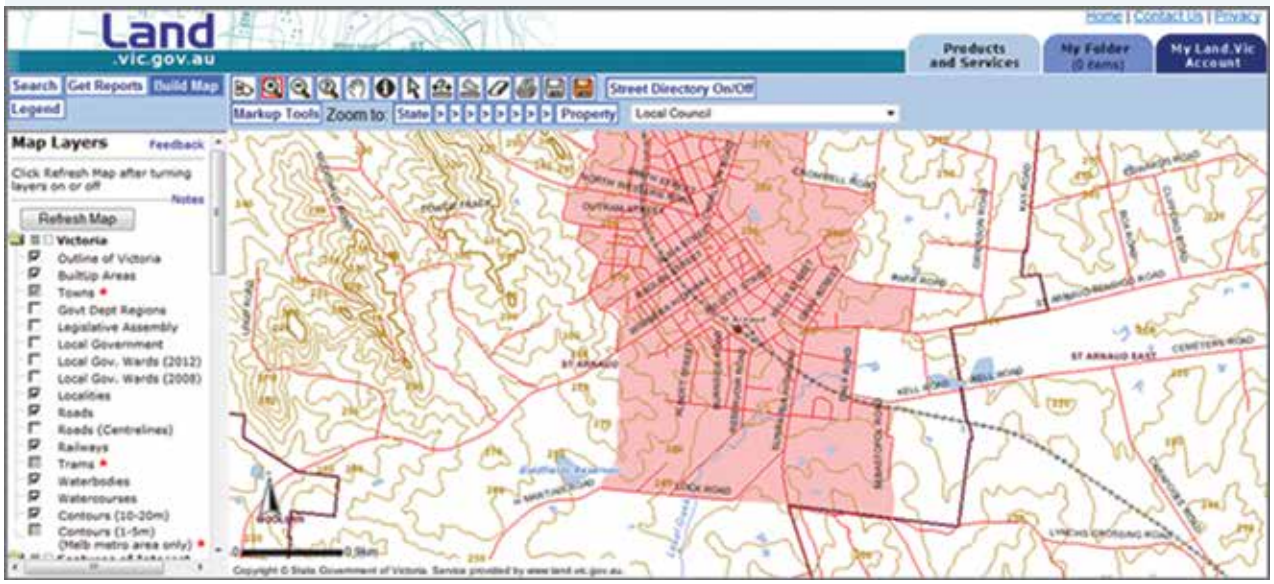
FIGURE 5 Sample layers available in map of St Arnaud region



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.

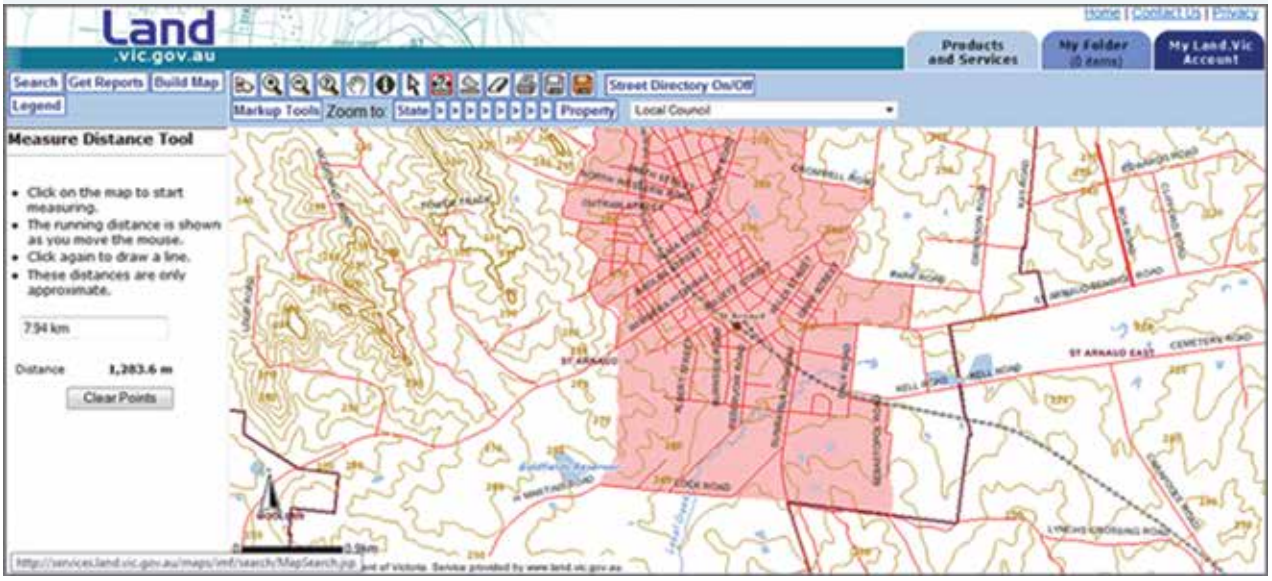
FIGURE 6 St Arnaud region with contours of 10–20 metres added



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 length of Box Road (see the bright red colour in the north-east of **FIGURE 7**) is 1283.6 metres. (Note that the distances are approximate and depend on the exact points that you select.)

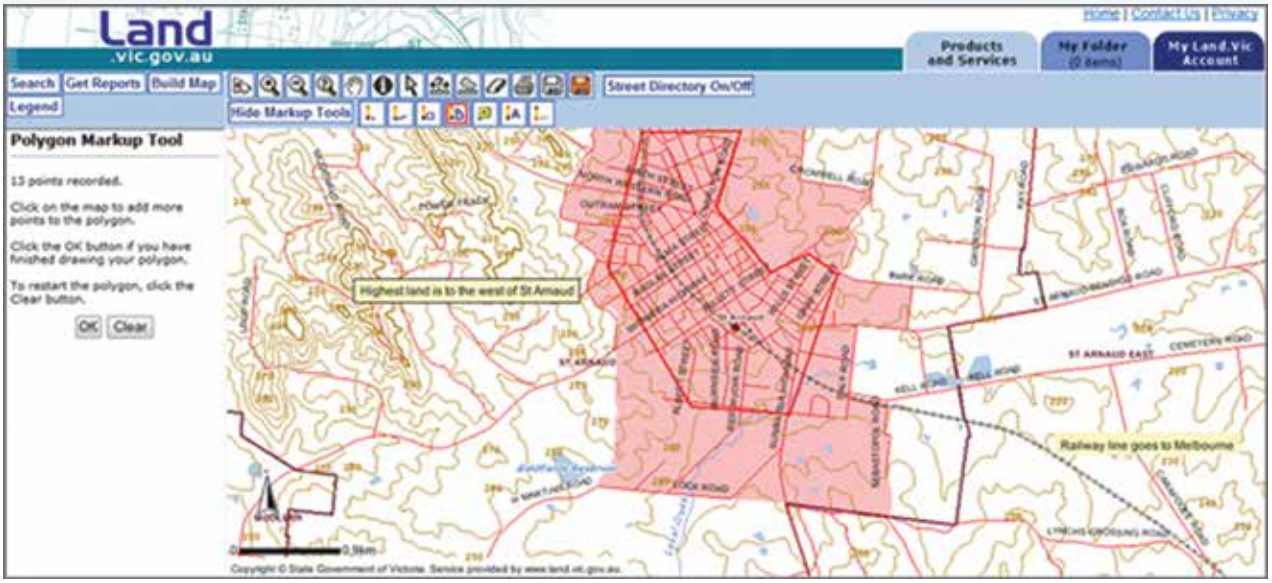
FIGURE 7 Applying the distance tool on the St Arnaud map



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.

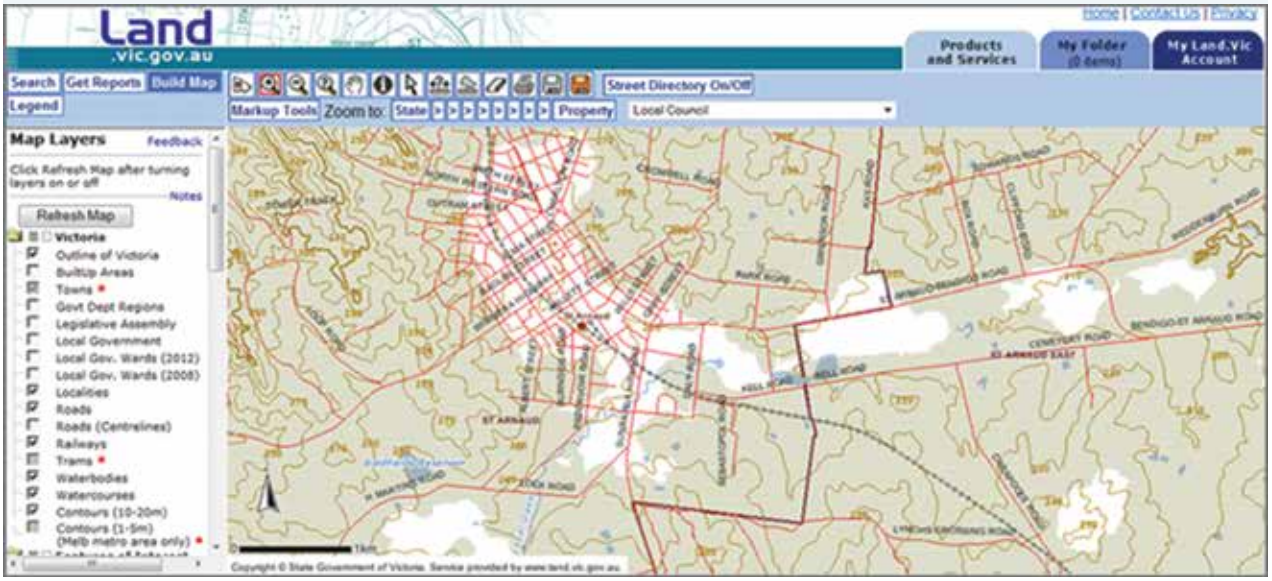
FIGURE 8 Labelling on the St Arnaud map



Step 6

In applying your information about the area, you might like to turn on the layer for bushfire hazard. Are there streets in St Arnaud that are in the bushfire risk area?

FIGURE 9 St Arnaud with an overlay of bushfire risk



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.

on Resources

Video eLesson	Building a map with geographic information systems (GIS) (eles-1754)
Interactivity	Building a map with geographic information systems (GIS) (int-3372)
Weblink	Land Victoria

1.17.3 Let me do it

Complete the following activities to practise this skill.

1.17 ACTIVITIES

1. Continue to use this website 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***. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions. Each question requires you to change maps and layers.
   a. Does water play a significant role in the ***environment*** that you are studying?
   b. Name and measure a significant road on your map.
   c. Use the Area tool to calculate the size of your built ***environment***.
   d. Use at least two m arkup tools to add information to your map.
   e. 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.

LESSON
1.18 SkillBuilder: Using Excel to construct population profiles

LEARNING INTENTION

By the end of this lesson you should be able to use Excel to construct population profiles.

1.18.1 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.

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.

1.18.2 Show me

How to draw a population profile using Excel

You will need:

- a set of population statistics
- the Excel program on your computer.

Model

FIGURE 1 Population pyramid, or profile, created from the Excel spreadsheet of population statistics for the United States, 2010

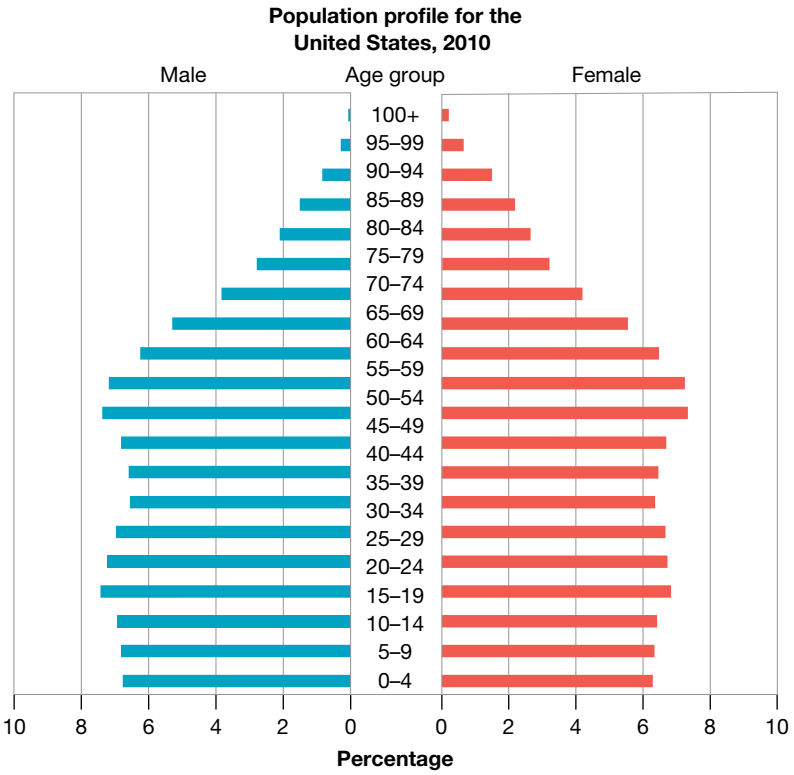


TABLE 1 Population table of the United States, 2010

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

Age	Male	Female
85–89	1 273 867	2 346 592
90–94	424 387	1 023 979
95–99	82 263	288 981
100+	9162	44 202
All ages	151 781 326	156 964 212

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 Σ (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 Σ 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

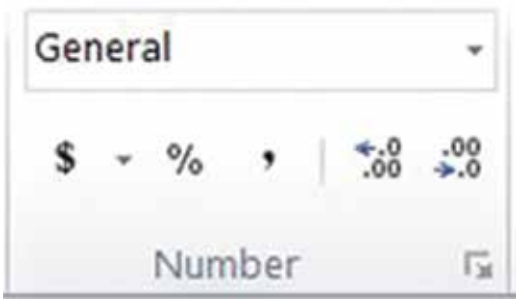
Step 4

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.

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



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.)

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 23 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, such as 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.

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 | =-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	

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.

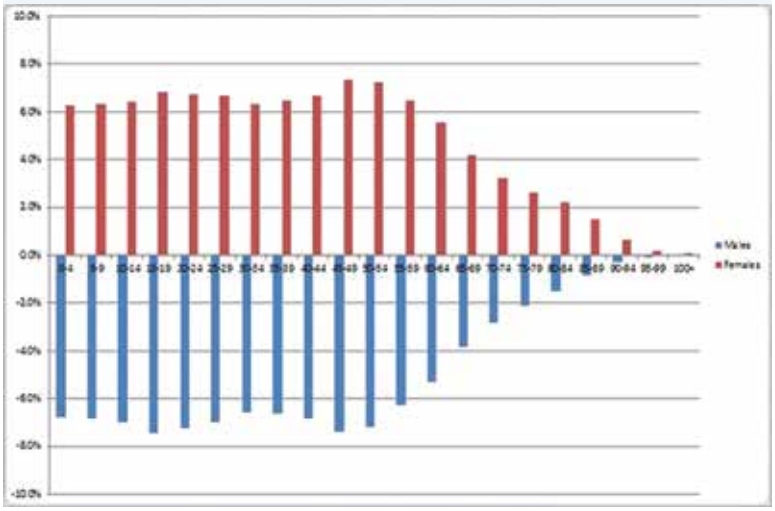
Step 5

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
- 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

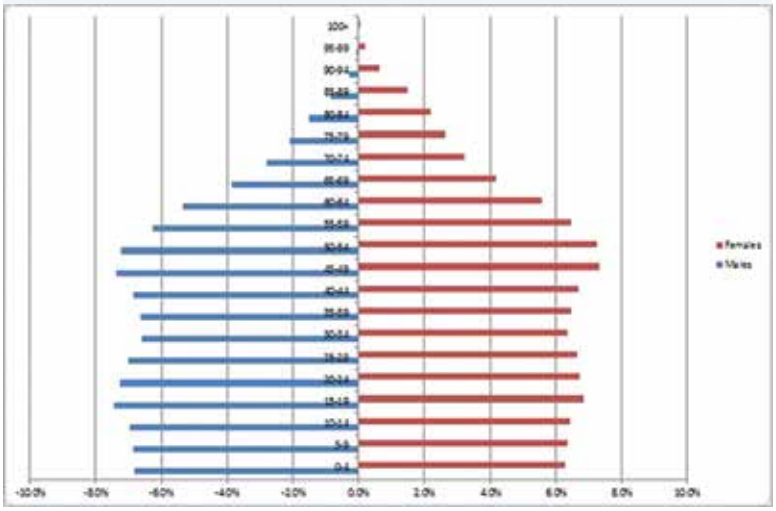


The next step is to change it. All versions of Excel are slightly different as to how this part is achieved and you may need to work your way through this by trial and error.

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.

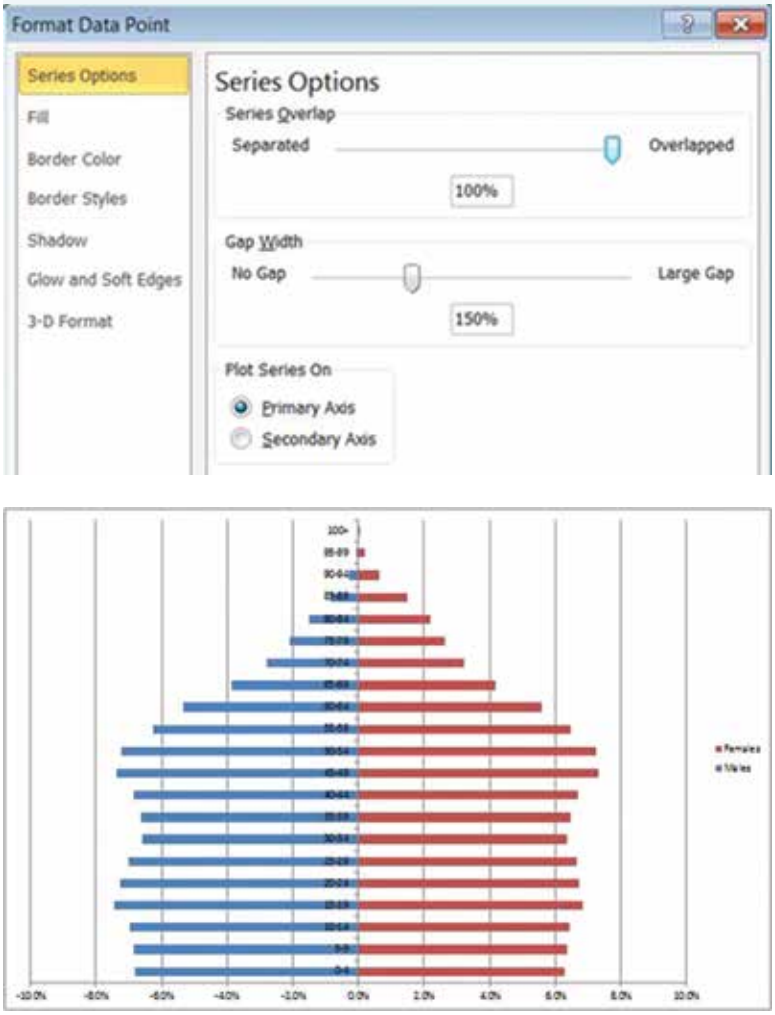
FIGURE 9 The graph now



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 and select Format Data Point… from the pop-up menu. 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

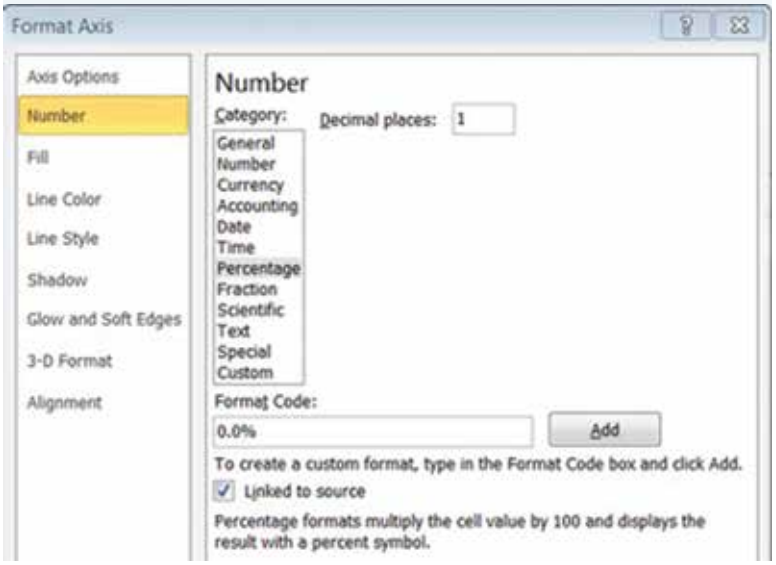
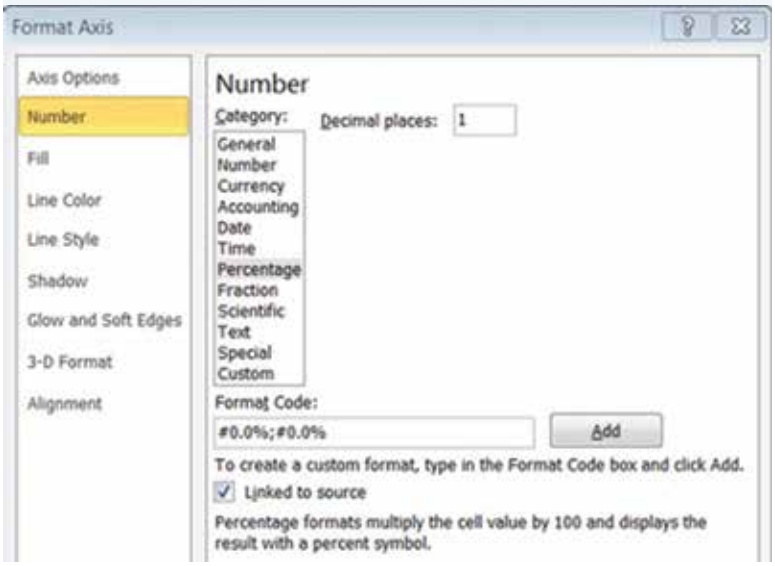
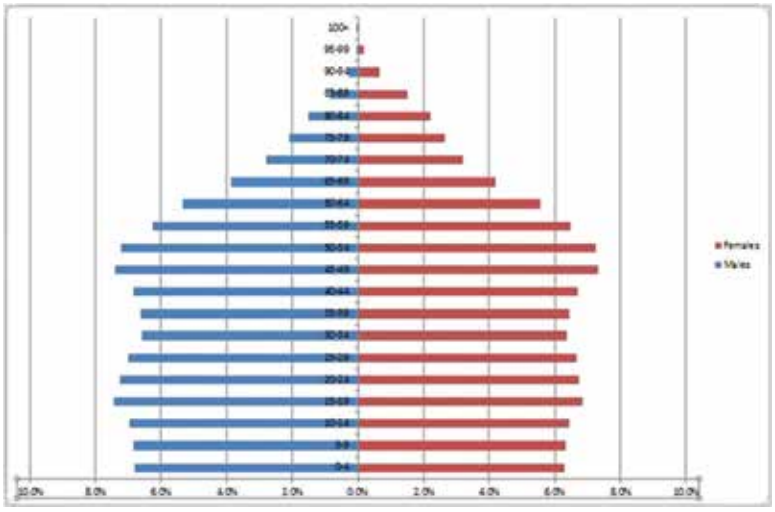


FIGURE 12 Removing the negative signs

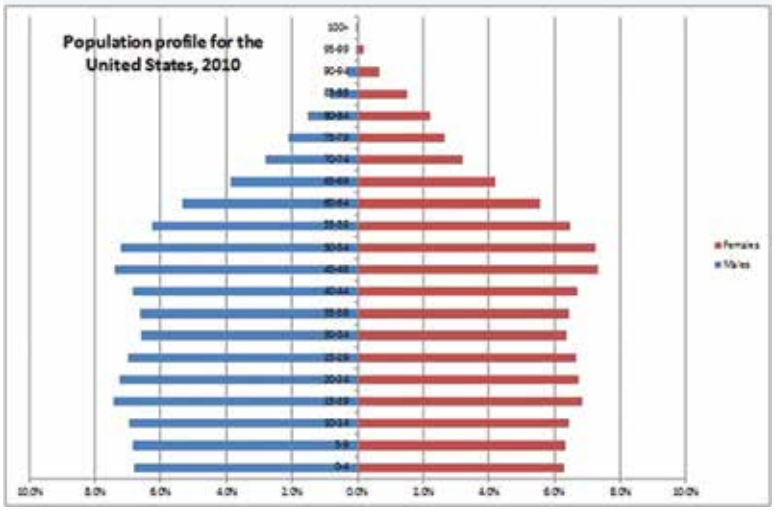




Step 9

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**).

FIGURE 13 Adding the chart title



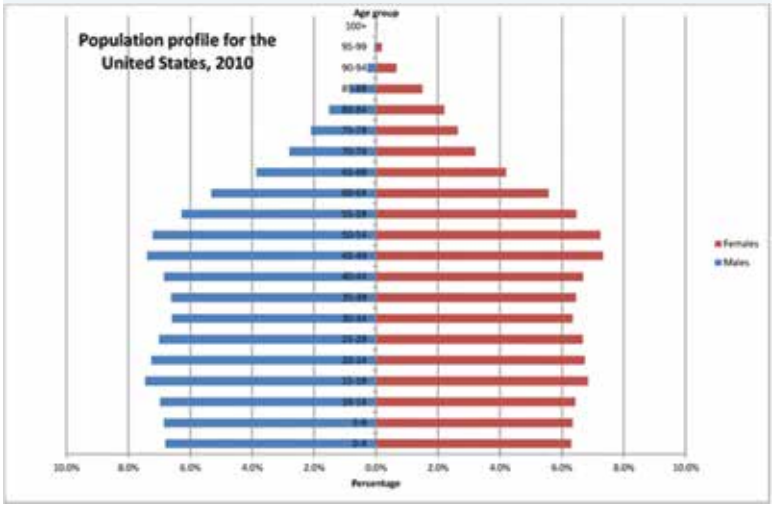
Step 10

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 14 Population profile for the United States, 2010



Resources

Video eLesson Using Excel to construct population profiles (eles-1758)

Interactivity Using Excel to construct population profiles (int-3376)

1.18.3 Let me do it

Complete the following activities to practise this skill.

1.18 ACTIVITIES

1. Using the Singapore Census data in **TABLE 2**, complete a population profile using Excel. Use the checklist to ensure you cover all aspects of the task.

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

2. Apply your skills to answer the following questions.
   a. Is your population profile that of a young population or an aged population?
   b. Which age group has the largest number of people?
   c. What percentage of the population is made up of children aged under 15?
   d. What percentage of the population is made up of people aged over 65 years?
   e. List two factors that the planners in this country need to take into consideration for the future wellbeing of the people.

Checklist

I have:

- carefully entered data
- met geographic standards — for example, the bars are aligned
- labelled the axes
- included a clear title.

LESSON
1.19 SkillBuilder: How to develop a structured and ethical approach to research

LEARNING INTENTION

By the end of this lesson you should be able to develop a structured and ethical approach to research.

1.19.1 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 important 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.

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.

1.19.2 Show me

How to conduct structured and ethical research

Model

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	7314.1	86.0	1.2
Victoria	5649.1	94.8	1.7
Queensland	4584.6	91.4	2.0
South Australia	1658.1	16.4	1.0
Western Australia	2451.4	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.

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.

On Resources

Video eLesson	How to develop a structured and ethical approach to research (eles-1759)
Interactivity	How to develop a structured and ethical approach to research (int-3377)

1.19.3 Let me do it

Complete the following activities to practise this skill.

1.19 ACTIVITIES

1. 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. Use the checklist to ensure you have covered all aspects of the task.
2. Apply your skills to answer the following questions.
   a. By your assessment, which ***place*** has the higher level of wellbeing?
   b. List three factors that you have used to come to this conclusion.
   c. Which factor would you hope to see improvement in? Why did you choose this factor?
   d. What ***changes*** in this factor would result in improvements to the community's wellbeing?
   e. Has your data been gathered with an ethical approach? Explain.

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.

LESSON
1.20 SkillBuilder: Understanding policies and strategies

LEARNING INTENTION

By the end of this lesson you should be able to understand policies and strategies.

1.20.1 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.

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.

A good understanding of policies and strategies:

- clearly identifies the difference between a policy and a strategy.

1.20.2 Show me

How to develop an understanding of policies and strategies

Model

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 coeducational 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.

You will need:

- to show knowledge of a particular field of study.

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 coeducational 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.

Resources

Video eLesson	Understanding policies and strategies (eles-1760)
Interactivity	Understanding policies and strategies (int-3378)
Weblink	Indigenous education

1.20.3 Let me do it

Complete the following activities to practise this skill.

1.20 ACTIVITIES

1. Use the **Indigenous education** weblink in the Resources panel 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. Use the checklist to ensure you cover all aspects of the task.
2. Apply your skills to answer the following questions.
   a. The policy on education for Indigenous children is part of a broader policy. What is that broader policy called?
   b. Research to discover when this policy came into being.
   c. List three strategies to support the education policy.
   d. Which strategy do you find the most interesting? Why?
   e. 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.

LESSON
1.21 SkillBuilder: Debating like a geographer

LEARNING INTENTION

By the end of this lesson you should be able to debate like a geographer.

1.21.1 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.

How is it useful to be able to debate like a geographer?

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.

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.

1.21.2 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 (contention), time to research and prepare arguments, a formal debate format and an outcome that is adjudicated by judges.

Step 1

Determine the contention to be debated, for example, 'Japan should be allowed to conduct whaling expeditions in the Southern Ocean'.

Step 2

Create two teams of three debaters. One team must argue in favour of the contention (the affirmative) and one team must argue against the contention (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. The **FIGURE 1** model 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. The chairperson and timekeeper sit facing the audience. The affirmative team is to their right, with the 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.

Model

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?
- 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

Resources

Video eLesson	Debating like a geographer (eles-1762)
Interactivity	Debating like a geographer (int-3380)

1.21.3 Let me do it

Complete the following activities to practise this skill.

1.21 ACTIVITIES

1. Consider the debate topic 'Australia should increase its intake of asylum seekers'.
   a. With a partner, undertake further research on the arguments for and against this contention.
   b. Using the framework provided in **FIGURE 1** in the Show me section, prepare a set of palm cards for that might be used in this debate by:
      i. the affirmative team
      ii. the negative team.
2. Organise a class debate on the topic. If you are not one of the active participants in the debate, ensure that you listen carefully to points raised by both sides so that you are able to complete activity 3.
3. Based on what you have learned in this lesson, apply your skills to answer the following questions. Use the checklist to ensure you cover all aspects of the task.
   a. What was the key argument for an increase in Australia's intake of asylum seekers?
   b. What was the key argument against an increase in Australia's intake of asylum seekers?
   c. Which team provided the most convincing arguments? Why?
   d. Which argument(s) did you not believe?
   e. What is your personal response to the issue after listening to both sides of the debate? Has your viewpoint been altered? Write a paragraph outlining your view.

Checklist

In debating like a geographer, I have:

- either developed arguments or listened intently to the arguments
- considered my opinion on the issue and am now better informed
- been able to write a paragraph summarising my views, based on the arguments presented.

LESSON
1.22 SkillBuilder: Writing a geographical essay

LEARNING INTENTION

By the end of this lesson you should be able to write a geographical essay.

1.22.1 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.

How 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:

- 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.

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.

1.22.2 Show me

You will need:

- a topic of interest
- paper and pen for brainstorming
- computer or paper and pen for drafting the structure of your essay
- access to research materials in a library or on the internet.

Model

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 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.

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, 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.

Procedure

Step 1

On a piece of paper, brainstorm all the ideas you can think of that relate to the topic. When you have finished, try to group the ideas into three or four themes. Connect ideas with a line. You could try using a fishbone diagram or some other graphic organiser.

Step 2

Use the **FIGURE 1** model to set 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.

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 1 will be about increased noise levels and will require data from other road developments to show the increase in noise levels. Paragraph 2 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 3 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; f or 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.

on Resources

Video eLesson Writing a geographical essay (eles-1763)
Interactivity Writing a geographical essay (int-3381)

1.22.3 Let me do it

Complete the following activities to practise this skill.

1.22 ACTIVITES

1. 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'. Use the checklist to ensure you cover all aspects of the task.
2. Based on what you have learned in this lesson, apply your skills to answer the following questions.
   a. What are three key themes that you outlined in your plan?
   b. List two facts that you would search for to support each theme.
   c. What would be your opening sentence of the introduction?
   d. What would be the final sentence of your essay?
3. Practise your skills further by conducting whatever research is required and writing the full essay outlined in your plan.

Checklist

In writing a geographical essay, I have included:

- 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.

2 Introducing environmental change and management

LESSON SEQUENCE

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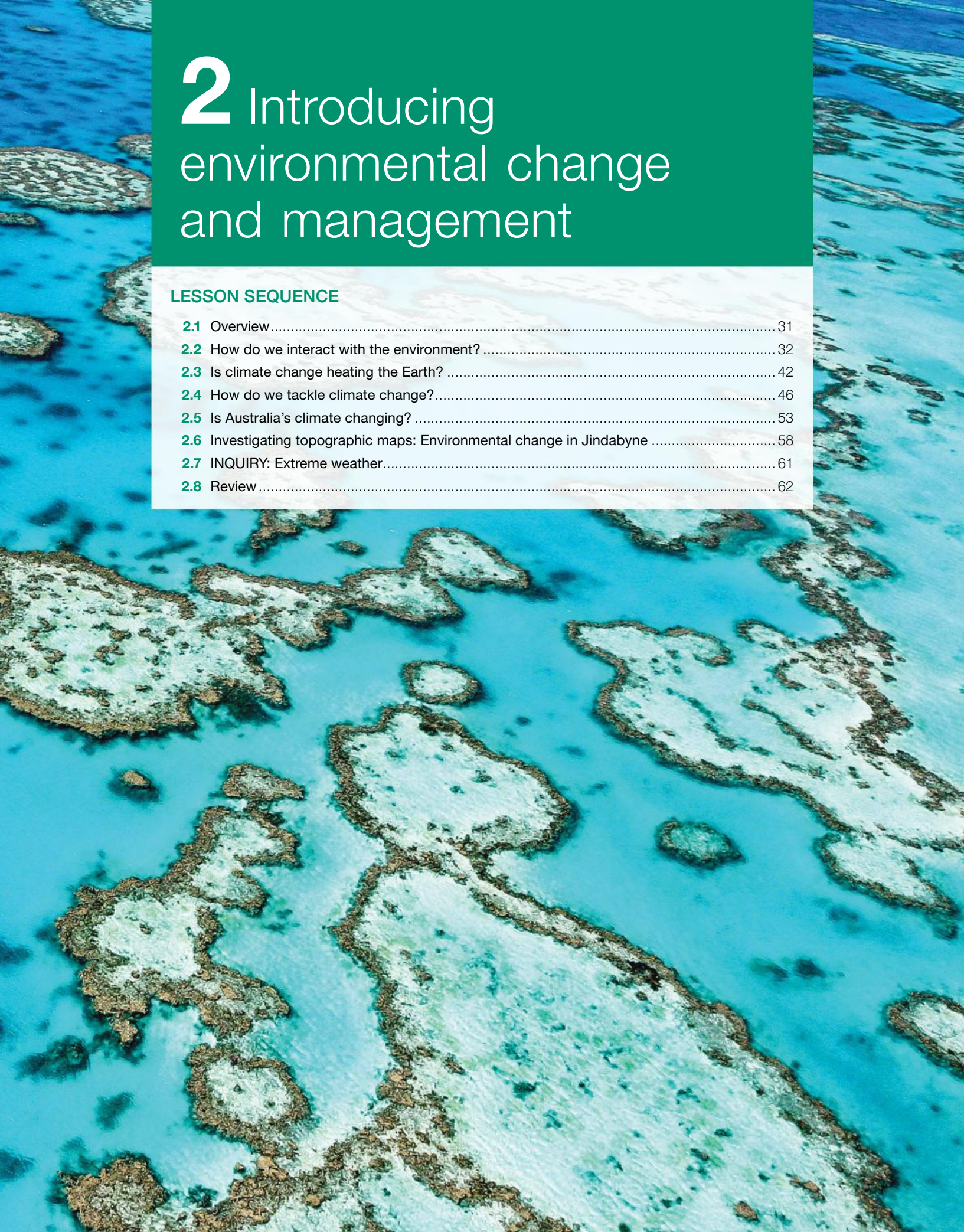


LESSON
2.1 Overview

Hey students! Bring these pages to life online

Watch videos

Engage with interactivities

Answer questions and check results

Find all this and MORE in jacPLUS

The Earth is our home and provides us with everything we need to live. What are we doing to it in return?

2.1.1 Introduction

Across the world, humans have caused many environmental changes: pollution, land degradation and damage to aquatic environments. People have different points of view, or worldviews, on many of these changes. Climate change is a major environmental change because it affects all aspects of the biophysical environment, such as plants and animals, our land, inland water resources, and coastal, marine and urban environments. It is vital that we respond to and effectively manage human-induced environmental changes to minimise negative social and economic impacts.

FIGURE 1 Human-induced climate change has led to increased severe weather events such as drought. Rivers can dry up, leading to the loss of plant and animal life.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11498)

Video eLesson What are we doing? (eles-1707)

LESSON
2.2 How do we interact with the environment?

LEARNING INTENTION

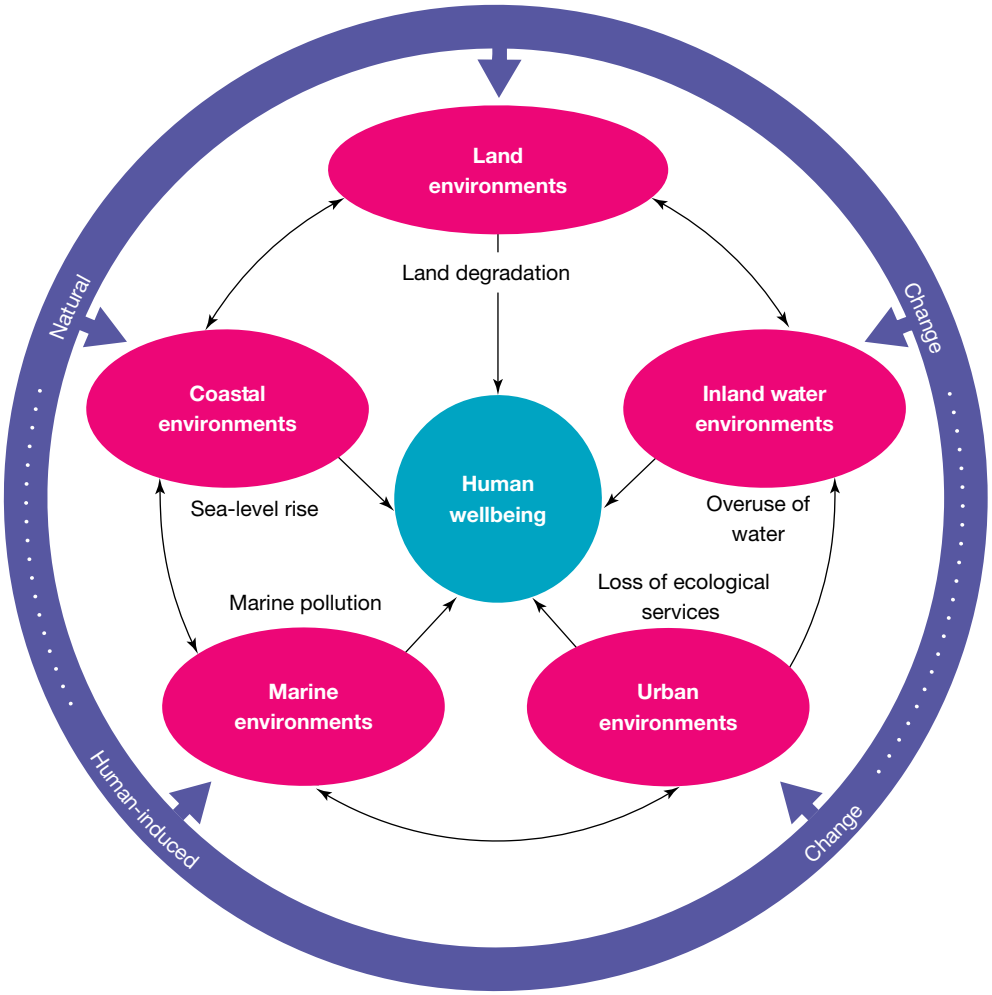
By the end of this lesson you should be able to explain the interconnection of people and the environment, and describe the concepts of ecological services, biocapacity and ecological footprint.

TUNE IN

Change is a natural process in the biophysical world in which we live. However, today we are seeing more examples of human-induced change that is having a negative impact on the environment.

FIGURE 1 looks at the range of human-induced impacts on the environment (apart from climate change) that can affect each environment system. Select one of the environment systems: land, inland water, urban, marine or coastal. Brainstorm examples of change in that system.

FIGURE 1 Interaction of environmental change with human wellbeing

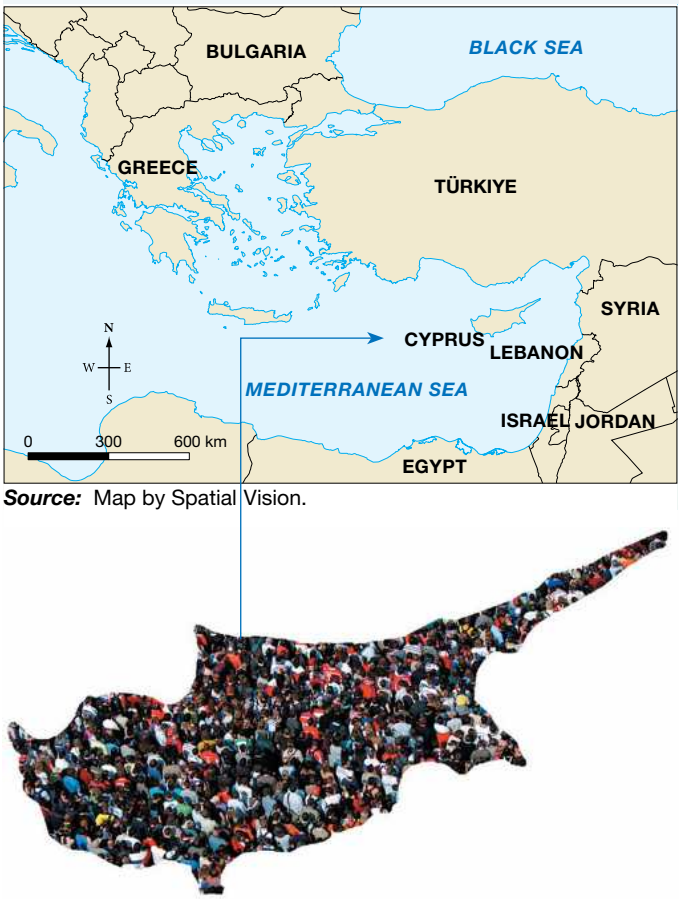


2.2.1 How much space do we need?

If you gathered all 8 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 2**). Clearly this would be impractical, and providing services to ensure human wellbeing in an area with a density of almost 1 000 000 per square kilometre would be impossible.

While it is unrealistic to suggest 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 occupy as individuals and, more importantly, how our needs for the Earth's resources can only be satisfied by major modifications to biomes.

FIGURE 2 Humanity crowded onto the island of Cyprus



Source: Map by Spatial Vision.

2.2.2 Human interaction 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 Earth-centred **environmental worldview**, which has a **stewardship** focus, foretold of problems with supplies of food and warned that there would be more deaths because of famine and wars over resources. In 1798 he wrote, 'The power of population is so superior to the power in the earth to produce subsistence for man …' At the time Malthus wrote his thesis, England was moving into a period known as the **Industrial Revolution**; a time when the human-centred environmental worldview of the government and leaders of industry was that the Earth's resources were limitless and the development of the economy should take priority over the preservation of the natural world.

Today, 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 land becomes unproductive because of overuse. Nevertheless, we should remember that change can happen naturally as well as being induced by humans.

Some topics that can help us explore change and the need for careful management include marine environments and coasts, the land, inland waters, and urban or built environments (see **FIGURE 1**).

environmental worldview varying viewpoints, such as Earth-centred as opposed to human-centred, in managing ecological services

stewardship the belief that humans have a responsibility to care for the Earth to protect its future

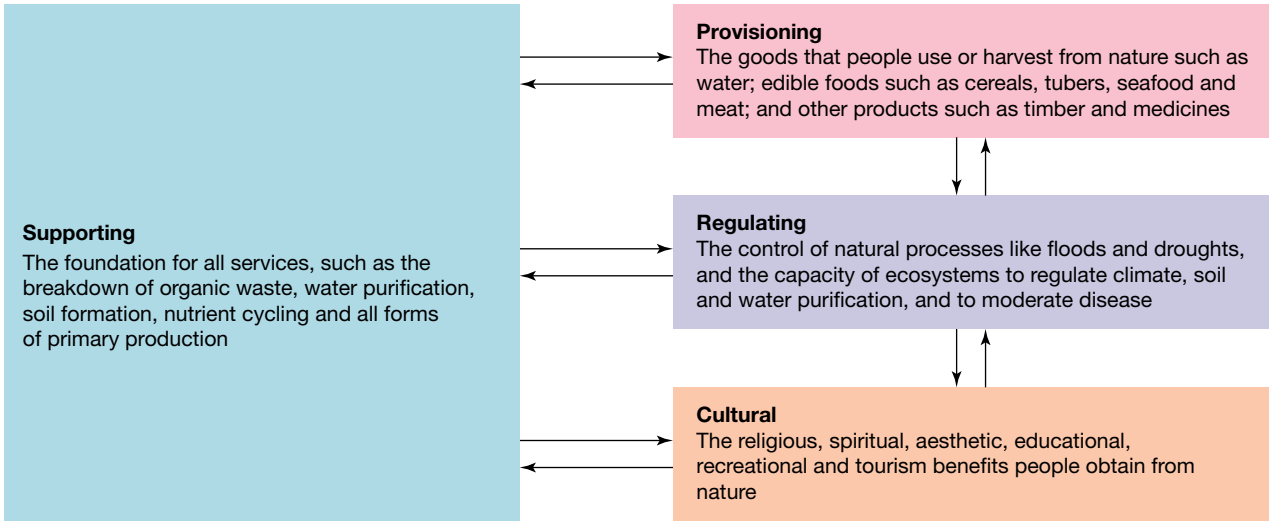
Industrial Revolution the period from the mid 1700s into the 1800s that saw major technological changes in agriculture, manufacturing, mining and transportation, with far-reaching social and economic impacts

2.2.3 What are ecological services?

A new view of the relationship between the environment and people is one of an **ecological service** or 'what nature provides for humanity'.

Ecological services can be thought of as biological and physical processes that occur in natural or semi-natural ecosystems and maintain the habitability and livelihood of people on the planet. These services are shown in **FIGURE 3**.

FIGURE 3 Ecological services



Understanding the link (interconnection) between ecological services and human action is important as it can lead to more sustainable practices. The idea of ecological management takes an Earth-centred environmental worldview, promoting stewardship or **custodial management**. This view considers caring for the land and the ecological services it provides as paramount, rather than owning or exploiting the land. By applying this Earth-centred viewpoint to human uses and management of the environment, future options for human wellbeing will be sustainable. The question is: how do we evaluate human impacts on the environment and what management strategies can be implemented to reverse damage and create a sustainable future? As such, we need to consider the costs and benefits, or more simply, the advantages and disadvantages of changes we make to the environment, as there will be consequences in terms of economic viability and social justice.

ecological service the benefits to humanity from the resources and processes that are supplied by natural ecosystems

custodial management a sense of responsibility towards land and the landscape. Includes the concepts of sustainable natural resource management and managing natural resources, both now and in the future.

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person for food, water, transport, housing, waste management and other purposes

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

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, and is calculated by measuring a total of six factors, shown in **FIGURE 4**. The ecological footprint is a useful indicator of environmental sustainability.

FIGURE 5 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 green background represents those regions that use less than their biocapacity.

In 2022 the total global ecological footprint was estimated at 1.75 planet Earths, which means that humanity used ecological services at 1.75 times the biocapacity of the Earth to renew them. The 1.75 ecological footprint figure represents an average for all regions of the Earth.

int-9110

tlvd-10757

FIGURE 4 Measuring the Earth's ecological footprint

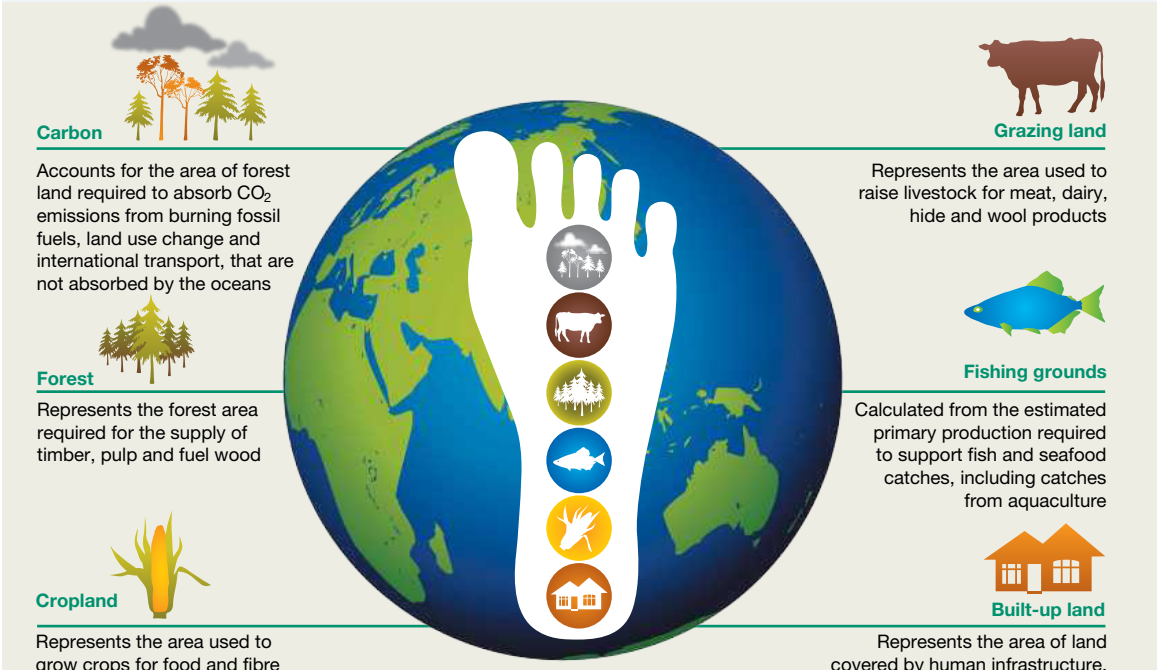


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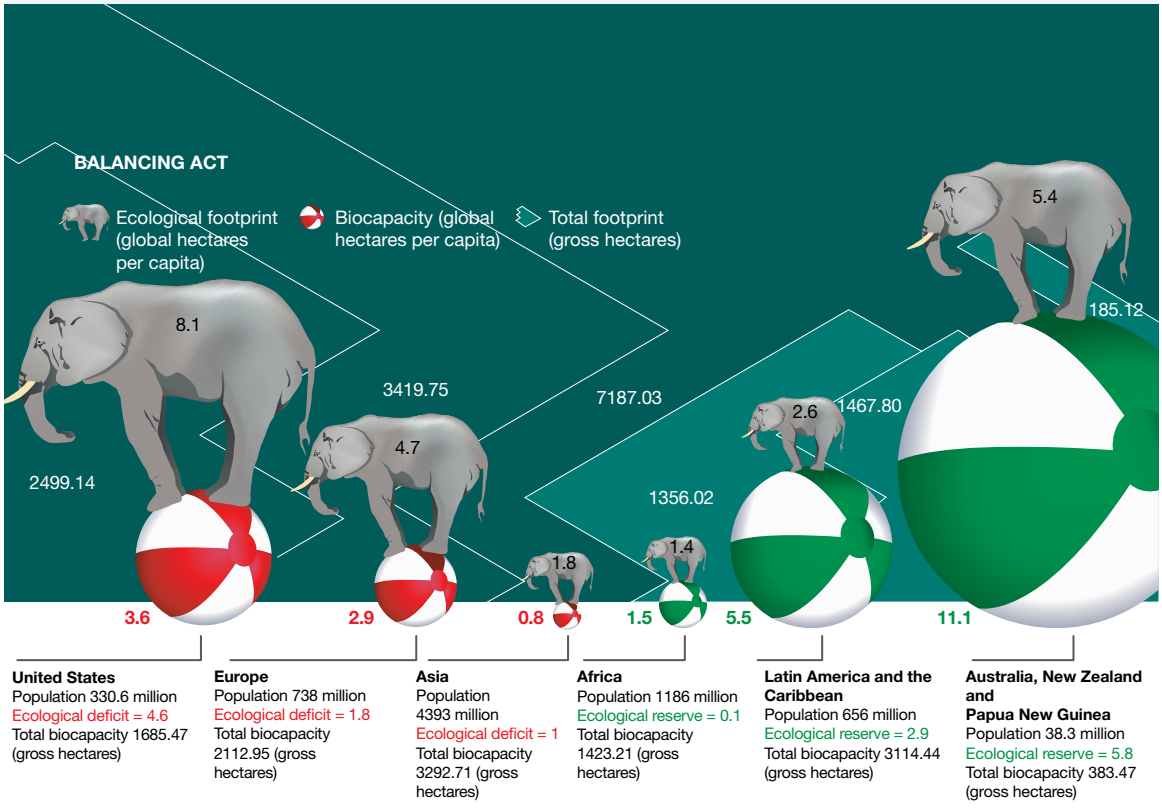
FIGURE 5 Biocapacity and ecological footprint



Source: Data from The Footprint Network, 'Biocapacity and ecological footprint data', https://data.footprintnetwork.org.

The United States ecological footprint per person is 8.1, much higher than the world average of 2.75 global hectares. This level of resource use is not sustainable into the future and raises questions of economic viability, environmental benefit and social justice. **FIGURE 6** shows a map of the Earth's ecological debt. Note there can be a surpising relationship between ecological footprint and a country's wealth and/or population. For example, the United States and much of Europe and Japan are wealthy countries with large ecological footprints and small biocapacities, and thus have large ecological deficits. With their smaller populations, Australia and New Zealand are in the fortunate position of having a large ecological reserve due to abundant natural resources, which gives a high biocapacity. It should be noted, though, that both Australia's and New Zealand's biocapacities are diminishing, which will result in a smaller reserve in the future; thus, we need to continue taking steps to reduce our ecological footprint.

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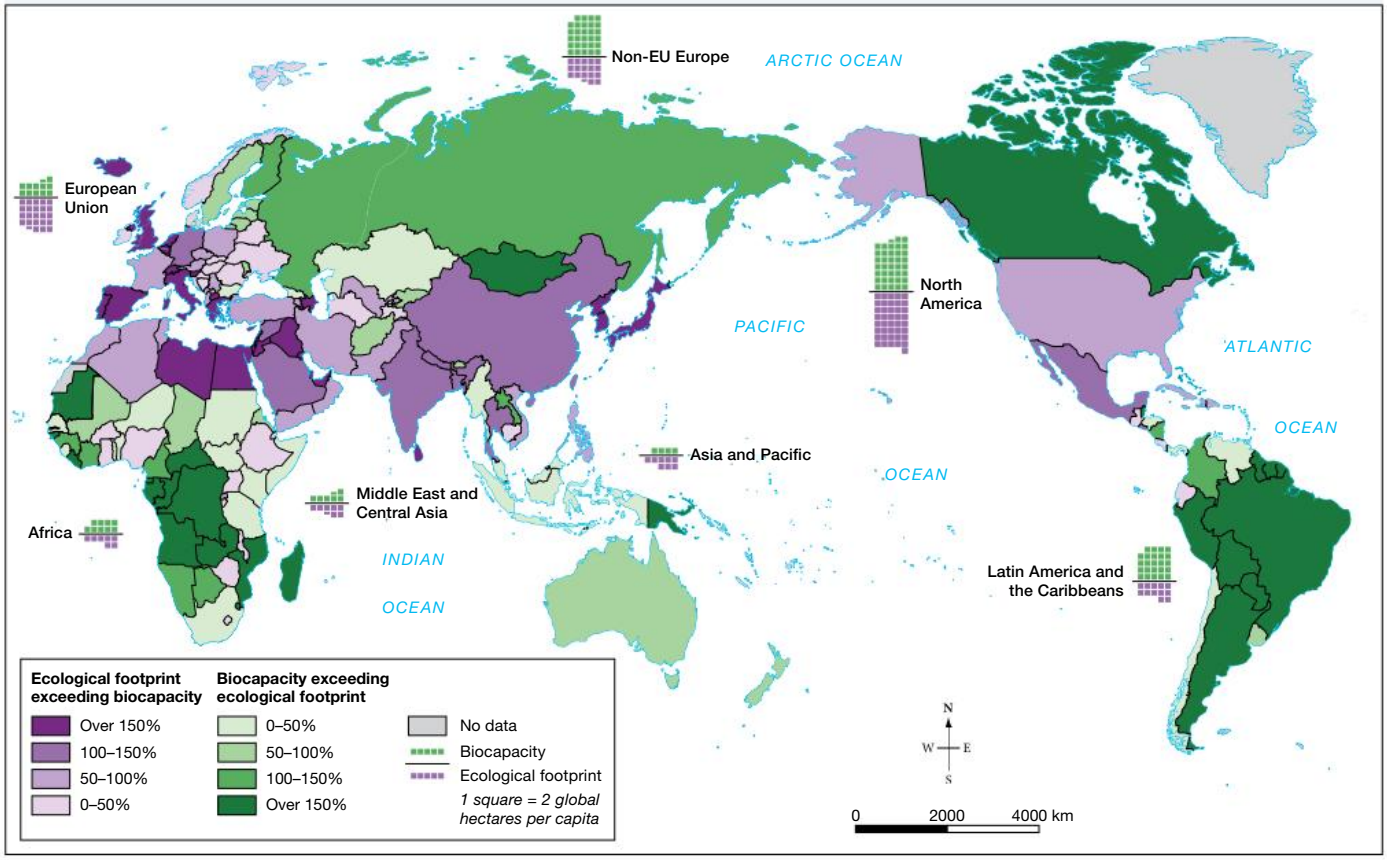
FIGURE 6 Ecological debt map



Source: Global Footprint Network.

Biodiversity hotspots

Biodiversity hotspots amount to approximately 3 per cent of the Earth's surface. They are regions that have great diversity of life that is at high risk of destruction. It is calculated that 44 per cent of the Earth's plants and 35 per cent of land animals live in these regions.

By definition, a biodiversity hotspot is a region that has lost 70 per cent or more of its biodiversity. These losses are mostly due to climate change impacts made worse by human impacts.

These impacts include:

- habitat loss and fragmentation
- hunting
- fishing and its bycatch
- overexploitation
- water abstraction

- nutrient enrichment
- pollution
- human introduction of invasive species
- pests
- diseases.

The 30 regions of the world that have been designated as biodiversity hotspots are said to be in a conservation crisis. Some of these regions are: the Andes Mountains tropics, the New Zealand archipelago, the Himalayan region and, in Australia, the south-west forests of Western Australia.

Developing an understanding of biodiversity hotspots can help inform all levels of government of where a nation, state or local region stands in a world where resources services are seen as limited.

Measuring sustainability

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 SSI gives values to 21 factors across a range of social, political, economic and environmental considerations. It asserts 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 investigating these indices as they offer many sound ideas about human wellbeing and the sustainability of the ecological services of the natural world.

DISCUSS

Consider the criteria for the Sustainable Society Index (SSI). Discuss the extent to which Australia might be considered 'a free, well-balanced society that is in harmony with nature'.

2.2.4 Custodial responsibility and environmental management by First Nations Australians

Since time immemorial First Nations Australians managed the land of their Country: lands, waterways, lakes and marine environments. In all cases their deep knowledge and connection to Country allows for sustainable environmental management of ecosystems and biomes. This reflects an Earth-centred worldview with a focus on custodial responsibility. This involves a responsibility and obligation for caring for Country and Place, including management of sea, land, waterways and sky based on the values and beliefs of First Nations Australian communities. Artwork can reflect the close connections with and management of the land to sustain their livelihood.

Land management practices and connection to the land

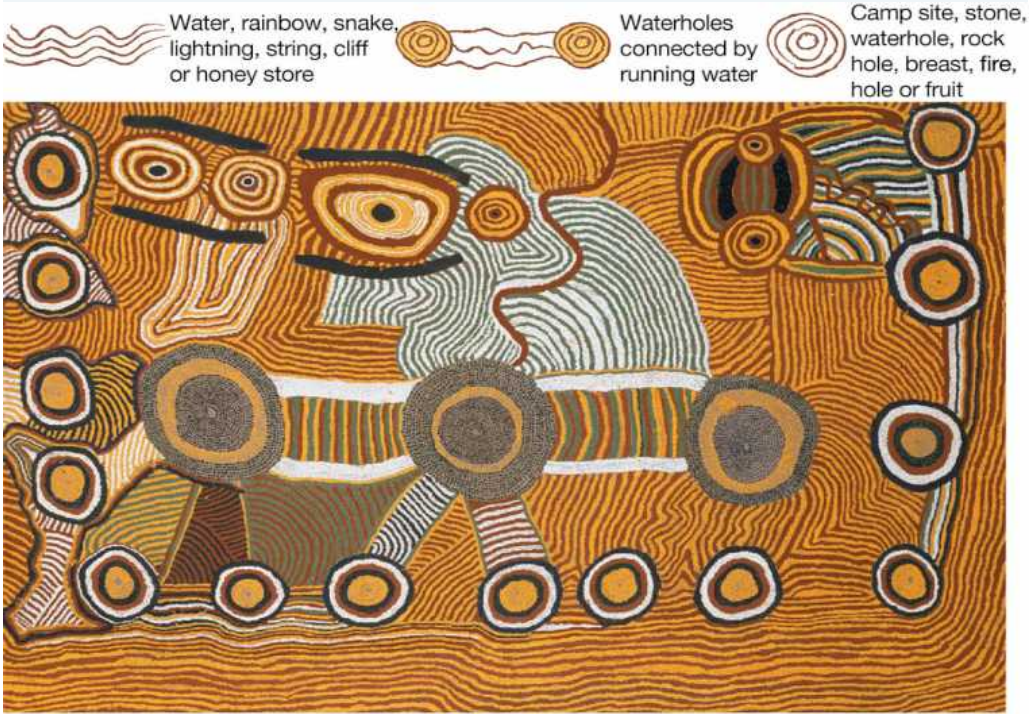
First Nations Australians occupied the whole continent of Australia, developing sustainable practices for at least 60 000 years. Spiritual and cultural connections to Country and Place are strong and the health of the land and its water resources are central to the wellbeing of the community. Land is not specifically owned by individuals but rather a system of tenure known as collective custodianship prevails.

Sustainable food and water resources

Through their detailed knowledge of Country, First Nations Australians could determine the seasonal availability of food from a wide range of uncultivated plants and wild animals. Some estimates suggest there

were up to 7000 different sources of food. The term 'bush tucker' has been developed to describe this sourcing of food from the natural environment. This involves working with the land and its elements rather than seeking to make dramatic changes. It includes farming and nurturing edible plant regrowth, maintaining animal habitats to ensure plentiful stock, and building fish traps. Some seeds from gathered plants are left behind to allow for new growth, and a few eggs are always left in nests to hatch. This ensures that species survive, and communities could expect to find food in the same place in the future.

FIGURE 7 A dot painting depicting land at Kiwirrkura, 400 kilometres west of Alice Springs



Source: © Donkeyman Lee Tjupurrula Kukatja (c. 1921)–1994 *Tingari Dreaming at Walawala* (1989)
Synthetic polymer paint on canvas, 119.7 × 179.3 cm
Purchased from Admission Funds, 1989
National Gallery of Victoria, Melbourne
© Donkeyman Lee Tjupurrula/Licensed by VISCOPY 2013

FIGURE 8 A selection of different foods and water resources

Cereal foods: Grass seeds from the clover fern were ground to form flour for damper. Many other seed types were similarly treated.

Fruit and vegetables: Fruits, berries, orchids and pods were available, depending on the region and seasonal availability (for example, sow thistle, lilly pilly, pigface fruit, kangaroo apple, wild raspberry, quandong and native cherry) as well as wild figs, plums, grapes and gooseberries. Also eaten were plant roots such as bull rushes, yams and bulbs; the heart of the tree fern and the pith of the grass tree; and the blister gum from wattles, native truffles and mushrooms.

Eggs: Emu, duck, pelican and many other birds' eggs were eaten.

Meat: Meats included insects such as the larval stage of the cossid moth or witchetty grub and the Bogong moth, honey ants, native bees and their honey and scale insects; animals such as kangaroos, emus, eels, crocodiles, sea turtles, snakes, goannas and other lizards; and birds such as ducks, gulls and pelicans.

Fish and shellfish: Freshwater fish such as perch, yabbies and mussels in creeks and rock holes, and all varieties of saltwater fish were caught.

Medicines: Over 120 native plants were used as sedatives, ointments, diarrhoea remedies, and cough and cold palliatives as well as for many other known treatments.

Water: Water was obtained from rivers, lakes, rock holes, soaks, beds of intermittent creeks and dew deposited on surfaces. Moisture obtained from foods such as plant roots and leaves also provided water.

The use of fire

Fire stick farming techniques are an important aspect of First Nations Australians' land management practices. What has been described as the 'park like' landscape of the Australian bush is purposely created in a controlled burn using fire sticks. After the fires, new plant growth with tender shoots attracts all types of birds and animals to the area. In fact, many native plant seeds need fire in order to germinate. The grassland areas that result from the controlled burning of the landscape became ideal places to hunt kangaroos. Burning also causes animals to be flushed out into the open where they could be speared.

The arrival of Europeans

Since European occupation, many First Nations Australians have been displaced from their Country and many cultural practices have been compromised. This is because government policies forced First Nations Australians to move to missions and denied them access to Country, with no understanding of the spiritual and cultural importance it possesses. This led to the loss of many sustainable land management practices that are only recently being revived.

2.2.5 CASE STUDY: Eel farming by the Gunditjmara people of Victoria

Starting with the introduction of the *Native Title Act 1993* and further government legislations, members of First Nations Australian communities have been able to use their deep knowledge of the land and connection to Country through collaborative land and water management projects. One example where the role of First Nation Australian Elders, community leaders and park rangers can be seen operating is in the Mount Eccles National Park near Portland in Victoria. As the traditional owners and custodians of the land, the Gunditjmara people manage the Budj Bim National Heritage Landscape through the Windamara Aboriginal Corporation and other Aboriginal organisations. This has helped foster First Nations Australian cultural values and practices through the sustainable management of Country.

FIGURE 9 Remains of Gunditjmara stone eel traps at Lake Condah

The Budj Bim National Heritage Landscape, which was World Heritage listed in 2019, is the site of one of Australia's largest ancient aquaculture systems dated from at least 6000 years BCE. The ancient site shows evidence of a large, permanent settlement of stone huts and channels used for farming and the local trade of eels. The Gunditjmara people managed this landscape by digging channels and constructing weirs to bring water and young eels from Darlot Creek to local ponds and wetlands. Woven baskets placed at the weirs were used to harvest the mature eels. The area provided an abundance of food, ensuring food security for all (see **FIGURE 9**).

Following European occupation of the area in the 1830s, the Gunditjmara people fought for their lands in the Eumerella Wars, which lasted for more than 20 years. Once occupied by European settlers, their lands were turned into mixed farming stations. By the 1860s the remaining Gunditjmara people were displaced to a government mission at Lake Condah. The mission lands were returned to the Gunditjmara people in 1987. Thereafter the Deen Maar Indigenous Protected Area (IPA) was declared in 1999 and the area was listed on the Australian National Heritage register in 2004.

Today the Gunditjmara Council and park rangers manage the 248-hectare Darlot Creek (Killara), which flows from Lake Condah in the Budj Bim National Heritage Landscape. They aim, through the application of custodial or stewardship-centred worldviews, to reinstate the wetlands and manna gum woodlands and re-establish the eel aquaculture industry as a sustainable business prospect. Further works are in progress to control weeds and feral animals and to expand tourism by building visitor boardwalks and information signage. The aim is the control of the human-induced environmental changes to the landscape, with Country being returned to close to its original natural state.

2.2 SKILL ACTIVITY: Interpreting and analysing geographical data and information

Complete the **Treading lightly** worksheet, in the eWorkbook section of the Resources panel, to explore this lesson's themes further.

on Resources

Interactivity Nature's bounty (int-3287)

2.2 Exercise

learnon

2.2 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 2, 3, 4, 6, 11	5, 7, 8	9, 10, 12

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Check your understanding

1. Insert the correct word into the sentence below: **benefits** / **dangers**
   Ecological services are the _____ to humanity from the resources and processes that are supplied by ecosystems.
2. **Select** the definition of an ecological footprint.
   - A. How much green space is left in a city
   - B. How much each person recycles
   - C. A measure of human demand on the Earth's natural systems
   - D. A measure of the Earth's demand on human natural systems
3. **Determine** whether the following statements are true or false.
   - a. Biocapacity is the capacity of a biome or ecosystem to generate a non-renewable supply of resources without processing its wastes.
   - b. There are two ecological services.

4. Match the ecological services to their descriptions.

Ecological service	Description
A. Provisioning	**a.** control of natural processes and capacity to regulate climate, soil and water
B. Regulating	**b.** goods that people use or harvest from nature
C. Supporting	**c.** religious, spiritual, aesthetic, educational, recreational and tourism benefits derived from nature
D. Cultural	**d.** the foundation of all services

5. Using details in **FIGURE 5**, explain what one global hectare (gha) represents.

Apply your understanding

Questioning and researching using geographical methods

6. **Name** six factors that are considered when measuring ecological footprints.
7. **Consider** and name the main criteria that the Sustainable Society Index uses to qualify *sustainable* human action.

Concluding and decision-making

8. Refer to **FIGURE 5**.
   a. **Reflect on** the reasons you believe the United States has such a large ecological deficit.
   b. Is Australia in an ecological deficit?
9. Study **FIGURE 6**. **Determine** from the following list the two areas with an ecological footprint of over a factor of 5 global hectares per capita.
   A. USA
   B. Asia
   C. Africa
   D. Europe
   E. Australia
   F. New Zealand
10. Refer to **FIGURE 6**. Of the world regions identified on the map, **decide** which ones have an ecological footprint in excess of biocapacity. **Explain** why this might be the case.

Communicating

11. **Define** what is meant by an 'Earth-centred worldview'.
12. **Discuss** how First Nations Australians use fire to manage the environment.

LESSON
2.3 Is climate change heating the Earth?

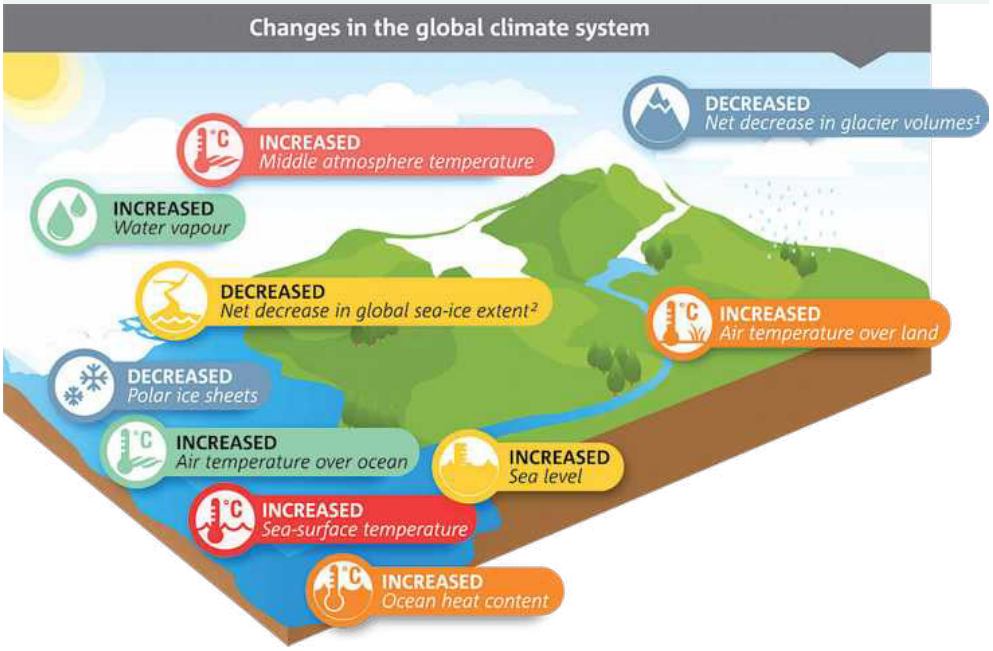
LEARNING INTENTION

By the end of this lesson you should be able to explain the processes through which the Earth's atmosphere is heated, and describe the role of human activity in the enhanced greenhouse effect.

TUNE IN

Climate change through global warming is a serious concern because it can cause changes to all natural environment systems as well as the built environment.

FIGURE 1 Consequences of changes in the global climate



Source: Bureau of Meteorology and CSIRO.

1. Select one environment shown in **FIGURE 1** and state what impacts that change could have on your lifestyle, in terms of increases and decreases shown.
2. Changes in polar ice sheets and in sea levels are very closely related. How would the melting of the polar ice sheets impact on coastal environments in terms of natural and built environment?

2.3.1 Climate change and global warming

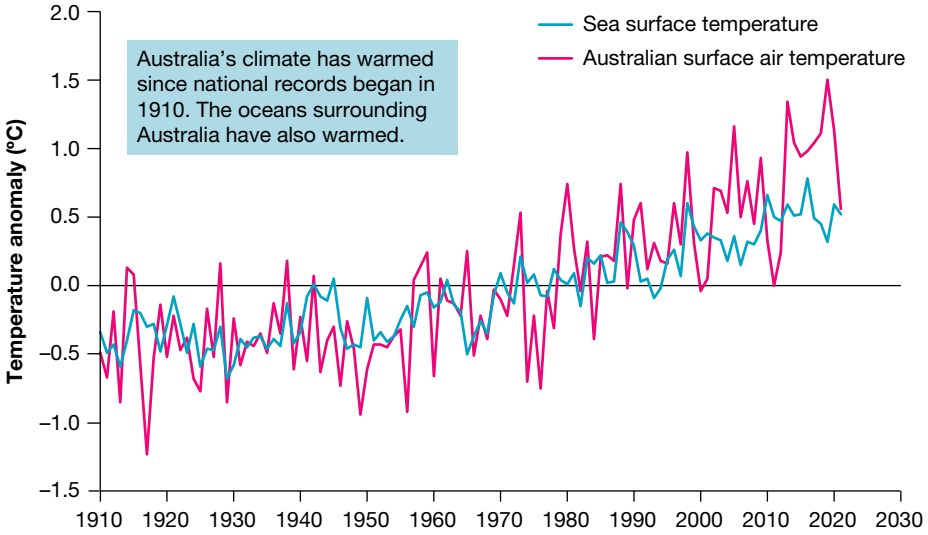
The world's climate has been changing for millions of years but, more recently, the concentration of greenhouse gases in the atmosphere has increased, leading to **global warming**. In particular, it is believed that burning fossil fuels such as coal and oil has led to what is known as the **enhanced greenhouse effect**, which is heating the Earth and its atmosphere. Despite ongoing debate about the nature and extent of climate change, the majority of the scientific community agrees that global warming and climate change exist and will result in ongoing changes to world weather patterns and, in the longer term, climates from the equatorial to polar regions. The wider consequences of global warming will also lead to environmental change across a wide range of biophysical systems (see **FIGURE 1**).

global warming the observable rising trend in the Earth's atmospheric temperatures, generally attributed to the enhanced greenhouse effect

enhanced greenhouse effect increasing concentrations of greenhouse gases in the Earth's atmosphere, contributing to global warming and climate change

Climate is the long-term weather patterns of a particular area, It is highly variable over the Earth's surface. For example, climates in the tropics are quite different from climates near the poles. Climate also varies over extensive periods of time. 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 we know that human activity is increasing the rate of global warming leading to **climate change**. This has particularly occurred in the past few hundred years, and can have serious consequences for the planet (see **FIGURE 2**).

FIGURE 2 Australia's temperature change to 2022



Source: Based on information taken from Bureau of Meteorology and CSIRO

climate change any change in climate over time, whether due to natural processes or human activities

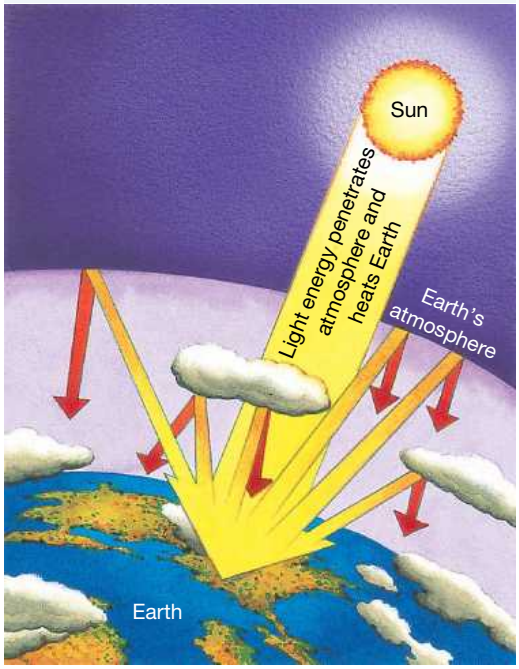
2.3.2 Human activity and the enhanced greenhouse effect

The greenhouse effect is the mechanism where solar energy is trapped by water vapour and gases in the atmosphere, heating the atmosphere and helping to retain this heat, as in a glasshouse (see **FIGURE 3**). 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.

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 '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 4**). 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.

FIGURE 3 How the greenhouse effect works

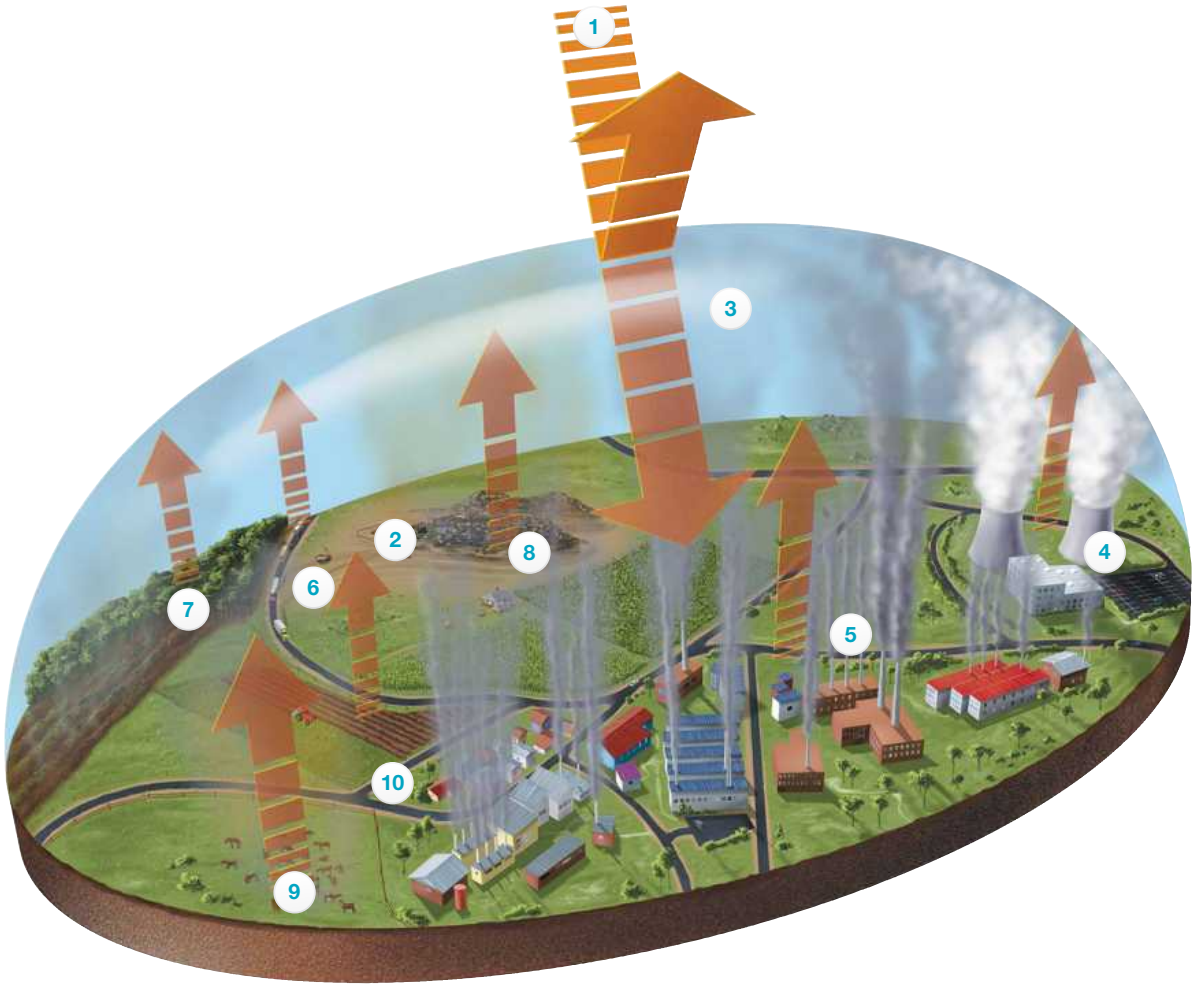


Six key risks that have been identified in Australia alone include:

- higher temperatures
- sea-level rise
- heavier rainfall
- greater wildfire risk
- less snow cover
- reduced run-off over southern and eastern Australia
- more intense tropical cyclones and storm surges along the coast.

int-7951

FIGURE 4 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

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

1. Using the information in **FIGURE 4**, work together in small groups to prepare a report that **explains** how the enhanced greenhouse effect operates. Here are some steps to get you started.
   - **Summarise** what the enhanced greenhouse effect is.
   - **State** its causes.
   - **Identify** its effects.
2. You may also need to carry out further **research** to gather more information.
3. **Create** a presentation for the class. Use a mix of text and visual material in your presentation.
4. The presentation should include your group's **proposals** about what we can do to reduce the impacts of the enhanced greenhouse effect.

2.3 Exercise

learnon

2.3 Exercise

Learning pathways

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

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. Climate change is the naturally occurring changing of the world's climate.
   b. Global warming is the result of greenhouse gases in the atmosphere increasing.
   c. Without the greenhouse effect, the atmosphere would be much cooler.
2. Why would sea levels be much lower in an ice-age period?
   A. Sea water evaporates at a faster rate than it is replenished.
   B. Sea water is stored in ice caps and glaciers.
   C. There is less rain as it is too cold to fall.
   D. All of the above
3. **Explain** what changes have occurred to the Earth's climate over geological time.
4. **Explain** the greenhouse effect.
5. **State** the three atmospheric gases responsible for the greenhouse effect.

Apply your understanding

Communicating

6. **Explain** the role that trees play in the carbon cycle and in controlling the level of greenhouse gases.

Interpreting and analysing geographical data and information

7. **Consider** what impacts global warming, and in particular higher water temperatures, will have on a marine ecosystem such as the Great Barrier Reef.
8. **Examine FIGURE 2**.
   a. What is the time period shown in the graph?
   b. What is the total temperature increase shown between the start and end points of the graph?
   c. **Identify** the general trend shown by the graph.
9. **Discuss** why the greenhouse effect is crucial to maintaining life on Earth.

Concluding and decision-making

10. a. **Determine** which energy-saving actions your household participates in.
    b. **Propose** other actions that could be taken in the future.

LESSON
2.4 How do we tackle climate change?

LEARNING INTENTION

By the end of this lesson you should be able to discuss responses to human-induced climate change at a range of scales, and explain the impact of fossil fuels and alternative energy sources.

TUNE IN

There are many options to create power other than coal-, oil- and gas-burning power stations. These fossil fuels emit carbon dioxide that is heating the Earth's atmosphere and causing global warming.

FIGURE 1 Some sources of renewable energy: (a) solar, (b) wind, (c) hydro-electric and (d) geothermal

1. Select one of the examples shown in **FIGURE 1** and comment on what natural resource of the environment is used to generate power/electricity.
2. Name any of these power-generating facilities you have seen in your travels and give a brief description of how it works.

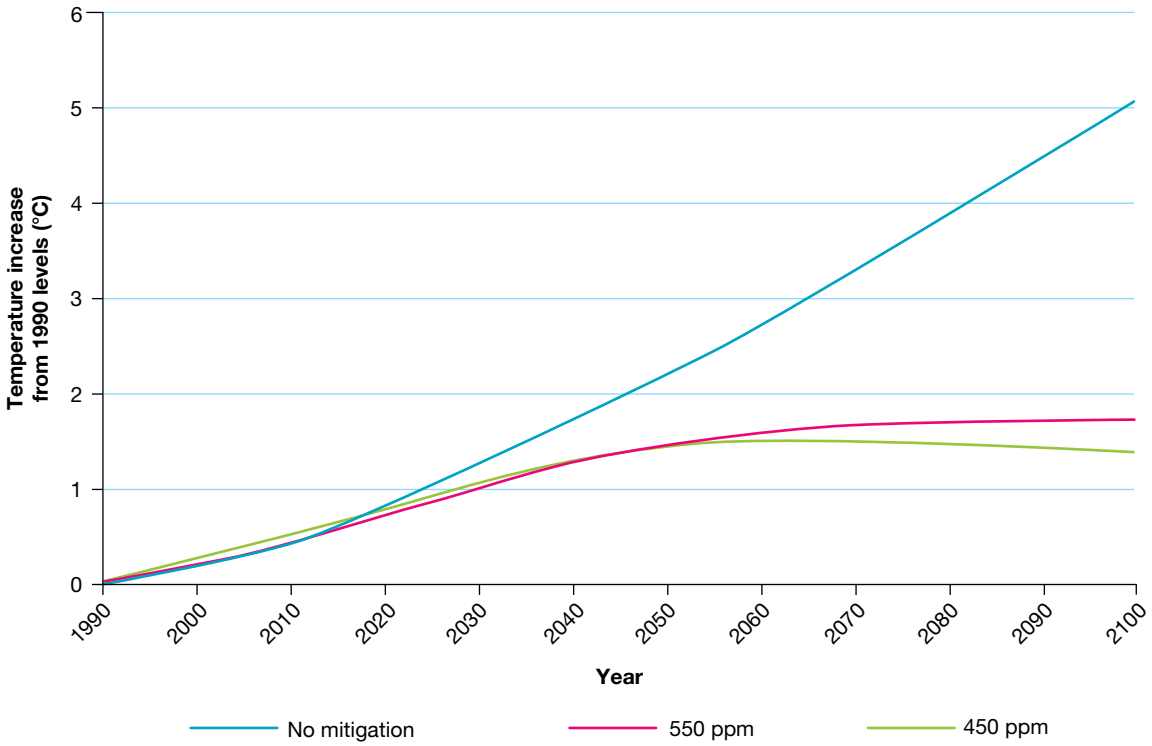
2.4.1 Global action

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 the United Nations Intergovernmental Panel on 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, 2010 in Cancun, 2015 in Paris and 2021 in Berlin, 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 2**. To date, 192 of the world's 195 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 United States has signed the Protocol but has not ratified emission targets and Canada has withdrawn from the Protocol.

FIGURE 2 *Global average temperature outcomes for three emissions cases, 1990–2100



*projected

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 volume 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 act as carbon sinks (such as tree planting and underground storage of CO_2).

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 credit a tradeable certificate representing the right of a company to emit one metric tonne of carbon dioxide into the atmosphere

2.4.2 Australia's action

The 2011 Garnaut Report and the findings of the 2021 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 the 2011 report were confirmed at the IPCC meeting in Paris in 2015. In 2022, the newly elected government Labor government announced their Commitments to Climate Change. A key part of this more ambitious plan was a commitment to reduce greenhouse gas emissions to 43 per cent below 2005 levels by 2030. The plan will help Australia meet its commitments by:

- establishing a new Department of Climate Change, Energy, the Environment and Water.
- passing a climate change bill in September 2022
- creating a Climate Change Authority
- releasing an annual climate change statement, reporting progress towards climate change targets
- creating new emissions strategies such as Rewiring the Nation to rebuild and modernise the electricity network, the National Electric Vehicle strategy, and directing part of the National Reconstruction Fund (NRF) to clean energy investment.

Australia has also committed to net zero carbon emissions by 2050. This means that, by 2050, the amount of CO_2 that is being removed from the atmosphere will have to be the same as, or more than, the amount that is emitted. The government plans to do this by using existing and emerging technologies, rather than by introducing a tax or a price on carbon that would create a disincentive on fossil fuel production. In 2020, Australia claimed success in meeting its targets under the Kyoto Protocol.

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.

2.4.3 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 ten-point plan that every Australian household can follow to reduce its level of greenhouse gas pollution (see **FIGURE 3**).

FIGURE 3 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 for a list of who qualifies.
2. ***Get rid of one car in your household***
   A car produces seven tonnes of greenhouse pollution each year (based on travelling 15 000 km 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.

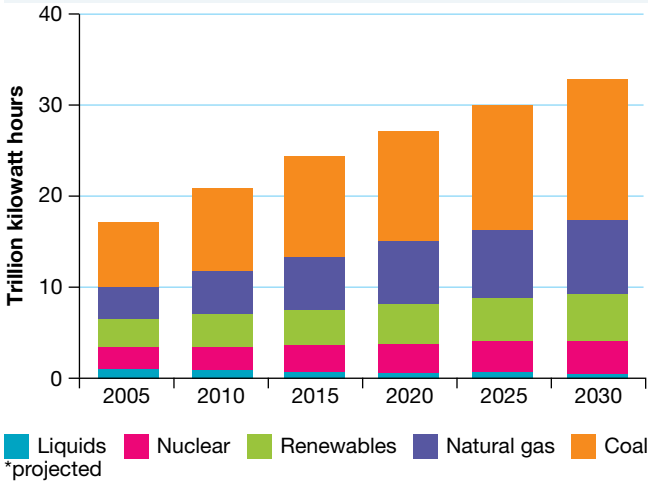
3. ***Take fewer air flights***
   A return domestic flight in Australia creates about 1.5 tonnes of greenhouse emissions (based on Melbourne to Sydney return). A return international flight creates about 9 tonnes (based on Melbourne to New York return). Holiday closer to home.
4. ***Use less power to 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 km 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.

2.4.4 The role of fossil fuels and renewable energy

Climate authorities have declared that global warming is possibly the most important issue affecting life on Earth now 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 recognised 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 4** and **5**).

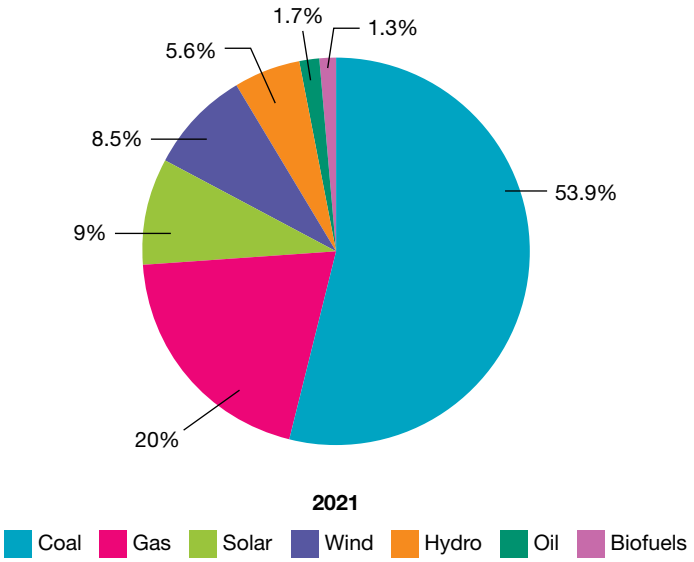
FIGURE 4 World electricity generation by fuel, 2005–30*



Source: Energy Information Administration.

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.

FIGURE 5 Australia's primary energy sources, 2021



Source: Department of Industry, Science, Energy and Resources, 2021.

The environmentally friendly alternative 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 1**). The movement to environmentally friendly alternative energy fuels will confirm a significant change in thinking, from a human-centred to an Earth-centred worldview. This change in thinking will lead to a more sustainable use of energy with a significantly lower impact of greenhouse gas emissions on the environment.

Many countries throughout the world are now using or developing sustainable energy industries. The United States, for example, has established the Clean Energy Plan and currently produces 1.66 per cent of its energy needs from solar power, with renewable energy sources comprising 10 per cent of its total electricity generation. In Europe, Germany has made great progress in harnessing renewable energy sources, which today provide 29.5 per cent of its power generation needs. Wind energy alone provides just over one-third of this amount.

In 2021, 29 per cent of Australia's total electricity generation was from renewable energy sources. With our 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. Small-scale solar generation (that is, on domestic houses) grew by 29 per cent in 2021 and an average of 28 per cent per year over the last 10 years. Solar now represents 4 per cent of all Australian electricity generation. 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.

2.4.5 Future action

In 2022, the IPCC confirmed the 2007 recommendations to reduce greenhouse gas emissions. They cover a wide range of human activities, with suggestions for management to mitigate global warming (see **TABLE 2**).

For each mitigation action shown in **TABLE 2** 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.

geothermal (power) 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.

TABLE 2 Reducing greenhouse gas emissions

	Ways to reduce greenhouse gas emissions
Energy supply	• Increasing use of renewables such as hydro-power, solar, wind, wave and tidal, geothermal and bioenergy • Switching from coal to gas • Carbon capture and storage (CCS) at fossil fuel electricity generating facilities • Developing safer and cleaner nuclear energy (although this is also debated in terms of its sustainability)
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.

DISCUSS

Is it the responsibility of the ordinary citizen or the government to accept the consequences of climate change and do something about it? Discuss your view.

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

1. Use the internet to **research** geothermal energy.
   a. Use these questions as a starting point:
      - What is it?
      - How is it captured or created?

- What are the positive and negative points about using it?
- Is it expensive?
- What technology does it use?

b. **Summarise** your information in a table.

2. **Investigate** its potential as a future energy source.
3. **Synthethise** your research and write a report on your findings.

Resources

Interactivity Small acts, big changes (int-3288)

2.4 Exercise

learnon

2.4 Exercise

Learning pathways

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

These questions are even better in jacPLUS!

- Receive immediate feedback
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Check your understanding

1. The _____ Protocol is an agreement that sets targets to limit greenhouse gas emissions, signed by 128 countries.
2. A 'fossil fuel' is composed of dead animal bones. True or false?
3. **Decide** what would be the most effective and safe renewable energy source for the future. Select your two preferred answers from the following list.
   - A. Nuclear energy
   - B. Wind farms
   - C. Coal-fired power stations
   - D. Hydro-electric power stations
4. **State** which arm of the United Nations is involved in formulating measures to tackle climate change.
5. **Name** five major renewable energy sources.
6. **Describe** why organisations such as the Australian Conservation Foundation would have different views about climate change and global warming than companies that produce electricity.

Apply your understanding

Interpreting and analysing geographical data and information

7. Refer to **FIGURE 2**. **State** how much temperatures will increase by 2070 if no mitigation actions are taken. **Identify** the emissions case that would reduce temperature change the most by 2100.
8. Refer to **TABLE 1** and the 450 ppm emissions case. **Identify** what percentage of species is at risk of extinction. **Predict** what might happen to the Great Barrier Reef under the 550 ppm case.
9. Refer to **FIGURE 5**. **Identify** what percentage of Australia's energy currently comes from renewable sources, and predict how Australia's primary energy source usage might change by 2030.
10. **Evaluate** why the use of fossil fuels isn't sustainable.

Concluding and decision-making

11. **Investigate** the environmental, social and economic consequences of the different management strategies adopted for renewable energy use in Australia, the United States and Germany, outlined in section 2.4.4.

LESSON
2.5 Is Australia's climate changing?

LEARNING INTENTION

By the end of this lesson you should be able to explain the interconnection of people with the environment, and evaluate the impacts of climate change on Australia.

TUNE IN

In Australia we are used to weather extremes that result in flood, drought and bushfires, but do you know the climatic reasons these phenomena occur?

FIGURE 1 Floods in Townsville, February 2019, due to tropical cyclone Oma

1. What impacts would the flood as shown in **FIGURE 1** have on the social and economic livelihood of the people living in this place?
2. What management strategies are you aware of that local councils, state and federal governments put into place to reduce the impacts of floods?

2.5.1 Impacts of climate change in Australia

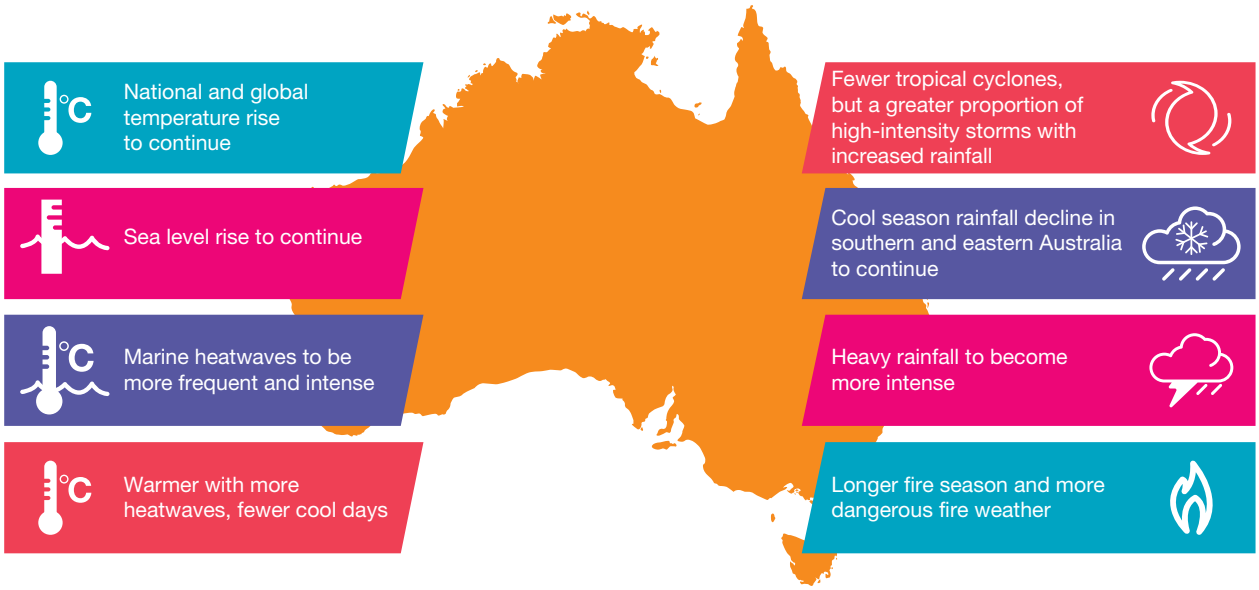
Research by government and non-government organisations, such as the Bureau of Meteorology (BOM), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the IPCC in 2022, has indicated that Australia is particularly vulnerable to climate change. The changes that will affect all Australian biophysical systems have been identified as eight key risks, which are outlined in **FIGURE 2**.

The challenge for the future is how to manage these risks to minimise negative consequences for the Australian environment, economy and social systems.

What changes are we seeing?

Australia's year-by-year climate statistics can be quite variable against long-term climate records, and floods and droughts have always occurred, breaking records in various regions. These variations in weather patterns are often referred to as climatic anomalies. The concern raised by global warming and climate change is the degree of climate variability and the likelihood of more extreme weather events. For instance, will we experience worse floods and droughts and more bushfires and severe cyclones, tornadoes and the like? Scientific evidence supports the view that there have been more extreme weather events in recent years and that the climate of Australia has undergone significant regional change (see **FIGURE 3**).

FIGURE 2 Key climate and severe weather risks for Australia



Source: Bureau of Meteorology and CSIRO

FIGURE 3 The *State of the Climate 2022* report

The *State of the Climate 2022* report, produced by the BOM and CSIRO made the following summary points.

- Australia's climate has warmed by an average of 1.47 ± 0.24 °C since national records began in 1910.
- Sea surface temperatures have increased by an average of 1.05 °C since 1900. This has led to an increase in the frequency of extreme heat events over land and sea.
- There has been a decline of around 15 per cent in April to October rainfall in the southwest of Australia since 1970. Across the same region, May to July rainfall has seen the largest decrease, by around 19 per cent since 1970.
- In the south-east of Australia, there has been a decrease of around 10 per cent in April to October rainfall since the late 1990s.
- There has been a decrease in streamflow at most gauges across Australia since 1975.
- Rainfall and streamflow have increased across parts of northern Australia since the 1970s.
- There has been an increase in extreme fire weather, and a longer fire season, across large parts of the country since the 1950s.
- There has been a decrease in the number of tropical cyclones observed in the Australian region.
- Snow depth, snow cover and number of snow days have decreased in alpine regions since the late 1950s.
- Oceans around Australia have continued to become more acidic, with changes happening faster in recent decades.
- Sea levels are rising around Australia, including more frequent extremes that are increasing the risk of inundation and damage to coastal infrastructure and communities.

Recent severe weather events

In 2022, in their annual report *Extreme Weather*, the Climate Council of Australia wrote:

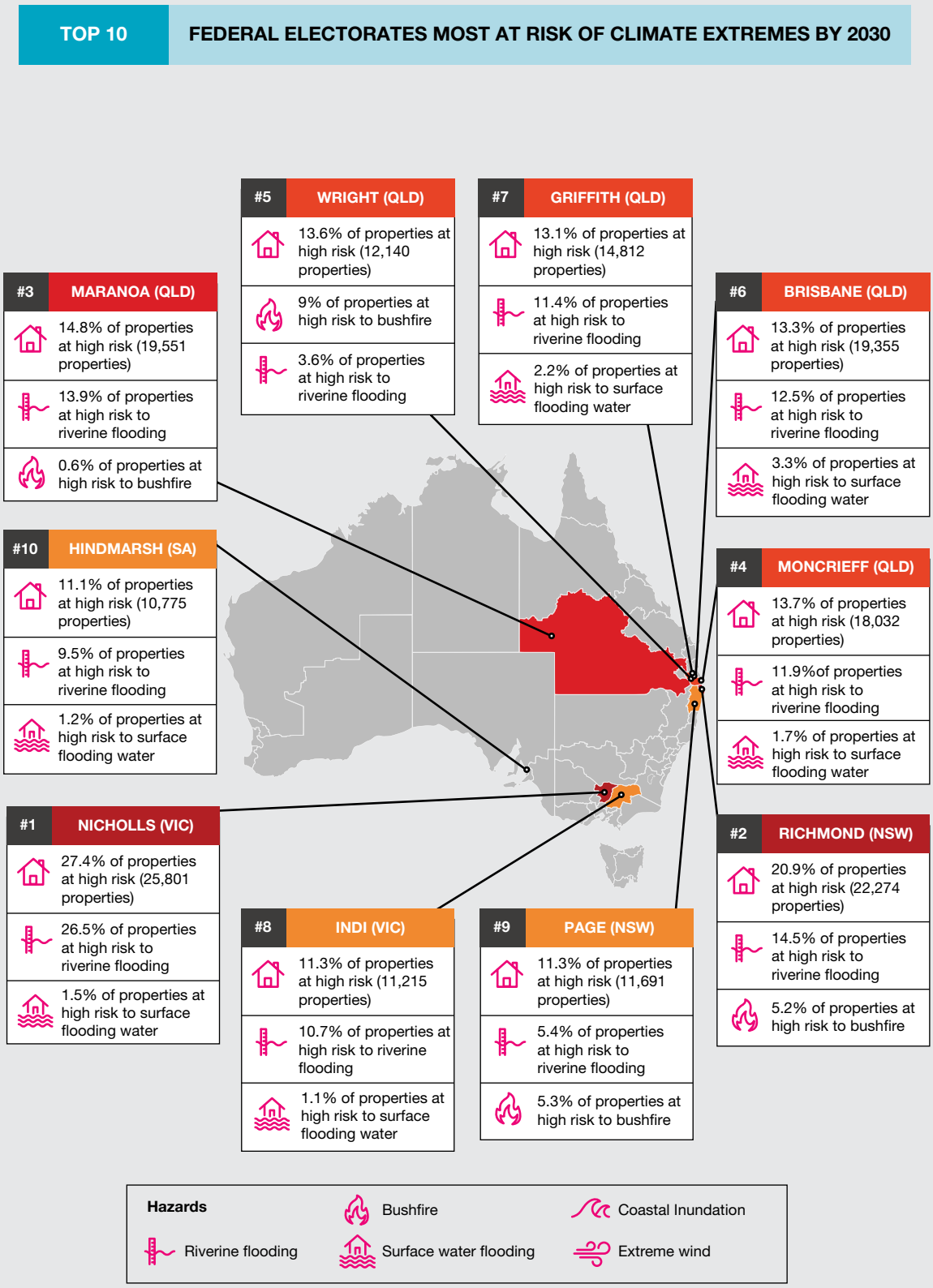
> Climate change is influencing all extreme weather events as they are occurring in a more energetic climate system. Australia is one of the most vulnerable developed countries in the world to the impacts of climate change. Heatwaves are becoming longer, hotter and starting earlier in the year. In the south of the country, where many Australians live and work, dangerous bushfire weather is increasing and cool season rainfall is dropping off, stretching firefighting resources, putting lives at risk and presenting challenges for the agriculture industry and other sectors, such as tourism.

Of particular concern is the spate of La Niña events that produced extreme flooding in NSW, Queensland and Victoria in 2021 and 2022. **FIGURE 4** outlines locations in Australia most at risk of climate extremes by 2030.

int-9112

tlvd-10760

FIGURE 4 Indications of climatic change from the Climate Council of Australia



Source: Was redrawn based on an image from https://www.climatecouncil.org.au/resources/uninsurable-nation-australias-most-climate-vulnerable-places/

2.5.2 Impacts on the environment, economy and social systems

Some of the impacts of climate change that will require management by governments and communities include:

- impacts on fragile and diverse biomes and ecosystems; for example, the Great Barrier Reef, where warming of 1 °C and acidifaction are expected to have significant impacts on biodiversity, with losses of species and associated coral communities and the potential for up to 97 per cent of the reef to be subject to coral bleaching
- changed temperatures and rainfall regimes affecting the potential of agriculture and forestry to maintain crop yields such as wheat, and timber yields from forests
- reduced river flows in the Murray–Darling Basin with significant impacts on agriculture, industry and urban household use
- more extreme weather events such as heatwave conditions, with an increase in the number of days when the forest fire index rating is very high or extreme
- more severe tropical cyclones, with associated property damage due to strong winds and flooding
- spread of tropical diseases such as dengue fever and malaria to southern regions.

FIGURE 5 Climate change is projected to have a significant impact on the biodiversity of the Great Barrier Reef.

Managing the impact of severe weather

Scientific experts agree that environments will change due to global warming and climate change and this will have a range of economic and social consequences, to which society will need to adapt. Industries such as agriculture and forestry may be particularly affected. When this occurs, governments and other agencies will need to encourage and facilitate employment opportunities in alternative industries, such as renewable energy.

A number of approaches can be taken to deal with the potential impact of severe weather events. The threat of flooding can be reduced with the redesign of urban infrastructure to improve storm water drainage. If redesign is not able to solve the problem, there may be a need for some people to consider relocating away from the flood-prone coastal and riverine locations in which they currently live.

Successful management strategies in relation to events such as cyclones and bushfires include the development of improved tropical cyclone warning systems. Monitoring is conducted and warnings issued by the Bureau of Meteorology, and bushfire warnings, issued by relevant state fire authorities. National and state-based agencies such as State Emergency Management Committee WA, Emergency Management Victoria and Emergency New South Wales all provide a range of information and resources aimed at minimising the impacts on communities of severe weather events. They also assist with management strategies such as emergency evacuation planning. Improved building design to withstand these severe weather events is another successful form of management strategy.

Government Disaster Relief programs that offer financial and other assistance to individuals and communities to recover after events such as flood, fire and drought are further examples of impact management.

Perhaps most importantly, the root causes of severe weather events as a consequence of global warming and climate change need to be addressed. The Australian Conservation Foundation's ten-point plan (see **FIGURE 3** in section 2.4.3) suggests a range of personal energy-use management strategies that aim to minimise individuals' contribution to greenhouse gas emissions, such as switching to solar energy and other renewables.

If adopted by businesses and the general community, these strategies will go a long way towards reducing the environmental impacts of climate change and global warming, thereby helping to reduce the social and economic impacts.

SkillBuilders to support skill development

- 7.16 Describing change over time

2.5 SKILL ACTIVITY: Questioning and researching using geographical methods

1. Use the internet to find out about Pacific Island nations that are threatened by rising sea levels because of climate change.
2. **Identify** where are they located.
3. **Summarise** any plans in place to protect these areas.
4. **Discuss** your findings with a partner.

2.5 Exercise

learnon

2.5 Exercise

Learning pathways

■ LEVEL 1	■ LEVEL 2	■ LEVEL 3
1, 2, 3	5, 6	4, 7, 8

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Check your understanding

1. Australia's temperatures are expected to increase because of climate change. True or false?
2. Climate change will have minimal impact on tourism in the Gold Coast region of Australia. True or false?
3. **Identify** three extreme weather events that are expected to increase in frequency due to climate change.
4. **Determine** three key points from the *State of the Climate 2022* report (**FIGURE 3**) that you consider to be correct.
   - A. Sea levels are rising around Australia.
   - B. The pH of the oceans is increasing.
   - C. Rainfall has increased across parts of northern Australia since the 1970s.
   - D. There has been a long-term increase in extreme fire weather, and in the length of the fire season, across large parts of Australia.
   - E. Streamflow has increased across southern Australia.

Apply your understanding

Interpreting and analysing geographical data and information

5. Study **FIGURE 4**, which outlines locations in Australia most at risk of climate extremes by 2030, to **investigate** the following:
   - a. The general pattern of hazards for the locations outlined.
   - b. The types of hazards experienced closest to where you live.

Concluding and decision-making

6. **Summarise** in dot point form an evacuation plan for a house or town in a bushfire-prone area.
7. **Predict** how rising sea levels will affect Australia's state capital cities that are located on the coast.

Communicating

8. **Discuss** strategies that you think people who live in tropical cyclone-prone areas could adopt to cope with increased severe weather events.

LESSON
2.6 Investigating topographic maps: Environmental change in Jindabyne

LEARNING INTENTION

By the end of this lesson you should be able to describe potential effects of environmental change in Jindabyne and provide examples from a topographic map to support your ideas.

2.6.1 Environmental change in Jindabyne

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 An oblique aerial view of Jindabyne

on Resources

eWorkbook	Investigating topographic maps — Environmental change in Jindabyne (ewbk-10069)
Digital document	Topographic map of Jindabyne (doc-36367)
Video eLesson	Investigating topographic maps — Environmental change in Jindabyne — Key concepts (eles-5242)
Interactivity	Investigating topographic maps — Environmental change in Jindabyne (int-8670)
Google Earth	Jindabyne (gogl-0102)

FIGURE 2 Topographic map of Jindabyne

Source: Spatial Vision

2.6 Exercise

learnon

2.6 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** the grid references of the following.
   a. Cobbon Farm
   b. Lakewood Estate
   c. Mill Ridge
2. **Identify** the direction, bearing and straight line distance from:
   a. Owl Moon Ridge to Grellenger
   b. Jindabyne Dam to Rainbow Drive
   c. Jindabyne Airport to Tigers Rest.
3. **Identify** and **describe** examples of the following landforms. Use area references to identify the locations in your descriptions.
   a. A saddle
   b. A plateau
   c. A valley

Apply your understanding

Communicating

4. **Examine** the features of the map and **FIGURE 1**. 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. **Propose** environmental management strategies that could be implemented to address this change.
5. **Outline** your route, including distances and directions of travel, if you were staying on the unsealed part of Rainbow Drive in Tyrolean Village overlooking Willow Bay and wanted to go fishing in the Thredbo River.
   a. Plan the most direct route.
   b. Plan the route that might offer the most interesting scenery. **Explain** your choices.
6. Based on the direction and features of the land, do you think the Old Kosciusko Road that ends in East Jindabyne used to meet up with the route of the current Kosciusko Road? **Justify** your answer using specific data from the map.

LESSON
2.7 INQUIRY: Extreme weather

LEARNING INTENTION

By the end of this lesson you should be able to investigate extreme weather events in Australia and outline the link between these events and climate change.

Background

In this inquiry, you will **investigate** extreme weather events in Australia and make connections between these severe events and climate change.

Before you begin

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

FIGURE 1 Droughts occur regularly in the Australian landscape.

Inquiry steps

These example inquiry questions can be used or adapted to focus the development of your geographical knowledge, understanding and skills.

- What extreme weather events has Australia experienced?
- What management options exist to combat climate change?
- How does Australia react to climate change and what are its consequences?

Step 1: Questioning and researching using geographical methods

Discuss the following with members of your class.

- What you know about extreme weather events
- How has human activity affected the world's environment and weather?

Write your selected inquiry question based on the focus of this topic.

Step 2: Interpreting and analysing geographical data and information

- **Conduct** research into extreme weather events in Australia and climate change.
- **Summarise** relevant data associated with climate change in table or graph form.
- **Select** annotated images and maps to illustrate different aspects of extreme weather.
- Write a short **summary analysing** how climate change affects Australia and the world. Make use of extreme weather examples.

Step 3: Concluding and decision-making

- Conclude your inquiry by **proposing** potential strategies to help combat climate change.

Step 4: Communicating

- Prepare a brief speech based on your findings and be prepared to deliver it to your class.

Complete your self-assessment using the **Inquiry rubric** or access the 2.7 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-39881)

LESSON
2.8 Review

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

Access the topic summary | Review your results | Watch teacher-led videos | Practise questions with immediate feedback

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2.8.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

2.2 How do we interact with the environment?

- Although the world is a huge space, population increases over the past 200 years have put a strain on the capacity of ecological services to sustain modern day societies.
- Changes in thinking about the environment from a human-centred to Earth-centred approach are offering hope that a sustainable world can be achieved by reducing the pressure of human activities on ecological services.
- First Nations Australians managed the environment in a sustainable manner based on a sophisticated understanding of food and water security and its association with the seasons.

2.3 Is climate change heating the Earth?

- The greenhouse effect has been affected by human activities, particularly activities to produce power, such that an enhanced greenhouse effect is leading to global warming of the Earth's atmosphere and oceans.
- Renewable energy sources such as solar, wind, tidal and hydro for power generation will reduce the level of global warming.

2.4 How do we tackle climate change?

- Meetings of world government bodies such as the IPCC have set goals for reducing greenhouse gas emissions.
- The Australian government, as a signatory to the Kyoto Protocol, which aims to reduce human-induced greenhouse gas emissions, has developed national plans to manage sustainable power sources.
- Fossil fuels are a major source of greenhouse gas emissions and many nations are seeking ways to develop renewable energy sources such as solar, wind, hydro, tidal, biomass and geothermal methods of producing electricity.
- The IPCC has set forth a wide range of management strategies to reduce greenhouse gas emissions.

2.5 Is Australia's climate changing?

- Australia's climate has been changing in the recent past because of the effects of global warming on temperature and precipitation regimes.
- Severe weather events have become more common with wider fluctuations of temperature and rainfall that can be attributed to climate change.
- The impact of climate change on the environment, economy and social systems is a major focus of management strategies for all levels of government in Australia.

2.6 Investigating topographic maps: Environmental change in Jindabyne

- Topographic maps can be used to understand and describe potential effects of environmental change in Jindabyne.

2.7 INQUIRY: Extreme weather

- The link between extreme weather events in Australia and climate change can be investigated.

2.8.2 Key terms

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

carbon credit a tradeable certificate representing the right of a company to emit one metric tonne of carbon dioxide into the atmosphere

climate change any change in climate over time, whether due to natural processes or human activities

custodial management a sense of responsibility towards land and the landscape. Includes the concepts of sustainable natural resource management and managing natural resources, both now and in the future.

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person for food, water, transport, housing, waste management and other purposes

ecological service the benefits to humanity from the resources and processes that are supplied by natural ecosystems

enhanced greenhouse effect increasing concentrations of greenhouse gases in the Earth's atmosphere, contributing to global warming and climate change

environmental worldview varying viewpoints, such as Earth-centred as opposed to human-centred, in managing ecological services

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.

geothermal (power) 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.

global warming the observable rising trend in the Earth's atmospheric temperatures, generally attributed to the enhanced greenhouse effect

Industrial Revolution the period from the mid 1700s into the 1800s that saw major technological changes in agriculture, manufacturing, mining and transportation, with far-reaching social and economic impacts

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

stewardship the belief that humans have a responsibility to care for the Earth to protect its future

2.8.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

The Earth is our home and provides us with everything we need to live. What are we doing to it in return?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-11498)
Reflection (ewbk-11799)
Crossword (ewbk-11800)

Interactivity Introducing environmental change and management crossword (int-7669)

2.8 Review exercise

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Multiple choice

1. Which of the following is another word for stewardship?
   - **A.** Ecological service
   - **B.** Biocapacity
   - **C.** Habitability
   - **D.** Custodial management
2. Which place has the largest ecological footprint?
   - **A.** The United States
   - **B.** Asia
   - **C.** Australia
   - **D.** Africa
3. Which of these statements is true about Australia?
   - **A.** Our biocapacity exceeds our ecological footprint.
   - **B.** Our ecological footprint exceeds our biocapacity.
   - **C.** Our biocapacity is more than twice our ecological footprint.
   - **D.** Our ecological footprint is more than twice our biocapacity.
4. What is global warming?
   - **A.** Changes in climate over time
   - **B.** Rising trends in global atmospheric temperatures
   - **C.** Human impact on the environment from carbon emissions
   - **D.** Long-term weather patterns
5. Which of the following is *not* one of the three most important gases for creating the greenhouse effect in our atmosphere?
   - **A.** Carbon dioxide
   - **B.** Nitrous oxide
   - **C.** Methane
   - **D.** Carbon monoxide
6. Which of these is *not* one of the six key risks to Australia of the enhanced greenhouse effect?
   - **A.** Sea levels rising
   - **B.** Increased risk of wildfires
   - **C.** Lighter rainfall in coastal areas in the south-west
   - **D.** More intense tropical cyclones
7. What can people do on a local scale to reduce their carbon emissions into the atmosphere?
   - **A.** Walk to work
   - **B.** Buy an older car
   - **C.** Use gas hot water
   - **D.** Remove house insulation

8. What is the IPCC?
   - **A.** United Nations' Intergovernmental Panel on Climate Change
   - **B.** United Nations' Intergovernmental Panel on Climate Crisis
   - **C.** United Nations' International Panel on Climate Change
   - **D.** United Nations' International Panel on Climate Crisis
9. What is a carbon credit?
   - **A.** A tax benefit to reward households who install solar panels
   - **B.** A subsidy for companies importing electric vehicles into Australia
   - **C.** A year in which the average global ocean temperature does not rise
   - **D.** A tradable certificate representing the right of a company to emit a specific amount of carbon dioxide into the atmosphere
10. How can industry reduce its greenhouse emissions?
   - **A.** More efficient equipment and power recovery
   - **B.** Loosening controls on gas emissions
   - **C.** Sending used fluorinated refrigeration gases to landfill
   - **D.** Ensuring all office buildings and workspaces maximise heat loss in cold weather

Short answer

Communicating

11. **State** three ways that you could improve your carbon footprint at home.
12. **Identify** a place in Queensland that would be negatively affected by some of the impacts of climate change. **Explain** how that place would be affected, and what the impacts would be.
13. **Create** your own Sustainable Society Index that outlines eight key rules which humans must follow to ensure their actions are sustainable. Include two social, two political, two economic and two environmental rules.
14. On balance, what is your worldview? Is it more human-centred or Earth-centred? Give reasons to **explain** your perspective.

Concluding and decision-making

15. Many Pacific island nations are threatened by rising sea levels. Do you think the global community has a responsibility to provide aid and relocation for people whose homes and traditional lifestyles are no longer possible because of climate change? **Justify** your view.
16. **Explain** what is meant by First Nations Australians' use of fire as a means of managing their environment.

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3 Land environments change and management

LESSON SEQUENCE

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LESSON
3.1 Overview

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In a world that continually demands more from the land, how can we manage change to meet our needs and protect Earth systems?

3.1.1 Introduction

Land is one of our most valuable resources. Left alone, it exists in a state of balance, and if managed wisely, will continue to do so. However, the land is under increasing pressure as a direct result of population growth; agriculture, mining and expanding settlements all have the potential to interfere with natural processes and cause environmental damage. Our challenge is to balance the needs of our growing population with sustainable land management practices, to protect this precious resource for future generations.

FIGURE 1 Without careful land management, severe environmental damage can occur.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11500)

Video eLesson Wasting our land (eles-1708)

LESSON
3.2 What are the causes and impacts of environmental change?

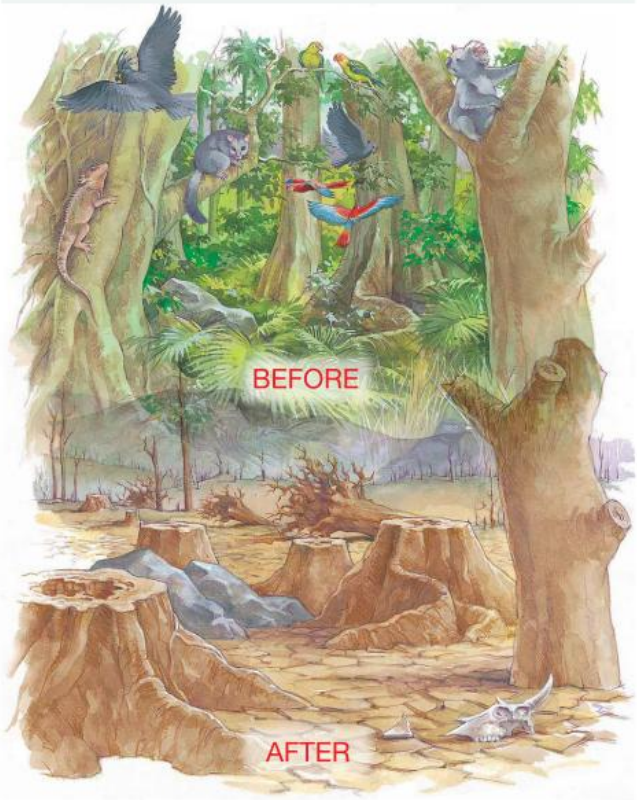
LEARNING INTENTION

By the end of this lesson you should be able to explain the causes and impacts of environmental change.

TUNE IN

Environmental change can cause the land to degrade and reduce its capacity to produce crops, support natural vegetation and provide fodder for livestock. Environmental change causes physical, chemical and biological changes; the natural environment deteriorates, and the landscape undergoes a dramatic change as shown in **FIGURE 1**.

FIGURE 1 Environmental change can have significant consequences for vegetation and fauna.



1. Describe the landscape that you observe in the before and after sections of **FIGURE 1**.
2. Rule up a table in your workbook, like the one shown.

Physical changes	Chemical changes	Biological changes
Loss of habitats	*Carbon dioxide released into atmosphere*	*Koalas starve*

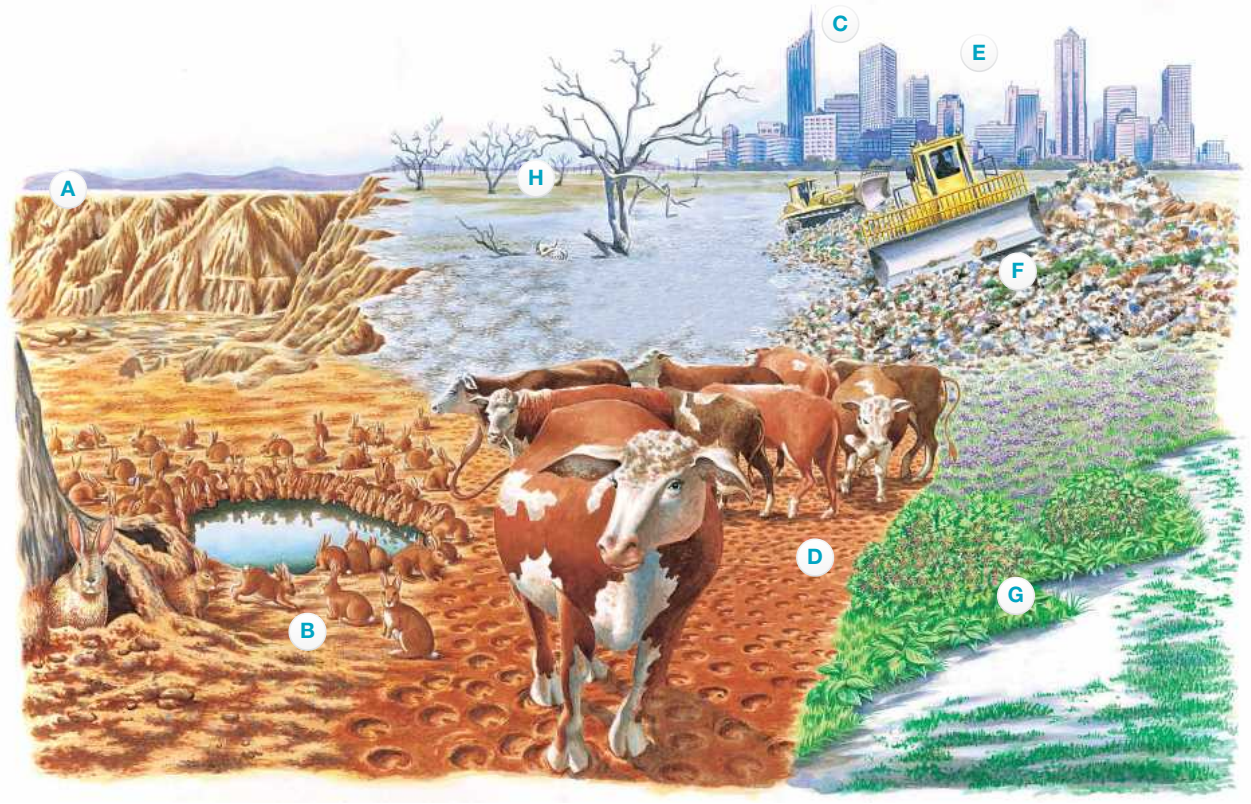
   a. Brainstorm a list of changes that might occur to the natural environment because of environmental change.
   b. Classify these changes as physical, chemical or biological and record your findings in the table. The first one has been provided for you.
3. There are many reasons for environmental change. Identify five things that you think might lead to environmental change. As a class, pool your results to determine the most common reasons identified.

3.2.1 What causes environmental change?

Environmental change, such as land degradation, has many causes, but most of these causes can be traced back to the influences of human activity on the natural environment. **FIGURE 2** outlines these activities and their impacts.

int-5591

FIGURE 2 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 is transported to rivers, where it can smother 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, making it increasingly difficult for native species to grow. 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 groundcover prevents light from reaching the soil.

H Salinity occurs naturally in areas where there is low rainfall and high evaporation and 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.

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.

FIGURES 3 and **4** show that agricultural activities and overgrazing combined account for more than 50 per cent of environmental change in the Asia–Pacific region and globally. Australia is ranked fifth in the Asia–Pacific region for clearing of native vegetation.

FIGURE 3 Causes of environmental change in the Asia–Pacific region

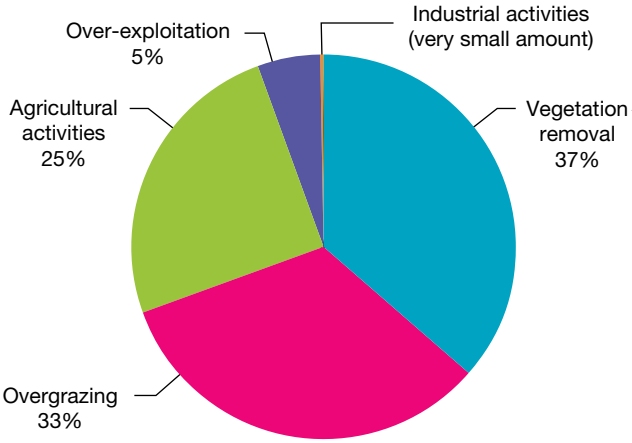
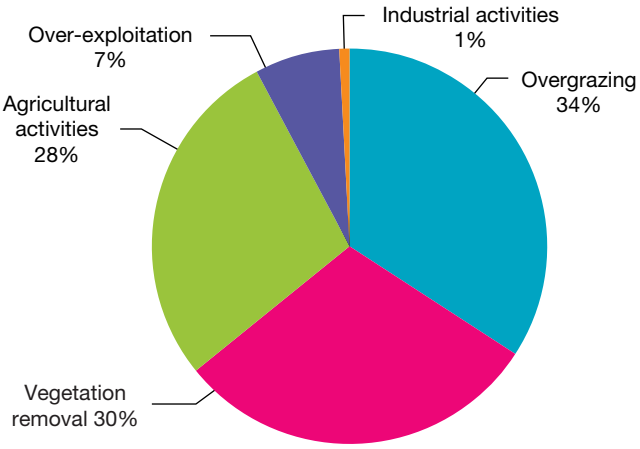


FIGURE 4 Main causes of environmental change globally



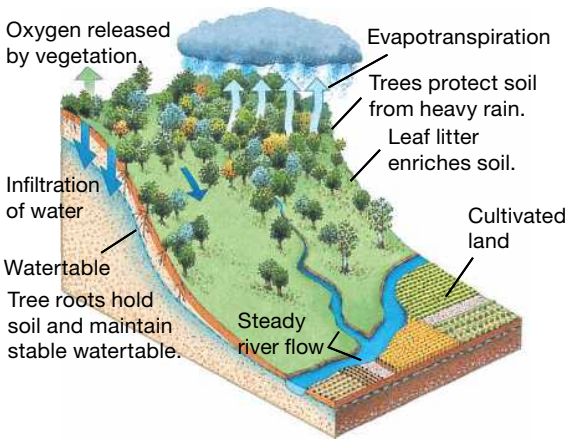
3.2.2 How has environmental change degraded the land?

Small changes can have a dramatic impact on the land. The shortcut from the oval to the classroom can reduce a grassy area to dust. Drought reduces the productivity of farmland. Poor farming practices over time will make the land unproductive.

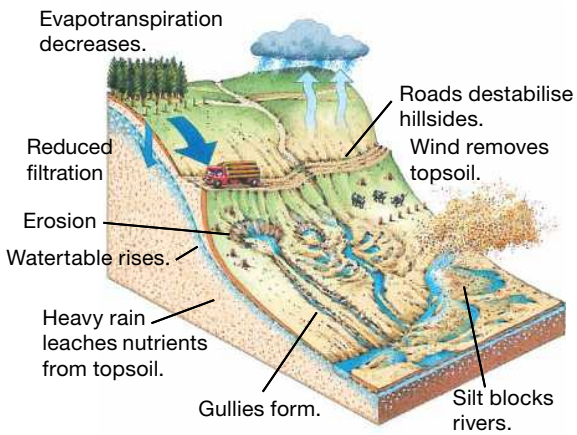
int-7952

FIGURE 5 Land clearing and deforestation leave the land vulnerable to erosion. When rain falls on a well-vegetated hillside, the water 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, especially when it rains. Rills and gullies form (see lesson 3.4) where the unprotected soil is washed away, and landslides may occur.

Forested hillside



After deforestation



The effects of land degradation are far reaching:

- Soil becomes exhausted.
- Crop yields fall.
- Costs rise as more fertiliser is needed to improve soil quality and crop yields.
- Valuable **topsoil** is washed into rivers and out to sea.
- Excess **nutrients** cause foul-smelling **algal blooms**.
- Water quality decreases; poisoning fish and posing a direct threat to all aquatic life.

3.2.3 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 seeds and hoofed animals from Europe with them. 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 very different to the land 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 and deforestation 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.

FIGURE 6 A former freshwater lake affected by salinity. The high salt levels have killed the native eucalypts; the smaller plants are more salt tolerant.

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. Overgrazing 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 kangaroos are not hard-hoofed; issues such as soil compaction and vegetation trampling would be lessened. There could also be human health benefits as kangaroo meat contains less fat and fewer calories than both lamb and beef. Those against the idea argue that because of various species characteristics, kangaroo farming is not commercially viable in the long term (see **FIGURE 7**).

topsoil the top layers of soil that contain the nutrients necessary for healthy plant growth

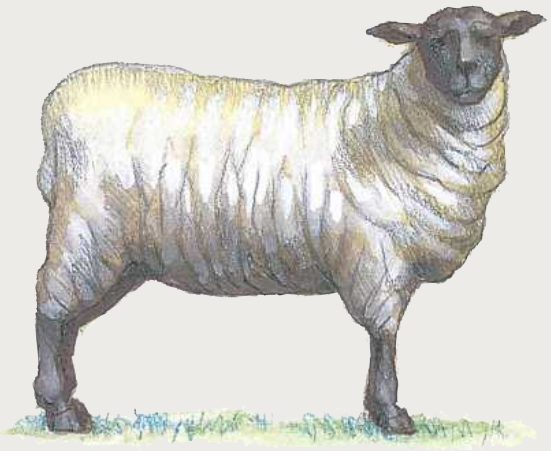
nutrients essential chemical substances in the soil needed for plants to grow and develop

algal bloom rapid growth of algae caused by high levels of nutrients (particularly phosphates and nitrates) in water

watertable upper level of groundwater; the level below which the earth is saturated with water

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-kilogram kangaroo yields 6 kilograms 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 to 6 months
- Yields 20 kilograms of prime meat
- Easier to herd and care for

3.2.4 Where is the land degrading?

Land degradation is a global issue. In 1961, globally, there were 0.37 hectares of arable (productive) land available to grow food for every man, woman and child. By 2018, this figure had fallen to 0.18 hectares. **TABLE 1** shows changes to arable land availability over time for Australia and the world. These changes are due to factors such as population growth, urban sprawl, land degradation and climate change. In Australia, approximately two-thirds of the land used for agricultural production is degraded. **FIGURE 8** shows the severity of land degradation in Australia.

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, the annual rate of population growth is 2.7 per cent annually — significantly higher than the world average of 1.15 per cent.

TABLE 1 Arable land per person over time (most recent World Bank data)

	Arable land per person (hectares)	
Year	Global	Australia
1961	0.37	2.88
1976	0.29	3.00
1991	0.23	2.64
2018	0.18	1.24

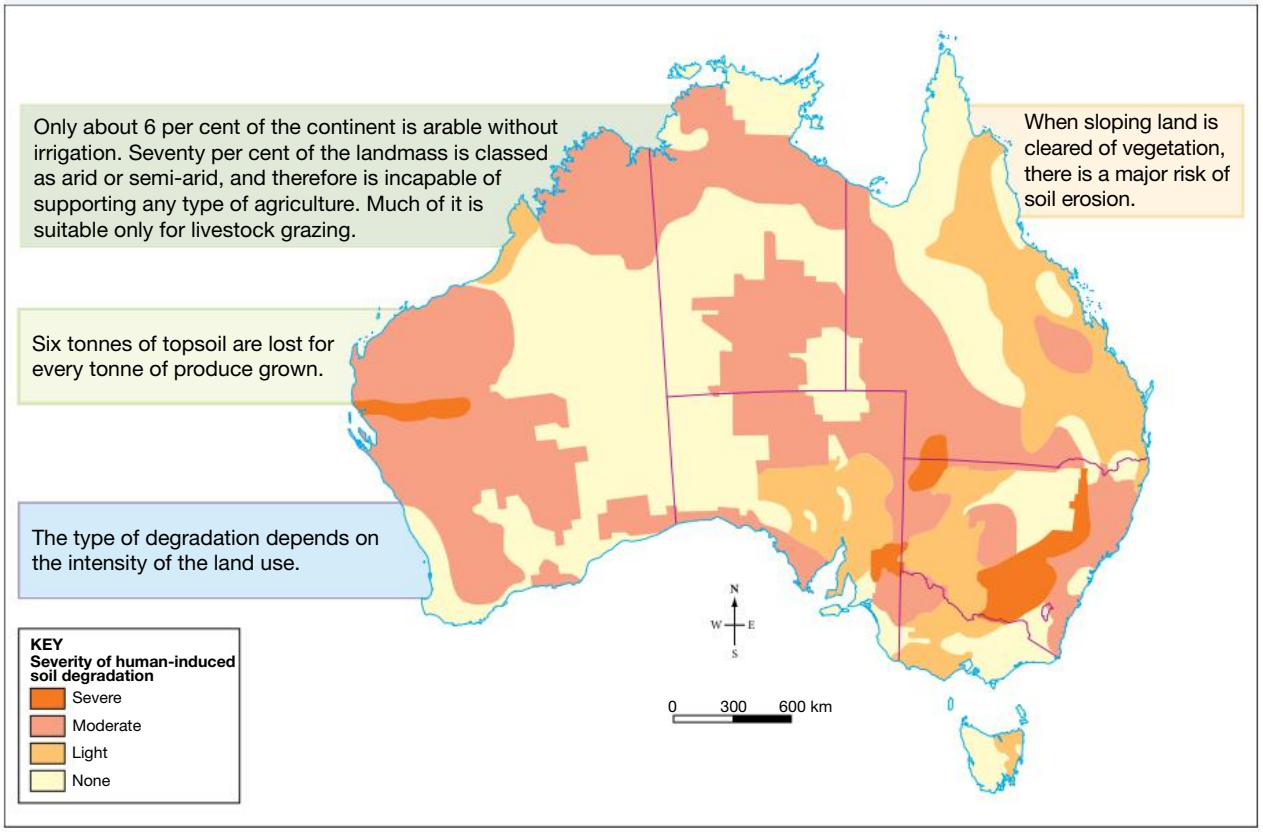
Africa is one of the most vulnerable continents, having lost 65 per cent of its arable lands and 25 per cent of its overall land area to desert. Experts estimate that 10 million hectares of land needs to be rehabilitated each year to reverse the current trends in land degradation.

In 1950, about 65 per cent of the world's population lived in developing nations; however, this figure is expected to rise to 85 per cent by the year 2030. These people are dependent on the most fragile environment for their survival.

int-7953

tlvd-10774

FIGURE 8 Severity of soil degradation in Australia



Source: MAPgraphics Pty Ltd Brisbane.

3.2.5 Challenges to food production

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. Since 1990, the amount of land irrigated for agriculture has doubled and agricultural production has trebled. The United Nations predicts that in the second half of the twenty-first century, the rate of population growth will slow and this rate will be close to zero by the end of the century. The world's population is expected to reach 9.9 billion by 2050 and 10.9 billion by the end of the century, even more pressure on the land and its resources.

DID YOU KNOW?

What has change since 1950?

- The population has more than tripled; from 2.5 billion to 7.9 billion.
- Primary energy use is five times higher.
- Fertiliser use has increased eightfold.
- The amount of nitrogen pumped into the ocean has quadrupled.

Globally, 75 per cent of the Earth's total land area is classed as degraded, and around 60 per cent of this degraded land is used for agricultural production. It is estimated that every year, 24 billion tonnes of fertile soil is lost worldwide, with the worst affected areas being in sub-Saharan Africa. Global food production 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.

Land degradation is a global problem. If the current trends continue, our ability to feed a growing world population will be threatened. 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.

FIGURE 9 Sustainable land use and catering for population growth may involve combining energy production and livestock grazing.

3.2 SKILL ACTIVITY: Questioning and researching using geographical methods, Concluding and decision-making

Investigate alternatives to traditional livestock farming of sheep and cattle, such as the farming of kangaroos or emus.

1. Use the information in this lesson to get you started.
2. **Summarise** your findings in two tables — one showing the advantages and disadvantages of traditional farming and one showing the advantages and disadvantages of alternative methods, as shown.

Traditional farming of	
Advantages	Disadvantages
•	•
Alternative farming of	
Advantages	Disadvantages
•	•

3. Once you have gathered your information, **identify** the points you think are based on emotion.
4. Use the information in your tables to **state** a reasoned argument for or against this type of farming as a sustainable alternative.
5. As part of your argument, **evaluate** emotional responses to the management of this type of farming.

on Resources

Interactivities Destroying the land (int-3289)
Soil degradation — a global problem affecting every permanently inhabited continent (int-5597)

3.2 Exercise

learnon

3.2 Exercise

Learning pathways

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

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- Access sample responses
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Check your understanding

1. From the provided list, identify the causes of land degradation. Select all that apply.
   - A. Overgrazing
   - B. Creating wetlands
   - C. Introduced species
   - D. Clearing dunes for tourism
   - E. Allocating green wedges
   - F. Climate change
   - G. Salinity
   - H. Maintaining national parks
2. Complete the following paragraph using the words provided below.

rubbish	decrease	reduce	liquid and solid waste	dry out	increase
soil	improve	eliminate	rise	hardly affect	

_____ seeps into groundwater and runs off into rivers and the sea, killing marine species.
Excess irrigation water seeps down into the groundwater, causing the watertable to_____.
The topsoil that is washed into our waterways often causes blue-green algal blooms that choke waterways.
These blooms _____ water quality, poison fish and pose a direct threat to other aquatic life.
Climate change will _____ the amount of rainfall and the amount of water in our water resources.

3. Land degradation is a process that:
   - A. reduces the quality of the soil so that it reduces the capacity of the soil to produce crops, support vegetation and provide food for livestock.
   - B. improves the quality of the soil so that it increases the capacity of the soil to produce crops, support vegetation and provide food for livestock.
   - C. reduces the quality of the soil so that it increases the capacity of the soil to produce crops, support vegetation and provide food for livestock.
   - D. improves the quality of the soil so that it decreases the capacity of the soil to produce crops, support vegetation and provide food for livestock.
4. **Explain** why land degradation is a current geographical issue.
5. European farming methods proved to be quite suitable for the Australian environment. True or false?

Apply your understanding

Interpreting and analysing geographical data and information

6. Do you think land degradation is happening on a small or large scale? **Explain**.
7. Study **FIGURES 1** and **5**.
   - a. In your own words, **describe** the damage that has occurred to the environment.
   - b. Suggest how these changes have come about.
   - c. Propose how you would try to restore these places and manage their resources in a sustainable manner.
8. Study **TABLE 1**. **Identify** the difference in arable land per person for 1961 and 2018, globally and in Australia.

Communicating

9. Land degradation is often the result of many 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 contributing to land degradation where you live. **Explain** the impact of these actions.

Concluding and decision-making

10. **Describe** an area or place that is near where you live, that you have visited recently or you have heard about in the media, and that you think is degraded. **Propose** reasons for your choice and suggest how and why you think this degradation came about.

LESSON
3.3 How do we manage environmental change?

LEARNING INTENTION

By the end of this lesson you should be able to identify the causes and likely consequences of environmental change, and identify and explain solutions to an environmental issue.

TUNE IN

Soil is a mixture of broken-down rock particles, living organisms and **humus**.

1. Work with a partner to develop a shared understanding of how soil is formed.
2. Explain why soil is important.
3. Brainstorm a list of consequences if there were no soil or the quality of the soil is poor.

FIGURE 1 Wherever soil forms, plants can take root.

3.3.1 The development and importance of 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.

The land is one of our most valuable resources. 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. While erosion is a natural process, farming land clearing and the construction of roads and buildings can accelerate the process.

humus decaying organic matter that is rich in nutrients needed for plant growth

3.3.2 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. Another solution is to 'terrace' the landscape — to form the land into a series of steps rather than a steep slope.

FIGURE 2 What evidence of sheet erosion can you observe?

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.

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.

FIGURE 3 In which direction do you think the water is flowing? Why?

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, through measures 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.

FIGURE 4 What impact will the falling water have? How could further damage be prevented?

mulch organic matter such as grass clippings

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.

FIGURE 5 What do you notice about the ground around these tunnels? What do you think will happen if water flows through them?

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. Strategies to combat wind erosion include planting bare areas with vegetation, mulching, planting wind breaks and avoiding overgrazing.

FIGURE 6 Wind erosion results when wind picks up and carries away fine soil particles. Did you know that soil from China has been deposited in the United States?

3.3.3 CASE STUDY: Managing environmental change in Costerfield, Victoria

How has Costerfield changed over time?

Costerfield is around 100 kilometres north of Melbourne (see **FIGURE 7**). The landscape is characterised by gentle slopes with undulating (wavelike) pastures. It has an average annual rainfall of around 575 millimetres, but with relatively high average evaporation rates, the climate is described as semi-arid or **Mediterranean**. Summers are hot and dry, and winters cool and wet. The area is subject to climate extremes, heavy rain, drought, frost and dust storms are not uncommon. Soils in the area are generally considered to have a low **carrying capacity** for livestock because of poor fertility levels. Bushfires were a constant threat throughout the nineteenth century.

Costerfield once had a dense covering of eucalyptus trees and native grasses. In 1835 **pastoral runs** were established and the land was extensively cleared for livestock grazing. Sheep, cattle, rabbits and foxes were introduced into the region. Land clearing meant rainfall could flow across the surface, eroding soil and making the run-off **turbid**. Rainfall was able to infiltrate the soil leading to sheet, rill and gully erosion (see **FIGURES 8** and **9**). Rabbits further exacerbated the problem. The discovery of gold at McIvor Creek in 1852 led to an influx of gold prospectors, causing the land to become more degraded.

Mediterranean (climate) characterised by hot, dry summers and cool, wet winters

carrying capacity the ability of the land to support livestock

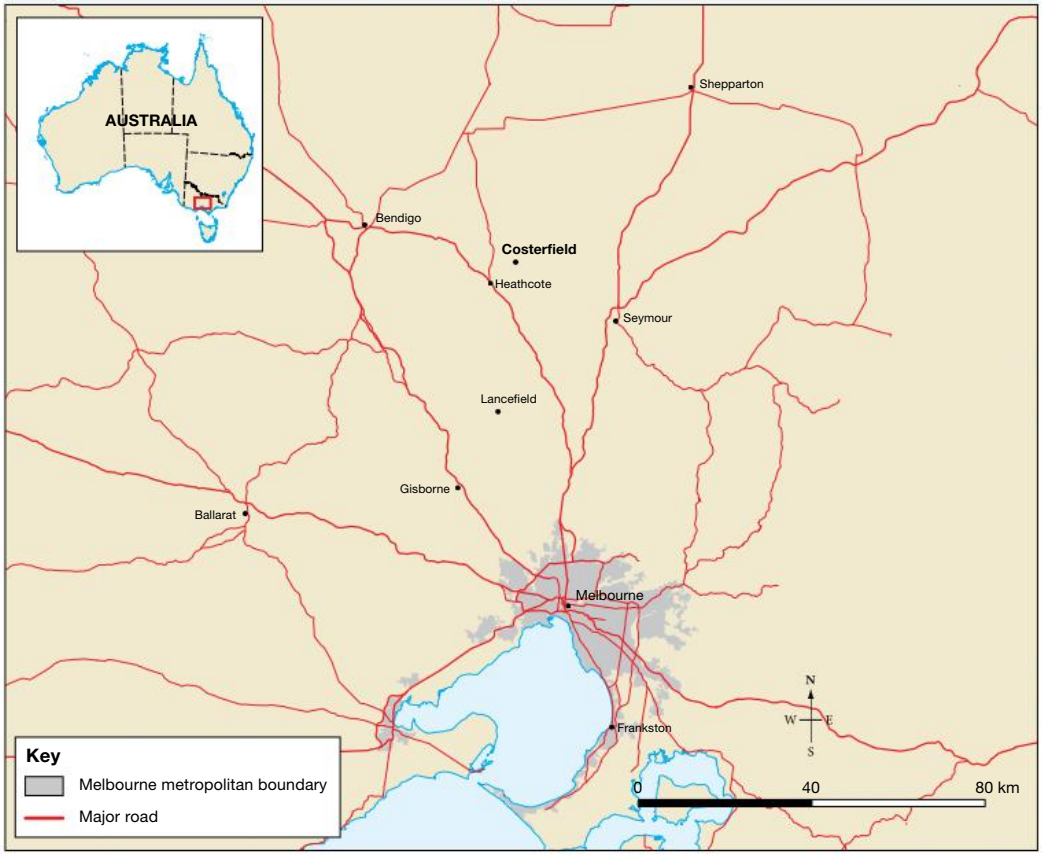
pastoral run an area or tract of land for grazing livestock

turbid water that contains sediment and is cloudy rather than clear

Following the gold rushes, livestock grazing again dominated the region.

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 Landcare groups to tackle the issues in the Costerfield area.

FIGURE 7 Costerfield lies approximately 100 kilometres north of Melbourne.



Source: © The State of Victoria, Department of Environment and Primary Industries 2013.

FIGURE 8 A dead tree stump or old fence post can allow water to infiltrate the soil.

FIGURE 9 Notice that tunnel erosion forms where the surface of the land is bare. What do you think is likely to happen next?

The gullies were stabilised by constructing banks, gully check dams (see **FIGURE 10**) and terracing, all aimed at reducing and redirecting run-off. Other strategies included:

- re-establishing ground cover, especially plants and grasses that are native to the region (see **FIGURE 11**)
- rabbit eradication programs to control the population 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 10 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.

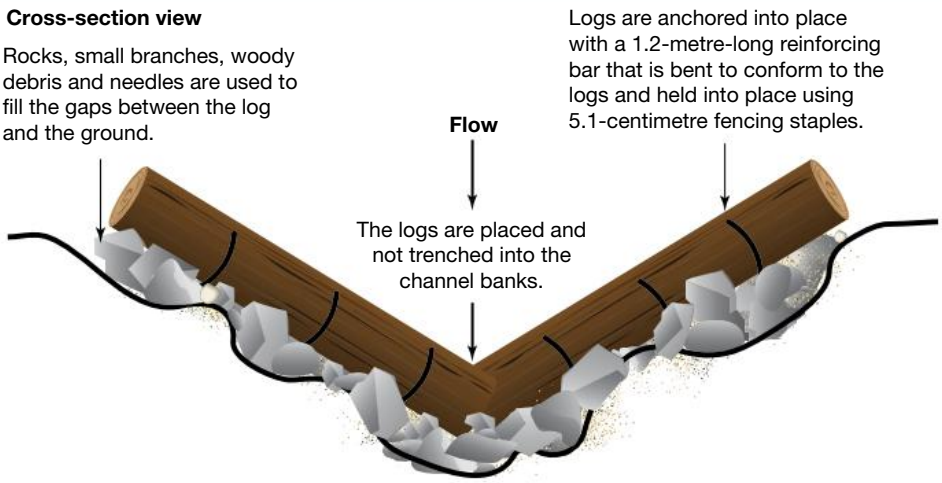


FIGURE 11 Revegetated area near Costerfield

3.3 SKILL ACTIVITY: Concluding and decision-making, Communicating

Working with a partner, use the internet to **investigate** an international environment, such as the Dust Bowl in the United States, the Amazon Rainforest, or the Yellow River in China, that has been degraded because of soil erosion.

1. **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.
2. Swap your eroded environment sketch with another pair who will **outline** 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.

on Resources

Interactivity Down in the dirt (int-3290)

3.3 Exercise

learnon

3.3 Exercise

Learning pathways

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

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Check your understanding

1. Complete the following sentence using the words provided below.

abundance	lack	assisting
eroding	water table	subsoil

The _____ of native vegetation cover allows rainfall to flow across the surface, _____ soil and making run-off turbid. It also allows rainfall to infiltrate the _____, leading to sheet, rill, gully and tunnel erosion.

2. How might the use of a check dam reduce the development of gullies?
   - **A.** They allow water to run freely over the land.
   - **B.** They guide water into the gullies.
   - **C.** They stop water from running freely over the land.
   - **D.** Check dams *encourage* the development of gullies.
3. **Identify** the types of soil erosion that occurred in Costerfield. **Select** all that apply.
   - **A.** Rill
   - **B.** Sheet
   - **C.** Wind
   - **D.** Gully
4. Complete the following sentence using the words provided below.

no sediment	a high level of sediment
clear	not clear

Turbid water has _____and is _____.

5. **Select** the best definition for the term ‘pastoral run’.
   - **A.** Area of land used to build a church
   - **B.** Area of grass land used to build a running track
   - **C.** Area of land left alone
   - **D.** Area of land used to graze livestock.

Apply your understanding

Interpreting and analysing geographical data and information

6. **Describe** why you think soil erosion in all its forms is such a significant cause of land degradation.

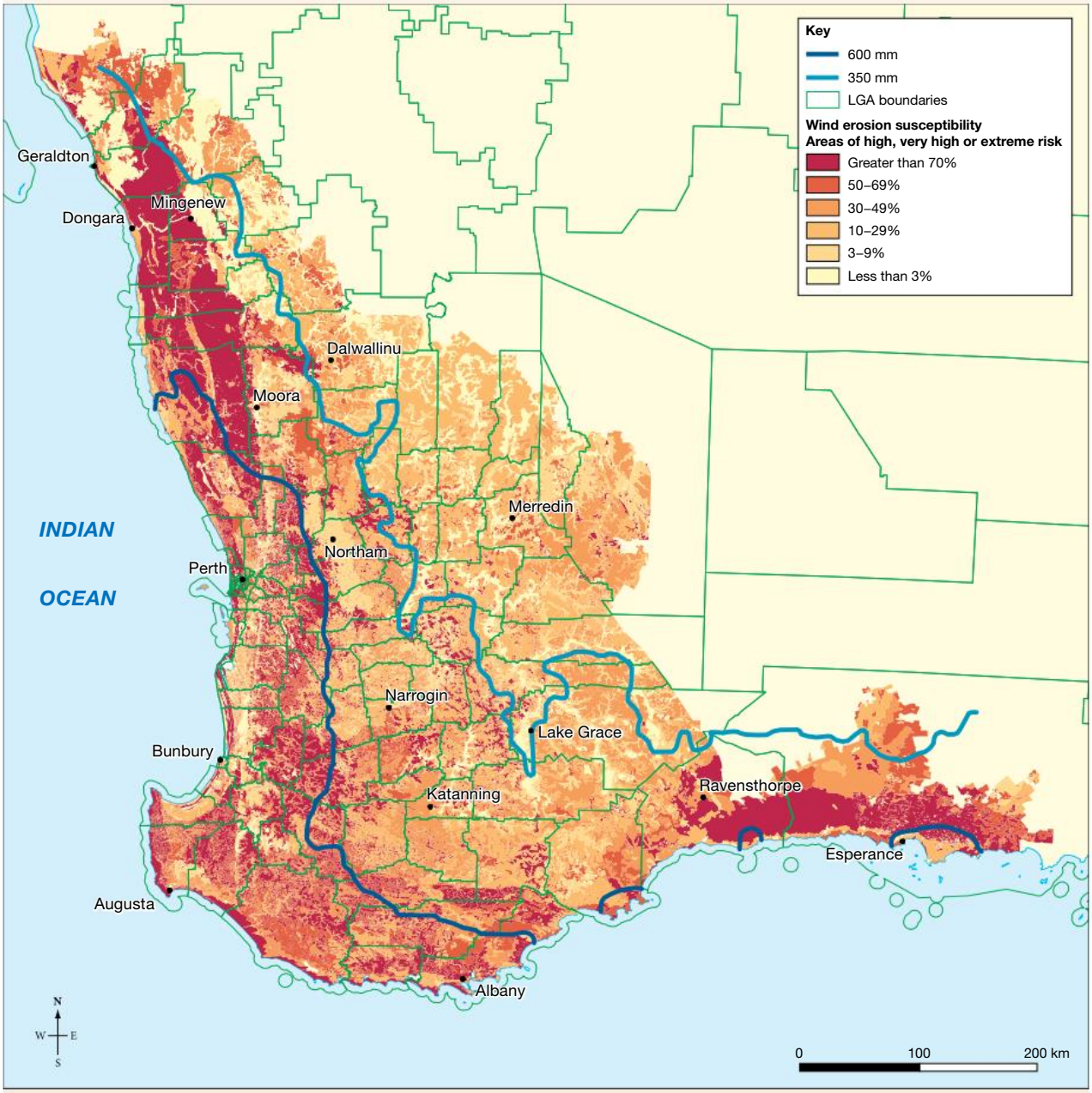
Questioning and researching

7. **Consider** how the arrival of gold prospectors would increase land degradation. **Explain** the type of erosion that would most likely occur and the activities relating to gold mining that might cause these changes to develop.
8. **Explain** the interconnection between rill erosion and gully erosion.

Interpreting and analysing geographical data and information

9. An important part of any land management program is the control of introduced species such as rabbits. **Explain** why rabbits are a problem in areas where the land has been degraded.
10. Look at **FIGURE 12**, which depicts the scale of soil erosion from wind in south-west Western Australia.
    a. **Identify** in which parts of the state erosion is highest.
    b. Use your atlas to find a map showing vegetation in Western Australia. **Explain** why wind erosion is more common in areas north of Perth and near Esperance.

FIGURE 12 Soil erosion in Western Australia



Source: Department of Primary Industries and Regional Development, WA Government.

LESSON
3.4 How does salinity change the environment?

LEARNING INTENTION

By the end of this lesson you should be able to explain the causes of salinity, describe why it is a serious environmental issue, and identify possible solutions to issues related to salinity.

TUNE IN

Did you know that 38 per cent of the Earth's land area (5 billion hectares) is used for agriculture: one-third as cropland and two-thirds for grazing livestock?

But how much of this land is affected by salinity?

- Africa: 2 per cent of the landmass
- China: 21 per cent of arid lands or around 30 million hectares of land
- Western Europe: 10 percent of the land area
- United States: 30 per cent of irrigated land across 17 states
- South America: most countries have areas of land affected
- Australia: 2.5 million hectares; around 30 per cent of arable land and increasing at between 2 and 5 per cent each year
- Worldwide: 20 per cent of arable land; without intervention, the affected area might triple by 2050

1. Brainstorm a list of sources of salt in the environment.
2. Salt is a naturally occurring substance. Suggest why it is harmful to the environment.

3.4.1 Where does the salt come from?

Salinity is not a new problem. In fact, it was an environmental issue for 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 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.

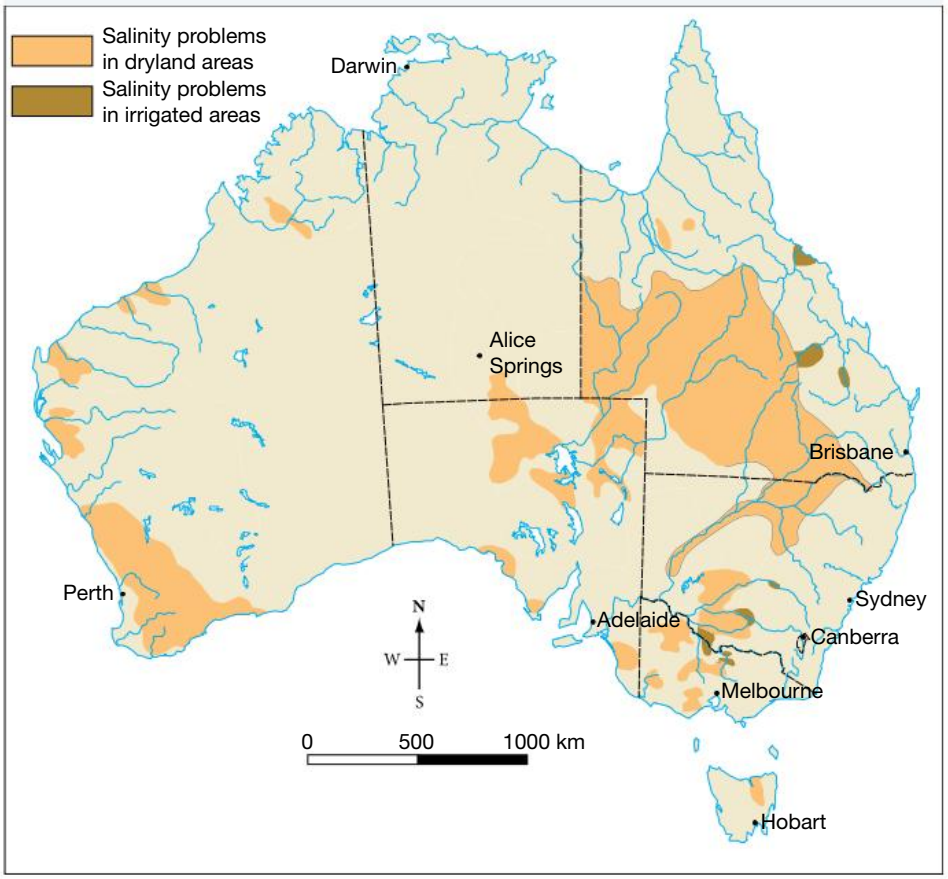
Australia's native vegetation had built up some tolerance to the salt levels in the soil. The deep-rooted vegetation also soaked up water in the soil before it could seep down into the groundwater. This meant that the watertable stayed at a fairly constant level, and that the concentrated salt stores 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.

salinity an excess of salt in soil or water, making it less useful for agriculture

groundwater water held underground within water-bearing rocks or aquifers

Salt has now become a serious problem. There are two ways in which the soil can become too salty: dryland salinity and irrigation salinity. The areas in Australia affected by salinity are shown in **FIGURE 1**.

FIGURE 1 Salinity distribution



Source: Spatial Vision.

3.4.2 What is dryland salinity?

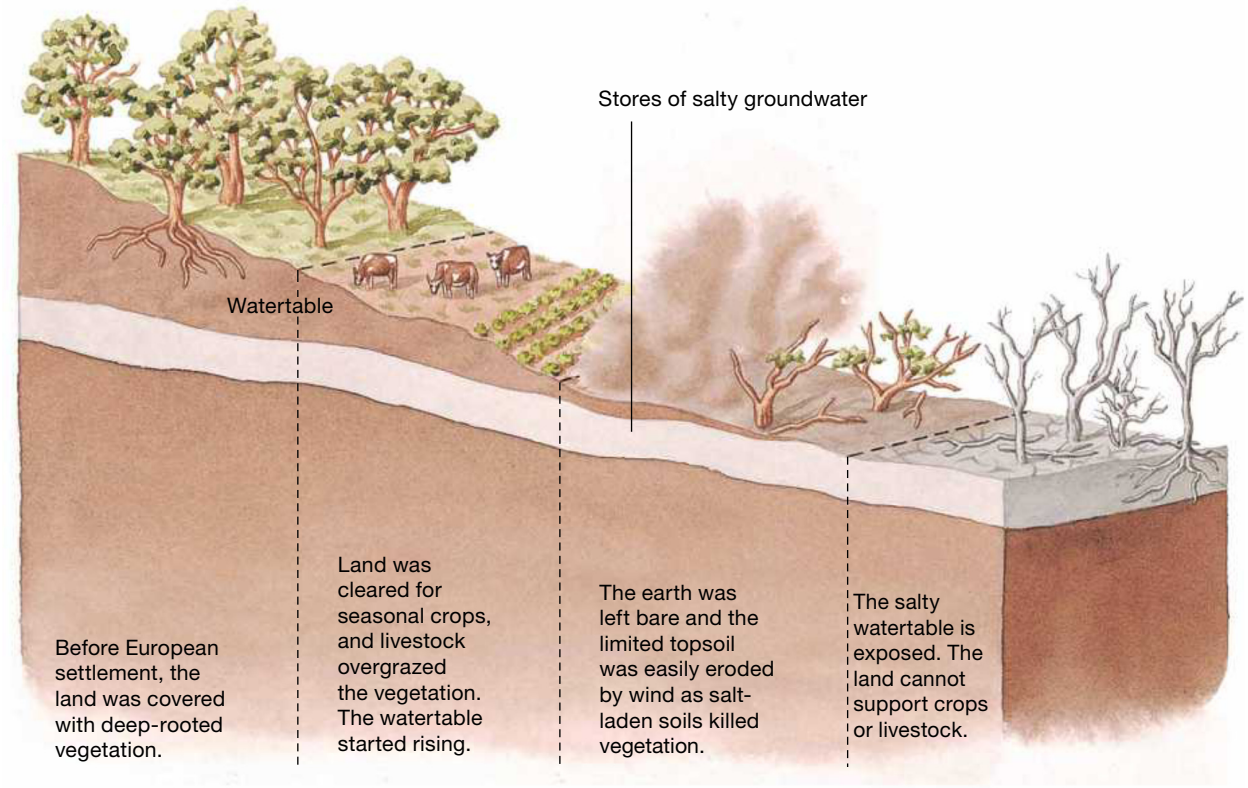
Dryland salinity occurs in areas that are not irrigated. When settlers cleared the land, they replaced deep-rooted native vegetation with crop and pasture plants. These plants generally have shorter roots and cannot soak up as much rainfall as native vegetation. Excess moisture seeped down into the groundwater, 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.

3.4.3 What is irrigation salinity?

One-third of the world's food is produced on irrigated land. Irrigation salinity occurs in irrigated regions and is a direct result of overwatering. 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.

salt scald the visible presence of salt crystals on the surface of the land, giving it a crust-like appearance

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 overwatering
- 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 of salinity on Australian grazing lands.

3.4.4 CASE STUDY: Salinity in the Murray–Darling Basin

The Murray–Darling Basin 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 (2508 kilometres), the Darling (2740 kilometres when including its three main tributaries) and the Murrumbidgee (1690 kilometres). It is the country's most significant agricultural region, producing close to 45 per cent of the nation's food. Due to low rainfall levels, 70 per cent of Australia's irrigation occurs here.

Over time, human activities in the Murray–Darling Basin have increasingly threatened the basin's **ecology** (see **FIGURE 4**). 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. It has been estimated that by 2050, 1.3 million hectares (or 93 per cent) of land in the region could be salt affected.

FIGURE 4 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

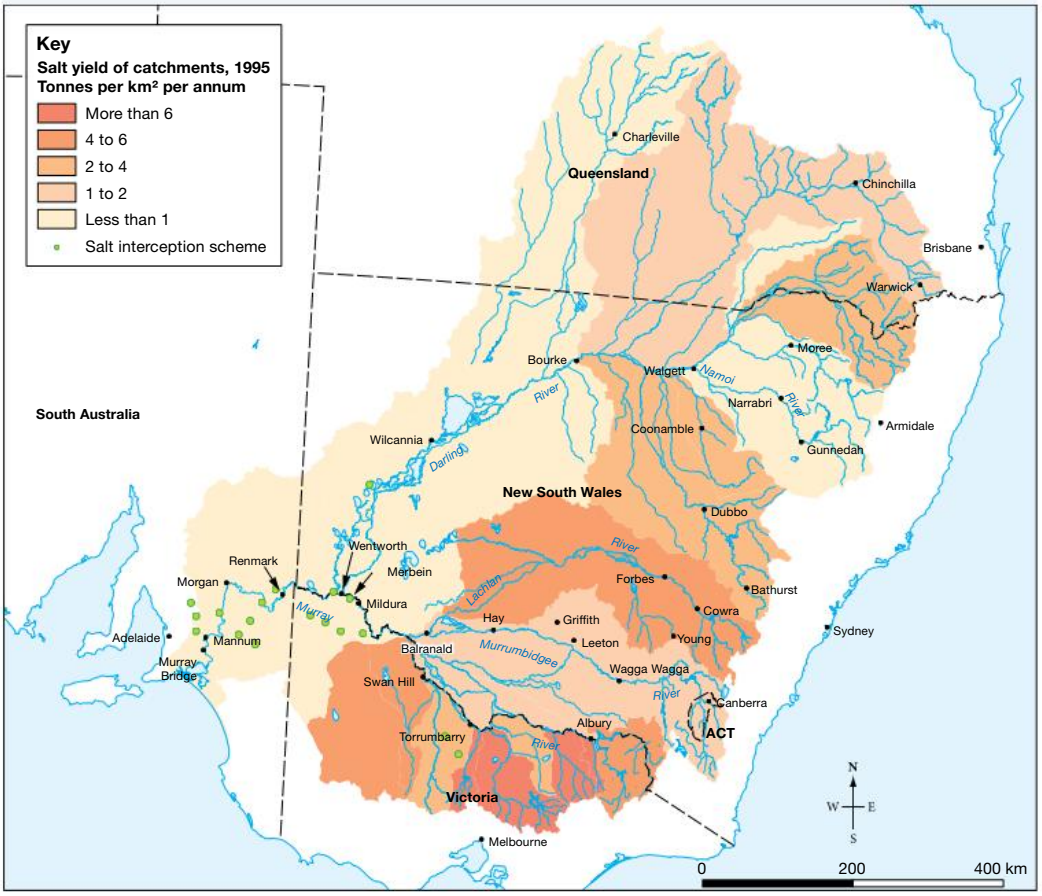
A range of strategies have been investigated to better manage the Murray–Darling Basin and reduce salinity problems. Strategies have included the development of action plans such as revegetation programs and educational programs. In 2008, the Commonwealth Government took control of the region to allow for the implementation of a comprehensive management strategy that would provide for the needs of all states and also be environmentally sustainable. The Murray–Darling Basin Authority (MDBA) was created to oversee the entire project.

As part of the measures to control salinity, salt-interception schemes have been established along the Murray River (see **FIGURE 5**). Collectively, they remove 500 000 tonnes of salt annually from groundwater and drainage basins (see **FIGURE 6**). Prior to these schemes, the Murray River carried huge amounts of salt — for example, 250 tonnes per day and 100 tonnes a day, respectively, past Woolpunda and Waikerie, between Renmark and Morgan in South Australia. Recent surveys show that salinity levels have decreased to less than 10 tonnes a day in each area.

drainage area (or basin) an area drained by a river and its tributaries

ecology the environment as it relates to living organisms

FIGURE 5 Salt interception in the Murray–Darling Basin



Source: © Commonwealth of Australia Geoscience Australia 2013. Map by Spatial Vision.

FIGURE 6 Salt harvested from evaporation ponds is exported all around the world.

Murray–Darling Basin Royal Commission 2018

In 2018, a report by the ABC program *Four Corners* levelled serious allegations of inadequate management, negligence and water theft in the Murray–Darling Basin. Following this, the South Australian Government ordered a **Royal Commission** into the management of the Basin.

The Royal Commission found that the existing management strategies were in need of a complete overhaul to ensure that more water was diverted from irrigation and back into the environment.

The report was also highly critical of the Menindee Lakes project (in NSW), which involved shrinking and emptying the lakes more often to save water from evaporation — an action that failed to take into account the impact not only on the environment when river flow stopped, but also on those further downstream in Victoria and South Australia.

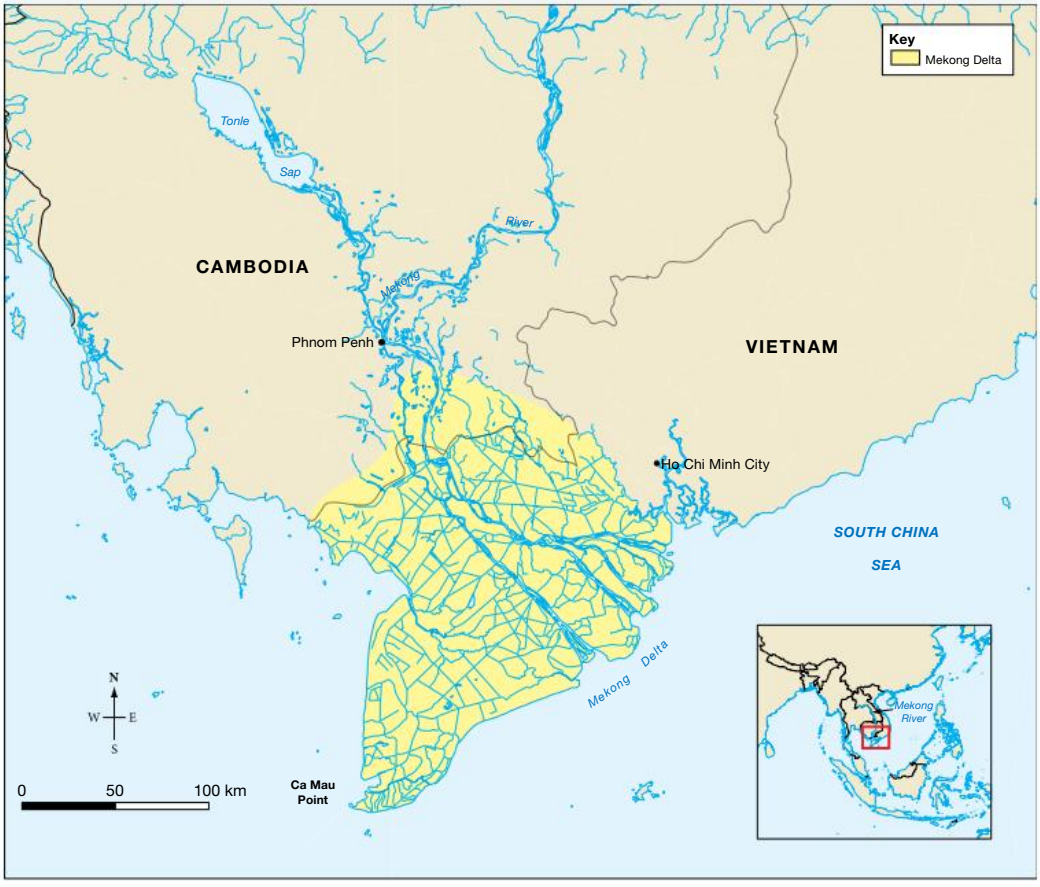
The report argued the aim of the MDBA should be to share limited water resources and ensure that the needs of the environment, agriculture, First Nations communities and 2.6 million people who depend on the Murray–Darling River system to supply their water should be considered — especially those who live downstream and all the way to the mouth of the river where it empties into the sea. The sustainable management of this vital water resource remains an ongoing challenge.

Royal Commission a public judicial inquiry into an important issue, with powers to make recommendations to government

3.4.5 CASE STUDY: Vietnam — adapting to salinity issues

Vietnam's Mekong Delta region (see **FIGURE 7**) 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.

FIGURE 7 The Mekong Delta



Source: Vector Map Level 0 Digital Chart of the World. Map by Spatial Vision.

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.

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.

FIGURE 8 Dry rice husks suitable only for poultry are the result of brackish water from the sea flowing inland.

brackish water that contains more salt than fresh water but not as much as sea water

3.4 SKILL ACTIVITY: Concluding and decision-making

Several strategies have been suggested to solve issues related to salinity. One of these strategies is to plant saltbush.

1. **Investigate** how saltbush may help reduce salinity.
2. **Create** an annotated diagram of a saltbush plant and its root system to **explain** this role.
3. **Evaluate** the effectiveness of using saltbush as a strategy to deal with salinity. Use evidence to support your evaluation.

FIGURE 9 The saltbush plant

on Resources

Interactivity A pinch of salt (int-3291)

3.4 Exercise

learnon

3.4 Exercise

Learning pathways

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

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Check your understanding

1. **Explain** why planting deep-rooted trees would help solve the problem of salinity.
   - A. Deep-rooted trees allow more rainfall to seep into the soil.
   - B. Deep-rooted trees soak up more rainfall that has seeped into the soil.
   - C. Deep-rooted trees soak up salt.
   - D. It wouldn't help the problem.
2. **Identify** actions an irrigation farmer could take to reduce the risk of salinity. **Select** all that apply.
   - A. Change irrigation practices to ensure that crops are not over-watered.
   - B. Plant deep-rooted plants and shrubs.
   - C. Avoid using technology to monitor and detect areas at risk from salinity.
   - D. Replace native grasses with introduced pasture ones.
3. **Select** the correct option to fill in the blank.

15	25	30	45	80

   The Murray–Darling Basin is one of the most significant agricultural regions in Australia, producing close to _____ per cent of the country's food.
4. **Explain** the interconnection between soil salinity and land degradation.
5. Refer to **FIGURE 1**. **Describe** the distribution of dryland salinity areas in Australia.

Apply your understanding

Questioning and researching using geographical methods

6. **Explain** what a delta is and why it is important.

Interpreting and analysing geographical data and information

7. **Identify** 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.
8. Refer to **FIGURE 5**.
   - a. **Identify** the aim of such salt-interception schemes.
   - b. **Judge** if you think this is a sustainable management strategy. **Explain**.
   - c. **Discuss** the impact of this scheme on river ecosystems.
   - d. **Consider** what you think happens to the salt that is extracted.
   - e. **Predict** if you think a similar scheme could be developed for the Mekong Delta. **Justify** your point of view.
9. **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.

Concluding and decision-making

10. **Determine** what factors have contributed to the degradation of the Murray–Darling Basin's land and water resources since the arrival of Europeans.

LESSON
3.5 How does desertification change the environment?

LEARNING INTENTION

By the end of this lesson you should be able to explain the causes of desertification and the areas most at risk, and discuss and evaluate strategies to deal with desertification.

TUNE IN

Land is changeable and can be influenced by many different environmental factors. Fertile land that is suitable for agriculture will not always be suitable.

FIGURE 1 Environments can change quickly or slowly.

1. What changes are taking place in **FIGURE 1**?
2. Suggest factors that may have led to these changes.
3. Brainstorm a possible definition of the term 'desertification'.

3.5.1 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.

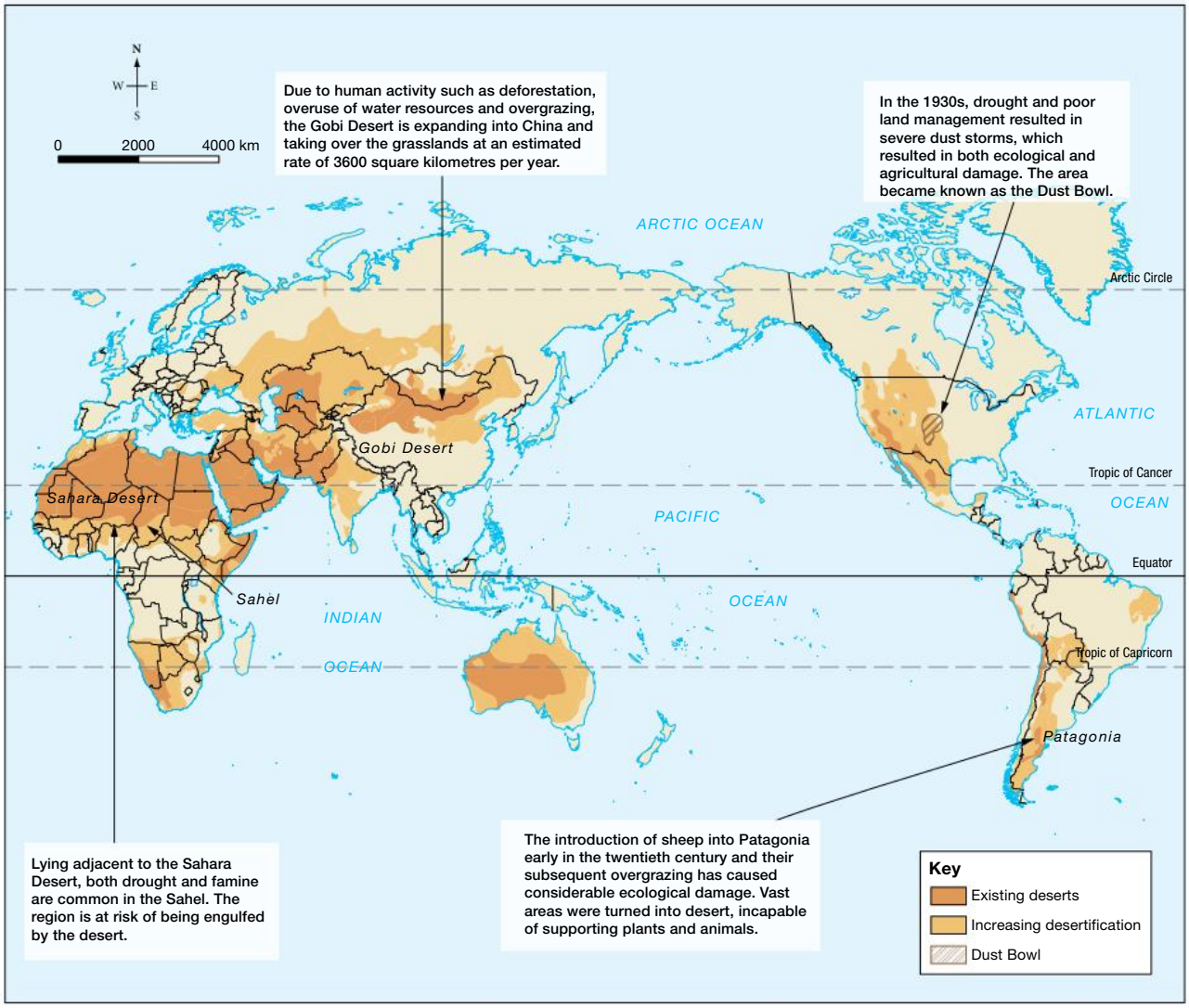
The United Nations estimates that approximately 41 per cent of the Earth's land surface is at risk of turning into desert. This is a process known as **desertification**, an extreme form of land degradation that affects arid, semi-arid and dry sub-humid areas of the Earth. These dryland regions often 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.

dryland ecosystems characterised by a lack of water, including cultivated lands, scrublands, shrublands, grasslands, savannas and semi-deserts; the lack of water constrains the production of crops, wood and other ecosystem services

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

The areas affected are home to more than two billion people in 168 countries. **FIGURE 2** shows the Earth's desert areas and those places most at risk from desertification. It is predicted that by 2050 Bangladesh will have no fertile soil. Productive land is being lost due to rising sea levels, poor agricultural practices and a growing population.

FIGURE 2 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.

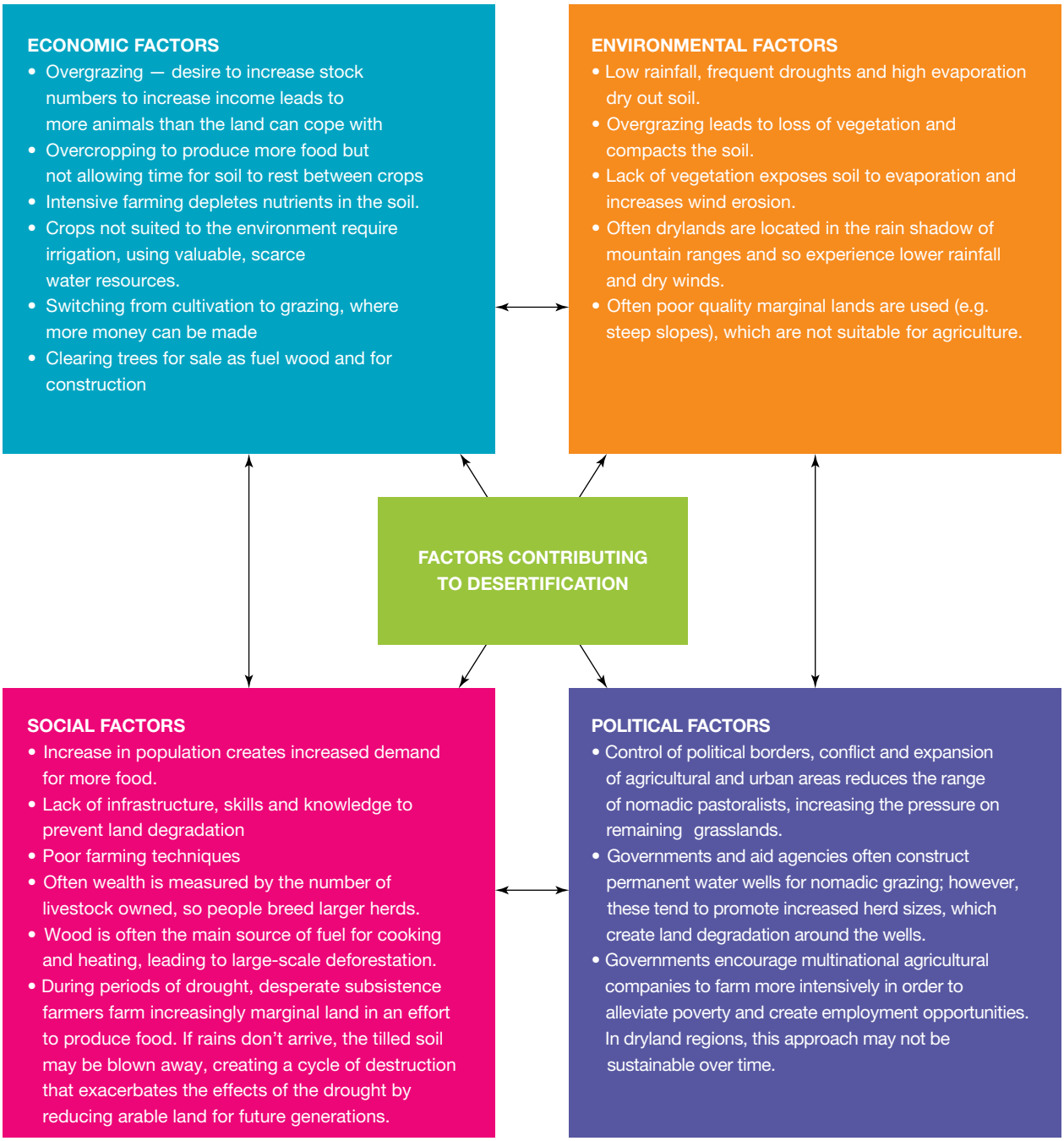


Source: UNEP World Conservation Monitoring Centre.

3.5.2 What causes desertification?

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 3**).

FIGURE 3 Factors contributing to desertification



3.5.3 The impacts of desertification

Currently, the world loses approximately 12 million hectares of land annually, an area almost three times the size of Switzerland, enough to grow 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 4**).

Desertification also affects the wellbeing of over one 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 become lost as whole villages can effectively be abandoned as people leave farming in search of employment in urban areas.

FIGURE 4 Fence drowned by a huge sand dune in the United Arab Emirates

3.5.4 Tackling the problem

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 1994 (UNCCD), an agreement supported by 197 parties 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 stewardship 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. World Day to Combat Desertification and Drought has been celebrated on 17 June each year since 2002, with a different theme and focus. The aim in 2021 was to restore one billion hectares of land by 2030; an area almost equivalent to the land area of China.

3.5.5 CASE STUDY: Combating desertification in China

China is one of the countries most severely affected by desertification; it affects about 25 per cent of the total land area (approximately 3327 million km^2) there and has a negative impact on 400 million people (see **FIGURE 5**).

In the wake of rapid population growth (from 550 million in 1950 to 1.45 billion in 2022), 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 increased exponentially. This expansion reflects an **anthropocentric** worldview or human-centred approach. This is where the wellbeing and needs of humans are placed above the needs of other species or consideration of the environment Thus, human activities in the form of inappropriate land use have magnified the problem of desertification (see **FIGURE 6**).

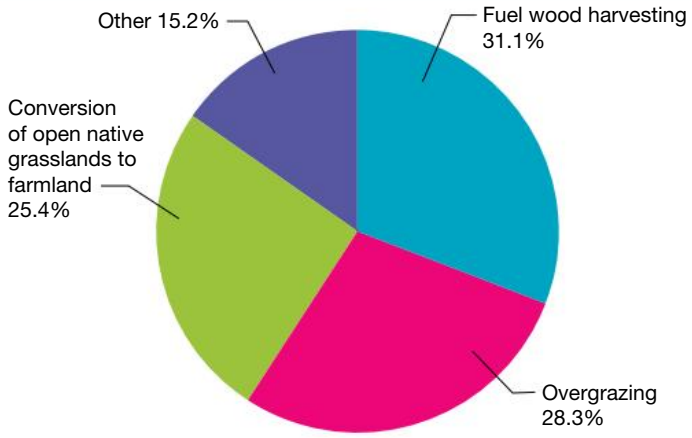
anthropocentric the belief that humans are the central and most important component of the universe

int-7954

FIGURE 5 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.

FIGURE 6 Causes of desertification in China



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 are carried eastwards by the prevailing winds, choking the city of Beijing: destroying crops, closing airports and creating a surge in respiratory ailments.

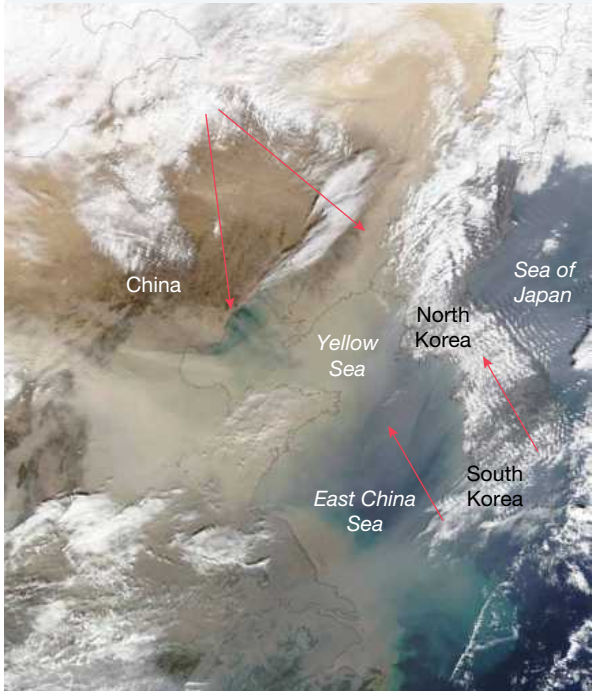
The sand storms, or 'Yellow Dragon' as they were traditionally called, continue their journey and affect international communities in South Korea, Japan, Russia and even the United States (see **FIGURE 7**).

The Chinese government has been working relentlessly on the problem, implementing a range of schemes, two of which are described in section 3.5.6.

China currently spends $5 billion each year on combating desertification. The aim is to reclaim all the treatable land area by 2050.

Already China has slowed the rate of desertification by more than one-third of 1999 levels, making it a world leader in this field.

FIGURE 7 A dust storm from China affecting neighbouring countries



3.5.6 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 8**).

Sahel a semi-arid region in sub-Saharan Africa; 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 4800-kilometre series of forest strips spanning the country from east to west, and stretching 1500 kilometres from the southern edge of the Gobi Desert, 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 88 billion trees.

By 2021, 18 million hectares of forest has been restored; increasing forest cover from 12 per cent in 1980 to 23 per cent, with the goal of

FIGURE 8 The Great Green Wall of China: an ambitious attempt to stop the advance of desert sands from the Gobi Desert

reaching a national forest cover of 42 per cent by 2050. However, an early 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**).

TABLE 1 Impacts of planting green walls

Environmental benefits	Environmental drawbacks
• Mass planting of fast-growing species (known as monoculture) helps to slow desertification. • Trees act as windbreaks and reduce erosion. • There is a long-term possibility of harvesting trees as a commercial wood crop or for pulp and paper. • Growth of trees acts as a carbon store, reducing greenhouse gases. • Thousands of kilometres of moving dunes are stabilised. • Frequency and severity of dust storms is reduced.	• 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 less nutrients are entering the soil.

While China reports an overall increase in forested areas, Greenpeace reports that only 2 per cent of China's original vegetation remains. Many of the trees planted have a lifespan of only 40 years. Nevertheless, in areas where the local community is prepared to care for the newly planted trees, the spread of the desert appears to have been halted, with the area of land affected by desertification shrinking by almost 2000 square kilometres annually. Sandstorms are now also reported to have decreased by 20 per cent.

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 to prevent further damage and halt the spread of the desert. Relentless sandstorms threaten the traditional lifestyles and farming practices of nomads in both Tibet and Mongolia. Failing crops and a lack of pasture for grazing livestock is forcing them to join other climate refugees and move into new settlements (see **FIGURE 9**).
- *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.* Between 2005 and 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 A$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. The grazing ban has since been extended, and is still in force, with farmers paid a subsidy to safeguard their livelihood. Additional bans were also put in place banning hunting and declaring some areas national parks. Money received by the traditional nomadic herders has been used to leave the land.

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. He noted through his research in Inner Mongolia that native grasslands will restore themselves in as little as two years, if protected from grazing animals and human activities.

monoculture cultivating a single crop or plant species over a wide area over a prolonged period of time

FIGURE 9 Nomadic grazing on grasslands in Mongolia. Why would this area be prone to desertification?

3.5 SKILL ACTIVITY: Concluding and decision-making, Communicating

Investigate the effectiveness of green walls in Africa or China as a means of dealing with the social and environmental impacts of land degradation.

1. **Create** a table that highlights the social and environmental impacts of green walls on dealing with desertification.

Social impacts	Environmental impacts

2. Highlight those entries in your table that show a positive impact.
3. Use the information you have collected to answer the following question.
   In your opinion, has human wellbeing been improved because of these initiatives? **Justify** your conclusion using information from your table.

on Resources

Weblinks
Great Green Wall of China (1)
Great Green Wall of China (2)
How China is reforesting the Gobi Desert

3.5 Exercise

learnon

3.5 Exercise

Learning pathways

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

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Check your understanding

1. Complete the following sentence using the words provided below.

drylands	deserts

_____ are an ecosystem in which few plants and animals exist. _____ on the other hand can support more vegetation, usually grass and shrubs, and if carefully managed the land can be cultivated.

2. Drylands are especially vulnerable to desertification because:
   - **A.** they are usually situated next to deserts.
   - **B.** they are a hardy environment that is resistant to degradation.
   - **C.** they are a fragile environment that degrades rapidly when not carefully managed.
   - **D.** they experience excessive rainfall.
3. **Select** the correct option to fill in the blanks.

bottom-up	top-down

A _____ approach means that the government dictates or imposes a solution on the people, whereas a _____ approach encourages and supports people in developing their own solutions.

4. Refer to **FIGURE 2**. **Describe** the distribution of those places in the world most at risk of desertification.
5. **Identify** the following impacts of desertification in China as economic, social or environmental.

	Economic	Social	Environmental
Increased poverty as land is no longer productive			
Decreased GDP			
Loss of topsoil and protective vegetation allows sand dunes to invade farmland			
Loss of productive farmland			
Influx of people from rural to urban areas			
Decreased food production			
Acceleration of land degradation			
Social and cultural networks lost as villages are abandoned			

Apply your understanding

Interpreting and analysing geographical data and information

6. How would you envisage the issue of desertification in China in the year 2050? **Justify** your answer.

Concluding and decision-making

7. 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? **Outline** and **justify** your views.

8. **Explain** in your own words what is meant by desertification and why it is a global issue.
9. **Examine** how effective a top-down approach could be in combating desertification in China. **Examine** how effective a bottom-up approach might be. **Explain** your view.
10. **Evaluate**, according to environmental, social and economic impacts, the effectiveness of:
    a. green walls
    b. grazing bans
    for combating desertification in China.

LESSON
3.6 How do invasive species change the environment?

LEARNING INTENTION

By the end of this lesson, you should be able to describe how invasive species cause environmental change in Australia, and identify and propose strategies to manage or eradicate invasive species.

TUNE IN

Did you know that the harlequin ladybird is the most invasive species on Earth? It has been intercepted at Australia's national borders and has the capacity to wipe out native species and threaten the agricultural industry. It feasts on vegetation and insects (including other species of ladybirds) and has been known to bite domestic animals and people.

1. Work collaboratively to define the term 'invasive species'.
2. Brainstorm a list of ways that invasive species might find their way into Australia.
3. Australia has strict import controls on agricultural products entering Australia.
   a. Do you think this is justified? Give reasons for your answer.
   b. Suggest reasons why the harlequin ladybird could pose a threat to Australia.

FIGURE 1 The harlequin ladybird

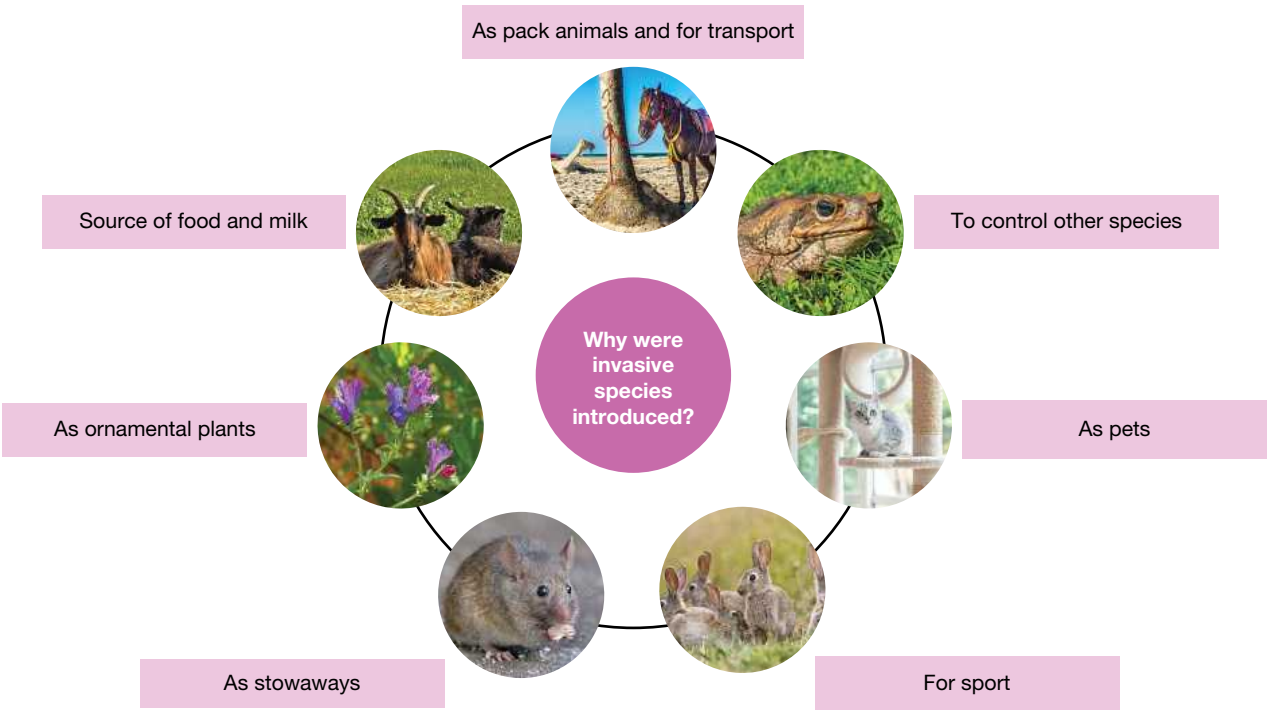
3.6.1 What is an invasive species?

An invasive species (sometimes referred to as an **exotic species**) is any plant or animal species that colonises areas outside its normal range and becomes a pest. Invasive species are a major cause of environmental change.

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 and native habitats (see **FIGURE 2**).

exotic species species introduced from a foreign country

FIGURE 2 Some invasive species are deliberately introduced; others arrive accidently as stowaways on ships or agricultural products brought into Australia.



3.6.2 Animal pests — goats, foxes and rabbits

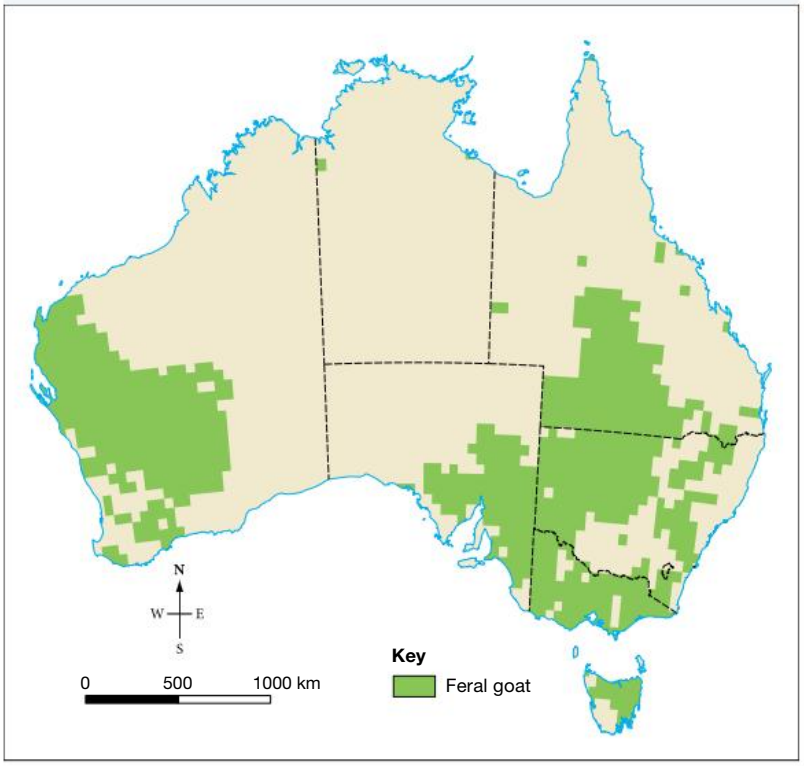
Goats

Goats arrived in Australia with the First Fleet in 1788 as a source of both milk and meat for early settlers and sailors. 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.

It is estimated that at least 2.6 million feral goats occupy approximately 28 per cent of Australia (see **FIGURE 4**), 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 scarcity 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.

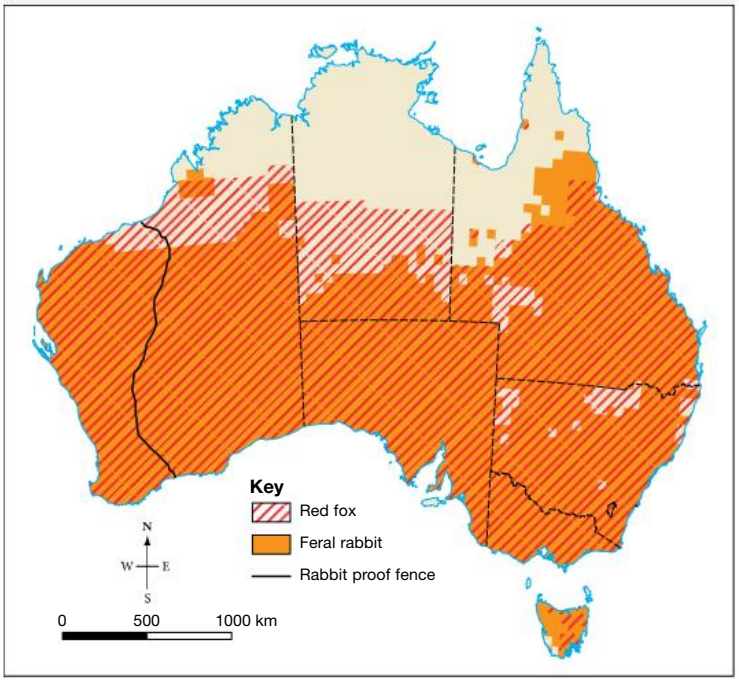
FIGURE 3 Goats were a food source for early settlers and sailors alike. Their size, hardiness and ability to eat a range of plants made them an ideal source of both meat and milk.

FIGURE 4 Spread of feral goats in Australia



Source: © Commonwealth of Australia Geoscience Australia 2013. © Commonwealth of Australia Department of Sustainability, Environment, Water, Population and Communities 2013. Map by Spatial Vision.

FIGURE 5 Distribution of red foxes and feral European rabbits in Australia



Source: © Commonwealth of Australia Geoscience Australia 2013. © Commonwealth of Australia Department of Sustainability, Environment, Water, Population and Communities 2013. Map by Spatial Vision.

Feral goats cause widespread damage to the environment. They damage the soil and overgraze all forms of native vegetation, causing erosion and preventing plant regeneration. Weeds spread more rapidly through seeds contained in their dung, Goats strip vegetation from steep hills, increasing the rate of erosion and leading to the development of widespread gullies.

During times of drought, they pose a direct threat to both domestic and native wildlife as they complete for food, water and shelter, creating an additional imbalance in the food chain. The impact of goats is worse in regions where rabbits are also out of control.

Foxes and rabbits

Both foxes and rabbits were introduced into Australia by the early settlers. With few 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.

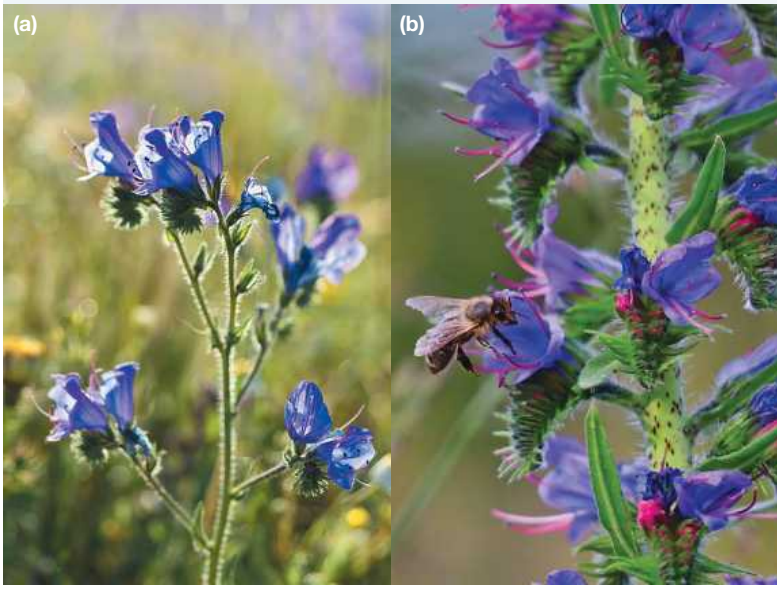
Rapid-breeding feral rabbits place significant pressure on the environment, competing with native wildlife for food and damaging vegetation. Rabbits eat plant roots as well as foliage. They **ringbark** trees and eat seeds and seedlings, so plants cannot regenerate.

ringbark removing 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

3.6.3 The problem of introduced plants

Invasive plant species are often referred to as weeds. Introduced primarily as garden plants they soon spread to other areas and now pose a significant threat to the environment and agriculture. Examples include Paterson's curse and Viper's Bugloss; both were introduced into gardens in the 1850s because of their attractive flowers.

FIGURE 6 (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 bluer, and prickles are visible on the stem.



Paterson's Curse and Viper's Bugloss are often found together; their seeds germinate earlier than native plants, enabling them to establish extensive root systems and spreading leaves, which crowd out other plant species. They thrive in areas of high winter rainfall and have adapted to cope with dry summers.

The nutritional value of Paterson's Curse is low, and if consumed in significant quantities it can be toxic, especially to horses and small animals. Their stomachs cannot fully process the plant, leading to liver damage, loss of condition and potentially death. Contact with these plants can cause skin irritations and other allergic reactions in humans and livestock.

- Area impacted — 33 million hectares.
- Cost to grazing industry — more than $250 million annually.

invasive plant species commonly seen as weeds; any species that dominates an area outside its normal region and requires action to control its spread

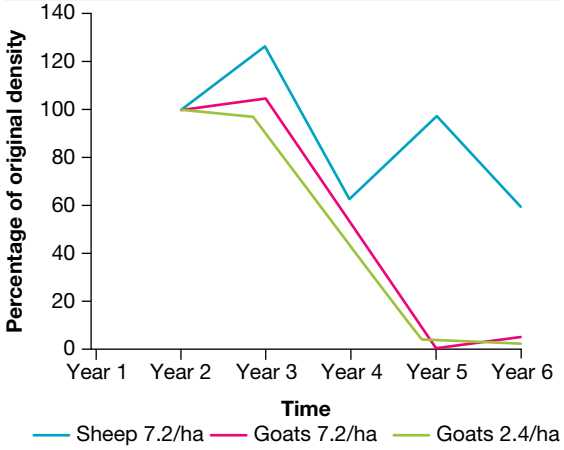
weed any plant species that dominates an area outside its normal region and requires action to control its spread

3.6.4 Controlling invasive species

Can one problem be part of the solution for another?

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 7**).

FIGURE 7 In Western Australian trials, goats almost completely eradicated saffron thistle within three years. Researchers will monitor the situation carefully, however, as seeds can lie dormant for up to ten years.



While we know that some weeds are spread passing through the digestive systems of animals, this is not the case with goats. Less than 1 per cent of the saffron thistle seeds were found in the goat dung, and these would not germinate. Similar results were found in test sites for the control of blackberries (see **FIGURE 8**). 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.

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, such as on steep slopes. In recent times, they have been used as a method of weed control in plantation forests and in limited numbers on large pastoral runs. They are also still kept as livestock.

FIGURE 8 Goats have been used successfully in the Tolt River Dam region in Seattle, Washington. There, a herd of 200 goats is used to control the spread of blackberries on ground that is too steep and uneven for mowing by machinery.

Mainland quokkas

The quokkas of Rottnest Island are well known both locally and internationally. In recent times, they have become social media celebrities, and taking a quokka 'selfie' is a must-do when visiting the island. Bald Island on the Western Australia south coast is also home to a colony of quokkas.

The quokka population on Rottnest Island is estimated at 8000 to 12 000, and Bald Island is home to about 1000 of the small marsupials. While the status of both these island populations is considered stable, mainland populations are under threat and in decline. They are officially listed as 'vulnerable'.

FIGURE 9 Mainland quokkas are threatened by feral foxes.

Mainland quokkas live in small isolated populations of often fewer than 50 and their conservation is considered important because these colonies contain higher levels of biodiversity than the island communities.

Foxes and feral pigs are two significant threats. Foxes were introduced in the late 1920s and have had a dramatic effect on quokka numbers. Feral pigs destroy dense swamp vegetation, allowing other predators to access these quokka habitats. Although fox baiting and pig control measures are considered partly effective, mainland quokkas remain severely threatened.

Can we control foxes and rabbits?

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 following methods:

- biological — introduction of viruses, such as myxomatosis and calicivirus
- chemical — laying poison baits or fumigating warrens
- mechanical — destroying warrens, shooting and laying traps.

Rabbits are highly destructive to the environment, but once they are eradicated from an area, the environment can regenerate (see **FIGURE 10**).

FIGURE 10 (a) Rabbits reduced Phillip Island (near Norfolk Island, off the east coast of Australia) to a wasteland. (b) After the rabbits were eradicated, the island's recovery was spectacular.

Hunting, baiting (poisoning) and shooting reduce adult fox populations in the short term; however, their populations soon recover. Scientists are now trialling biological controls and working to develop some form of virus or birth control that will interfere with the reproductive system of the fox, making them infertile and incapable of breeding.

Middle Island Maremma Project

Middle Island, a small rocky island about 2 hectares in size off the south-western Victorian coast near Warrnambool, is home to a Little Penguin colony. At low tide, less than 12 centimetres of water separates the island from the mainland, providing easy access for predators such as foxes.

In 1999, Middle Island had a thriving colony of Little Penguins, of about 600 birds. By 2005, foxes had reduced the population to fewer than 10, with only two breeding pairs remaining. In 2006 an ambitious experiment was launched using Maremma dogs to guard and protect the remaining penguins (**FIGURE 11**). This breed of dog has long been used to guard livestock, including chickens, with reports that once the dogs were on duty, fox kills stopped.

After some initial teething problems, the program has proved highly successful. Within a short time, there was evidence of the penguins breeding. By 2013 the Little Penguin population had rebounded to 180. In a cruel twist of fate, however, 70 penguins were killed in a fox attack in 2017, reducing the breeding population to just 14. The dogs had been taken off the island for the winter season due to high tides and bad weather.

However, numbers appear to have started to grow again with five breeding pairs in residence for the 2019–20 breeding season. Experts now estimate that 70 to 100 Little Penguins are on Middle Island. Accurate counts were not possible in 2021–22 due to ongoing COVID-19 complications and poor weather conditions.

FIGURE 11 Using Maremma dogs to guard the penguins on Middle Island from fox attacks proved to be a highly successful strategy. The island's penguin population, previously close to extinction, continues to grow under the protection of the dogs.

3.6 SKILL ACTIVITY: Questioning and researching using geographical methods, Concluding and decision-making

1. Copy the table provided into your workbook.
2. Use information in this lesson, your own general knowledge, your atlas and the weblinks in the Resources tab to complete the table. **Identify** as many species as you can and **state** why they might have been introduced.

Introduced species	Reasons for introduction

3. Refer to your completed table and **select** one example of an invasive plant species and one example of an invasive animal species.
4. Find an image of each of your chosen species. **Annotate** your images with the following information:
   a. Reasons for their introduction
   b. Their impact on the environment
   c. **Propose** a strategy for eradicating, controlling or minimising the impact of the species.
   d. **Evaluate** the effectiveness of your chosen strategy.
5. Share your findings with other members of the class.

on Resources

Weblinks Weed species
Middle Island project
Invasive Species Council
Invasive Species in Australia

3.6 Exercise

learnon

3.6 Exercise

Learning pathways

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

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Check your understanding

1. Why do people say that rabbits cause the demise of native plant and animal species?
   - **A.** They prevent plant regeneration as they eat the roots as well as the foliage.
   - **B.** They compete with native species for food and their burrows undermine surface structure.
   - **C.** They ringbark trees and eat plant seeds and seedlings.
   - **D.** All of the above
2. Complete the following sentences using the words provided below.

only on mainland Australia	on both mainland	Australia and Tasmania	only in Tasmania
one-quarter	three-quarters	all	

Both rabbits and foxes are found _____. They range over approximately _____ of the mainland, extending just beyond the 18th parallel.

3. Complete the following sentence using the words provided below.

less	more
higher	lower

Control of invasive species is _____ feasible in island communities as the risk of reinfestation is considerably _____ than on the mainland.

4. **Explain** why goats are an effective method of controlling invasive plant species.
5. **Justify** the classification of goats as an environmentally friendly method of controlling invasive plant species.

Apply your understanding

Interpreting and analysing geographical data and information

6. The invasive animal species described in this lesson have proven more difficult to control than the plant species. **Propose** a reason for this.

Concluding and decision-making

7. **Infer** why foxes are not found in Australia's tropical regions.
8. **Consider** the three methods of rabbit control by completing the following tasks.
   - **a.** Copy the following table. In the second column, write your own definition for each of the control methods.
   - **b.** Complete the remaining columns, **outlining** the advantages and disadvantages of the three methods.
   - **c.** **Compare** the advantages and disadvantages of the three main methods of rabbit control. Which method do you think is the most effective? **Justify** your answer.

Method	Definition of method	Advantage	Disadvantage
Biological			
Chemical			
Mechanical			

9. **Examine FIGURE 10. Describe** the appearance of the environment in each image. Do these images represent the same place? **Propose** reasons for the changes that have occurred in this environment.

Communicating

10. **Create** your own sustainable and environmentally friendly strategy for controlling an invasive species. **Outline** the steps in your plan and why you think it would be successful.

LESSON
3.7 How do native species change the environment?

LEARNING INTENTION

By the end of this lesson you should be able to explain the threats to biodiversity from native species and environmental change.

TUNE IN

Did you know that around 4 million people visit Yellowstone National Park each year?

Many flock there to watch the world's most famous geyser. In 60- to 110-minute cycles, the geyser shoots tens of thousands of litres of boiling water to heights ranging between 32 and 55 metres, with each eruption witnessed by up to 2000 people.

Based on the height and duration of the last eruption, park rangers can predict, to within 10 minutes, the time of the next eruption.

1. What do you understand by the term 'national park'?
2. Brainstorm a list of reasons for the existence of national parks.
3. Other than national parks, how can we protect the habitats of plant and animal species?

FIGURE 1 Old Faithful geyser in Yellowstone National Park

3.7.1 Protecting biodiversity

To protect native species, governments have established national parks. The world's first **national park** was Yellowstone National Park in the United States of America established in 1874. The second, the Royal National Park, was established in Sydney, Australia five years later.

These parks are intended to provide safe habitats for native plant and animal species and thus help safeguard **biodiversity**. However, biodiversity is not just under threat from introduced species; left unchecked, native species can also cause widespread damage to the landscape.

national park an area set aside for the purpose of conservation
biodiversity the variety of plant and animal life within an area

3.7.2 Should we cull iconic Australian natives?

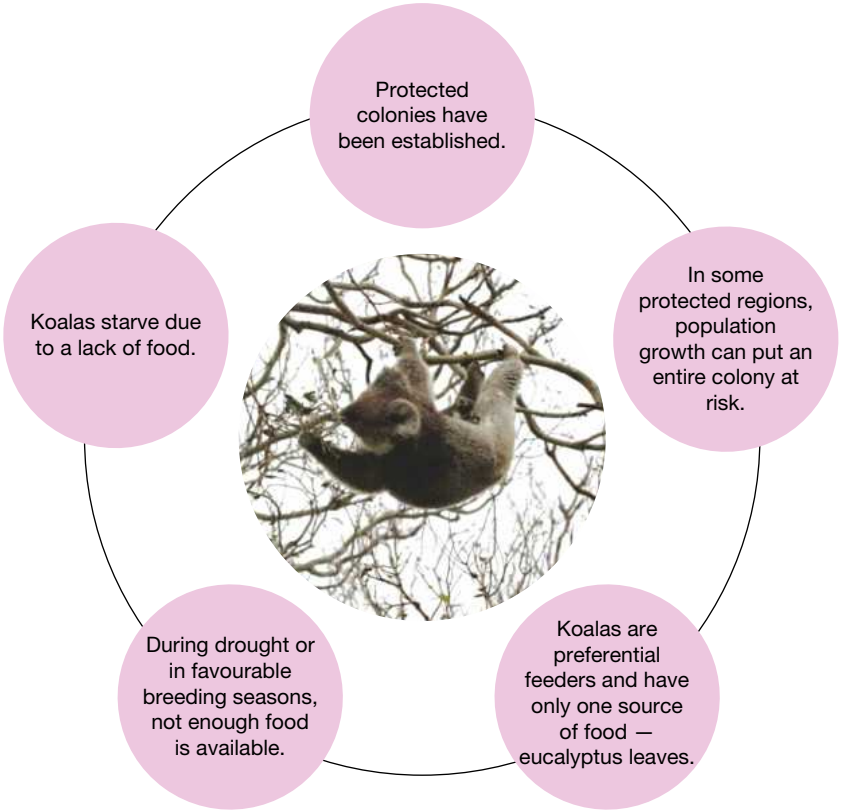
Many native Australian species have been threatened by the spread of urban settlements. As human populations expand, the natural range of animals such as koalas, kangaroos and wallabies are diminished. Despite the number of national parks that exist, native species can be found not only on the fringe of urban areas, but also taking refuge in our backyards where they face increasing risk from vehicles, domestic pets and poisons.

FIGURE 2 A koala drinking from a dog's water bowl in a suburban backyard

In 2013 and 2014, 700 koalas were killed in what the Victorian government described as humane euthanasia to prevent the animals from starving to death due to overpopulation of the manna gum forests in the Otway Ranges. Opponents of the move described it as a secret **cull**.

In late 2015, researchers called for koalas to be culled in parts of Victoria, New South Wales and Queensland, in areas where the local populations were infected with the disease **chlamydia**. Culling, the researchers suggested, would prevent further spread of the disease to healthy animals and allow the population to rebound over the next ten years. Others have argued that the disease, in its early stages, can be treated with antibiotics.

FIGURE 3 Protected colonies have been established to ensure the survival of koalas — examples include the Otway Ranges and French Island in Victoria. In northern New South Wales, an entire housing development named Koala Beach has been designed with koala conservation in mind.



In 2019, the koala was listed as vulnerable in Queensland, New South Wales and the ACT, and in 2022 the Australian Government officially listed koalas as an endangered species, with loss of habitat cited as the major area of concern. Even within remaining habitats, a lack of diversity exists among eucalyptus species. Preferred control methods are sterilisation and relocation. Sterilisation prevents a population outstripping its food source; however, it does not allow the population to

cull selective reduction of a species by killing

chlamydia a sexually transmitted disease infecting koalas

rebound after natural disasters such as bushfires. Relocation is only a short-term fix, as shown on Kangaroo Island — koalas relocated there have flourished, mainly because of their proximity to a commercial blue gum plantation; however, the population will once again be decimated once the trees are harvested.

3.7.3 What about the African elephant?

In 1930, some 10 million elephants roamed across 37 countries in Africa. By 1979, almost 90 per cent of the wild elephant population had been wiped out, with their numbers estimated at 1.3 million. By 2007, the estimated range of elephant numbers had declined even further (see **FIGURE 4**). In 2018, the population had continued to decline, with numbers down to around 415 000. At this rate, it is possible that the elephant could become extinct in the wild by 2050. Some estimates put the number of animals killed at up to 100 per day, as poachers seek to make their fortune selling meat, ivory and body parts to the lucrative Asian market. From

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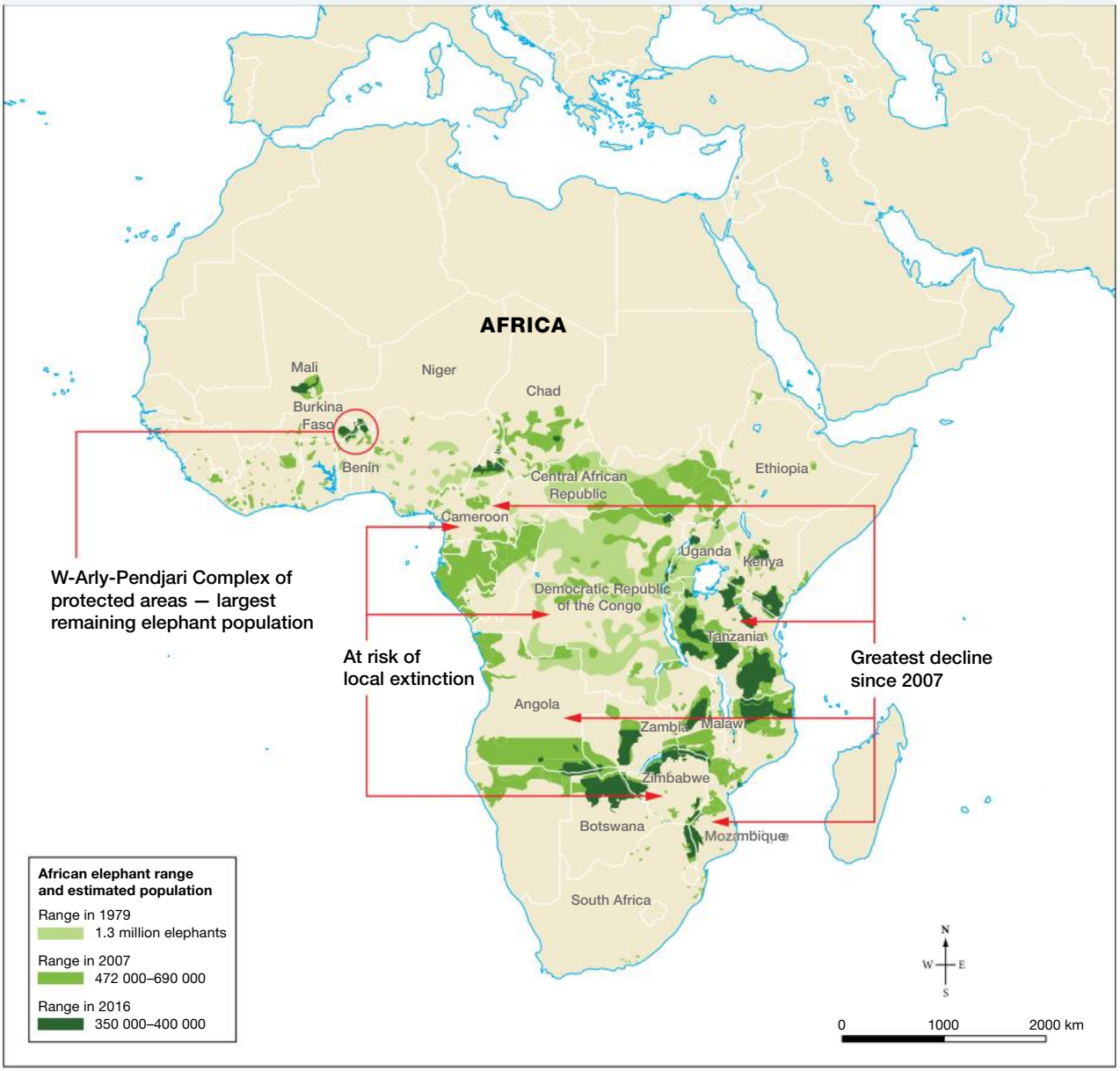
FIGURE 4 African elephant range and estimated population



Source: National Geographic and IUCN Red List.

2011 to 2014 the price of ivory alone tripled in China, peaking at $2100 per kilogram. In 2017, a ban imposed by the Chinese government on ivory saw the price fall to $750 per kilogram.

Elephants are also under threat from expanding human populations. As the number of people increases, so too does their need for land to grow crops and raise livestock, and people encroach further and further into the elephants' rangelands. Struggling farmers can also earn more from a single elephant kill than from a year of toiling on the land. When elephants enter these newly created farmlands and damage crops, the temptation to kill them intensifies.

Elephants are a key **ecological species**, sometimes referred to as caretakers of the environment. The loss of elephants poses a significant environmental threat to local ecologies.

FIGURE 5 Elephants are sometimes referred to as caretakers of the environment.

Elephants create and maintain their ecosystem and, in the process, create habitats for a wide range of plants and animals.

- When they dig for water using their tusks, other animals gain access to this water.
- By eating small shrubs and trees, they maintain the open space of the plain.
- Their high consumption of plants and dung affects soil quality. This encourages a higher diversity of plants and animals.
- Gaps created in vegetation allow new plants to grow in the spaces created and pathways are made for smaller animals such as lizards who make their homes in elephant-damaged trees.
- Up to 30 per cent of African trees depend on elephants to assist with the dispersal and germination of their seeds.

However, the practice of confining large animals such as elephants to national parks free from predation and with an abundant water supply can result in a population explosion. An adult elephant consumes up to 136 kilograms of food in a single day.

The search for food can see them cover vast distances, in the process stripping bark from, ripping branches off and pushing over trees. As the process of confining animals to reserves continues, traditional migration paths are interrupted. The population flourishes and the landscape becomes degraded as the rate of change speeds up.

Africa's first national park was established in 1926. Covering almost 20 000 square kilometres, it is one of the largest reserves in Africa. Culling of elephants within the national park was banned in 1994.

While elephant numbers are declining elsewhere, within Kruger National Park they are increasing. This has prompted some to suggest that culling as a means of population control should be reinstated to limit numbers to a sustainable level of 7000 to 8000, rather than the current 17 000, which places both the elephants and their habitat in jeopardy.

ecological species species that helps maintain or care for the ecology of an area, and creates and maintains habitats for other species

3.7.4 Ecological corridors

An **ecological corridor** enables wildlife to move between similar habitats that might have become separated by human development. They enable the seasonal migration of animals for breeding and feeding and facilitate the dispersal of plant species, maintaining ecological connectivity and the continuation of viable populations.

Ecological corridors have been established on both land and sea; their presence limits human encroachment that may put biodiversity at risk. Additionally, genetically different populations remain connected and allow for the re-colonisation of an environment that may have been disturbed.

FIGURE 6 An ecological corridor, such as a bridge over a multi-lane highway, helps maintain biodiversity by allowing animals to safely access all parts of their ecosystem.

Canada: Banff wildlife bridges

The Trans-Canada Highway passes through Banff National Park in Canada carrying large volumes of traffic and dissecting the major migration route of a variety of animals, including deer, moose, porcupines, mountain lions and bears. Along the 88-kilometre stretch of road, 41 underpasses and seven overpasses have been constructed as ecological corridors to enable animals to safely cross the highway and access habitats. The passages vary in width from 10 metres to 60 metres, and the overpasses are covered in native vegetation (see **FIGURE 7**).

An 85 to 95 per cent reduction in collisions between animals and vehicles has been recorded along the highway. The provision of both tunnels and bridges caters for the preferential needs of different species; grazing animals such as deer and moose prefer to use the open-air overpasses, while more predatory animals such as cougars and black bears prefer the tunnels.

Genetic diversity is ensured as the corridors re-connect habitats that were previously fragmented by the highway and enable the interaction of different groups within the same species.

ecological corridor wildlife corridor that connects wildlife habitats that have been separated by human activity or structures such as roads, enabling wildlife to move between habitats that have become fragmented

FIGURE 7 An overpass connects habitats on both sides of the Trans-Canada Highway

Australia: Christmas Island bridges and tunnels for crabs

Every year on Christmas Island, 40 to 50 million red crabs migrate from the forest to the ocean to breed. This mass migration is triggered by the onset of the wet season, usually around October or November.

Almost two-thirds of Christmas Island is national park, and park rangers have identified major road crossing points used by the crabs. Tunnels have been built under the road and overpasses above it to protect the crabs from vehicles (see **FIGURE 8**). Additionally, there are 12 kilometres of permanent fencing that the crabs cannot climb over along the sides of the road to funnel the crabs to these crossing points. In peak season, park rangers will close the roads to facilitate the mass movement of crabs, which has become a major tourist attraction for the island.

FIGURE 8 Fencing along the side of the road ensures the red crabs will use the specially constructed bridge during their mass migration to the coast to breed.

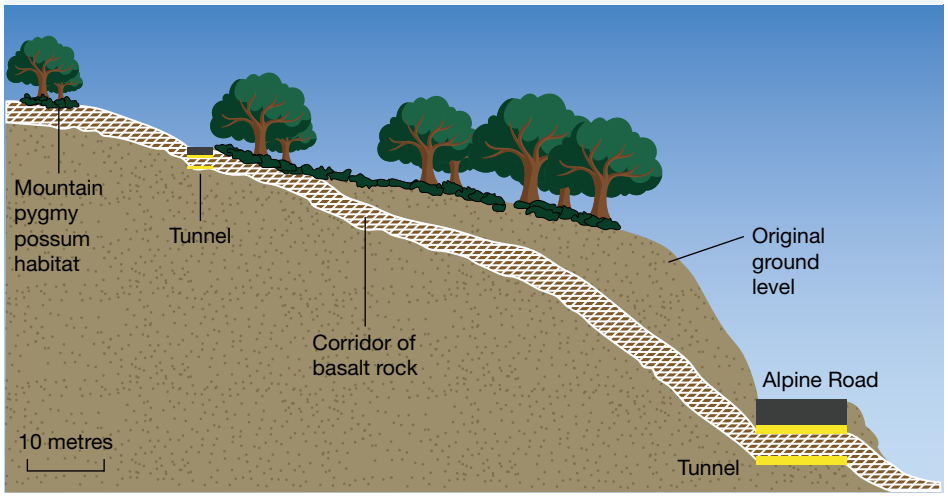
Australia: Mount Hotham 'tunnel of love'

The habitat of the mountain pygmy possum has been altered, reduced and broken up by snow compaction, removal of boulders and vegetation, and the development of ski fields, villages, car parks and roads in the Alpine National Park region.

Male and female pygmy possums only meet during the breeding season. Females liver higher up in the mountains in the boulder fields that attract the bogong moths, while the males prefer poorer habitats lower down on the mountains.

The construction of ski runs, and the Alpine Road at Mt Hotham, effectively blocked the migration route that enabled male pygmy possums to access the female habitats during the breeding season. Males faced increased risk from predators and increased traffic flow on the Alpine Road. The construction of a rock corridor and 'tunnel of love' under the Alpine Road enabled safe passage for males and allowed young possums to leave and find new habitats (see **FIGURE 9**).

FIGURE 9 Cross-section of the tunnel of love



3.7 SKILL ACTIVITY: Concluding and decision-making and Communicating

Individuals have different **perspectives** and **worldviews** on environmental issues. Think about possible responses of vegetarians, environmentalists and farmers to the following statement.

'Culling our native animals is cruel, unethical and unnecessary'.

Identify the different positions each group might have on these issues and **describe** the cultural values and beliefs that might influence their differing perspectives.

1. Use the information in this lesson to get started. As you carry out your research, remember to compile a bibliography and submit this with your work.
2. Ask yourself the following questions:
   a. Why might animals need to be culled?
   b. Do any alternatives to culling exist?
3. Rule up a table such as the one provided to organise your research. Place the ideas and arguments you find under one of these headings.

Vegetarian's view	Environmentalist's view	Farmer's view	Cultural values and beliefs reflected

4. **Create** a poster that enables you to present your ideas in an interesting and engaging way. Include images that reflect the perspectives and worldviews of each group in your table.

perspective the way in which a person views things based on their current position; reflects current views and is affected by personal circumstances

worldview reflects your fundamental beliefs and values based on your idea of what is fair and right; may be aligned with the values of the wider community or time in which you live

3.7 Exercise

learnon

3.7 Exercise

Learning pathways

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

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Check your understanding

1. What is an ecological corridor?
   A. An area without native flora and fauna
   B. A controlled environment
   C. A passage connecting habitats fragmented by human development
   D. A genetically modified environment
2. **Identify** the statement that is incorrect.
   A. Ecological corridors enable seasonal migration where habitats are fragmented.
   B. Ecological corridors are only found on land.
   C. Ecological corridors assist in maintaining biodiversity.
   D. Ecological corridors facilitate the dispersal of plant species.
3. Native species can cause the land to be degraded by:
   A. killing other native species.
   B. damaging buildings when they climb into roof cavities.
   C. damaging crops and orchards, and eating pasture.
   D. sleeping in trees.
4. **Explain** how a national park can act as a safeguard for biodiversity.
5. **Describe** the distribution of elephants in Africa.

Apply your understanding

Concluding and decision-making

6. **Explain** how human population growth leads to the fragmentation of koala habitats.
7. **Predict** what might happen to the koala population, over time, in the Otway Ranges or on French Island if no action was taken to control the koala population.

Interpreting and analysing geographical data and information

8. **Explain** the threats to the African elephant population.

Communicating

9. Referring to the threats to African elephants, what do you consider to be the greatest threat to the long-term survival of this species? **Justify** your response.
10. Do you think that culling is a viable solution to ensure the long-term survival of elephants or koalas? **Justify** your answer.

LESSON
3.8 How do First Nations Australians manage the land?

LEARNING INTENTION

By the end of this lesson you should be able explain how traditional owners use their cultural knowledge and practices in the management of their Country and environments.

TUNE IN

For more than 60 000 years, First Nations Australians have worked with the environment and used a complex system of land management to care for Country. Their systems were sustainable and provided everything they needed to survive.

FIGURE 1 One land management system used by First Nations Australians

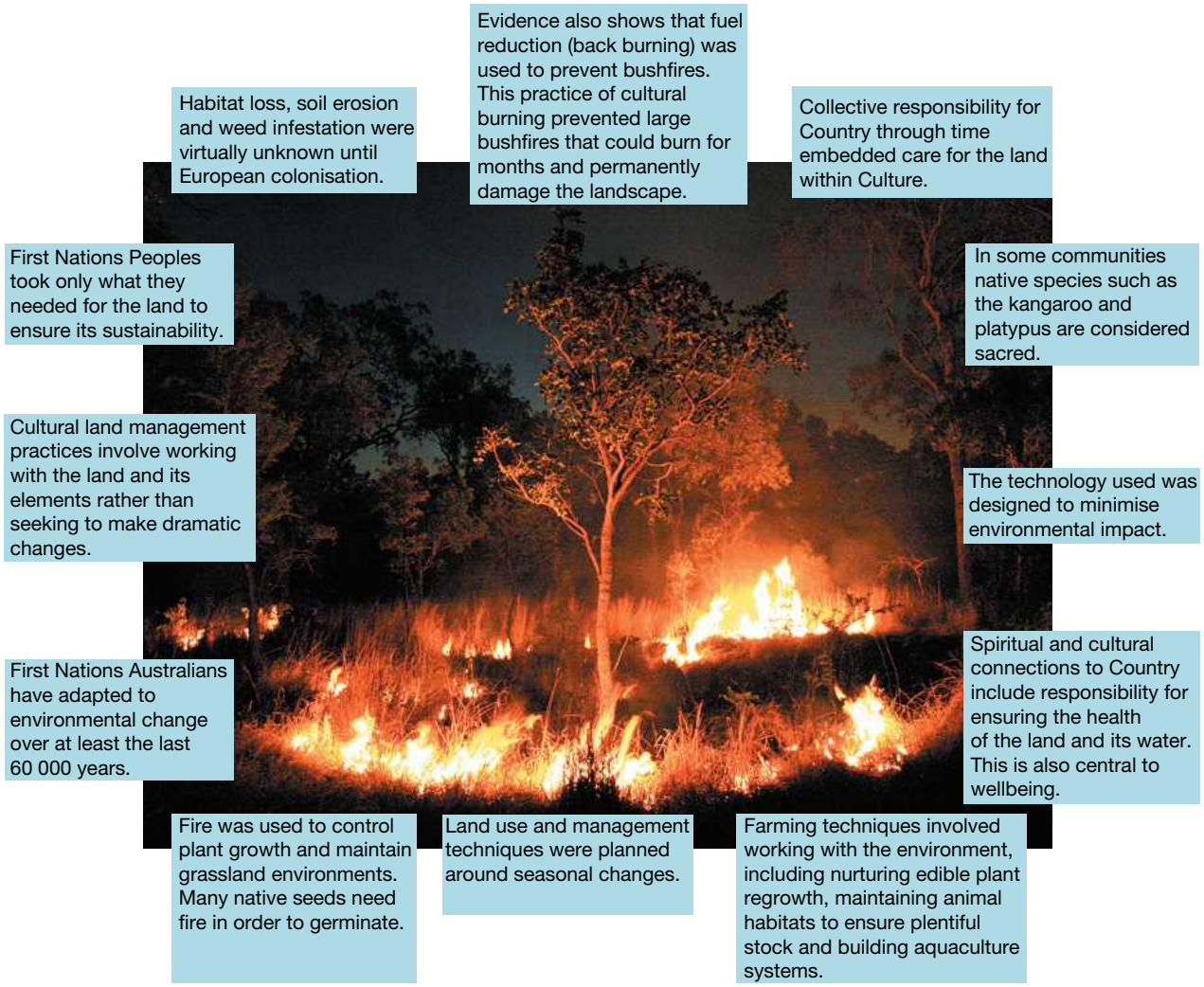
1. Examine **FIGURE 1**. What system of land management is being used?
2. In Australia, we fear bushfires, and yet they are an integral part of land management for First Nations Australians. Work with a partner to suggest a theory that explains how First Nations Australians were able to use fire to manage, rather than destroy, the land.
3. Brainstorm a potential list of benefits from this type of land management.

3.8.1 Land management technologies

Before the arrival of Europeans, First Nations Australians had their own systems of land management, each developed to suit their own Country.

Land management practices that maintained Country were intrinsically linked to First Nations Australians' knowledges, along with roles and responsibilities that were determined by a sophisticated societal structure based on kinship. For example, grasslands were managed through the use of fire, which encouraged plant regrowth and attracted a variety of animals. Management strategies were largely governed by the seasons and the local cycles of growth and weather, with each change dictating a change in the use of the land and its management. The use of cultural burning practices enabled First Nations Australians to shape the land to best suit their needs while also maintaining sustainable and healthy environments.

FIGURE 2 Cultural land management practices



Environmental change is not new. First Nations communities around the world, including in Australia, managed their environments carefully and have been practising **environmental stewardship** for tens of thousands of years. First Nations Australians' strong connection to Country and sense of responsibility in protecting and conserving environments has maintained biodiversity throughout the generations. In **FIGURE 2** you can see how fire was used to manage the landscape by some First Nations Australian communities. It is interesting to note that the use of fire in this way for

environmental stewardship a worldview that maintains we have an ethical responsibility to care for and manage the environment in a responsible manner, and that humans should act as the caretakers of the environment

more than 60 000 years had a significant impact on the species of plants that thrive in Australia today. Those plants that adapted to the use of fire thrived; for example, eucalypts. Using fire is just one of a variety of strategies employed by First Nations Australians to ensure the land is managed in a sustainable manner.

3.8.2 Season-based land management

First Nations Australians were very careful in maintaining Country and ensuring its resources remained plentiful through seasonal migration. This land management practice was heavily influenced by deep knowledge of the environments that they lived in and were culturally responsible for. Detailed knowledge of weather systems and what these specific times supplied in terms of resources allowed First Nations Australians to move about their Country with specific purpose at various times of the year, thus contributing to a sustainable and thriving society. For example, the Yolngu People, who live in north-east Kakadu, knew that each of their five seasons (**FIGURE 3**) brought different opportunities for food collection and cultivation. They hunted and fished for particular species and harvested bulbs, fruits and other edible vegetation at different times of the year. Different Peoples' and Cultures' calendars varied, but whatever the location, seasonal events provided information about what to do. For instance, the arrival of march flies might signal the time to collect crocodile eggs and bush honey.

FIGURE 3 The activities of the Yolngu were defined by the observable changes in the seasons.

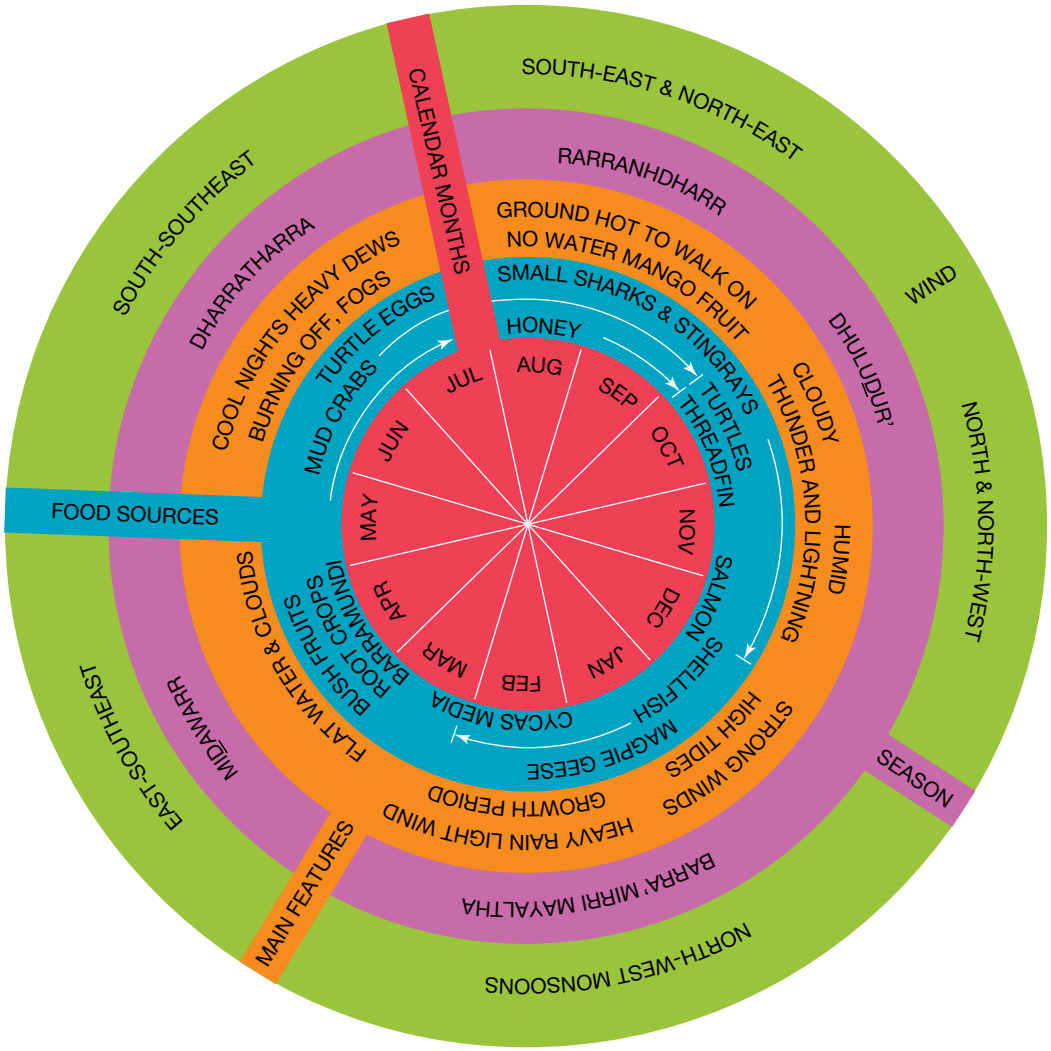


FIGURE 4 Wetlands after removal of buffalo and before burning

FIGURE 5 Wetlands after burning

CASE STUDY: Managing Kakadu Wetlands

Kakadu is a kaleidoscope of both cultural and ecological biodiversity. The landscape varies from savannah and woodlands to escarpments and ridges as well as wetland, flood plains and tidal flats. The region includes more than 2000 plant species that have provided food, medicine and weaving materials for the Bininj (in the north) and Mungguy (in the south) communities that have inhabited the region for some 50 000 years. Over this time they have defined six distinct seasons, all signalled by subtle changes in the weather patterns that mark the transition from one season to the next. They managed and maintained the landscape through the use of fire.

The arrival of European colonisers saw a massive change in the region. Buffalo were introduced in the early to mid 1800s to serve as a food supply for new settlers. However, once these new settlements were abandoned in the mid 1900s, the buffalo population expanded from a modest population of less than 100 animals to more than 350 000. The impact on local habitats was extreme.

Natural habitats were devastated. The now-feral buffalo took over wetland areas, disturbed native vegetation, caused significant soil erosion and changed the characteristics of the region's floodplains. Saltwater intrusion of freshwater wetlands caused the region to become further degraded, leading to a rapid decline in the flora and fauna, including waterbirds that had sustained local communities.

In the late twentieth century, the Department of Sustainability, Environment and Water authorised a massive culling program to remove the feral buffalo and allow the region to regenerate. However, an invasive native plant species that had once been the main food source of the buffalo spread unchecked. It choked the wetlands and prevented waterbirds from feeding and recolonising the region.

The CSIRO undertook extensive research into the Bininjs and Mungguy's sustainable land management practices. A joint management initiative was introduced into the area. At the heart of the initiative was traditional fire management.

The results have been dramatic. The wetlands are once again home to a rich assortment of flora and fauna. The project provides an internationally recognised example of sustainable land management using the practices developed and perfected by traditional owners over thousands of years. Some First Nations Australian communities in the Kakadu region rely on the buffalo as a food source. They have negotiated permission to raise and maintain a domestic herd.

3.8.3 Using traditional knowledges today

Traditional knowledges that protect and manage land and sea environments are being used more often in conjunction with conservation techniques that developed from European traditions and science. For example, the number of Indigenous Protected Areas (IPAs) across Australia is increasing, as is the number of Ranger programs. In 2020, there were 78 dedicated IPAs over 74 million hectares across the country and 4 million hectares of sea country.

An IPA is a sea or land area that is protected and conserved under the management of local First Nations Australians, which helps to maintain continuing cultural connection with Country and preservation of important sites with traditional land management technologies. Indigenous Ranger programs employ First Nations Australians in conservation programs to protect Country. The programs aim to combine contemporary and traditional land management knowledges to protect vulnerable sea and land environments and threatened species, and to reduce the impact of introduced species.

The diverse and exceptional knowledge that First Nations Australians have of Country and how to care for it has gained greater respect today in relation to sustainably managing the land. Cultural practices that successfully maintained Country for tens of thousands of years are now being recognised for their dynamic ability to counteract the impact of exploited lands today.

Further, the value of native plants and their uses is being respected, with many First Nations Australian businesses and communities at the forefront of introducing and advocating native plants as a source of both food and healing. This is directly aligned with knowledge systems that hold a deep understanding and respect of Country and the environment.

SkillBuilders to support skill development

- 1.16 Describing change over time

3.8 SKILL ACTIVITY: Concluding and decision-making, Communicating

Environmental change, such as salinity, was not an issue in Australia when First Nations Australians were its sole inhabitants. With the aid of diagrams, **explain** how land-use practices have changed over time.

Make sure you include links to reflect the following:
- traditional practices that promoted sustainable use of the environment
- changes that would have resulted in salinity and degraded the environment.

Compare your diagrams and ideas to those of other members of your class.

on Resources

Video eLesson First Nations Australian land management — Key concepts (eles-6137)

Interactivity First Nations Australian land management (int-9132)

Weblinks Wetland burning videos
First Nations Australians' fire management

3.8 Exercise

learnon

3.8 Exercise

Learning pathways

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

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Check your understanding

1. Why wasn't land degradation an issue before European colonisation?
   - A. Climate change started when European settlers arrived.
   - B. First Nations Peoples managed the land, using it to supply their needs and did not deplete the natural resources.
   - C. First Nations Peoples used the land to supply needs and depleted the natural resources.
   - D. Land degradation *was* an issue before European settlement.
2. Complete the following sentence using the words provided below.

animals	fire	sea water
animals	settlers	seasons

First Nations Australian communities used _____ to encourage new plant growth and attract wildlife to a region. Their land management techniques were governed by the _____.

3. Why are water buffalo considered a significant threat to the Kakadu wetlands? **Select** all that apply.
   - A. They attack other native species.
   - B. They destroy native vegetation.
   - C. They drink too much of the water.
   - D. They cause significant soil erosion.
4. **Explain** why the use of fire was an important component of managing the land.
5. **Explain** how the Yolngu calendar (**FIGURE 3**) demonstrates an interconnection between their beliefs about the land and sustainable management of the environment.

Apply your understanding

Concluding and decision-making

6. The Yolngu calendar (**FIGURE 3**) demonstrates an intricate understanding of the environment.
   - a. **State** how long you think it would have taken the Yolngu people to develop this understanding.
   - b. **Explain** how you think this knowledge would have been passed from generation to generation.
7. It has been suggested that the four seasons currently used in Australia do not adequately reflect the changing nature of our seasons.
   - a. Do you agree or disagree with this suggestion? **Justify** your opinion based upon the area you live in.
   - b. Do you think the First Nations Australian seasons calendar of each region should be adopted and used as an additional strategy for the sustainable management of environmental issues? **Justify** your point of view.

Interpreting and analysing geographical data and information

8. Study **FIGURES 4** and **5**. **Describe** the environment shown in **FIGURE 4** and the changes that have occurred in **FIGURE 5**.

Communicating

9. **Describe** the steps that might have been taken to turn the landscape shown in **FIGURE 4** to the one shown in **FIGURE 5**.
10. Do you think the land management practices used in Kakadu could be used in other parts of Australia? **Justify** your point of view.

LESSON
3.9 Investigating topographic maps: Managing environmental change in the Parwan Valley

LEARNING INTENTION

By the end of this lesson you should be able to describe the extend of environmental change in the Parwan Valley.

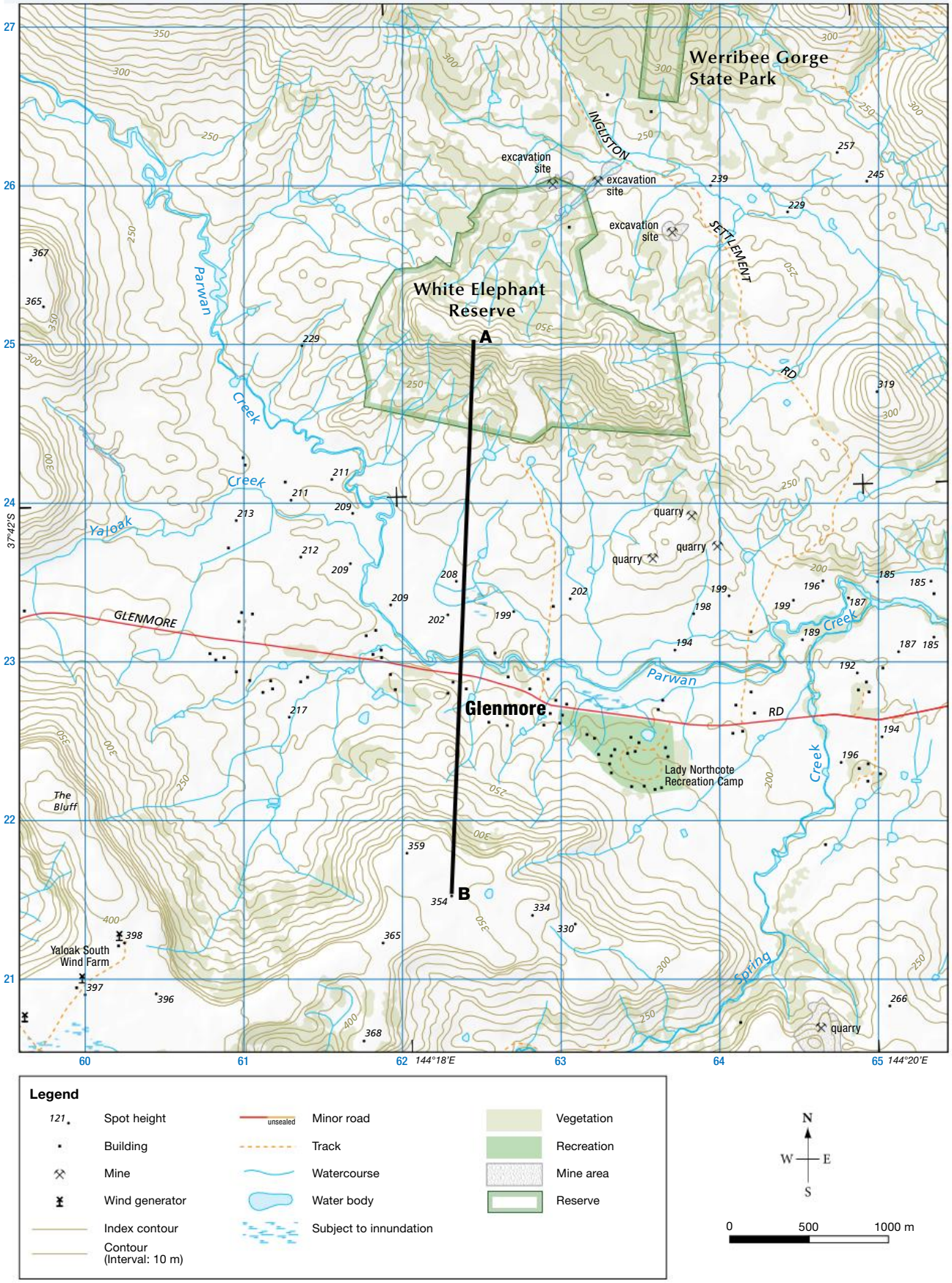
3.9.1 Parwan Valley

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.

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 in the Parwan Valley

FIGURE 2 Topographic map of the Parwan Valley



Source: Data based on Vicmap, Department of Environment, Land, Water and Planning.

Resources

eWorkbook	Investigating topographic maps — Managing land degradation in the Parwan Valley (ewbk-10089)
Digital document	Topographic map of the Parwan Valley (doc-36368)
Video eLesson	Investigating topographic maps — Managing land degradation in the Parwan Valley — Key concepts (eles-5251)
Interactivity	Investigating topographic maps — Managing land degradation in the Parwan Valley (int-8677)
Google Earth	Parwan Valley (gogl-0103)

3.9 Exercise

learnon

3.9 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** the name of the area found in AR6225.
2. **Describe** the topography of the Parwan Valley.

Apply your understanding

Interpreting and analysing geographical data and information

3. **Explain** why some parts of the built environment have had a greater influence on erosion in the area than others.
4. **Calculate** the gradient from point A to Glenmore.

Communicating

5. **Explain** how the topography might influence land degradation in the area.
6. **Create** 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.

LESSON
3.10 INQUIRY: First Nations Australians' land practices

LEARNING INTENTION

In this lesson you will investigate partnerships between government, agencies such as the CSIRO, and First Nations Peoples of Australia to learn more about how traditional practices and new technologies can work harmoniously.

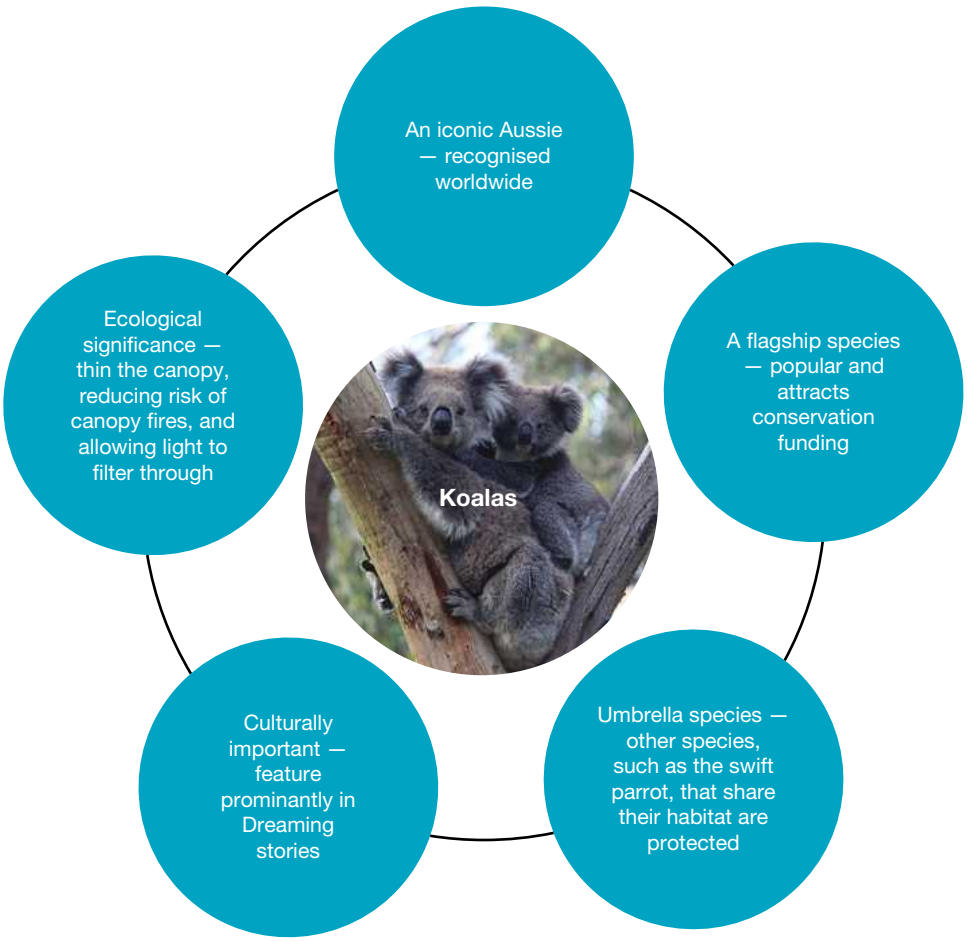
Background

In this inquiry, you will **investigate** the relationships between government agencies such as the CSIRO, and First Nations Peoples of Australia to gain a deeper understanding of how traditional practices and modern technologies can seamlessly work together and support First Nations Peoples in caring for Country.

Before you begin

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

FIGURE 1 To First Nations Peoples of Australia, all parts of the environment are significant.



Inquiry steps

Step 1: Questioning and researching using geographical methods

Discuss the following:

a. What do you know about land management practices used by First Nations Peoples of Australia?
b. What do you know about Indigenous Protected Areas and the work of the CSIRO in supporting the role of Indigenous Rangers in caring for Country?
c. What would you like to know?
d. Are you particularly interested in an environment such as Kakadu or Uluru, or a particular species such as magpie-geese or koalas?

Write your inquiry question

- Write your selected **inquiry question** based on the focus of this topic.

Investigate your inquiry question

Conduct research on the collaborative work between First Nations Peoples of Australia, the CSIRO and the Australian Government.

- Some of the following weblinks in the Resources tab might help you to get started: **Indigenous science, Kakadu management, Magpie geese, Kakadu Rangers, National Koala Monitoring Program, Protecting Koalas Project.**
- Make notes about the strategies being used and how multiple groups are working collaboratively.
- Collect any available statistics and images such as before-and-after shots.

Step 2: Interpreting and analysing geographical data and information

- **Create** a summary table of problems, solutions and impacts.

Step 3: Concluding and decision-making

- **Evaluate** your findings.
- **Develop** a point of view to respond to your inquiry question.

Step 4: Communicating

- **Decide** how you will communicate your findings. This might be in the format of a written report, PowerPoint presentation or video documentary.

Complete your self-assessment using the **Inquiry rubric** or access the 3.10 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-40155)

Weblinks
Indigenous science
Kakadu management
Magpie geese
Kakadu Rangers
National Koala Monitoring Program
Protecting Koalas Project

LESSON
3.11 Review

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

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

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3.11.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

3.2 What are the causes and impacts of environmental change?

- Land degradation is a complex issue; however, most of the causes of this degradation are human induced.
- As the population of the Earth increases the land is under more and more pressure to house and accommodate this growing population.
- The land becomes degraded when we alter its natural state, through vegetation removal and introduced species, predominantly to expand our cities and increase our agricultural land.
- Developing nations, where the population is growing fastest (especially those in sub-Saharan Africa) are most at risk; when the land becomes degraded, they lack the resources to deal with the issue.
- Land degradation presents challenges to future food production.

3.3 How do we manage environmental change?

- A critical issue in land degradation is the loss of fertile soil. This soil has taken decades and, in some areas, hundreds or thousands of years to develop. However, clearing the land of vegetation leaves it vulnerable to erosion.
- Erosion of the topsoil may lead to rill, gully and tunnel erosion that affects the capacity of the land to support vegetation. Strong winds can pick up the soil and carry it large distances; this is a dust storm.
- The only way to repair the damage is through revegetation and programs designed to stabilise the soil.
- Costerfield is an example of how poor land management can have a devastating impact on the environment; however, it is also an example of how improving land management strategies can restore the land, enabling it to be used in a sustainable way.

3.4 How does salinity change the environment?

- Salt occurs naturally in the environment; in Australia, it has lain dormant far below the surface in the groundwater.
- Poor irrigation practices and the removal of deep-rooted vegetation have seen this salt rise to the surface, reducing the fertility of the land.
- Salinity is a major issued in the Murray–Darling Basin and in other parts of the world such as in the Mekong Delta.
- In order for issues related to salinity to be addressed, it is essential to consider the needs of all stakeholders, and especially the needs of the environment.

3.5 How does desertification change the environment?

- Experts estimate that 41 per cent of the Earth's surface is at risk of turning into desert, largely due to poor management of the semi-arid lands on the margins of the desert.
- Desertification is a human-induced problem; population growth and the need to increase food production place drylands under increasing pressure. Once the land has been overrun by the desert, it is difficult to reclaim.
- China is attempting to halt the spread of the desert by planting a massive green wall along the southern border of the Gobi Desert. A similar project is taking place in the Sahel in Africa to halt the spread of the Sahara Desert.

3.6 How do invasive species change the environment?

- Introduced species can have a devastating impact on the environment. Early settlers brought animals and plants with them — animals as a source of food and plants for their gardens.
- Over time, these species can escape and take over the landscape. Goats, for example, have no natural predators, compete with native animals for food, damage the soil and overgraze the land. Introduced plants such as Paterson's Curse choke out natural vegetation and prevent sunlight from reaching the soil.
- Introducing goats to areas that are infested with invasive plant species can assist in reclaiming the land and keeping this pest at bay.
- Other species such as foxes and rabbits have been more difficult to control. However, Maremma dogs have been used to protect colonies of penguins from foxes.

3.7 How do native species change the environment?

- Native species can also cause significant environmental change — koalas can literally eat themselves out of house and home. Koalas have, however, lost much of their original habitat, so issues related to food supply are largely caused by fragmented habitats; that is, they have nowhere to go.
- Elephants, because of their size, can cause damage to the environment. However, they are also an ecological species in that they maintain their ecosystem. Elephant numbers are declining in Africa, placing these ecosystems at risk.
- Ecological corridors help prevent the loss of biodiversity caused by human-induced environmental change. These corridors link similar habitats, provide migration routes and assist with the dispersal of plant species, on both land and sea.

3.8 How do First Nations Australians manage the land?

- Before European colonisation, First Nations Peoples of Australia lived in harmony with the land; much of this management involved the use of fire, which maintained a grassland environment, encouraged new vegetation growth and assisted them in hunting animals.
- First Nations Australians also had their own unique calendar, linked to the environmental and seasonal changes that they observed. These changes governed their lifestyle and the food they ate throughout the year.
- Management practices were designed to ensure that there would always be a plentiful supply of food from year to year and the land would not be harmed.

3.9 Investigating topographic maps: Managing environmental change in the Parwan Valley

- The Parwan Valley has suffered significant degradation since the arrival of European settlers.
- Strategies to address this degradation are needed.

3.10 INQUIRY: First Nations Australians' land practices

- Government departments and agencies such as the CSIRO support First Nations Australians to care for Country.
- Land management practices of First Nations Australians benefit Country.

3.11.2 Key terms

algal bloom rapid growth of algae caused by high levels of nutrients (particularly phosphates and nitrates) in water
anthropocentric the belief that humans are the central and most important component of the universe
biodiversity the variety of plant and animal life within an area
brackish water that contains more salt than fresh water but not as much as sea water
carrying capacity the ability of the land to support livestock
chlamydia a sexually transmitted disease infecting koalas
cull selective reduction of a species by killing
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
drainage area (or basin) an area drained by a river and its tributaries
dryland ecosystems characterised by a lack of water, including cultivated lands, scrublands, shrublands, grasslands, savannas and semi-deserts; the lack of water constrains the production of crops, wood and other ecosystem services

ecological corridor wildlife corridor that connects wildlife habitats that have been separated by human activity or structures such as roads, enabling wildlife to move between habitats that have become fragmented

ecological species species that helps maintain or care for the ecology of an area, and creates and maintains habitats for other species

ecology the environment as it relates to living organisms

environmental stewardship a worldview that maintains we have an ethical responsibility to care for and manage the environment in a responsible manner, and that humans should act as the caretakers of the environment

exotic species species introduced from a foreign country

groundwater water held underground within water-bearing rocks or aquifers

humus decaying organic matter that is rich in nutrients needed for plant growth

invasive plant species commonly seen as weeds; any species that dominates an area outside its normal region and requires action to control its spread

Mediterranean (climate) characterised by hot, dry summers and cool, wet winters

monoculture cultivating a single crop or plant species over a wide area over a prolonged period of time

mulch organic matter such as grass clippings

national park an area set aside for the purpose of conservation

nutrients essential chemical substances in the soil needed for plants to grow and develop

pastoral run an area or tract of land for grazing livestock

perspective the way in which a person views things based on their current position; reflects current views and is affected by personal circumstances

ringbark removing 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

Royal Commission a public judicial inquiry into an important issue, with powers to make recommendations to government

Sahel a semi-arid region in sub-Saharan Africa; 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

salinity an excess of salt in soil or water, making it less useful for agriculture

salt scald the visible presence of salt crystals on the surface of the land, giving it a crust-like appearance

topsoil the top layers of soil that contain the nutrients necessary for healthy plant growth

turbid water that contains sediment and is cloudy rather than clear

watertable upper level of groundwater; the level below which the earth is saturated with water

weed any plant species that dominates an area outside its normal region and requires action to control its spread

worldview reflects your fundamental beliefs and values based on your idea of what is fair and right; may be aligned with the values of the wider community or time in which you live

3.11.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

In a world that continually demands more from the land, how can we manage change to meet our needs and protect Earth systems?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customised worksheets for this topic (ewbk-11500)
Reflection (ewbk-12515)
Crossword (ewbk-12516)

Interactivity Land environments: change and management crossword (int-7670)

3.11 Review exercise

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Multiple choice

1. Which three options explain some of the processes that can cause the land to degrade?
   A. Land clearing **B.** Introduced species **C.** Undergrazing **D.** Salinity
2. Identify the link between soil erosion and the removal of vegetation.
   A. Vegetation loosens the soil.
   B. Vegetations stops the soil getting wet so it dries out and blows away.
   C. Vegetation washes the topsoil away.
   D. Without vegetation the rain falls on bare soil and washes the topsoil away.
3. Identify the difference between dryland and irrigation salinity.
   A. Irrigation salinity occurs in areas with irrigation, whereas dryland salinity occurs in areas that are not irrigated.
   B. Dryland salinity occurs in deserts, whereas irrigation salinity occurs in grasslands.
   C. Dryland salinity only involves the salt from groundwater.
   D. Irrigation salinity is the result of human inaction.
4. State which feature both dryland and irrigation salinity will cause to rise.
   A. Watertable **B.** Ground water **C.** Bore water **D.** Topsoil
5. Predict two ways that introduced species can cause land degradation.
   A. They compete with native species for habitat and food.
   B. Their manure fertilises the soil causing too much vegetation growth.
   C. They take over the land and have the capacity to choke out native vegetation.
   D. They are poisonous to their natural predators.
6. Define the term ‘ringbarking’.
   A. To cut a tree by first marking a ring around its trunk
   B. To remove the bark from a tree in a ring that goes all the way around the trunk
   C. To remove the bark from a tree to stop a possum climbing it
   D. To remove the bark from a tree to encourage new growth
7. Identify two human practices that encourage the process of desertification.
   A. Deforestation and undergrazing
   B. Overgrazing and reforestation
   C. Deforestation and overgrazing
   D. Climate change
8. Identify *two* invasive species in Australia.
   A. Rabbits and penguins
   B. Cane toads and mosquitoes
   C. Possums and foxes
   D. Rabbits and foxes
9. Identify two deserts that are the site of green walls to prevent further desertification.
   A. Sahel and Gobi
   B. Sahel and Sahara
   C. Gobi and Tanami
   D. Tanami and Atacama

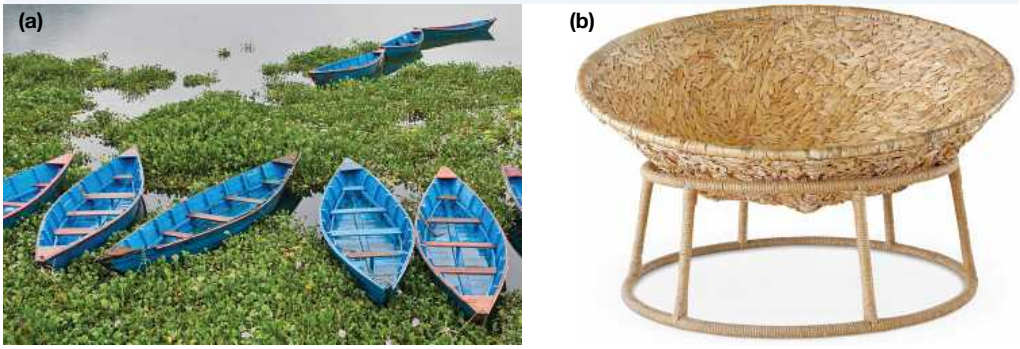
10. Clarify why topsoil is important.
    - **A.** It stops weeds growing.
    - **B.** It provides a soft surface for hooved animals.
    - **C.** It contains the nutrients necessary for healthy plant growth.
    - **D.** It provides nutrients for the watertable.

Short answer

Concluding and decision-making

11. 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. 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 can be useful, and humans have found a number of uses for it, including cleaning industrial wastewater, as a source of biofuel and to make furniture.

FIGURE 1 (a) Water hyacinth, a serious problem in many parts of the world, and (b) being used in other areas to make furniture.



    a. Do you think other invasive plant species could be used commercially? **Justify** your answer.
    b. **Design** an advertising campaign to convince people to purchase furniture made from water hyacinth.

12. Carp 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.
    a. **Explain** why carp might make an effective fertiliser.
    b. **Identify** the advantages a product such as Charlie Carp might have over chemical-based fertilisers.
    c. **Predict** whether a product such as this could eliminate the need for chemical fertilisers. **Justify** your answer.
13. **Identify** the type of salinity you think is of most concern in Australia. **Justify** your answer.
14. a. **Define** the term 'ecological corridor'.
    b. Using an example, **explain** how ecological corridors can help protect biodiversity.
15. **Describe** the interconnection between First Nations Peoples' management of the land and a seasons calendar.

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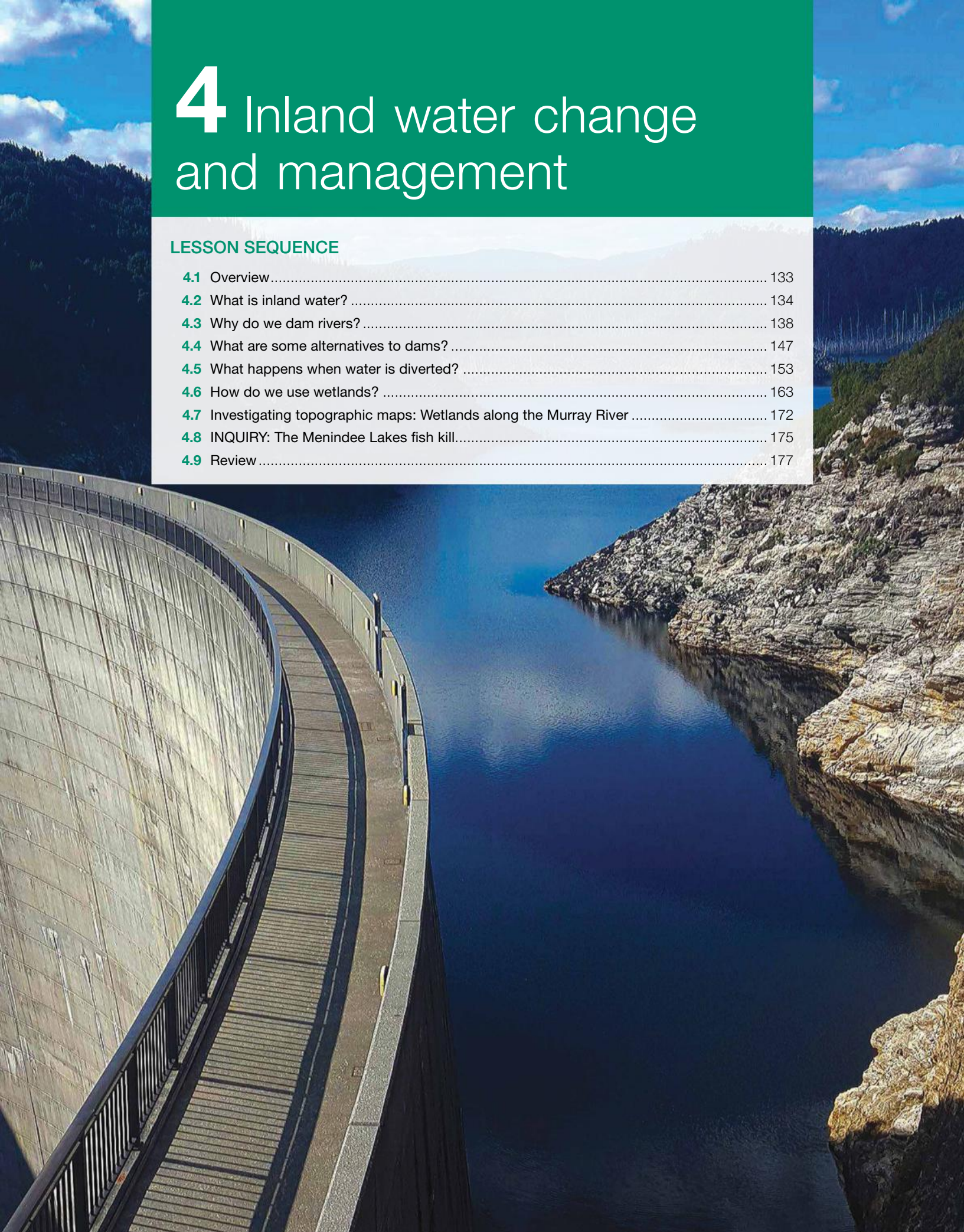
4 Inland water change and management



LESSON SEQUENCE

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LESSON
4.1 Overview

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Both humans and natural systems would find life very hard without healthy inland water sources. How do worldviews influence the ways in which people use and manage these sustainably?

4.1.1 Introduction

Water makes life on Earth possible — rivers are like blood running through the veins of a body. Our inland waters are important sources of water for both environments and people.

Over time we have dammed, diverted and drained our water sources, and this has brought about significant environmental change. Careful management of our water resources will help ensure a sustainable future.

FIGURE 1 Water is vital for our lives and the environment.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11502)

Video eLesson Drained away (eles-1709)

LESSON
4.2 What is inland water?

LEARNING INTENTION

By the end of this lesson you should be able to describe the different types of water bodies that make up inland water, explain their importance and identify the changes that human activities can bring to inland waters.

TUNE IN

Imagine being parachuted from a plane into this environment with the aim of hiking from north to south.

FIGURE 1 The Parana River floodplain in northern Argentina shows a variety of different types of inland water.

1. What can you see in this photograph?
2. What might be some of the challenges you might face moving through this environment?
3. How might the role of the body's arteries be compared to rivers in an environment?
4. Brainstorm the many ways that humans use water.

4.2.1 What is inland water?

Of all of the water that covers and surrounds planet Earth, only 3 per cent is fresh, and of that, only 0.5 per cent is available to us as 'inland water'; the rest is frozen in ice sheets and glaciers. The rivers, lakes and **wetlands** that make up our inland water supply our domestic, agricultural, industrial and recreational water use. They also provide important habitats for a wide range of aquatic and terrestrial life.

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**, standing (like lakes) or flowing (like rivers — see **FIGURE 1**). There are interconnections between surface water and **groundwater**, and between inland and coastal waters.

wetland an area covered by water permanently, seasonally or ephemerally. They include 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.

perennial describes a stream or river that flows permanently

ephemeral describes a stream or river that flows only occasionally, usually after heavy rain

groundwater water held underground within water-bearing rocks or aquifers

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.

4.2.2 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.

4.2.3 What are the threats to inland water?

Inland water is extremely vulnerable to change. It has been estimated that in the twentieth century, the United States, Europe and Australia have lost over 50 per cent of their inland water (excluding lakes and rivers). Those systems remaining are often shrunken and polluted. This loss is largely a result of human-induced environmental changes. **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.

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; transport of sediment may be blocked, dams may 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 onto land	• Change in water quality, habitat • Pollution of groundwater	• Decline in water quality for domestic and agricultural use • Change in ecology of water systems

FIGURE 2 Wetlands are an example of inland water systems that are vulnerable to human-induced damage.

4.2 SKILL ACTIVITY: Communicating

Create a simplified sketch of **FIGURE 1** and clearly label an example of each of the following features: main channel, tributary, anabranch, meander, oxbow lake (or billabong), floodplain. A dictionary may help you **define** the terms.

4.2 Exercise

learnon

4.2 Exercise

Learning pathways

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

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Check your understanding

1. Match the following terms with their correct definition in the table below: main channel, tributary, anabranch, meander, oxbow lake (or billabong), floodplain.

Term	Definition
	A smaller stream that flows into a larger stream
	A bend in the river
	An area of relatively flat, fertile land on either side of a river
	A main river
	A cut-off meander bend
	Where a river branches off and joins back into itself

2. Refer to **TABLE 1**. **Determine** whether the following statements are true or false.
   a. Large-scale draining of wetlands will not affect groundwater.
   b. The spread of settlement over a floodplain will alter the amount of water available to replenish groundwater.
   c. Habitat destruction can occur with both draining of wetlands and construction of dams.
   d. Water that is diverted from one drainage basin to another is lost to the water cycle
3. Look at the many inland water storage features below and classify them according to whether they are surface or underground, natural or human-made. (Note that some can be both natural and human-made.)

	Surface	Underground	Natural	Human-made
Dam/reservoir				
River/creek/stream				
Wetland/swamp				
Irrigation channel				
Groundwater/aquifer				
Well				
Lake				

4. **State** the difference between a perennial and an ephemeral river.
5. **Propose** two reasons why a wetland, such as that shown in **FIGURE 2**, might be drained.

Apply your understanding

Questioning and researching using geographical methods

6. a. Refer to **TABLE 1**. **Describe** the ways in which urban development across a floodplain can impact the environment.
   b. **Reflect** on reasons why people might want to live on floodplains.
7. **Predict** two short-term and two long-term examples of human-induced changes that could have an impact on the wetland in **FIGURE 2**.
8. The Parana River is 4880 kilometres long, making it the second longest river in South America. The river flows south from the south-east central plateau of Brazil to Argentina. **FIGURE 1** is a small section of this river. **Identify** what evidence there is to suggest that this river frequently floods.
9. 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. **Identify** where this sediment has come from.
   b. **Describe** how the sediment gets onto the floodplain.
   c. If the river is dammed upstream, **predict** the changes that are likely to happen to the sediment carried and to the floodplain.

Concluding and decision-making

10. Refer to **FIGURE 1**. Imagine that the Parana River flooded and the floodwaters have now subsided. **Determine** whether the floodplain would look the same as it does in this image. **Explain** your answer.

LESSON
4.3 Why do we dam rivers?

LEARNING INTENTION

By the end of this lesson you should be able to describe the benefits and drawbacks of large-scale dams around the world. You should also be able to compare and evaluate the strategies used for managing the changes brought to the environment and people by large-scale dams.

TUNE IN

Are dams marvellous feats of modern engineering or are they environmental nightmares?

FIGURE 1 Gordon Dam in Tasmania

1. What is happening in this image?
2. How might the water be different on each side of the dam?
3. Why do we build dams?
4. How might we use water stored in dams?
5. How do you think this environment might have looked before the dam was constructed?

4.3.1 Why dam rivers?

Possibly the most extreme form of human-induced environmental change is the changes made to river systems by the construction of dams. 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 increasingly, the social, economic and environmental costs are emerging.

A reliable water supply has always been critical for human survival and settlement. The global demand for water increased by 600 per cent in the last century — more than twice the rate of population growth. If this rate continues, global water demand will exceed supply by 2030. Water is also unevenly distributed across the globe; some places suffer from regular droughts, while others experience massive floods. 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 frequently contributes to unsustainable use of water. Globally, over 60 per cent of the world's major rivers are controlled by dams.

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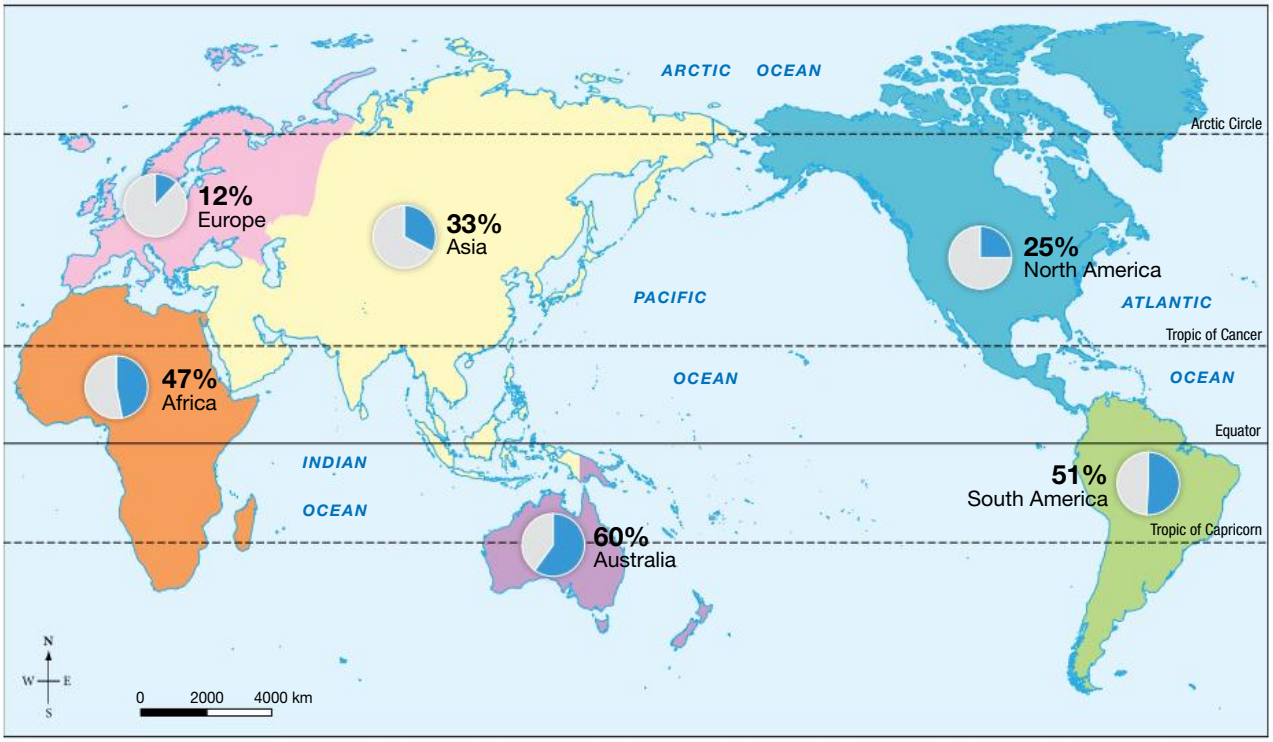
FIGURE 2 Percentage of very large rivers (longer than 1000 km) that remain free-flowing, by continent



Source: Map drawn by Spatial Vision.

FIGURE 2 shows that only 37 per cent of the world's longest rivers are free flowing; the remaining major rivers suffer from **river fragmentation**. This can take the form of dams blocking the main channel and tributaries, as well as significant changes to the natural flow of rivers as water is stored or diverted elsewhere.

Dams, **reservoirs** and **weirs** have been constructed to improve human wellbeing; however, while there are many benefits, large-scale or mega dams bring significant changes to the environment and surrounding communities, both positive and negative, as shown in **FIGURE 3**.

4.3.2 Why should a river flow?

Traditionally, water flowing outcd, then it could be used. Little thought was given to the health of the river and the importance of keeping water in a stream. This is very much a human-centred rather than Earth-centred worldview. Governments around the world have favoured damming rivers to make use of water resources. But is this the only solution to our growing water needs?

Mega dams have been linked to economic development and improvement in living standards. Only in recent times have people questioned the real cost of these schemes — environmentally, economically and socially.

There is also the concern that multi-purpose dams have conflicting aims. To generate hydro-electricity, you need to release a large volume of stored water. To provide **flood mitigation**, you need to keep water levels low. To use water for irrigation, you need a large store. Mega projects and their infrastructure — dams, canals and pipelines — make water artificially plentiful, promoting an increased need for more dams that can then develop into unsustainable water use and environmental degradation (see **FIGURE 4**).

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

flood mitigation managing the effects of floods rather than trying to prevent them altogether

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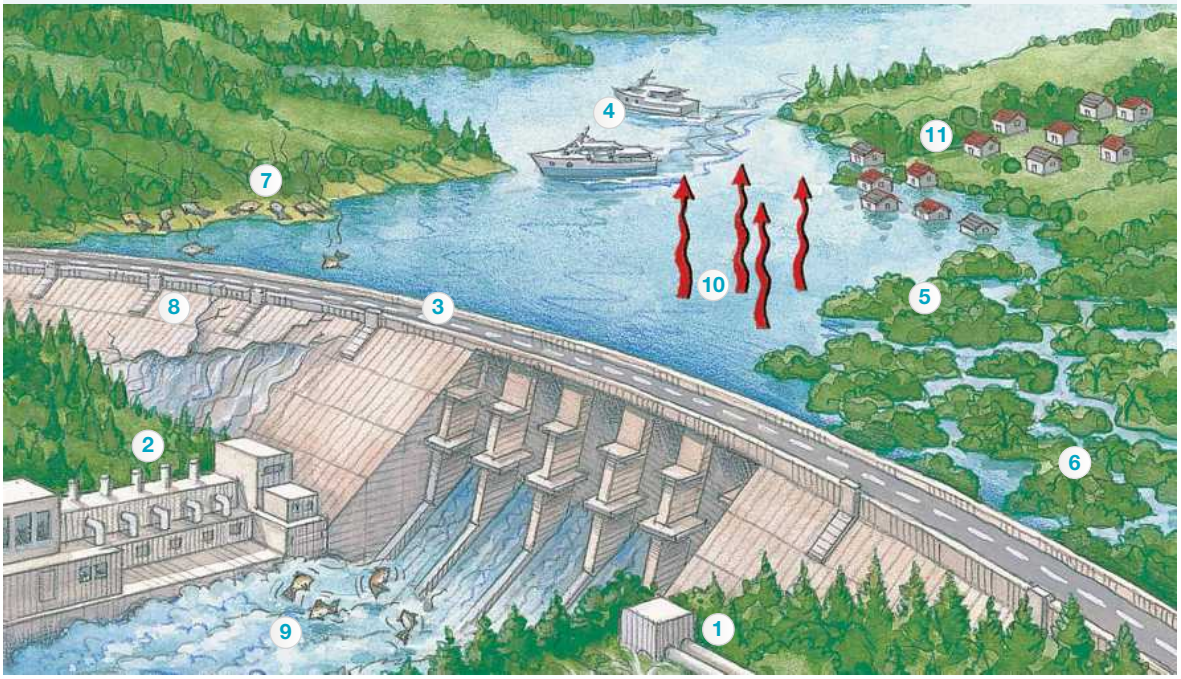
FIGURE 3 The advantages and disadvantages of large-scale dams



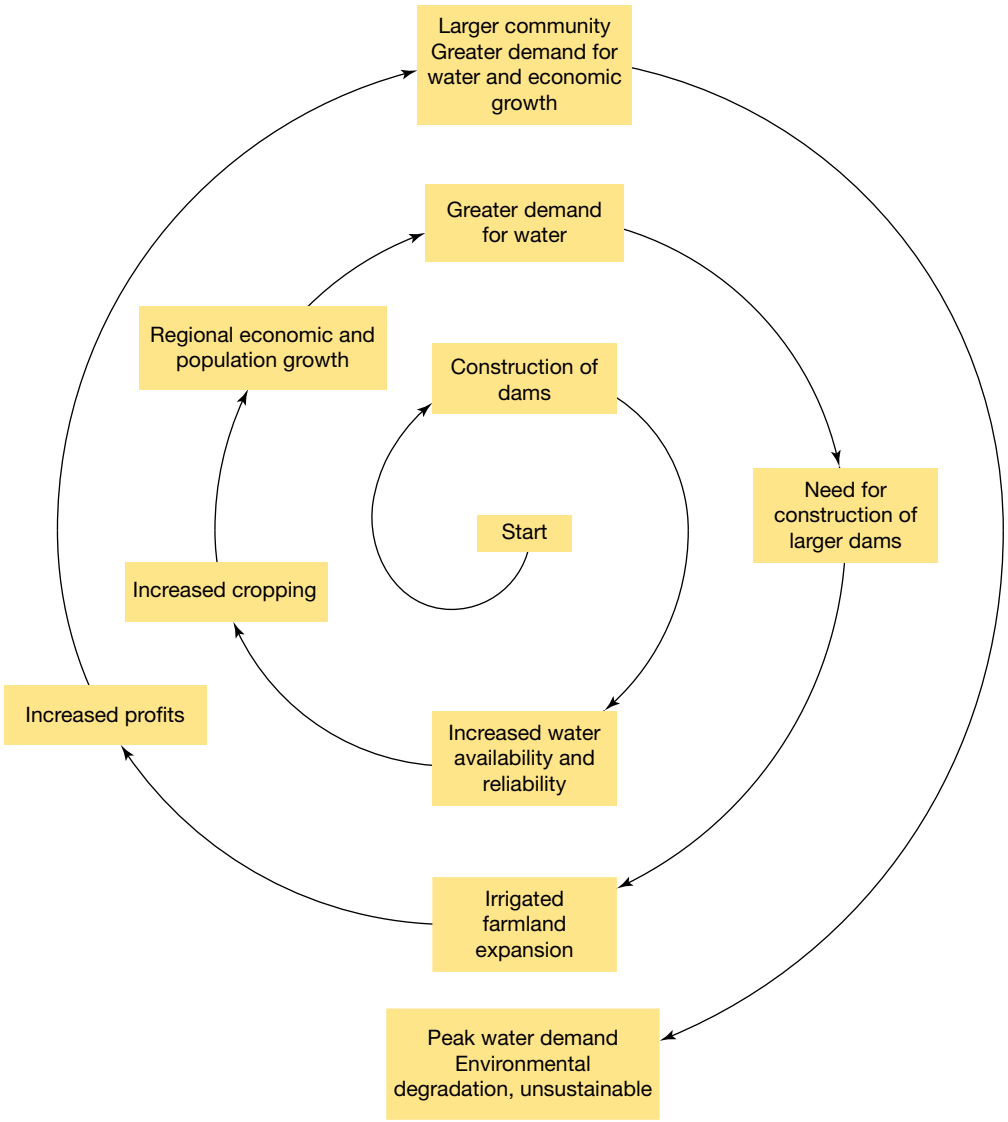
Positive changes

1. A regular water supply allows for irrigation farming. Only 20 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 15 per cent of the world's total electricity and 30 per cent of all 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 as water backs up behind the dam wall to form a reservoir. Alluvium or silt that previously would have enriched floodplains is deposited in the calm water and can build up, reducing the dam's water-holding capacity.
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, increasing the risk of damage to dam walls and the potential to flood downstream.
9. Dams block the natural migration of fish upstream. Since 1970, the world's freshwater fish population has declined by 80 per cent, threatening food security.
10. Over 7 per cent of the world's fresh water is lost through evaporation from water storages and this is likely to increase with global warming.
11. A conservative estimate has stated that dams have negatively affected 472 million people worldwide. Tens of millions have been relocated from dam sites while other communities, both upstream and downstream, have lost their livelihoods or had their land flooded.
12. Dams have resulted in a massive loss of biodiversity from the lands that become flooded and from the rivers that become blocked. The Three Gorges Dam in China has resulted in the loss of 6000 plant species, 550 terrestrial vertebrates and 400 species of fish.
13. Global warming can increase the risk of drought. In 2001, drought caused reservoirs on five continents to drop below the critical level to produce hydro-electricity, resulting in power blackouts and huge social and economic impacts.

FIGURE 4 A flow diagram to illustrate how dam construction can contribute to a demand for further construction



More than one billion people worldwide lack access to a decent water supply. 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 was spent on constructing more than 50 000 dams. The emphasis now is to switch from *controlling* river flow to *adapting to* river flow. In other words, shifting from a human-centred to an Earth-centred approach. This means building small-scale projects that promote social and environmental sustainability (see lesson 4.4). In many regions of the world, there are ongoing community protests against the need for mega dams in preference to smaller schemes that benefit local people directly.

4.3.3 People versus power?

Across the globe, there has been a growing movement of community and environmental groups challenging the construction of mega dams in terms of location, sustainability and the potential social, economic and environmental impacts. Globally, there are 509 dams currently being planned or built, especially in parts of Africa and South America, that are in legally protected regions such as national parks and lands inhabited by Indigenous Peoples, the very areas that need the most protection. This occurs when the dams are planned before a protected area is declared or when governments change the laws to downgrade or eliminate the special protections. While making up only 5 per cent of the world's population, Indigenous Peoples are the guardians to 80 per cent of the world’s biodiversity.

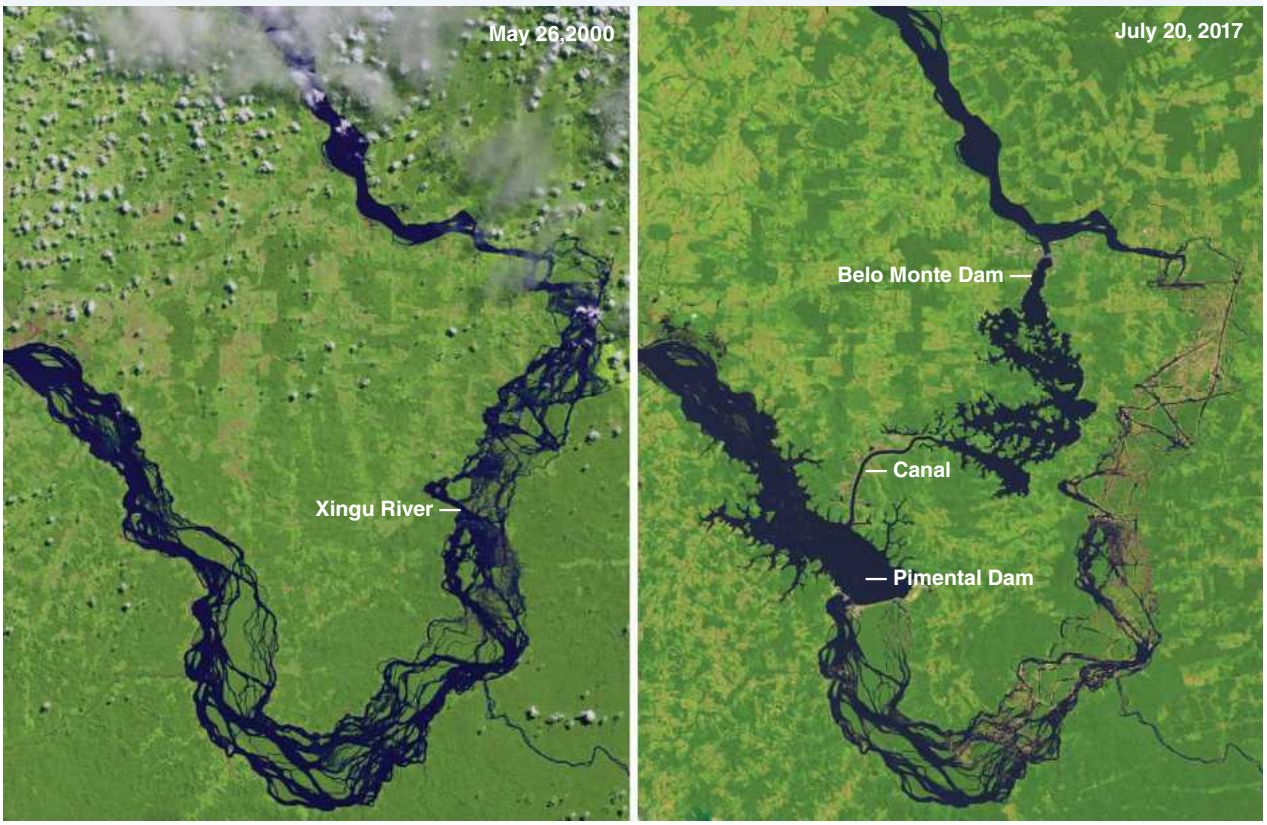
4.3.4 CASE STUDY: Belo Monte dam, Brazil

Brazil has been a major leader in hydro-electricity production, particularly in the Amazon region. Largely driven by political and economic factors, the Amazon has been 'opened up' to agriculture, mining, settlement and hydro-electricity. Interestingly, urban dwellers tend to reap the benefits of reliable power and more produce, while rural dwellers cope with the social and environmental impacts of such expansion.

For over 20 years, there has been an ongoing protest over the construction of the Belo Monte dam in a region of rich biodiversity that is home to 25 000 Indigenous Peoples in the heart of the Amazon. Indigenous Peoples' viewpoints state that Mother Earth (Pacha Mama) has the right to live well, just as much as the people who occupy the land (Buen Vivir). This contrasts with the human-centred viewpoint of the government which, despite a pledge to the United Nations to stop and reverse deforestation, has been actively encouraging clearing and development, and has even reduced funding to environmental organisations. The government's aim was to increase the country's energy security by constructing another hydro-electricity plant.

The original design called for five huge dams on the Xingu River but, after large-scale local and international protests by Indigenous Peoples' groups and environmentalists, the scheme was delayed multiple times, then scaled back to one large dam, the Belo Monte, currently the world's third largest. The dam has created huge environmental, social and economic changes in the Amazon (**FIGURE 5**).

FIGURE 5 (a) The Xingu River flowing naturally in 2000 and (b) in 2017, after the Belo Monte dam has been constructed. This has reduced the flow downstream by 80 per cent, seen as the orange/brown dry areas in the satellite image.



Some of the many issues related to this mega dam include:

- The **environmental impact assessment** was done after work had already started on the project and without consulting local Indigenous peoples on how they may be affected by the dam.

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

- More than 80 per cent of the river's flow is to be diverted to create the reservoir, flooding 515 km^2 of rainforest while 100 kilometres of river channel will largely be left dry.
- Between 20 000 and 40 000 Indigenous Peoples have been displaced from their traditional lands and lifestyle.
- The loss of river flow has reduced fish populations, increasing the risk of food insecurity.
- There has been a reduction in river trade, which provides the main transport route for people to move around the region.
- While the government has claimed the dam will provide **green energy**, the amount of greenhouse gases released from drowned and rotting vegetation behind the dam wall will contribute to global warming for some years.
- River flow in the region is seasonal, so hydro-electricity can only be generated for a few months of the year, which may necessitate construction of another dam.
- Downstream, the town of Altamira rapidly expanded during the construction period. Land prices skyrocketed, the cost of living rose and crime rates soared.
- The energy company Norte Energia was fined for failing to provide promised services, such as schools and clinics for local communities displaced by the construction.
- Traditional subsistence lifestyles became more westernised. Shopping replaced traditional hunting and fishing, motorbikes and outboard motors replaced canoes while fast food, sweets and alcohol were introduced.

In 2021, Norte Energia was granted permission to divert more water, but this has since been suspended to allow for more studies on the possible impacts. It is likely that the government will reverse this suspension using the law that 'hydro-electricity is more important for the economy than environmental and human rights concerns'. With the threat of climate change and recent drought, which has reduced flow along the Xingu River, the Belo Monte dam may never meet its promised economic or energy-producing goals. Scientists are now questioning whether large-scale **infrastructure** projects can balance economic benefits with environmental and social costs.

4.3.5 CASE STUDY: Itaipu dam, Paraguay and Brazil

With any major water infrastructure project, there is always a trade-off between providing the benefits of damming water for hydro-electricity and the impacts of damming to the environment and people. The management of the Itaipu dam has succeeded in operating a mega dam at peak performance while ensuring the catchment area of the dam itself is sustainably maintained, as well as being supportive to the population and economy. The dam, one of the largest hydro plants in the world, straddles the Parana River, shared by both Brazil and Paraguay (**FIGURE 6**). This has necessitated both countries working together to establish Itaipu Binacional (IB), the company that manages the site.

To run a hydro-electricity scheme, you need a *reliable* and *clean* source of water. Deforestation and unsustainable land clearing upstream in the Parana River **catchment** created the threat of large-scale erosion, which reduces both water quality and reliable flow. Continually dredging a dam is a very expensive and repetitive process that creates its own set of environmental problems. Cropping and grazing are regionally important land uses but they contribute pesticides and animal excrement, which then washes through the river system and into the dams, causing further deterioration in water quality.

At the start of dam construction, IB introduced a series of restorative programs that focused on creating a long-term solution to provide reliable, clean water while also delivering a range of social and environmental benefits to local communities and biodiversity in the region. A sample can be seen in **TABLE 1**.

There have been some drawbacks as the initial flooding of the dam resulted in an estimated 80 per cent loss in biodiversity around the dam. Also much of the water flowing into the dam comes from far upstream on the Parana River and out of IB's area, so unsustainable farming practices in other places can still impact on water quality and quantity downstream.

green energy sustainable or alternative energy (e.g. wind, solar and tidal)

infrastructure the basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society

catchment (or drainage basin) any area of land where precipitation collects and drains off into a common outlet, such as a river, bay or other body of water

Essentially IB have introduced nature-based strategies to ensure the sustainability of their power production. The environment has benefited from improved vegetation cover and biodiversity corridors, and communities have benefited economically from improved farming and farmland and socially by being included in the management of shared resources.

FIGURE 6 The Parana watershed upstream of the Itaipu dam

Source: Map drawn by Spatial Vision based on information from The Paraná watershed upstream of the Itaipú dam. Source: Saenz, L., 2017 Rycerz, R., Bugler W., Messling, L., and Wade, G. (2020) Itaipú Dam: How natural ecosystems support one of the world's largest hydroelectric dams. Resilience Shift Case Study.

TABLE 1 Strategies used in management of Itaipu restoration program

Aim	Strategies used	Benefits
Protection of existing forests	• Purchased additional land that could be kept as protected areas	• Vegetation cover reduces erosion and provides habitat and increases moisture into the atmosphere
Reforestation of degraded land	• Establishing a 30-metre-wide green belt of vegetation along the riverbanks **(FIGURE 7)**	• Protected waterways from runoff and erosion • Enabled green biodiversity corridors to link to nearby national parks
Improved land management practices	• Encouragement and support to farmers to farm on terraces rather than steep land • Use no-till methods which means that the soil is not left bare • Encourage organic farming	• Reduces soil erosion on slopes • Crops harvested but not cleared so that roots hold soil • Reduces pesticides entering soil and water • Schools and communities in region benefit from organic food from 1200 farms that have converted to organic farming
Improving waste management	• Recycling program for paper, plastics and metals	• Reduces waste that would end up in landfill or dumped into rivers

FIGURE 7 Vegetation corridors along the Parana River

DISCUSS

Does a large company such as Norte Energia have responsibilities and obligations to the people displaced by such a large-scale scheme? Before deciding, carefully consider the consequences of the company being deemed responsible or not responsible.

4.3 SKILL ACTIVITY: Questioning and researching using geographical methods, Concluding and decision-making

1. Use the **Controversial dams** worksheet in your Resources panel to view images and read about some of the world's most controversial dams. **Create** a table with the following headings and summarise details about each project.

Dam name	Location	Purpose of dam	Reasons for controversy
Three Gorges Dam	.....	.....	.....
	.....	.....	.....
	.....	.....	.....

2. **Select** one of the dams from the table in question 1 and conduct further research into its status. Write a paragraph or two to detail your findings.

on Resources

Interactivity Dam it (int-3292)

4.3 Exercise

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4.3 Exercise

Learning pathways

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

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Check your understanding

1. Complete the following paragraph using the words provided below.

velocity	flood	straightened	electricity	sediment	agricultural
decreases	dams	meander	increases	transport	

The main human activity responsible for river fragmentation is the construction of _____ for domestic, _____ and industrial use as well as for _____ control, recreation and the generation of _____. Rivers such as the Mississippi and Rhine have also had their courses _____, by removing _____ area bends, to improve river _____ and avoid the build-up of _____ on the bends, which can hinder navigation. Note that straightening a river channel also increases the _____ of a river (which helps scour the channel of sediment but also _____ flood damage).

2. **Determine** whether the following statements are true or false.
   a. The primary aim of an environmental impact assessment is to identify the environmental, social and economic impacts, both positive and negative, of a project after decision making and construction.
   b. The global demand for water increased by 600 per cent in the last century, more than twice the rate of population growth.
   c. Indigenous Peoples, who represent only 5 per cent of the world's population, are the guardians of 80 per cent of the world's biodiversity.
3. Complete the following paragraph.
   Water flowing out to sea has been considered a waste because _____.
   This is a _____, rather than _____, point of view. It does not take into account the natural flow of a river and its importance in maintaining the river's health.
4. **Summarise** three important environmental strategies that IB introduced for the Itaipu region.

Apply your understanding

Interpreting and analysing geographical data and information

5. Using information from **FIGURE 3** and the text in this lesson, **construct** a table with the following headings to classify the impacts of dam building.

Positive effects for people	Negative effects for people
Positive effects for the environment	**Negative effects for the environment**

6. **Compare** the factors influencing the worldviews of the developers behind the Belo Monte and Itaipu dams.

Concluding and decision-making

7. **Suggest** reasons why large-scale dam projects have been seen as indicators of development and progress.
8. **Identify** what makes a place suitable for a large dam. Consider landforms, climate, soil and rock type.
9. Is there a sustainable future for mega dam projects such as the Belo Monte and Itaipu dams? **Justify** your answer.
10. '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? **Justify** your point of view.

LESSON
4.4 What are some alternatives to dams?

LEARNING INTENTION

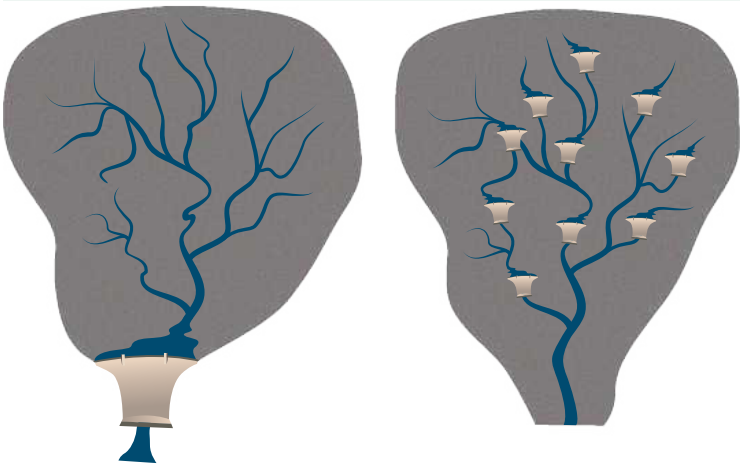
By the end of this lesson you should have a better understanding of the different alternatives to large-scale dams and the role that local communities can play in managing water sustainability.

TUNE IN

Limiting water usage, even just within your household, can have a much larger impact than you might think.

1. Have you have ever had to live with water restrictions? What was this like?
2. If you had to reduce your family's water use by half tomorrow, how would you do this? Brainstorm with a partner and see if you can come up with different methods.
3. **FIGURE 1** is a diagram of a river catchment showing two alternative scenarios, (i) One large dam built across the main channel and (ii) a series of micro dams built across some of the tributaries. How effective do you think each scenario would be in trapping water and supplying local communities?

FIGURE 1 Research in India has shown that 10 micro dams with one-hectare catchments will store more water than one dam of 10 hectares.



4.4.1 How can water be saved?

Traditionally, managing water has been focused on exploiting resources rather than conserving them. However, there are viable alternatives to dams that are often cheaper and have fewer social and environmental impacts. The focus has to be, first, on reducing demand for water and, second, on using existing water more efficiently.

Considerable water savings can be made using desalinated seawater. Desalination provides 45 per cent of Perth's and 50 per cent of Saudi Arabia's water needs. The drawbacks are that desalination is extremely costly and uses vast quantities of energy. Recycling of grey (waste) water is a sustainable source of water for agricultural, industrial and domestic use. London's water supply is recycled seven times while Israel reuses 90 per cent of its wastewater.

Agriculture

Globally, more than 70 per cent of fresh water is used for agriculture, but it is not always used efficiently, for example:

- governments often encourage farmers to grow water-thirsty crops, such as cotton, in dry regions
- poorly designed or old irrigation schemes can have high rates of wastage through evaporation and leaks
- excessive watering can lead to a loss of soil quality through waterlogging or salinity
- often the cost of water is too cheap to create incentives for farmers to save water.

Vast quantities of water could be saved by improving irrigation methods, switching to less water-consuming crops and taking poor quality land out of production. Pakistan, for example, has one of the most wasteful water systems in the world. With the same quantity of water and an efficient system, Israel produces 70 per cent more food. Globally, if the amount of water consumed by irrigation was reduced by 10 per cent, water available for domestic use could double.

Urban use

Researchers state that 30 per cent of all clean drinking water is said to be lost through leaking pipes. For example, the United States loses 8 trillion litres of water each year through deteriorating infrastructure. Countries could make savings 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. For example, 40 per cent of Singapore's water needs are met using treated wastewater.

Small-scale solutions

Currently, researchers estimate it will cost US$114 billion per year to meet the United Nations' goal of achieving universal access to clean water and adequate sanitation; hence, the growing awareness of investing in small-scale technologies. Rather than one large expensive dam, smaller projects that benefit local communities can be more desirable (see **FIGURE 1**). These are often constructed and maintained by people who benefit directly from control over their own resources, at a minimal cost.

rainwater harvesting the accumulation and storage of rainwater for reuse before it soaks into underground aquifers

micro hydro-dams dams that produce 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.

4.4.2 How can we reduce the need for dams?

As many countries are actually running out of suitable places to locate large dams, we need to find alternatives. **Rainwater harvesting** schemes, as illustrated in **FIGURE 2**, can be used for storing water. **Micro hydro-dams** (see **FIGURE 3**) can be used for generating electricity. Both of these schemes are easier and cheaper to build than large dams, and have lower environmental impacts.

FIGURE 2 Two methods for water harvesting: (a) rainwater tank, (b) groundwater recharging

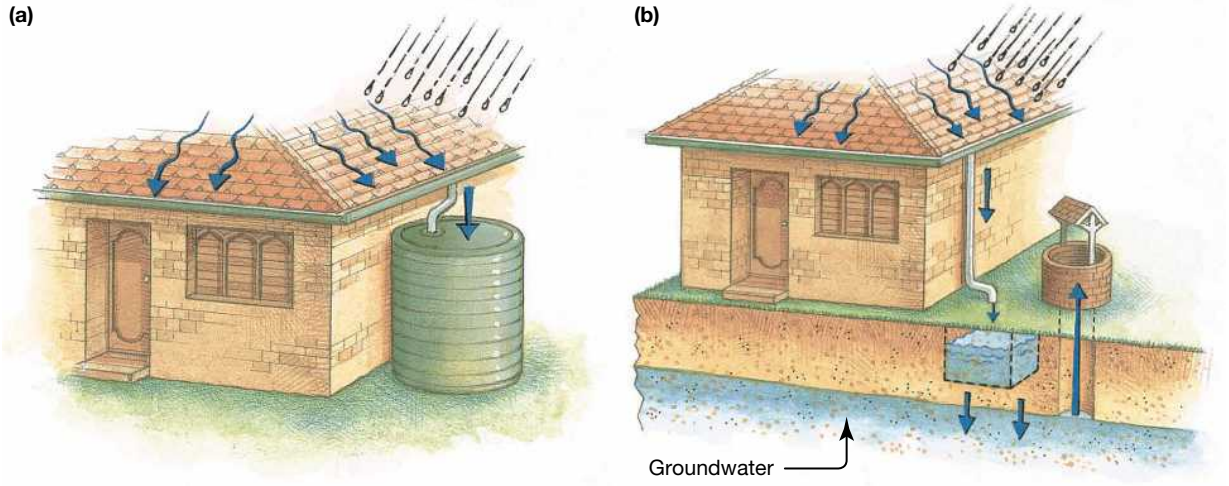


FIGURE 3 Water collected from a stream uphill rushes down the pipe and drives a small turbine in the hut to generate electricity for a local community in the Philippines.

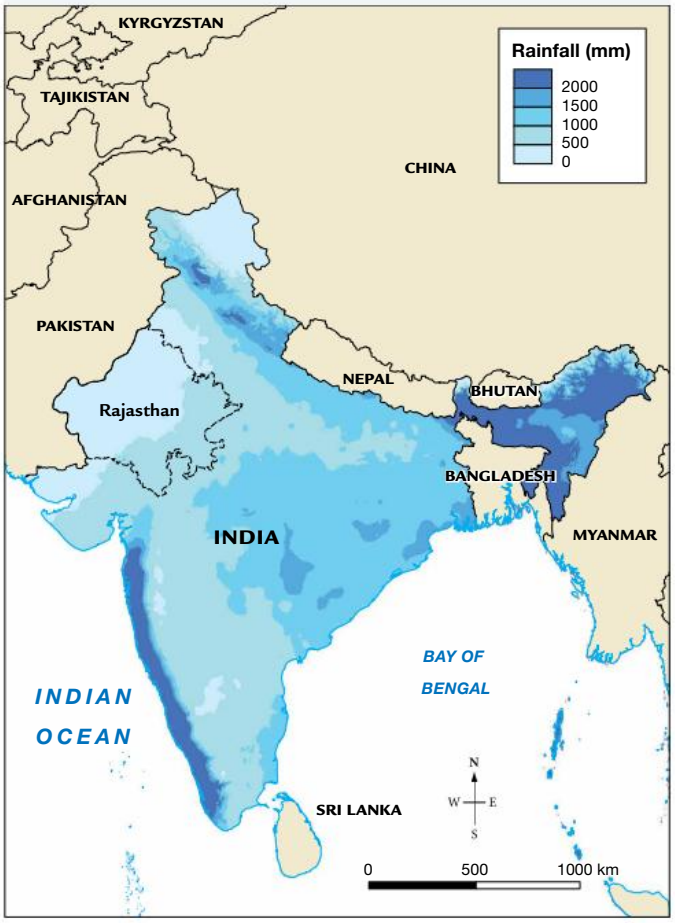
4.4.3 CASE STUDY: Traditional water harvesting in India

The state of Rajasthan is located in the arid north-west of India (see **FIGURE 4**). The largest state in India faces both water scarcity and frequent droughts. Continual pumping of groundwater has seen underground water supplies dropping.

Traditionally, local communities shared and sustainably managed the natural resources, such as water, forest and grasslands. The government, however, took control of local resources and promoted excessive mining and clearing in the region. This in turn saw reduced river and well flow, failed crops and a decline in biodiversity and habitat. Government policies have been more focused on large-scale dams, with the corresponding displacement of populations and environmental change.

There was little motivation for villages to maintain traditional water systems, or *johads* (small earth, concrete or stone ponds) and so there was a gradual decline in people's economic and social wellbeing.

FIGURE 4 Distribution of rainfall in India. The state of Rajasthan is outlined.



Source: World Climate - http://www.worldclim.org/; map by Spatial Vision

Under the guidance of aid agency Tarun Bharat Sangh (TBS), villagers were encouraged to re-establish traditional water management practices. Essentially, any rain that falls, usually during the monsoon season, is captured in johads rather than running off and evaporating. Each village may construct several johads, each serving a different purpose: domestic, irrigation, cattle and recharging groundwater. The johads trap the water, allowing it to infiltrate the ground where it can later be withdrawn when needed via wells.

FIGURE 5 A johad or traditional small water harvesting dam in India

What have been the benefits?

Environmental benefits

- Groundwater has risen from depths ranging from 10 to 120 metres up to 3 to 13 metres below the surface.
- Five rivers that flowed only after the monsoon season now flow all year (fed by **base flow**).
- Revegetation and agroforestry schemes have increased forest cover from 7 to 40 per cent, which helps improve the soil's ability to hold water and reduce evaporation and erosion.
- The area under single cropping (one crop grown per year) has increased from 11 to 70 per cent and the area under double cropping (two crops per year) has increased from 3 to 50 per cent.
- The water is shared among the villagers, and farmers are not allowed to use it to grow water-thirsty crops.

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 have become more economically viable.
- Over the region, there has been a reduction in the number of people migrating out of villages to the cities in search of work.
- The adoption of the johad system has encouraged communities to use their own knowledge, skills and labour to ensure their own sustainable water supply system. This can be done without the need for high finance, high tech designs or government action.
- Many villages have taken on similar community management of other resources such as forests and woodlands.

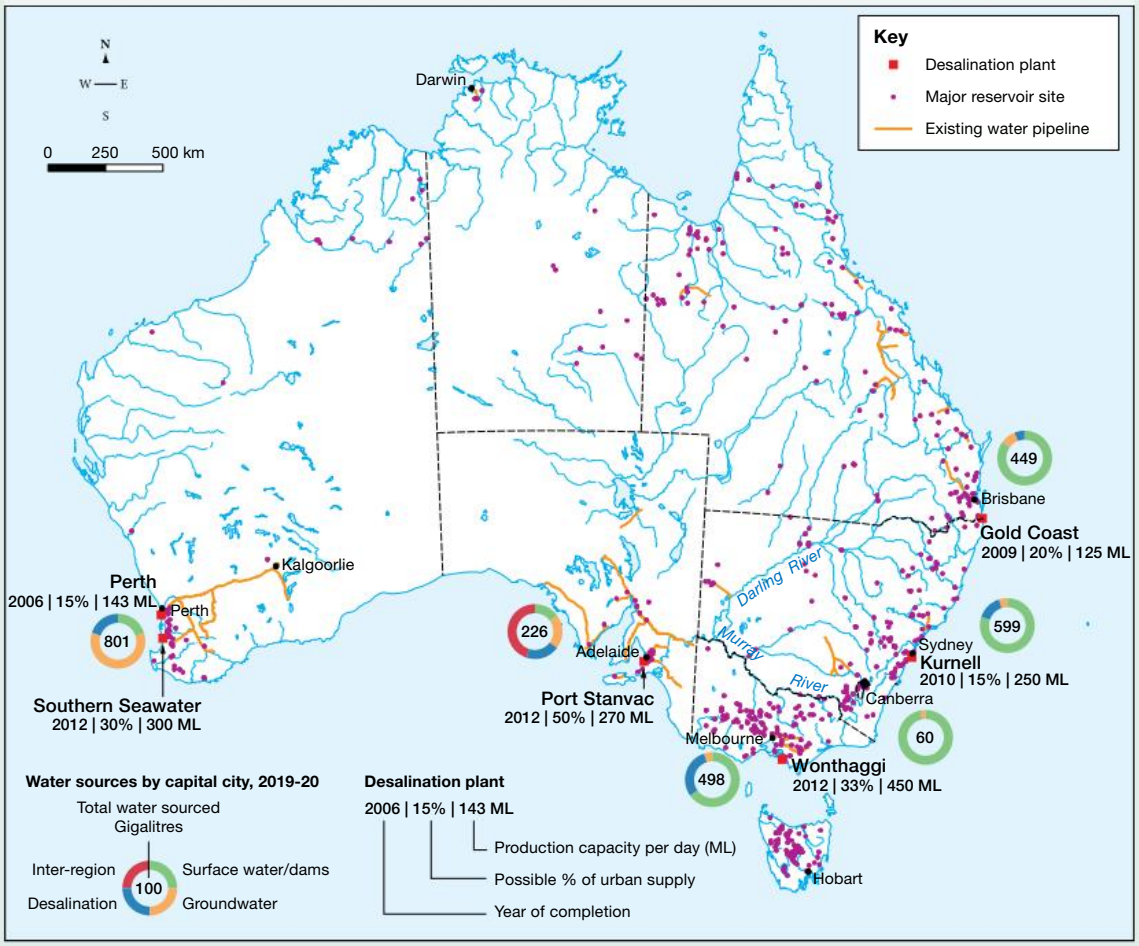
Economic benefits

- Average cost of renovating or constructing a johad estimated at 100 rupees (<A$2) per person compared to the building of the Namada dam which averaged close to A$1000 per person.
- A more reliable water supply ensures increased food production. This helps to increase incomes.

base flow water entering a stream from groundwater seepage, usually through the banks and bed of the stream

4.4 SKILL ACTIVITY: Interpreting and analysing geographical data and information, Concluding and decision-making

FIGURE 6 The distribution of major dams, water pipelines and desalination plants in Australia



Source: Based on information taken from Bureau of Meteorology, Sutori and Sydney Desalination Plant. Map redrawn by Spatial Vision.

Study **FIGURE 6**.

1. **Describe** the distribution of those places in Australia that have the highest concentration of large reservoirs.
2. **Suggest** two reasons for this distribution.
3. **Explain** why the desalination plants are located near major capital cities.
4. There is a proposal to pipe water long distances from northern Western Australia to Perth and Kalgoorlie. **Consider** the reasons for this proposal.
5. In your view, what would be the advantages and disadvantages of such a scheme?

4.4 Exercise

learnon

4.4 Exercise

Learning pathways

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

These questions are even better in jacPLUS!

- Receive immediate feedback
- Access sample responses
- Track results and progress

Find all this and MORE in jacPLUS

Check your understanding

1. How can water be wasted through poor farming methods? **Select** all that apply.
   - **A.** Avoiding spray irrigation
   - **B.** Growing crops that require large amounts of water
   - **C.** Harvesting rainwater on the property
   - **D.** Leaking irrigation channels
   - **E.** Large shallow farm dams that allow for high evaporation
2. Complete the following paragraph by circling the correct words.
   Rajasthan receives very **low** / **high** rainfall. Approximately **one-quarter** / **two-thirds** of the state receives less than **200** / **500** millimetres of rainfall while one-third, in the eastern part of the state, receives **200** / **500** millimetres of rainfall per year.
3. Which of the following is not a benefit of revegetation schemes around the villages restoring johads?
   - **A.** Reduced evaporation
   - **B.** Decreased forest cover
   - **C.** Reduced erosion as plants hold soil together
   - **D.** Decreased soil moisture
4. **Discuss** two advantages and two disadvantages of micro hydro-dams (refer to **FIGURE 3**).
5. **Suggest** one environmental, one social and one political factor that have contributed to the decline in water availability in Rajasthan.

Apply your understanding

Questioning and researching using geographical methods

6. The two goals of sustainable water management are to reduce the demand for water, and to use existing water more efficiently. **Propose** two methods that your family could use to meet these goals.

Interpreting and analysing geographical data and information

7. Study the information in **FIGURE 4**. **Explain** why Rajasthan has water issues. Use data in your answer.
8. Some places in India can receive up to 2500 mm of rainfall per year, but this can all fall in 100 hours. **Suggest** possible consequences of this for local communities.

Concluding and decision-making

9. **Evaluate** the effectiveness of the johads scheme in terms of environmental and social sustainability.
10. Do you think the johad method of water harvesting could be used in other places around the world? **Justify** your answer.

LESSON
4.5 What happens when water is diverted?

LEARNING INTENTION

By the end of this lesson you should be able to describe the concept and benefits of groundwater use. You should also be able to explain the purpose of water diversion and discuss the scale of impacts of water diversion in China and Iran.

TUNE IN

Refer to **FIGURE 1**.

Mentally divide this image into three sections: front left, front right and background.

1. What is the main feature that you can see through the centre of the image?
2. Why is there so much difference between the left and right areas of this photo?
3. What sort of climate might this area receive?
4. How can you have a large city (seen in the background) in such an arid environment?

FIGURE 1 An irrigated region of Arizona, United States

4.5.1 Why is water diverted?

Because populations and water sources are distributed unevenly, we often need to transfer or divert large amounts of water. This means piping or pumping water from one drainage basin to another: for example, in Australia, 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.

4.5.2 What are the advantages of using groundwater?

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 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.

However, 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. Unsustainable use of groundwater can result in wells running dry, less water seeping into rivers and even land **subsidence** or sinking.

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

4.5.3 CASE STUDY: Why is China drying up?

What is happening to groundwater in China?

Despite having large freshwater resources, China faces serious shortages due to the uneven distribution of both rainfall and population. The highly populated northern regions receive only 20 per cent of the country's rainfall and suffer acute water shortages while the southern regions receive a plentiful supply and suffer from frequent floods (refer to **FIGURE 2**).

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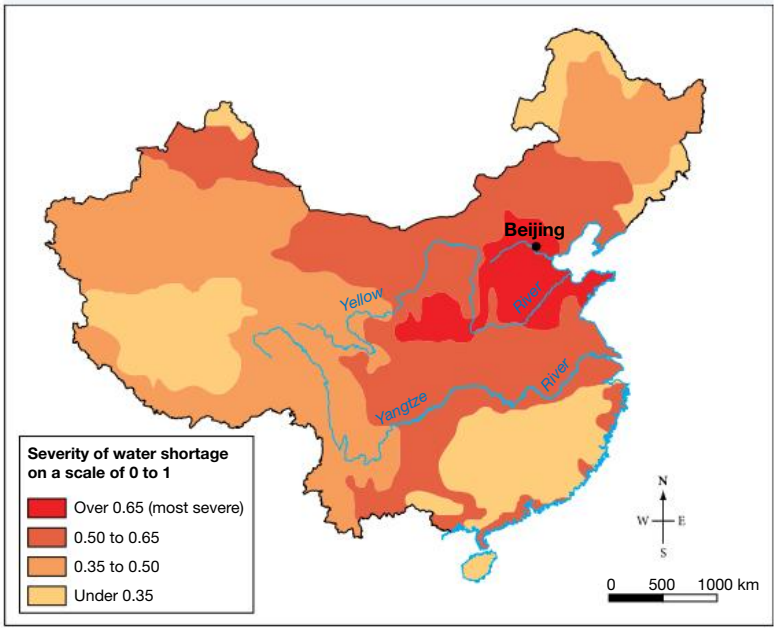
FIGURE 2 Predicted water shortages for China



Source: Map drawn by Spatial Vision.

Rapid government-encouraged growth in population, irrigated agriculture and industry saw increased pumping of groundwater in the north, where it supplies 70 per cent of water needs for over 100 million people. Consequently, the **watertable** around Beijing dropped by an average of 5 metres per year (see **FIGURE 3**). Compounding the problem was widespread pollution of both ground and surface water.

In summary, China faced a national water quality, quantity and uneven distribution problem. The solution was to develop the world's largest water diversion project.

The South–North Water Transfer Project

In 2002, an ambitious 50-year project was started to effectively 're-plumb' the country: the South–North Water Transfer Project. At an estimated cost of US$70 billion, over 44.8 billion cubic metres of water per year is diverted north from the Yangtze River via three canals into the Huang He River Basin in the north of the country (see **FIGURE 4**).

Before the transfer project development, the Yangtze River, on average, released 960 billion cubic litres of fresh water into the sea each year. Construction of the central and eastern sections has been completed, but the western route is highly controversial as it crosses earthquake-prone mountain regions, which could increase the risk of landslides and earthquakes. The completed central section now supplies 73 per cent of Beijing's tap water, to provide for its population of 21.5 million people. The water transfer has reduced the need to pump 800 million cubic metres of groundwater. As the extra surface water filters into the ground, the watertable has started to rise, with levels increasing by around half a metre.

watertable upper level of groundwater; the level below which the earth is saturated with water

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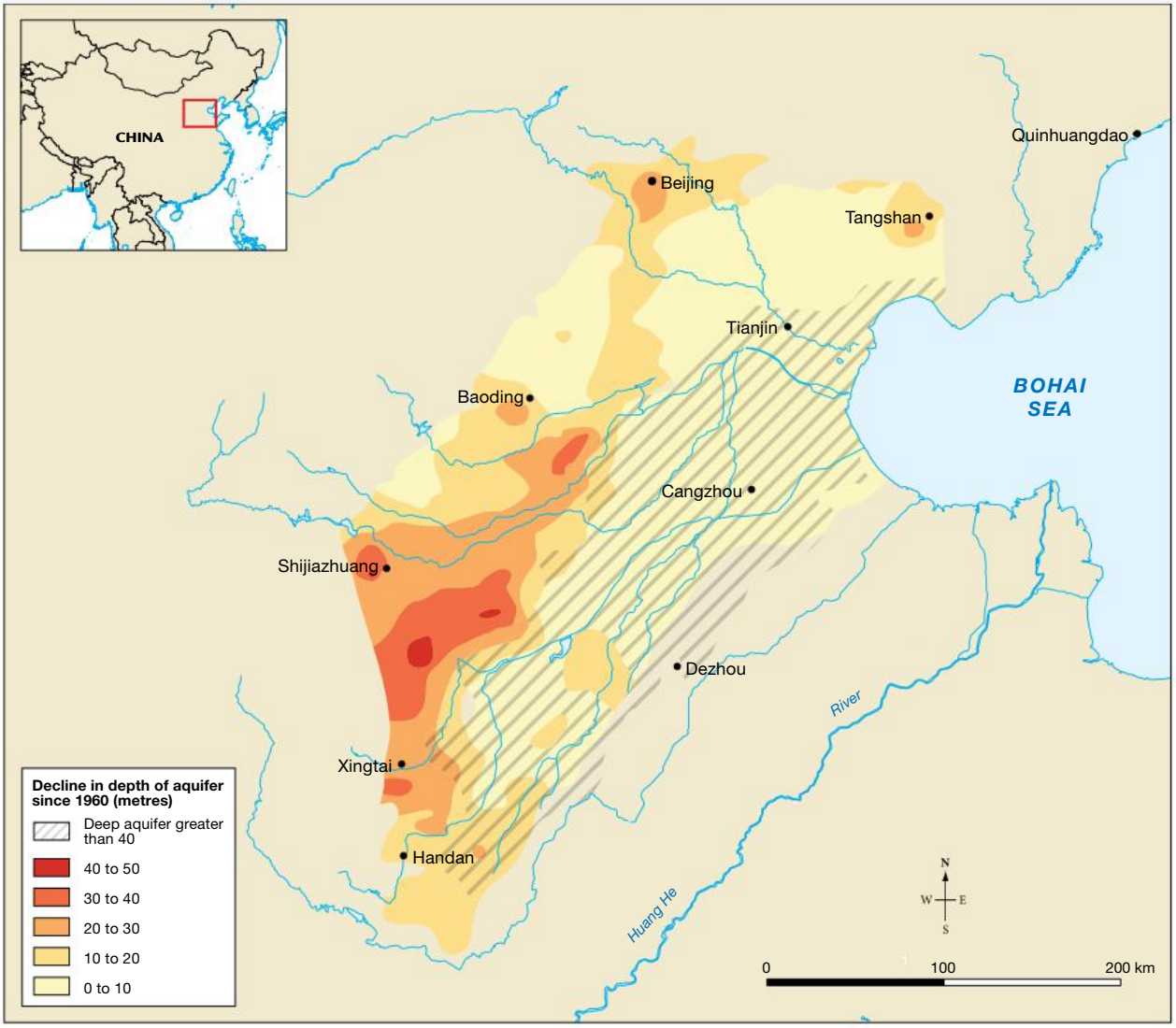
FIGURE 3 Decline in the aquifer under the North China Plain



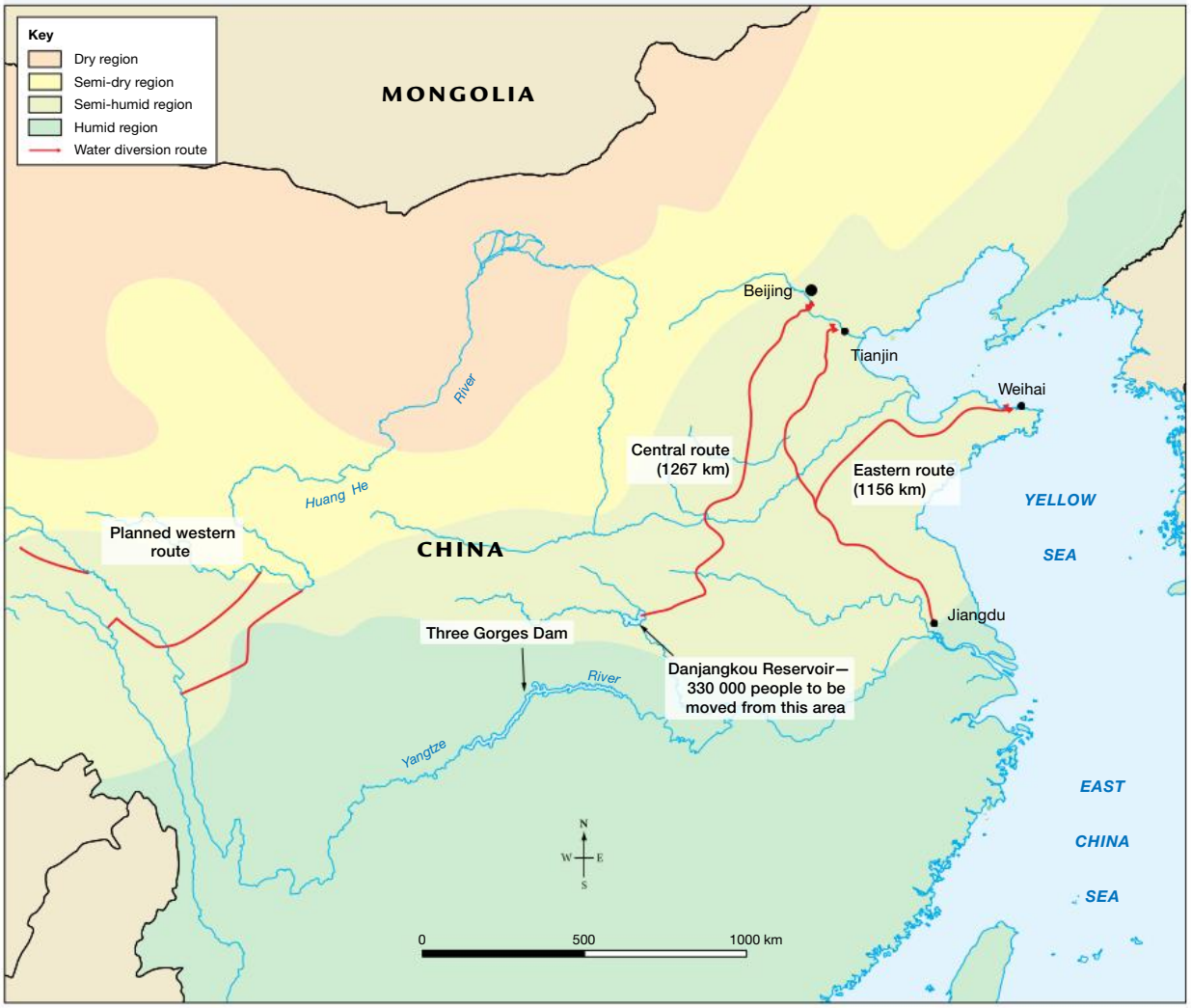
Source: UNEP Global Environmental Alert Service GEAS. Map by Spatial Vision.

Impacts of the project

- Large-scale changes to natural landscapes and the flow of four major rivers as water is diverted from one mega-region in the north at the expense of another megaregion in the south
- Climate change could bring less rainfall to the south, which has already experienced periods of drought, creating potential conflict over who gets the water, the north or the south?
- Loss of biodiversity in rivers and lakes, reduced movement of fish and the threat of invasive plant species from the south moving further north along the canals
- The construction and flooding of the Danjiangkou dam (**FIGURE 4**), in the central section, saw the relocation of more than 330 000 people as well as industries and other land uses. Insufficient compensation and lack of employment opportunities have created changes to people's livelihoods and created social unrest.
- The region around the dam was historically besieged with water-quality problems as the Huang He River collected more than 4.29 billion tonnes of waste and sewage a year and the Yangtze River collected 40 per cent of China's total wastewater.

int-9121

FIGURE 4 South–North Water Transfer Project for transfer of water from the Yangzte River in the south to the Huang He River in the north



Source: BBC News, http://news.bbc.co.uk/2/hi/8545321.stm.

To improve water quality, the government has now introduced strict controls on the use of insecticides and pesticides on farmland and improved wastewater systems in towns. Extensive reforestation was undertaken to filter water flowing into the dam. Highly polluting industries were relocated or closed.

While people in the north now enjoy the benefits of a reliable clean water supply, those in the towns and villages around the dam are still reliant on polluted groundwater and are suffering the social and economic fallout of forced relocation, farming on often inferior replacement land and the higher cost of organic farming.

When dealing with water issues, the emphasis in China has always been economic growth and large-scale 'engineering fixes' to increase supply rather than looking at more sustainable methods: using water more efficiently, reducing demand by increasing the cost, reducing irrigation wastage and improving the catchment areas to recharge the **aquifers**. Water recycling, desalination and harvesting more rainwater are more environmentally friendly and sustainable methods of supplying water.

aquifers layers of porous rock that can hold large quantities of water in the pore spaces

FIGURE 5 Polluted water flows into the Yangtze River

4.5.4 Why are lakes shrinking?

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.

4.5.5 CASE STUDY: A dying lake in Iran

The largest lake in the Middle East and one of the largest salt lakes in the world is drying up. Since the 1970s, Lake Urmia in northern Iran has shrunk by nearly 80 per cent. In 1998, the lake's volume was 30 billion cubic metres; by 2022, this had reduced to 2.9 billion cubic metres, exposing extensive areas of salt flats (see **FIGURE 6**).

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, such as flamingoes, that feed on the lake's shrimp. This shrimp is the only thing, other than plankton, that can live in the salty water. The wildlife and salt waters proved a popular destination for tourists.

Lake Urmia is a **terminal lake**; the rivers that flow into the lake (some permanent and some ephemeral) bring naturally occurring salts. Because of the arid climate, high evaporation causes salt crystals to build up around the shoreline. **FIGURE 7** shows the rapid decline in the surface area of Lake Urmia from 2006 to 2013 and a slight increase from 2013 to 2017.

Ramsar Convention an international treaty for the conservation and sustainable use of wetlands

UNESCO biosphere reserve The Man and Biosphere Programme is an international scientific program established by the United Nations to create biosphere reserves as 'learning places for sustainable development'.

terminal lake a lake where 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.

Why did the lake dry up?

A combination of environmental, economic, political and social factors has been blamed for the large-scale changes in Lake Urmia.

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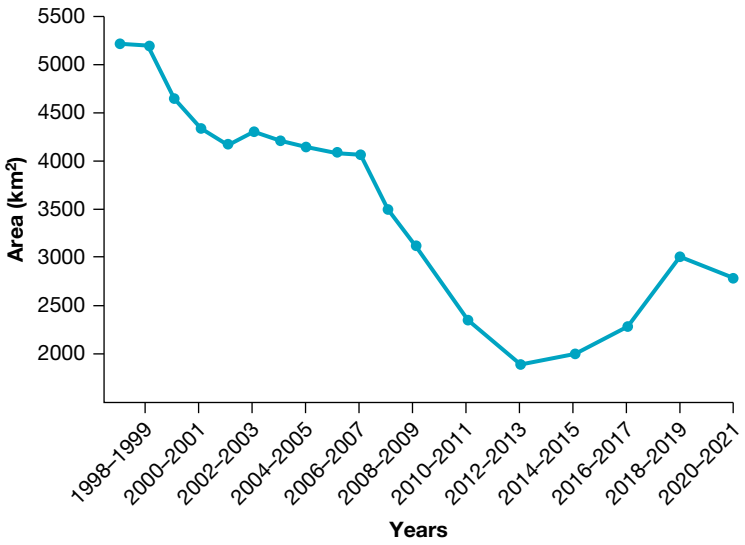
FIGURE 6 Lake Urmia (a) in 1998 and (b) in 2019

FIGURE 7 Surface area of Lake Urmia



Following the 1979 revolution, Iran adopted a policy of food self-sufficiency for its rapidly growing population. Traditional drought-tolerant crops were replaced by more water-thirsty ones, such as apples and sugar beets. Almost every river that fed into Lake Urmia was dammed, diverting the water away from the lake and into new irrigation projects, thus reducing the flow of freshwater into the lake (**FIGURE 8**).

Water diversions have been blamed for 40 per cent of the lake's decline, with the remaining 60 per cent attributed to climatic factors — more frequent droughts and higher temperatures, which increase evaporation rates. The result is a form of 'socioeconomic drought' — a human-induced drought caused when the demand for water is greater than the available supply.

Impacts of the decline in the size of the lake include:

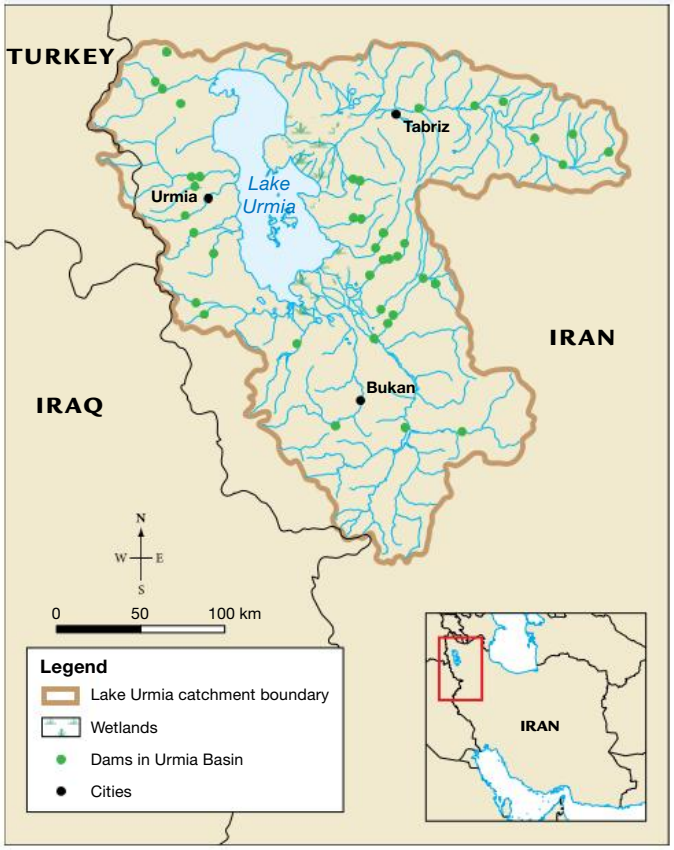
- increased salinity due to high evaporation and reduced freshwater flowing in via rivers
- collapse of the lake's ecosystem and food chain
- loss of habitat as surrounding wetlands dry up, resulting in loss of migratory bird population
- losses of more than US$1.6 million (2019) to eco-tourism, recreation and educational activities
- over 400 km^2 of exposed lakebed around its shores is nothing but salty deserts, unable to support native vegetation or food crops
- more than 6 million tonnes of dust and salt blow in sand storms, damaging farmland and creating a health risk for people
- less water available to produce food crops.

The lake is divided in two by a causeway and bridge constructed to improve access across the lake (the bridge can be seen in **FIGURE 6B**). However, there is concern that the nearly 1.5 kilometre-long bridge does not allow sufficient mixing of water between the north and south sections of the lake. The bridge, completed in 2008, is already rusting as a result of the highly saline water.

- Three decades of drought contributed to the unsustainable pumping of groundwater to provide irrigation water.
- Pumping groundwater at a faster rate than it is replenished increases levels of salt in the soil, which then affects soil fertility in food-producing regions.
- This has led to the collapse of the regional economy as orchards, farms and villages were abandoned.

int-9122

FIGURE 8 Distribution of dams, existing and under construction, in the lake's catchment area. This level of diversion is unsustainable.



Source: Map redrawn by Spatial Vision, based on information taken from United Nations Environment Programme.

The current situation

The Lake Urmia Restoration Program was established by the government in 2013 with the aim of rehabilitating the lake. An ecological target water level was set (see **FIGURE 9**), which would see increases in water volume, decreases in salt levels and the re-establishment of brine shrimp (basis of food chain) in the lake.

New strategies have been put in place to help reverse 25 years of unsustainable development and decline around Lake Urmia. The three focus areas are environment, sustainable livelihood development and surface water control.

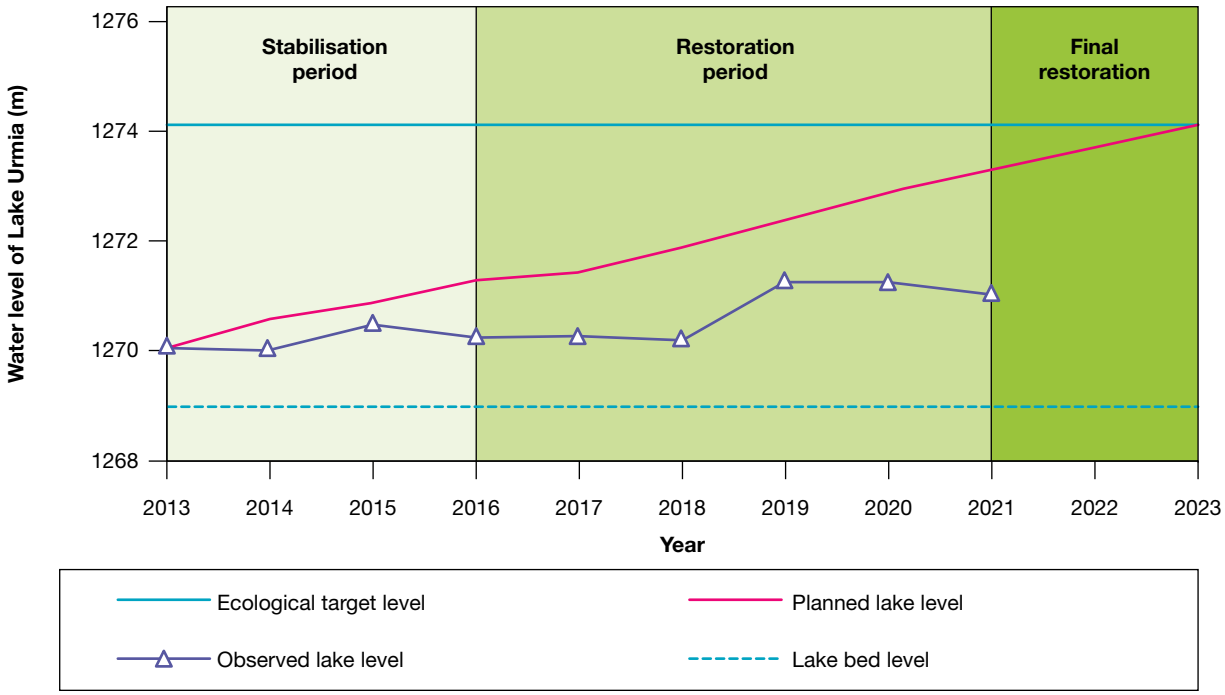
Some of the strategies include:

- As agriculture uses 85 per cent of the lake's water, the government hopes to replace 'thirsty' crops and reform irrigation practices without losing food security; for example, watering crops at night uses less water and reduces evaporation. Much depends on changing the culture of people to accept more sustainable methods.
- Construction of a 35-kilometre tunnel to transfer water from the Little Zab river basin in neighbouring Iraq is almost complete but is creating tensions. Protesters in the Little Zab region believe that they are going to suffer the same water shortage problems as Urmia.

- Construction of 13 treatment plants in the region to treat wastewater from urban areas and deliver it to the lake.
- A development plan launched in 2017 to reduce consumption of potable water by 30 per cent by 2021 and to use desalinated water to meet 30 per cent of the water demands in South Iran.
- Planting vegetation to reduce wind speed and salt storms.
- Local rivers have been dredged to remove silt and sand that was blocking them, and more water has been released from nearby dams.

int- 9187

FIGURE 9 Road map of Lake Urmia Restoration Program



Source: https://www.sciencedirect.com/science/article/pii/S2214581821000410

Restoring the lake has cost $1 billion so far and has been tackled at all scales:

Global — United Nations Development Program
International — countries such as Japan donating $7 million towards the project
National — the Iranian Government
Local — communities around the lake

In 2021, the lake had increased in size, but was still 3 metres below its water target level (**FIGURE 7**). Brine shrimp had started to return, and the number of flamingos increased from 4000 in the driest period to 60 000. Agricultural water use has dropped by 35 per cent and use of pesticides by 40 per cent.

Scientists are unsure how much of this improvement can be attributed to water restoration and how much to heavy rainfalls in 2019 and 2021. There is a fear that engineering schemes only encourage increases in demand for water and repeat unsustainable mistakes. They also ignore community needs and input. The destruction of the lake has helped change many people's beliefs, leading to a more Earth-centred viewpoint, that with time and careful management could help restore the lake.

SkillBuilders to support skill development

- 7.5 SkillBuilder: Creating a fishbone diagram
- 7.15 SkillBuilder: Comparing aerial photographs to investigate spatial change over time

4.5 SKILL ACTIVITY: Questioning and researching using geographical methods, Interpreting and analysing geographical data and information

FIGURE 10 Boat ruins lie in a dry lake bed.

Conduct some **online research** and **investigate** the decline of either Lake Chad in Africa, Owens Lake in the United States or the Aral Sea on the Kazakhstan–Uzbekistan border. Use the following as a research guide for elements to include in your 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.

on Resources

Interactivity Wetland wonderlands (int-3294)

4.5 Exercise

learnon

4.5 Exercise

Learning pathways

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

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- Receive immediate feedback
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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. Environmental factors would have been the most influential factor in the decision behind the creation of the South–North Water Transfer Project.
   b. The impacts of the water transfer from the south to the north of China would only occur at the local scale.
   c. Climate change could be a contributor to changing environments around Lake Urmia.
   d. The decline in water levels in Lake Urmia would have minimal impact on the surrounding wetlands.
2. Study **FIGURE 3**. **Select** the correct words to describe the location of the North China Plain.
   The North China Plain is located in _____ China. Beijing is located at its _____ point. The aquifer beneath this plain extends in a _____direction for approximately 800 kilometres, and _____for approximately 400 kilometres at its widest point.
3. Lake Urmia is a terminal lake. **State** what this means.

Apply your understanding

Questioning and researching using geographical methods

4. **Discuss** the advantages and disadvantages of diverting water from rivers using the case studies in this lesson.
5. Refer to **FIGURE 2**. **Compare** the severity of the predicted water shortages for the region around Beijing and the region south of the Yangtze River.
6. **Consider** whether the South–North Water Transfer Project a realistic solution for China's water issues. **Identify** whether a human-centred rather than Earth-centred viewpoints is the best option for water management in northern China. Write a paragraph outlining your views.
7. **Discuss**, with examples, the tensions and conflicts that can develop because of large-scale water diversions.
8. **Examine FIGURES 6a** and **b**. Compare the appearance and size of Lake Urmia in 1998 and 2019.

Concluding and decision-making

9. Refer to **FIGURE 9**.
   a. **Describe** the progress of the Lake Urmia Restoration Program in 2021 in terms of observed and planned lake levels and the planned ecological target. Use data in your answer.
   b. Do you think there is a future for Lake Urmia? How successful will the restoration project be? **Explain** your answer.

Communicating

10. There is often talk about transferring water from the wetter regions of northern Australia to the water-hungry regions further south. **Identify** what you need to know before planning a project like the one in China. Thinking geographically, **create** a list of ten questions to consider before designing such a project.

LESSON
4.6 How do we use wetlands?

LEARNING INTENTION

By the end of this lesson you should be able to describe the functions and importance of wetlands and explain the environmental changes to wetlands due to human activities. You will also compare ways in which wetlands are managed at a range of scales and analyse a case study of the sustainable restoration of a wetland.

TUNE IN

There are a number of different kinds of wetlands that exist around Australia.

1. Refer to **FIGURE 1**. What do all these environments have in common?
2. Over time, wetlands have been viewed as wastelands. Why do you think people had that viewpoint?
3. Looking at the images, why might these landscapes be important environments?
4. Brainstorm the ways that early First Nations Australians might have used these places and their resources.

FIGURE 1 Different types of wetlands

4.6.1 What are 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. Wetlands are areas that are covered by water permanently, seasonally or ephemerally and can include fresh, salty and brackish waters. They include such things as ponds, bogs, swamps, marshes, rice paddies and coastal lagoons. Wetlands are interconnected with other elements in the landscape, especially rivers and floodplains as water, nutrients and sediments move between them (see **FIGURE 2**).

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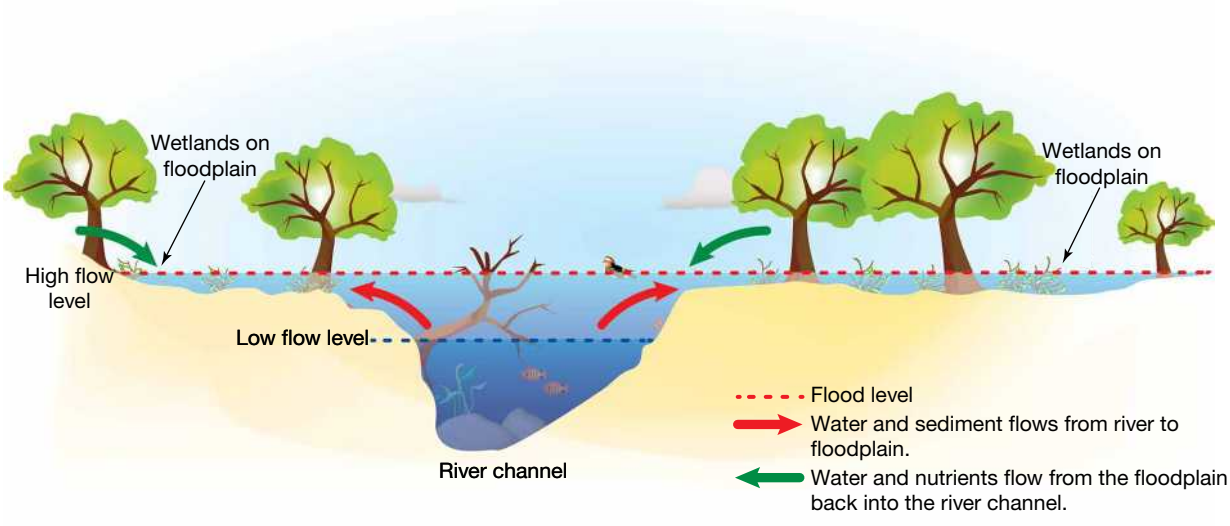
tlvd-10767

FIGURE 2 Interconnections between the river and wetlands on the floodplain

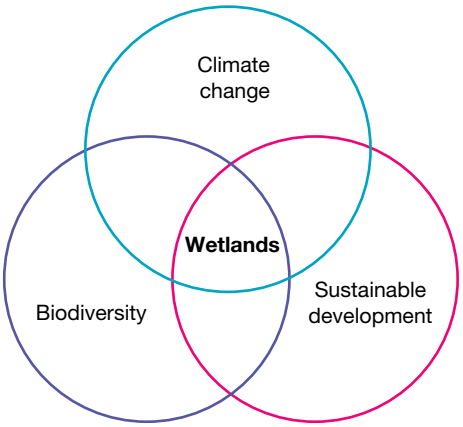


An area does not have to be permanently wet to qualify as a wetland. Flooding or soaking can occur regularly, irregularly or totally randomly. However, the area needs to be wet long enough for the plants and animals who have adapted to the watering pattern to be able to regenerate and reproduce.

The importance of wetlands

Wetlands perform many important functions. They purify water; for example, much of Melbourne's sewage water is filtered through a series of lagoons and wetlands at the Western Treatment Plant in Werribee, producing high-quality recycled water. Wetlands located along river floodplains reduce the impact and speed of floods by holding vast quantities of flood water and then slowly releasing it back into the river system. Water in wetlands also infiltrates the soil, recharging groundwater reserves. In addition, wetlands provide habitat and breeding grounds for 40 per cent of the world's species, such as aquatic fish, insects, reptiles and birds. Globally, more than 1 billion people rely on wetlands for a living, for their water and food supply, and for tourism and recreation.

FIGURE 3 Sustainable development of wetlands



Wetlands are the most effective of all land-based ecosystems for managing climate change as they can take up and store carbon at rates greater than even tropical rainforests. Wetlands can form an interconnection between climate change, biodiversity and sustainable development as seen in **FIGURE 3**.

Improving the management of wetlands brings health, food and water security benefits, critical to the health and livelihoods of people who are reliant on wetlands. The global value of wetland ecosystem services for human health, wellbeing and security is estimated to be $47.4 trillion a year.

4.6.2 What are the threats to wetlands?

The degradation and loss of wetlands and the species that inhabit them have been more rapid than for any other ecosystem; in fact, they are disappearing three times faster than forests. It has been estimated that between 1970 and 2015, the world lost 35 per cent of its wetlands. Competition from other land uses and increasing populations have contributed to the decline. Not only have wetlands been degraded and drained, but they have also become more fragmented. The loss of connection contributes to the further loss in animal movements and biodiversity.

- Agricultural expansion is the largest contributor to wetland loss and degradation globally. Farming often requires the draining of wetlands to create more land, reducing biodiversity. In addition, the water run-off from agriculture is often polluted with fertilisers and pesticides and increased pumping from aquifers depletes groundwater resources.
- Dams alter seasonal floods and block supply of sediment and nutrients onto the floodplain and deltas. Often, damming means little water and sediment reach the mouths and deltas of large rivers.
- 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. For example, 70 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. Wetlands are often treated as dumping grounds, as seen in **FIGURE 4**.
- 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.

Wetlands, like all other water resources, are prone to over-exploitation and need to be managed carefully to ensure sustainable use.

impervious a rock layer that does not allow water to move through it due to a lack of cracks and fissures

eutrophication a process where water bodies receive excess nutrients that stimulate excessive plant growth

FIGURE 4 A polluted and degraded wetland

4.6.3 How are wetlands managed?

The Convention on Wetlands (known as the Ramsar Convention) is the first modern international treaty aimed at conserving natural resources. The main aim is to halt the global loss of wetlands and to conserve those that remain.

Steps that are taken to achieve these aims:

- Recognition of places that have rare or unique wetlands or are important for conserving biological diversity.
- Once designated, the sites are added to the Convention's List of Wetlands of International Importance and become known as Ramsar sites.
- Countries that have signed the convention (172) agree to set up management programs to conserve the wetland, ensuring its wise use.

At a global scale, there are 2400 wetlands that are listed as Ramsar sites and are under the protection of the treaty. These make up 13 to 18 per cent of the world's wetlands. Currently, Australia has 66 Ramsar-listed wetlands that cover an area larger than Tasmania. They represent a wide range of different types of wetland in every climatic zone.

on Resources

Interactivity That sinking feeling (int-3293)

4.6.4 Where has the water gone in the Murray–Darling Basin?

The rivers, lakes and wetlands of the Murray–Darling Basin (see **FIGURE 5**) form an interconnected network and it is Australia's most important inland water body. Decades of continually blocking and diverting water from its rivers and prolonged periods of drought have brought significant changes to the rivers, surrounding floodplains and surrounding wetlands. The amount of water taken out of the river system has increased fivefold over the past century.

The basin has over 30 000 wetlands, 16 of them listed internationally for their importance to migratory birds that visit the site. To be healthy and promote life, the wetlands of the basin need to be alternately wet and dry, yet due to overuse of water in the basin, 90 per cent of wetlands have been lost and **river regimes** been permanently changed. The floodplains of the Murray River are now flooded once every 10 to 12 years compared to three to four years out of every five a century ago. Rivers have lost their connection to the floodplains.

river regime the pattern of seasonal variation in the volume of a river

int-9124

tlvd-10768

FIGURE 5 Key features of the Murray–Darling Basin

Source: © Commonwealth of Australia Geoscience Australia 2013. Murray Darling Basin Commission. Map by Spatial Vision.

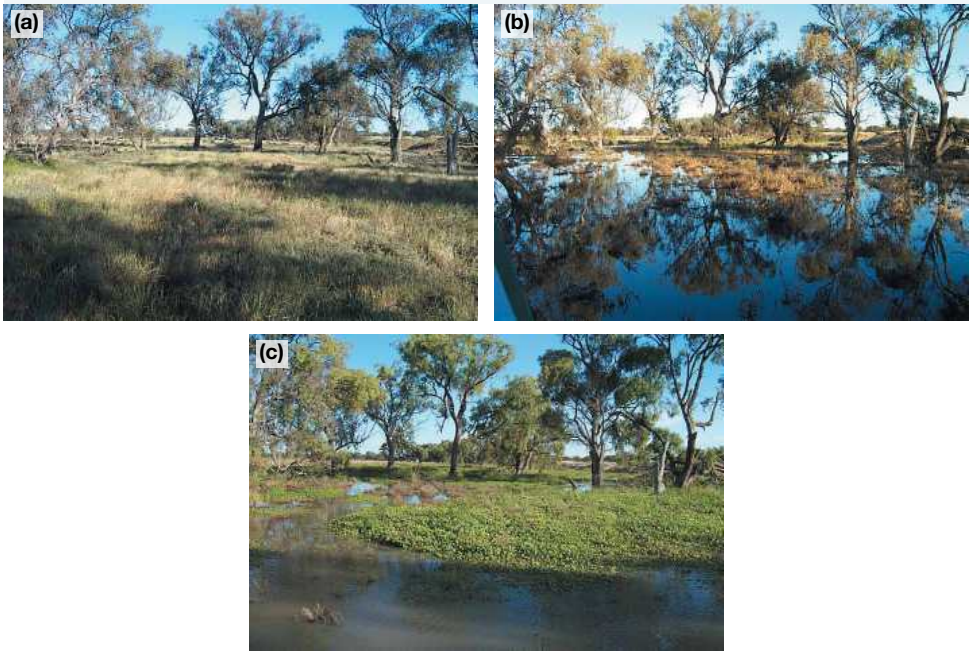
4.6.5 What changes have resulted from the overuse of water?

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. In the twentieth century, the management of the river switched focus from using the river for transport to expanding agriculture. This period saw a rapid rise in the amount of water withdrawn and a decline in the health of river ecosystems. Consequently, 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 6 Wanganella Swamp (Deniliquin, NSW): (a) before, (b) during and (c) after an environmental flow



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.

There have been several government initiatives put in place over the years to reduce the amount of water being harvested from the river. One of the most important is The Living Murray Program, which tries to improve the health of rivers. To do this, the Murray–Darling Basin Authority (MDBA) concentrates on maintaining the health of six **icon sites** (see **FIGURE 5**) by providing them with additional water from **environmental flows**. Water 'savings' have to be made elsewhere through improvements in water storage, distribution and irrigation methods. **FIGURE 6** shows the effects of an environmental flow on a stressed wetland. As a member of the Ramsar Convention, Australia is required to promote the wise use of all of the basin's water resources and the conservation of declared Ramsar sites.

Note that it is extremely difficult for water managers to balance the need for natural river flows while also protecting farmers' water needs and preventing large floods.

Menindee Lakes fish kill

The summer of 2019 saw more than 1 million fish killed by extremely poor water quality in the Menindee Lakes storage system (see **FIGURE 7**). Water levels in the lakes were extremely low and the system had stopped flowing. On average 4000 GL flows into the Barwon–Darling river system and then into the lakes where it can be released to flow downstream into South Australia. The lakes are very shallow and 20 to 30 per cent of the water evaporates each year. Management tries to avoid this by releasing water in a 'use it or lose it' manner.

High temperatures and calm warm water provided ideal conditions for the growth of blue-green algae, which smothered the water surface turning it green. A cold front moved across the region, dropping water temperatures, which served to kill off the algal bloom. The rapid growth of bacteria that feeds off dead algae used all the oxygen in the water, causing the fish to suffocate. Essentially insufficient water was available in the system to provide environmental flow.

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 flows the quantity, quality and timing of water flows required to sustain freshwater ecosystems

Calculating how much water can be diverted from the river system is usually based on 'full rivers'; little planning is done to manage flow in times of drought. Current water licences are also based on the height of a river. If one person leaves water in the river, the next person downstream can take more.

FIGURE 7 Fish killed at the Menindee Lakes

In 2018, in the wake of ongoing concerns about the management of the basin, a Royal Commission was held to investigate the operations and effectiveness of the Murray–Darling Basin Plan. The Commission report, released in January 2019, contained 111 findings and 44 recommendations to overhaul the Plan, including adjusting the balance between irrigation and environmental flows, to give more water back to the environment. The nearly 750-page report highlighted the complexities and challenges of balancing environmental, social and economic needs in relation to a water source on which millions of people depend.

4.6.6 How do First Nations Australians value wetlands?

First Nations Australians have long-held cultural and traditional responsibilities to protect and manage their land and its resources, including wetlands; they were the first river custodians. First Nations Australians manage or co-manage 11 of the 65 Australian wetlands internationally recognised under the Ramsar Convention. Wetlands are important to the lives and wellbeing of First Nations Australians. They act as ceremonial sites, traditional hunting and gathering grounds, and as borders between nation groups. First Nations' beliefs see the interconnections between land, water, sea and sky. Traditionally, most of the plants and animals could be used for food, fibres, medicines, tools, weapons and shelter. Both federal and state governments work with First Nations Australians to develop policies and management plans. Under the Ramsar Convention, there is recognition of the cultural and spiritual value of wetlands and the traditional knowledge that can be used in their sustainable use and management.

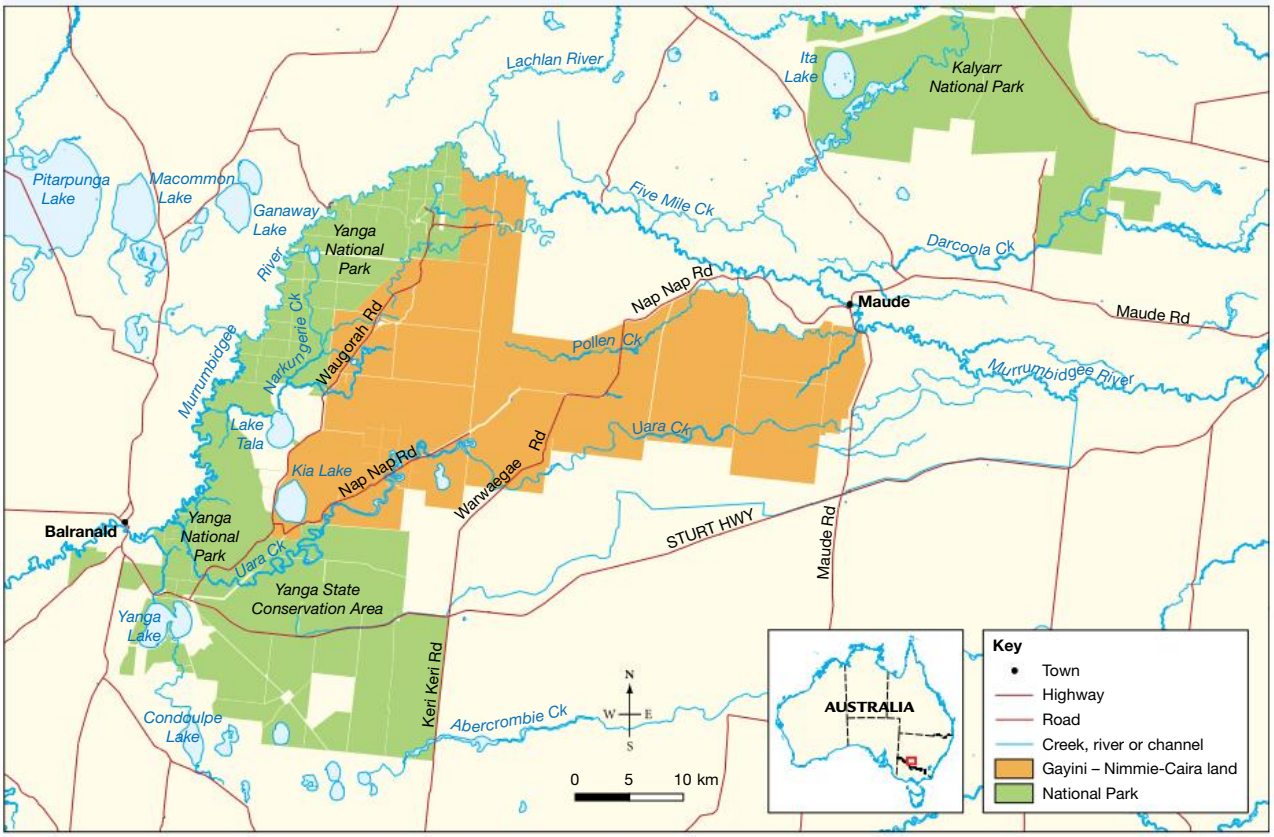
4.6.7 CASE STUDY: How a wetland was restored

Gayini (a Nari Nari word for water) is an 88 000-hectare property and the largest remaining area of wetland located on the floodplains of the Murrumbidgee River (**FIGURE 8**) in southern New South Wales. The property incorporates extensive wetlands that are habitats and breeding grounds for countless species of birds, amphibians and reptiles. It is often referred to as the 'Kakadu of the south' for its spectacular birdlife.

Traditionally, this area was the homeland for the Nari Nari people for more than 60 000 years. Following European colonisation, the land was taken from them and developed for farming. Extensive channels were developed to capture flood and river water for crops and livestock. As part of the Murray–Darling Plan, the state and federal governments purchased the land and handed it back to the Nari Nari people who will be paid to manage the restoration of the wetland and run the property, supported by The Nature Conservancy and various expert groups. Additionally, in 2023 the NSW Government established the Gayini Nimmie-Caira Conservation Area, which covers 55 220 hectares of the property (the equivalent of nearly 30 000 Sydney Cricket Grounds). This ecologically important wetland will be conserved in perpetuity; this means it must be preserved forever.

A land and water management plan has been developed to enable Gayini to remain a working farm, as well as focusing on three main areas, as seen in **TABLE 1**.

FIGURE 8 Location of Gayini Nimmie-Caira



Source: Map redrawn by Spatial Vision, based on information taken from Spatial Services (NSW) and Department of Industry (NSW).

TABLE 1 Management focus and strategies for Gayini

Management focus	Strategies
Environmental protection	Money made from farming will be reinvested into restoring and protecting a valuable wetland using both traditional and modern techniques • Removal of thousands of feral animals, such as wild pigs, deer and foxes, which compete with native animals for resources and damage the wetlands • Creation of a more natural flooding pattern across the wetland, which when combined with environmental flows from The Murrumbidgee River will help restore wetland vegetation and habitat
First Nations engagement and participation	• The Nari Nari Tribal Council will manage the property and provide employment opportunities and reconnection to Country • The protection of more than 2000 cultural sites on the property, including burial grounds, middens and camp sites
Sustainable development	• Promoting commercial activities that can boost the local economy, such as allowing only low-impact grazing and, over time, introducing other sustainable land uses on the property • A future education program to share traditional environmental knowledge with western science • A planned ecotourism development for educational and volunteer groups.

According to the Chairman of the Nari Nari Tribal Council, 'we can continue to protect the environment, preserve the Aboriginal heritage of the land and enable the intergenerational transfer of knowledge of caring for country'.

FIGURE 9 The wetlands of Gayini showing farmland in the distance. Compare the difference between the two land uses.

4.6 SKILL ACTIVITY: Interpreting and analysing geographical data and information, Concluding and decision-making

Create a bar graph to demonstrate the main human activities that contribute to the degradation of Wetlands of International Importance. Complete your graph with full BOLTSS.

Category	Human activity	Percentage
Water regulation	Water removal	13
	Water releases (flooding)	8
	Drainage of wetlands	17
	River regulation (control of river flow)	11
Changes to ecosystems	Vegetation clearing	14
	Dams and water management	19
Agriculture	Wood plantations	3
	Livestock farming	19
	Cropping	15

1. **Identify** which three human activities are most responsible for the degradation of important wetlands.
2. In terms of the category of human activities, **identify** which appears to be the most destructive to wetlands. Use data and examples in your answer.
3. **Suggest** two ways in which vegetation clearing could impact on the health of a wetland.
4. **Select** one example from your graph and **create** a management strategy that could help reduce the impacts of the human activity on wetlands.

4.6 Exercise

learnon

4.6 Exercise

Learning pathways

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

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- Receive immediate feedback
- Access sample responses
- Track results and progress

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Check your understanding

1. What are wetlands?
   - A. Areas permanently covered by water
   - B. Areas covered by water permanently, seasonally or ephemerally
   - C. Rivers and lakes
   - D. Wet areas near oceans
2. **Select** three major threats to wetlands.
   - A. Native species
   - B. Agricultural expansion
   - C. Construction of dams
   - D. Lack of algal blooms
   - E. Cleaning for urban growth
3. **Determine** whether the following statements are true or false.
   - a. An environmental flow is designed to provide a wetland with the correct quantity and quality of water to mimic a natural flood.
   - b. The wetlands of the Murra–Darling Basin have generally been left untouched over the development of the basin.
   - c. The waters of the Murray–Darling Basin are used by four states and one territory.
   - d. The Nari Nari people had little use for the wetlands that covered their lands near the Murrumbidgee River as they were too swampy.
4. Study **FIGURE 2**.
   - a. **Describe** how a flood can change the movement of sediment and nutrients in a wetland.
   - b. **Predict** what might happen to the wetland in the diagram if a dam was constructed upstream.
5. **Identify** the factors that have contributed to the poor health of the wetlands of the Murray–Darling Basin.

Apply your understanding

Communicating

6. **Explain** eutrophication, its causes and the impact it has on a wetland.
7. **Explain** how the Nari Nari people can mix traditional and western understanding to restore and manage the wetlands at Gayini.

Concluding and decision-making

8. a. **Consider** whether worldviews applied in the management of Gayini would be Earth- or human-centred. **Justify** your answer.
   b. **Reflect** on whether the ecosystem management of Gayini could be used in other places to restore wetlands in rural areas.

LESSON
4.7 Investigating topographic maps: Wetlands along the Murray River

LEARNING INTENTION

By the end of this lesson you should be able to explain the importance of managing wetlands.

4.7.1 Tar-Ru Wetlands

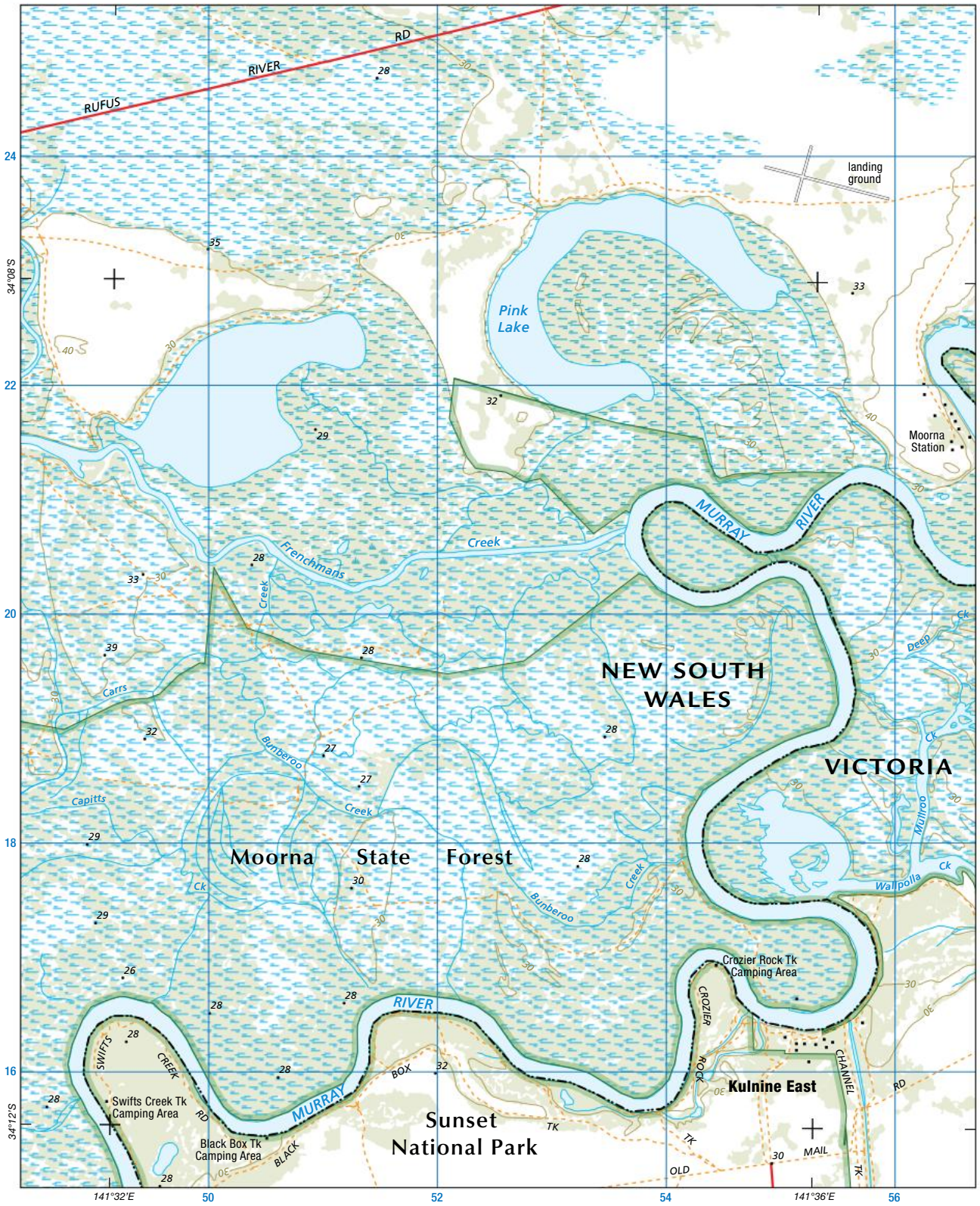
The Tar-Ru Wetlands within the Carrs, Capitts and Bunberoo Creeks are located on the floodplains within Locks 9 and 8 of the Murray River and Frenchmans Creek, about 45 kilometres west of Wentworth, New South Wales. Over time, the natural water flows of the wetlands have been interrupted by river regulation methods, such as weirs and levee banks. Managing the health of the Murray–Darling Basin wetlands is essential to the functioning of the entire ecosystem, as wetlands provide an abundance of food and support the majority of native fish at some point in their lifecycle.

In April 2016, a project was initiated to spread nearly 1 billion litres of environmental water across five sites on Tar-Ru Lands. This included 60 hectares of wetlands between the Carrs, Capitts and Bunberoo Creek systems. This project was expected to increase the biodiversity of native waterbirds, the population of the southern bell frog and improve the health of river red gums. It saw immediate results.

In the weeks after the watering of the wetlands, the number of observed bird species more than doubled and the number of individual birds increased by 250 per cent. In addition, there were, sightings of two species of frogs, and new green vegetation and new aquatic vegetation increased tenfold. The Tar-Ru Wetland is managed by the Tar-Ru Aboriginal Land Managers, who will assist in maintaining the health of the aquatic habitat and ongoing environmental monitoring.

FIGURE 1 Southern bell frog

FIGURE 2 Topographic map of Tar-Ru Wetlands, west of Wentworth, New South Wales



Legend

39 Spot height	unsealed	Minor Road		Subject to inundation
Building		Track		Wetland
Contour		Runway		Vegetation
Index contour (Interval: 10 m)		Watercourse		Reserve boundary
State border		Water body		

N W E S

0 1 2

Source: Data based on Spatial Services 2019, Spatial Datamart, sourced on 16 December 2020, https://services.land.vic.gov.au/SpatialDatamart/ and © State of Victoria (Department of Environment, Land, Water and Planning)

Resources

eWorkbook	Investigating topographic maps — Wetlands along the Murray River (ewbk-10145)
Digital documents	Topographic map of Wentworth, New South Wales (doc-11569) Topographic map of the Tar-Ru Wetlands (doc-36369)
Video eLesson	Investigating topographic maps — Wetlands along the Murray River (eles-5259)
Interactivity	Investigating topographic maps — Wetlands along the Murray River (int-8681)
Google Earth	Tar-Ru Wetlands (gogl-0142)

4.7 Exercise

learnon

4.7 Exercise

Learning pathways

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

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- Receive immediate feedback
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Check your understanding

1. **Identify** and give the grid reference for the following in **FIGURE 2**.
   a. Crozier Rock Track Camping Area
   b. The aircraft landing ground
   c. A spot height over 30 m in Victoria
   d. The eastern most point of Pink Lake
2. Mark the locations of the following water-management constructions on your map, and add an appropriate symbol to the legend.
   a. Lock 9 (GR524163)
   b. Weir/bridge (GR493196)

Apply your understanding

Interpreting and analysing geographical data and information

3. Use evidence from the map to **identify** the changes that people have brought to the Tar-Ru Wetlands.
4. Providing evidence (such as elevation and proximity to waterways), **discuss** why the buildings on Moorna Station might have been built in their given location.

Concluding and decision-making

5. Imagine you are planning to hike from the airstrip (landing ground) around Pink Lake and back. The weather forecast suggests that heavy rain is expected from mid-afternoon.
   a. **Outline** the route you would take, including grid references, distances and appropriate positional language.
   b. **Explain** why you chose this route.
6. If a dam was built two kilometres upstream of the most north-easterly point of the Murray River shown on **FIGURE 2**, **predict** what changes are likely to occur to:
   a. the wetlands
   b. people's access to homes, towns and settlements
   c. people's ability to access the parks and reserves of the area.

LESSON
4.8 INQUIRY: The Menindee Lakes fish kill

LEARNING INTENTION

By the end of this lesson you should be able to interpret and analyse data about the Menindee Lakes fish kill and communicate this in a report.

Background

In this inquiry you will investigate the mystery of the Menindee Lakes fish kill to write a front-page investigative report for your news service (print or online).

During the summer of 2018–19, a massive fish kill occurred in the Menindee Lakes in western New South Wales. A fish kill involves the death of large numbers of aquatic animals over a short period, often within a defined area. More than one million native fish died; community outrage ensued.

The lakes form a chain of seven natural shallow bodies of water connected to the Darling River in the Murray–Darling Basin. They have been modified to improve their storage capacity to help manage floods and provide water for surrounding towns and agriculture, and to be released for downstream users. The amount of water in the lakes is controlled and there is considerable controversy over the management of water in the Darling River, especially between upstream users (particularly those irrigating large water-hungry cotton farms) and downstream users of water, which include the city of Broken Hill and farmers and towns all the way to the mouth of the Murray River in South Australia.

FIGURE 1 Fish killed at the Menindee Lakes

Before you begin

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

Inquiry steps

As a reporter for a national news service, you have been sent to the small town of Menindee to investigate the reasons for the fish kill, the impacts of the kill on the people and environment and what steps could be taken to prevent another kill from happening.

Discuss the following:

(a) **What** do you know about the impacts of large-scale water withdrawals from rivers?
(b) **When** looking at the image above, what human and natural factors might have contributed to the fish kill?
(c) **What** management strategies could be introduced to reduce the risk of another fish kill?

Step 1: Questioning and researching using geographical methods

Write down your selected **inquiry question**.

Investigate your inquiry question.

- **Conduct research** into the Menindee Lakes fish kill: background to the lakes becoming a storage facility, recent weather conditions, how the lake waters are used.
- Include in your research a suitable map showing the location of the Menindee Lakes within the Murray–Darling Basin and any other suitable images and other data that can be mapped or graphed.
- **Identify** different viewpoints for people involved who could be 'interviewed' and quoted in your newspaper article; for example, a local resident, fisherman, farmer, councillor, someone from the Murray–Darling Basin Authority or a scientific 'expert'.

Step 2: Interpreting and analysing geographical data and information

- **Identify** the main factors (political, environmental, economic, social) responsible for the fish kill.
- **Create** a summary table outlining the impacts of the fish kill on people and the environment.
- **Decide** on possible strategies to reduce any further risks of fish kills in the lakes (these may be suggested from your interviews).

Step 3: Concluding and decision-making

- **Evaluate** which of your suggested strategies would be the most effective based on:
  - Economic viability (affordability)
  - Environmental benefit (reducing the risk of future fish kills)
  - Social justice (fairness for all users of the lakes water).

Step 4: Communicating

- **Design** or search the internet for a suitable template for a newspaper front page and select an appropriate masthead, main headline and sub-headlines.
- Write the article for the newspaper using sub-headlines to break up your content and to ensure that you cover all tasks. Make sure that a location map and annotated images are included.
- Review your finished newspaper front page, carefully checking spelling and grammar. Complete your bibliography, listing details of all sources used.

Complete your self-assessment using the **Inquiry rubric** or access the 4.8 exercise set to complete it online.

Resources

Digital document Inquiry rubric (doc-40156)

LESSON
4.9 Review

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

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

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4.9.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

4.2 What is inland water?

- Inland water covers a range of different landforms and environments.
- Water that is stored in rivers, lakes and groundwater provides a wide range of environmental services.
- Changes as a result of human activities can alter the environmental functions of inland water bodies.

4.3 Why do we dam rivers?

- Dams provide many benefits to societies, from supplying water and electricity to preventing floods and providing irrigation water.
- At the same time, dams create river fragmentation, displace communities and change river flows.
- Large-scale mega dams have always been associated with economic development and progress.
- Mega dams have had significant environmental and social impacts.
- Globally, there are questions about the economic, social and environmental worth of mega dams.
- Local and environmental groups have challenged the construction of a mega dam, the Belo Monte, in Brazil.
- Partly as a result of the controversy, costs and corruption involved in the dam's construction, the Brazilian government will cease to build mega dams.
- The Itaipu Dam, while classified as a mega dam, has been able to sustainably manage water quality in the catchment as well as improving the environment and helping the community.

4.4 What are some alternatives to dams?

- More attention is now being paid to small-scale, community-based water management schemes.
- Rainwater harvesting schemes and micro hydro-dams are two alternatives.
- Use of traditional small water harvesting dams (*johads*) in India are providing significant benefits — both environmental and social.

4.5 What happens when water is diverted?

- Water and populations are not always distributed evenly, which then requires large-scale diversion of water from places of surplus to places of shortage.
- 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.
- The overuse and diversion of water is causing over one-third of the world's major surface water supplies to dry up.
- Lake Urmia in Iran is an example of where over-extraction of water led to the decline in the health and size of the lake.
- It is possible to restore Lake Urmia given enough funds and more sustainable farming practices.
- Water availability is unevenly distributed in China, with much more water available in the south than the north.

- In China's north, unsustainable use of water is lowering groundwater reserves.
- A large-scale transfer of water from the south to the north of China has been constructed.
- There are many social, economic and environmental impacts from such a scheme.

4.6 How do we use wetlands?

- Wetlands are a very important biome.
- Wetlands are constantly under threat from a range of human activities.
- The Murray–Darling Basin has over 30 000 wetlands, including 16 of international importance.
- The Living Murray Program aims to create environmental flows to improve the health of six icon wetland sites.
- Wetlands are very important spiritually and culturally to First Nations Australians.
- Gayini is a working property in the Murray–Darling Basin, which is now having its wetlands restored by its First Nations custodians.

4.7 Investigating topographic maps: Wetlands along the Murray River

- The natural flow of water into and out of the Tar-Ru Wetlands has been affected by river regulations.
- A release of environmental water into the wetlands in 2016 saw immediate benefits, with increased growth of vegetation and an increase in biodiversity.
- The wetlands are now managed by the Tar-Ru Aboriginal Land Managers who monitor the health of the wetlands.

4.8 INQUIRY: The Menindee Lakes fish kill

- Investigating the causes of the massive fish kill in the Menindee Lakes in western New South Wales during the summer of 2018–19.

4.9.2 Key terms

aquifers layers of porous rock that can hold large quantities of water in the pore spaces

base flow water entering a stream from groundwater seepage, usually through the banks and bed of the stream

catchment (or drainage basin) any area of land where precipitation collects and drains off into a common outlet, such as a river, bay or other body of water

environmental flows the quantity, quality and timing of water flows 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

ephemeral describes a stream or river that flows only occasionally, usually after heavy rain

eutrophication a process where water bodies receive excess nutrients that stimulate excessive plant growth

flood mitigation managing the effects of floods rather than trying to prevent them altogether

green energy sustainable or alternative energy (e.g. wind, solar and tidal)

groundwater water held underground within water-bearing rocks or aquifers

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 a rock layer that does not allow water to move through it due to a lack of cracks and fissures

infrastructure the basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society

micro hydro-dams dams that produce 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.

perennial describes a stream or river that flows permanently

rainwater harvesting the accumulation and storage of rainwater for reuse before it soaks into underground aquifers

Ramsar Convention an international treaty for the conservation and sustainable use of wetlands

recharge the process by which groundwater is replenished by the slow movement of water down through soil and rock layers

reservoir large natural or artificial lake used to store water, created behind a barrier or dam wall

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

subsidence the gradual sinking of landforms to a lower level as a result of earth movements, mining operations or over-withdrawal of water

terminal lake a lake where 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.

UNESCO biosphere reserve The Man and Biosphere Programme is an international scientific program established by the United Nations to create biosphere reserves as 'learning places for sustainable development'.

watertable upper level of groundwater; the level below which the earth is saturated with water

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

wetland an area covered by water permanently, seasonally or ephemerally. They include 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.

4.9.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

Both humans and natural systems would find life very hard without healthy inland water sources. How do worldviews influence the ways in which people use and manage these sustainably?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-11502)
Reflection (ewbk-12518)
Crossword (ewbk-12519)

Interactivity Inland water: change and management crossword (int-7671)

4.9 Review exercise

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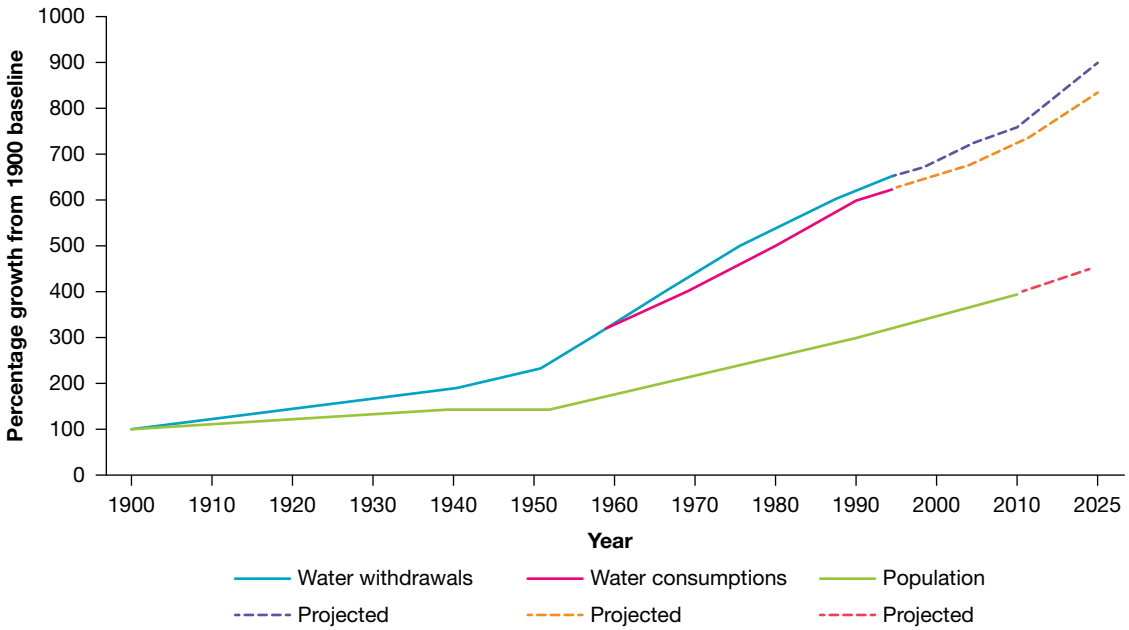
Multiple choice

1. Define a wetland.
   - **A.** Any water that is not salty
   - **B.** An area covered by water permanently, seasonally or ephemerally, including fresh, salt and brackish waters
   - **C.** An area covered by water permanently, seasonally or ephemerally, but only fresh waters
   - **D.** A tributary flowing from a lake to the ocean

Refer to the graph in **FIGURE 1** to answer questions 2 and 3.

FIGURE 1 A comparison of the rate of population growth, water consumption and water withdrawals



2. Compare the growth in water consumption with the growth in world population over time.
   - **A.** Water consumption has increased at a greater rate than population.
   - **B.** Water consumption has increased at a lesser rate than population.
   - **C.** The rate of growth has been the same in both areas.
   - **D.** None of the above
3. Select the feature shown on the graph which has shown the greatest rate of increase.
   - **A.** Water consumption
   - **B.** Population
   - **C.** Water withdrawals
   - **D.** None of the above

4. Reservoirs around the world trap more than 2.3 gigatons (1 billion metric tonnes) 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.
Where does the sediment trapped in reservoirs come from?
   - **A.** From soil, sand and other material that is washed off/eroded from land surfaces upstream of the dam
   - **B.** Stirred up from the bottom of the reservoir
   - **C.** Illegally dumped
   - **D.** Created when water evaporates
5. In which *four* locations would sediment normally end up if rivers were not blocked by dams?
   - **A.** On floodplains
   - **B.** On the sea bed
   - **C.** Deposited to form beaches along the coastline
   - **D.** In the mountains
   - **E.** Deposited at the mouth of the river to form deltas and bars
6. Select two methods of water harvesting.
   - **A.** Rainwater tank and groundwater recharging
   - **B.** Digging a well
   - **C.** Using a bore
   - **D.** Piping water from urban areas
7. Study **FIGURE 6** in section 4.5.4.
Identify the four changes that have occurred between 1998 and 2019.
   - **A.** Environmental flows have flushed the lake system.
   - **B.** Salt deposits have increased.
   - **C.** The lake has shrunk.
   - **D.** Islands in the lake are now surrounded by land.
   - **E.** The lake has expanded in size.
   - **F.** The depth of the lake has decreased.
   - **G.** The lake has deepened.
8. Water is diverted from rivers and other sources:
   - **A.** for domestic purposes only.
   - **B.** for domestic and agricultural purposes only.
   - **C.** for industrial purposes only.
   - **D.** for domestic, industrial and agricultural purposes.
   - **E.** for agricultural purposes only.
9. Select the three options that are negative impacts of controlling the flow of rivers on floodplain wetlands.
   - **A.** Flooding would be unlikely to occur.
   - **B.** The reproduction cycle in plants and birds is interrupted.
   - **C.** The river red gums will not drop their seeds.
   - **D.** Only insects will be affected, so it doesn't really matter.
10. Select three reasons that wetlands are important to migratory birds.
   - **A.** They allow birds of different species to mix.
   - **B.** They provide food, water and shelter for migratory birds.
   - **C.** Breeding pairs from different habitats can mate.
   - **D.** They are important nesting sites.
   - **E.** Many bird species travel flight paths that link one wetland to another.

Short answer

Interpreting and analysing geographical data and information

11. 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 2** and **3**. **State** as many points as you can think of to **describe** the changes dam construction has brought to the natural environment.
- **b.** Refer to **FIGURE 4**. **Explain** why there is a need to relocate so many people when constructing a dam. **Identify** which province had the largest number of people relocated. How many?
- **c.** Study the information in **FIGURES 2, 3** and **4**. **Construct** a table to highlight the benefits and drawbacks of the dam project.

12. Are large dams now a thing of the past? **Consider** whether large-scale dam projects, such as the Three Gorges Dam, could be initiated in Australia. **Explain** reasons for your answer.

FIGURE 2 Changes to the natural landscape due to the Three Gorges Dam

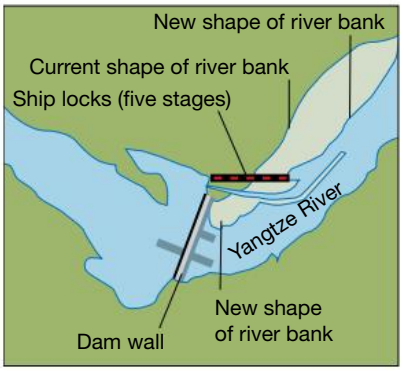


FIGURE 3 Features and benefits of the Three Gorges Dam

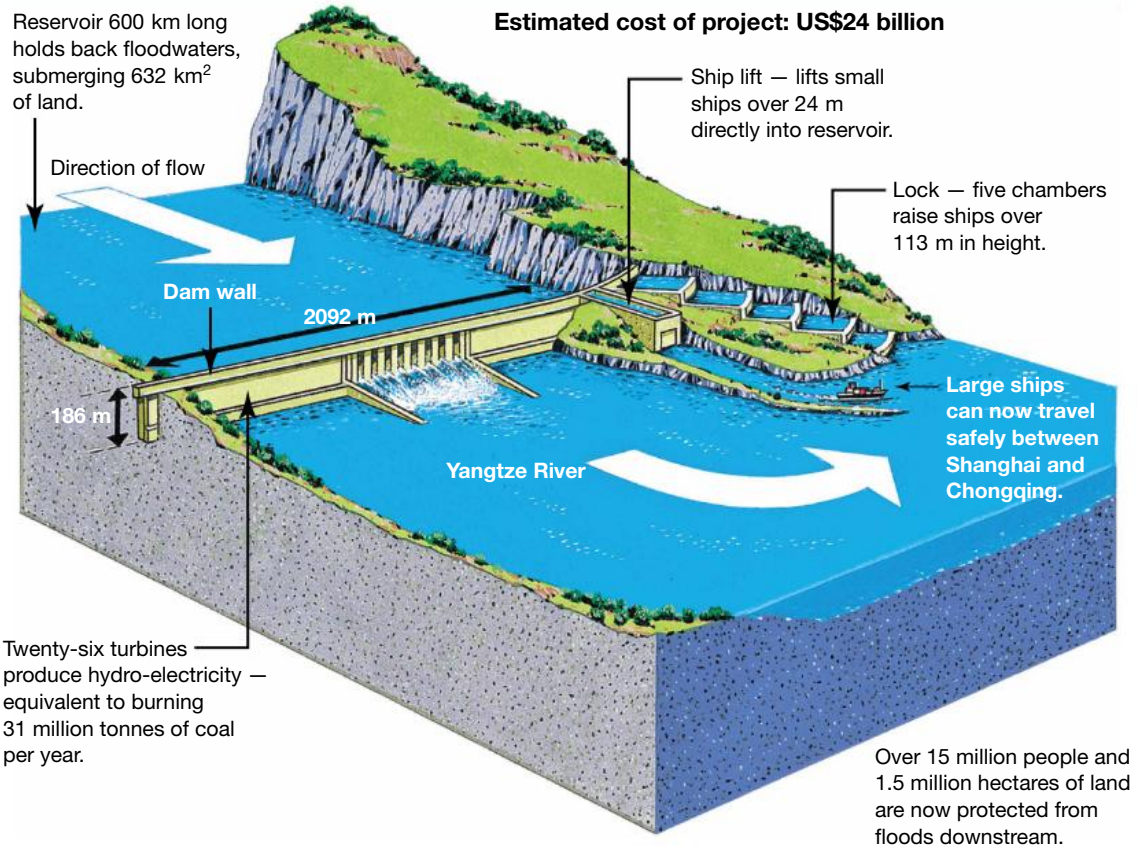
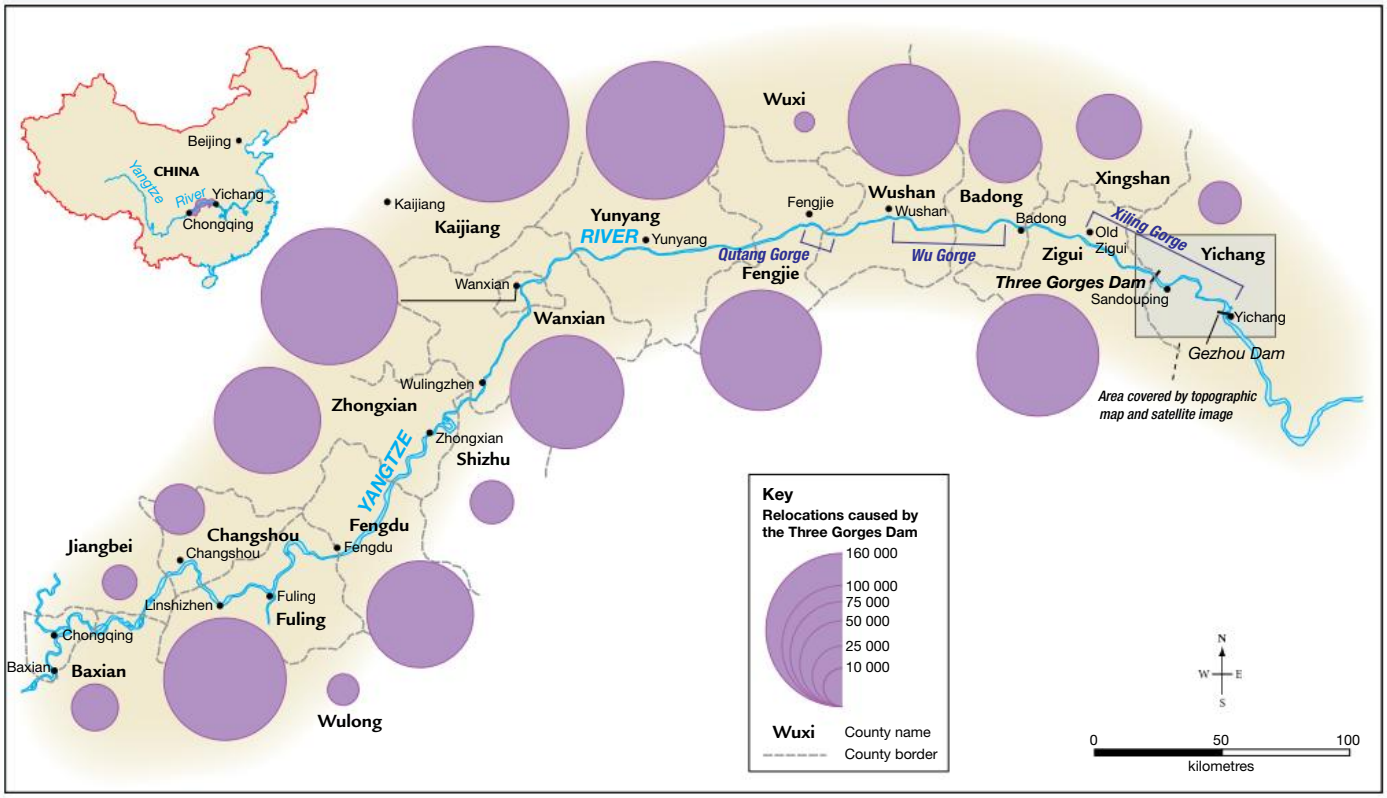


FIGURE 4 Number of people relocated by the Three Gorges Dam



Source: MAPgraphics Pty Ltd, Brisbane

13. The construction of the Belo Monte Dam in Brazil displaced thousands of Indigenous Peoples. A local federal prosecutor brought Norte Energia (the company building the dam) to court on charges of 'ethnocide against the Indigenous Peoples'. (Ethnocide is the deliberate and systematic destruction of the culture of an ethnic group.)
    a. **Propose** an argument to support this case and then a counter-argument to represent an opposing viewpoint.
    b. **Identify** which viewpoint you support. Give reasons.
14. **Evaluate** how successful the restoration of the Gayini wetlands has been, using social criteria.
15. **Identify** with the use of case study examples, **discuss** how the causes and consequences of an environmental change to inland water has contributed to more sustainable strategies being introduced to manage the water resource.

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5 Coastal change and management

LESSON SEQUENCE

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5.2 How are coasts formed and changed? 186
5.3 What are the challenges to coastal environments? 195
5.4 How do we manage coastal change? 207
5.5 Investigating topographic maps: Consequences of coastal change in Merimbula 213
5.6 INQUIRY: Threats to the Great Barrier Reef 216
5.7 Review 218

LESSON
5.1 Overview

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Although it may not be obvious, coasts are constantly changing. How do natural and human processes contribute to this?

5.1.1 Introduction

The coast is home to 80 per cent of the world's population, and 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.

FIGURE 1 Changes in coastal environments can threaten human settlements.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11504)

Video eLesson Washed away (eles-1710)

LESSON
5.2 How are coasts formed and changed?

LEARNING INTENTION

By the end of this lesson you should be able to explain the ways in which coasts are constantly changing, and identify various coastal landforms and the processes by which they are formed over time.

TUNE IN

People build close to the coast to enjoy the general environment including the view, the climate, the beaches and possibly a relaxed lifestyle.

1. There are many positives about living on the coast but there are also negatives. What do you see in the image that suggests coasts are not necessarily a safe place to live?
2. In your travels, have you been to the coast and, if so, what features of the environment did you enjoy? Did you see any evidence of coastal management through built structures?

FIGURE 1 Storm surges and rising sea levels pose a significant threat to some coastal communities.

5.2.1 The importance of the coast

Coasts are a dynamic natural system. The forces of nature are constantly at work, either creating new land or wearing it away. Over 85 per cent of Australians live within 50 kilometres of the coast. As well as being a favoured place to live, the coast is the most popular destination for tourists and visitors.

All forms of human activities can have impacts on coastal landforms and the **ecosystems** of plant and animal life. Australia's coasts need to be managed to achieve goals of sustainable living for all who share this common environment. In addition, there is a need to balance the diverse viewpoints of human-induced development with conservation principles.

5.2.2 The coastal zone

The coastal zone may be broadly defined as the zone where the land meets the sea (see **FIGURE 2**). It includes an area of water known as coastal waters (waters within three nautical miles of the shore) and an area of land called the **hinterland**, which extends several kilometres inland of the coast. The Australian coast, which is approximately 37 000 kilometres in length, consists of many different environments such as plains, rivers and lakes, rainforests, wetlands, mangrove areas, estuaries, beaches, coral reefs, seagrass beds and all forms of sea life found on the adjoining continental shelf.

Many of Australia's World Heritage sites are found in these varied coastal environments, such as the Great Barrier Reef (see **FIGURE 3**), Lord Howe Island, Fraser Island and Shark Bay. The coast is also important for human settlement: urban complexes, ports and harbours. Many First Nations Australians have lived and continue to live in coastal communities. Torres Strait Islander Peoples have a profound understanding of the sea, including its tides and sea life. Historical evidence of middens, art sites, fish traps, stone and ochre quarries, and burial and religious sites show the long history of First Nations

ecosystems systems formed by the interactions between the living organisms (plants, animals, humans) and the physical elements of an environment

hinterland the land behind a coast or shoreline extending a few kilometres inland

FIGURE 2 Typical Australian coastal scenario, Point Danger, Tweed Heads, New South Wales

FIGURE 3 The Great Barrier Reef was placed on the World Heritage List in 1981.

Peoples living by the Australian coast. It is important that we understand our coastal environments in order to ensure their sustainable management, to maintain marine biodiversity and so that they may be preserved for the many generations to come.

5.2.3 Coasts as natural systems

Coasts are natural systems consisting of landforms (beaches, dunes and cliffs) as well as biotic elements (aquatic and terrestrial plants and animals). Geographers refer to all these things as biophysical elements. Coasts are also said to be in a state of **dynamic equilibrium**, which means they are constantly changing. Examples of small-scale and short-term agents of change are the tides, ocean currents and wave action. Examples of large-scale agents of change (which happen over vast periods of geological time) include continental drift, uplift and sinking of land, movement of sea levels due to ice ages and warm periods, and creation of islands by volcanic activity.

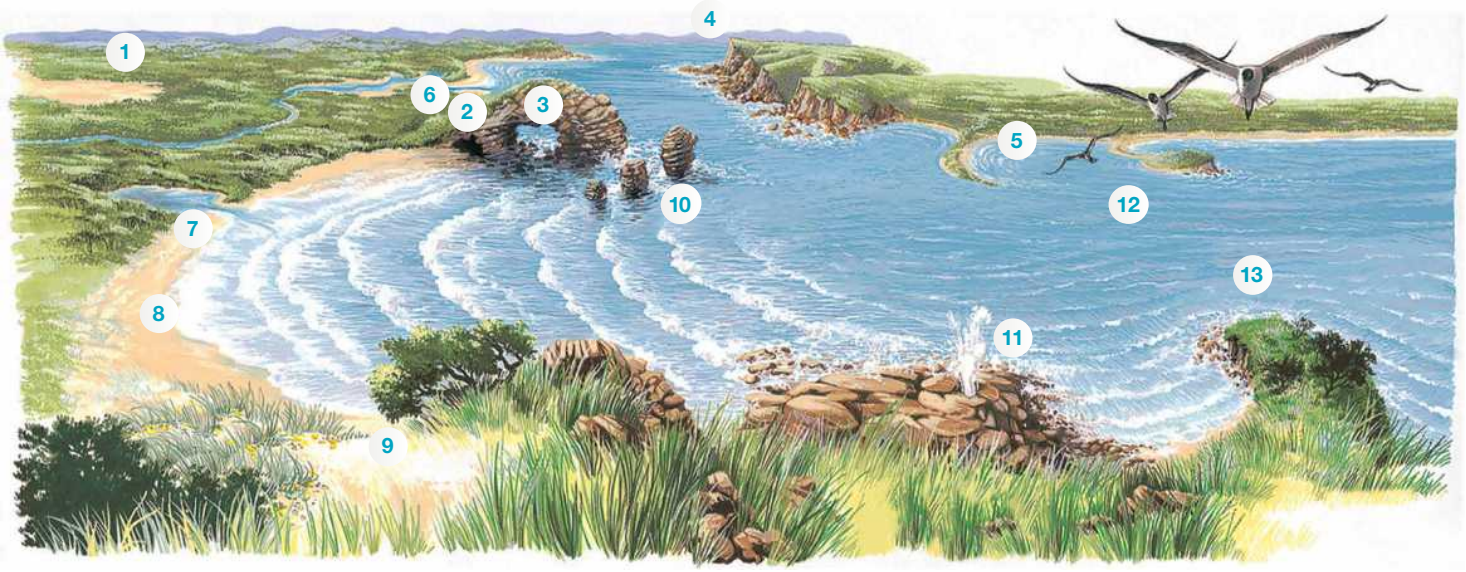
dynamic equilibrium when the input of a coastal system such as winds and waves moving sediments onshore is equal to the output that moves sediments offshore, the system is said to be in a steady state. It is therefore not unstable and it has a dynamic equilibrium.

5.2.4 Coastal landforms

There is a wide range of marine and terrestrial structures found at the coast. Many are familiar to us, such as the landforms of beaches, bays, dunes and cliffs (see **FIGURE 4**). Others such as fiords are unique to polar regions, which were affected by ice ages. Structures found under the sea are not so widely known and can include the continental shelf, canyons and trenches.

int-5594

FIGURE 4 The range of coastal landforms



1. Dune blowouts occur when loose sand is blown from the dune because vegetation has been removed.
2. Waves are refracted (bent) towards a headland and release energy either side of it. Caves will be formed where weak rocks are eroded on each side of a headland.
3. Over time the caves will erode on either side of a headland and join to form an arch.
4. Erosion between low and high tides undercuts rocks and a rock platform develops. This undercut section eventually becomes weak and collapses, creating a cliff.
5. Longshore drift moves sand and other material along a beach. If this drift occurs mainly in one direction, sand may extend along the coastline forming a spit.
6. Estuaries are the parts of a river that are tidal and occur at the sea. They catch mud, sand and nutrients.
7. A lagoon is formed when a sandbar begins to develop, eventually closing an estuary.
8. Beaches are formed when material is brought to the shore by waves. The material can be sand, stones or pebbles.
9. Dunes are formed when sand on a beach is stabilised by vegetation.
10. Further erosion of the rock supporting the arch will cause it to collapse, leaving a stack.
11. If caves develop in places exposed to the sea and waves, water rushes in and can cause pressure to build at the back of the cave. If a section of rock in the roof of the cave is weak, part of the roof may collapse and a blowhole is formed.
12. A spit can sometimes join two land areas. This is called a tombolo.
13. Headlands are formed when coastal rocks are very hard and resist erosion from the waves. Softer rocks either side of the headland are eroded and transported elsewhere.

5.2.5 Ocean processes

Waves and the movement of coastal waters caused by tides, currents, rips, storm surges and tsunamis are ongoing processes that mould the coast, creating and destroying landforms and submarine forms. Tides, which are generated by the gravitational pull of the moon and the sun, cause changes in sea level; this can vary between low and high tide by as much as 10 metres, such as is found in Broome, Western Australia.

Waves are generated by winds out at sea and this creates what is called swell; the larger the fetch area or distance to the coast, the greater the potential height of the wave, particularly in storm conditions. Waves that are generated in storm conditions are called destructive waves, and these lead to increased erosion of coastal forms (see **FIGURE 5**). Waves that are generated in calm conditions are known as constructive waves, and these may build up sediments, giving rise to beaches and dunes (see **FIGURE 6**).

FIGURE 5 Destructive wave

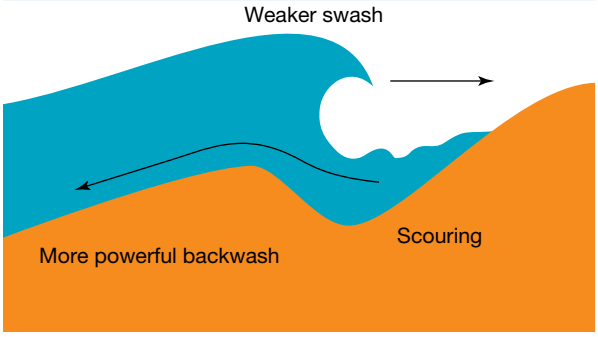
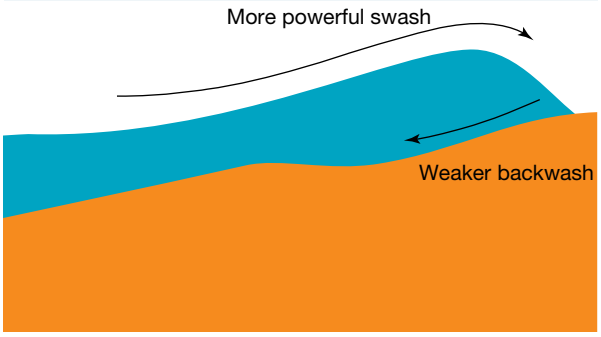


FIGURE 6 Constructive wave



As a wave approaches the coast it translates into a swash, or forward movement, and to a backwash, or return to the sea, after its encounter with the land. Surfers look for the swash element of waves to carry them actively forwards (see **FIGURE 7**). If waves come into the coast at an angle, the swash will move up the beach at that angle but the backwash returns under the action of gravity directly down the beach. This leads to what is called longshore drift (see **FIGURE 8**), which can move large quantities of sand along the coast and lead to spectacular forms such as spits, bars, barriers and tombolos.

FIGURE 7 How a wave breaks

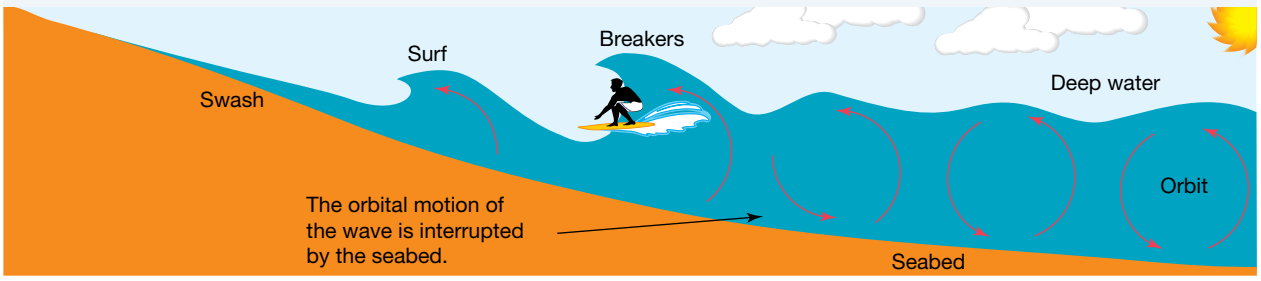


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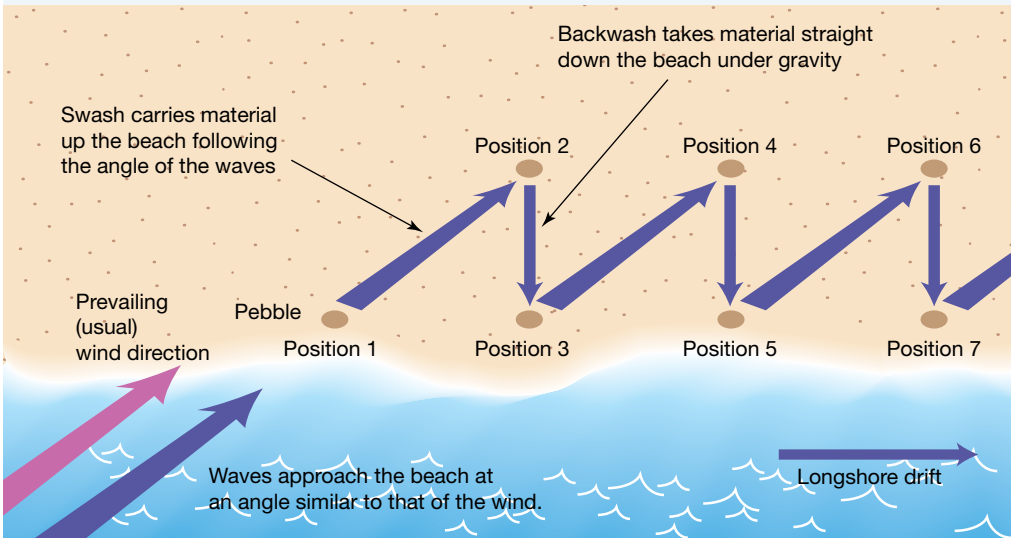
FIGURE 8 Longshore drift



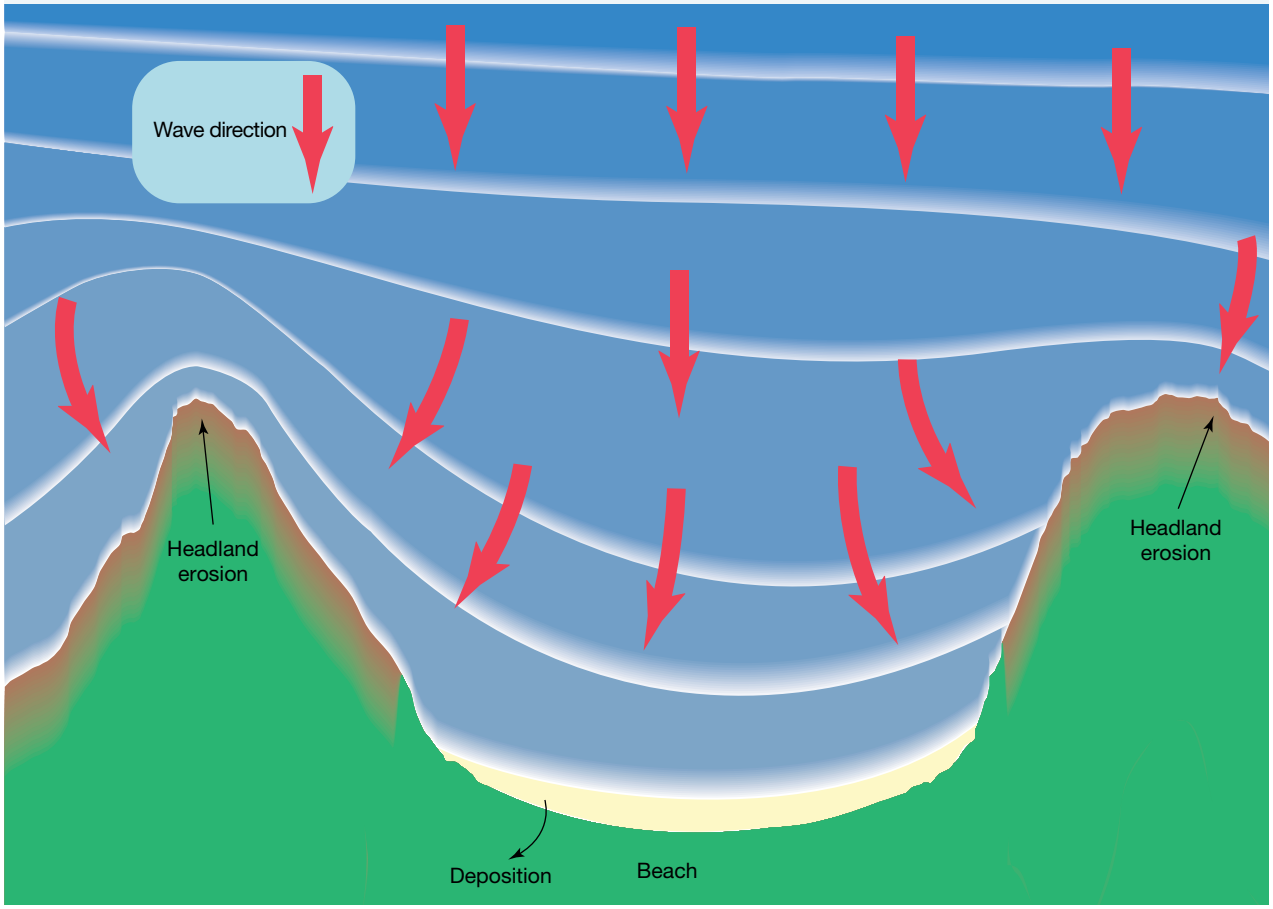
5.2.6 Erosional forms

As noted, erosion through the power of waves is significant in creating coastal landforms. For instance, during storm conditions it has been estimated that the hydraulic action or weight and pressure of water hitting the coast can amount to 10 tonnes per square metre. The mere contact of sea water with coastal rocks can lead to weathering, whereby rocks or loose sediments are either dissolved or abraded or worn away by the action of waves armed with pebbles and sediments. In some cases a section of the coast that is undermined by the sea may collapse; this is referred to as **mass wasting**. Erosional landforms include headlands, bays and bights, cliffs, platforms, caves, arches, blowholes and stacks.

Headlands and bays

Headlands and bays are created by a process of differential erosion. Some parts of the coast may be made up of harder rocks or rocks that have fewer fractures, and these areas form headlands that tend to resist erosion. Bays, on the other hand, are composed of softer or more fractured rocks that are more easily eroded, leading to coastline retreat (see **FIGURE 9**).

FIGURE 9 Wave refraction is the bending of a wave front as it travels at different speeds over water of different depths, leading to convergence on the headland and divergence in the bays.

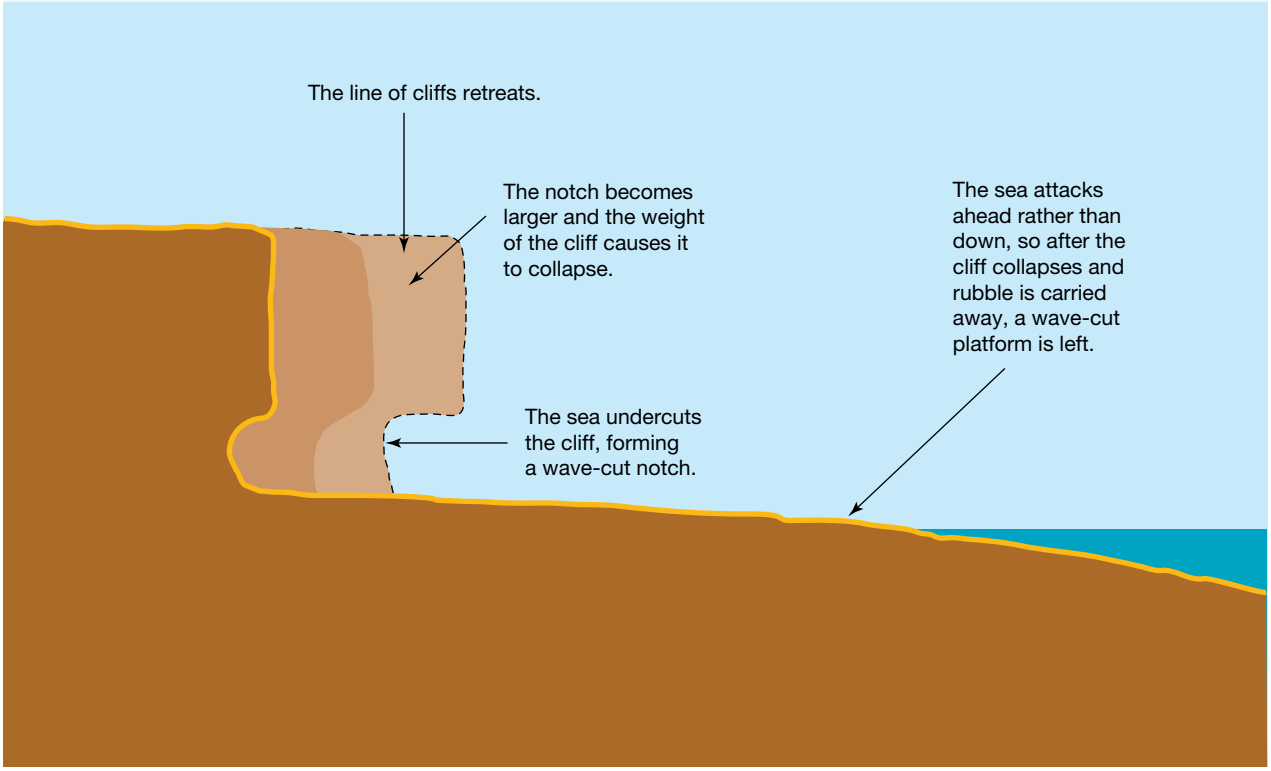


Cliffs and platforms

As waves approach the coast, their erosive powers will have an impact on rock structures. The force of the water acting on any raised rocky structure will create what is called a cliff. A notch, which is a zone where active wave energy is concentrated, will form at the base of the cliff, and this will lead to the cliff collapsing into the sea and the coastline retreating inland. With cliff retreat, as the active wave zone in the ocean waters becomes enlarged, a platform will develop (see **FIGURE 10**).

mass wasting the movement of rock and other debris downslope in bulk, due to a destabilising force such as undermining compounded by the pull of gravity

FIGURE 10 Formation of cliffs and rocky platforms



Caves, arches, blowholes and stacks

Differences in the hardness of rocks and its joints and fractures can be exploited by erosion to create features such as caves, arches (see **FIGURE 11**) 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 of the cave collapses, in-rushing waves may be channelled up this chimney structure, forcing water and air out at the horizontal land surface above (see **FIGURE 12**). Stacks are simply remnants of cliff areas that have resisted erosion and been left stranded out to sea.

FIGURE 11 Tasman Arch, Tasmania

FIGURE 12 Waves are forced upwards through the blowhole at Quobba Point near Carnarvon, Western Australia

5.2.7 Depositional forms

Depositional coastal forms include beaches, sand dunes, bars and barriers, spits, sand islands, tombolos and lagoons. Processes that create these features are generally associated with constructive waves, movement and accumulation of sands due to longshore drift, and wind blowing sandy sediments onshore.

Beaches

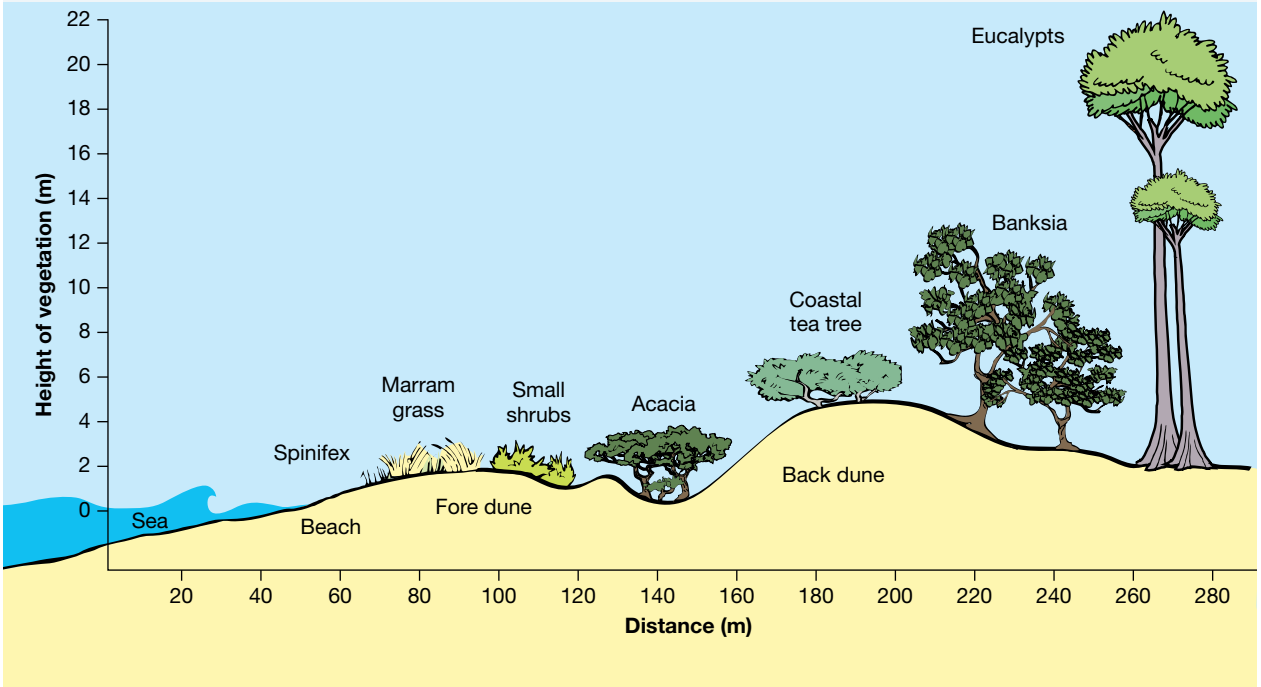
Australia has many beaches, and we are all familiar with their structure. Sediments and sands from which beaches are formed come from materials eroded from cliffs and, more particularly, sediments brought down to the coast by rivers. Waves wash these sediments onto shallow sloping coastal platforms. As beaches are composed of soft materials, they are easily eroded in storms, but generally sands that are taken offshore will return when calmer conditions return and constructive waves can move the sediments back.

Dunes

At the back of the beach and in the zones above high tide, sandy sediments dry out. The wind can then pick these up and move them onshore and inland. Usually a fore dune will form (see **FIGURE 13**) and a depression will be found just inland behind it. If sufficient sand is available, a secondary dune may form, and in some cases dune fields may result with many lines of dunes. The development of dune vegetation that has adapted to survive in harsh conditions is important to stabilise dunes. This vegetation becomes larger and more varied as soil and freshwater conditions on the dune improve inland; this process is known as **coastal dune vegetation succession**. Dunes, due to their sandy structure, are particularly fragile and need to be managed carefully so that pedestrian traffic does not disturb stabilising plant life. Fraser Island in Queensland is composed of sandy sediments and covered with dunes that were built up during the last ice age.

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

FIGURE 13 Transect showing the beach and stable and well-vegetated dunes



Other depositional coastal forms

Spits are sandy extensions of beaches formed by longshore drift currents (see **FIGURE 14**). There is a large spit at the mouth of the Noosa River in Queensland. Bars and barriers are sandy offshore structures that run parallel to the coast, and lagoons or wetlands may form behind them. The Coorong at the mouth of the Murray River in South Australia is an example of these features.

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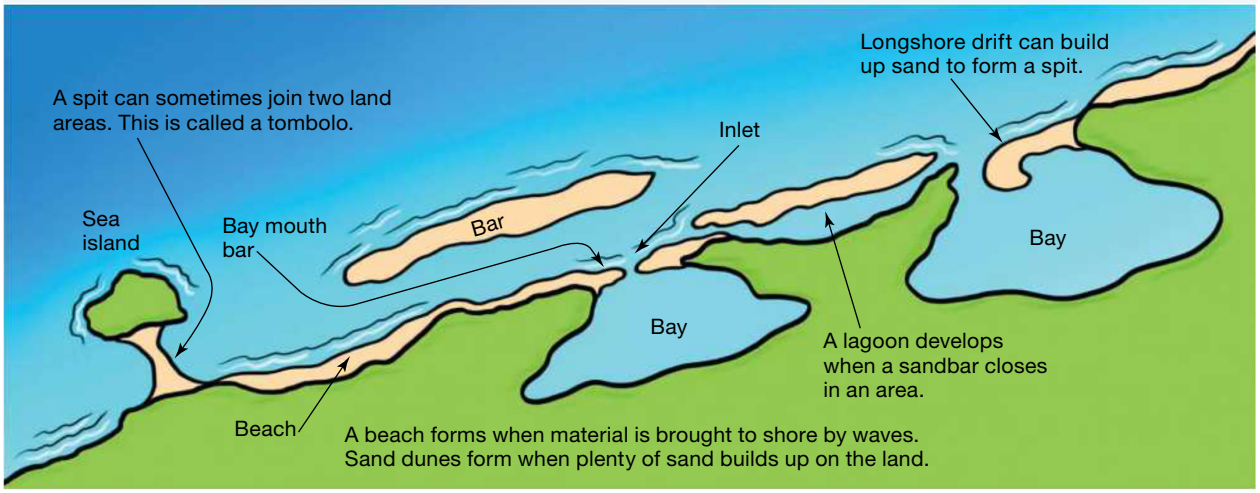
FIGURE 14 Coastal landforms created by transportation and deposition



5.2 SKILL ACTIVITY: Questioning and researching using geographical methods

1. **Investigate** the location of World Heritage sites in the coastal zone. Start by locating a list of sites, then list which are located in the coast.
2. On a world map, label each site.
3. **Comment** on the reason for the significance of each site.

5.2 Exercise

learnon

5.2 Exercise

Learning pathways

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

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Check your understanding

1. Coasts are important to people because:
   - **A.** people like living near them.
   - **B.** they provide food.
   - **C.** they are good for tourism.
   - **D.** All of the above.
2. What are the two main coastal processes that form coastal landforms?
   - **A.** Erosion and deposition
   - **B.** Erosion and waves
   - **C.** Tides and waves
   - **D.** Tides and deposition

3. **Determine** whether the following statements are true or false.
   a. Constructive waves build up sediments and destructive waves cause erosion of coastal forms.
   b. Over 85 per cent of Australians live within 50 kilometres of the coast.
   c. The coastal zone includes only the area of land called the hinterland and does not encompass any area of water.
   d. All forms of human activities can have impacts on coastal landforms and the ecosystems of plant and animal life.
4. Refer to **FIGURE 2**. **Identify** what land use is found at Point Danger. **Consider** how might this might affect the dynamic nature of the coastal zone.
5. Refer to the vegetation transect in **FIGURE 13**.
   a. **Outline** why the vegetation changes as you move inland.
   b. **Identify** what adaptations dune vegetation shows in terms of being adapted to dry, windy coastal environments.
   c. **Describe** what would happen to the vegetation on the back dune if a blowout removed all the vegetation from the fore dune.

Apply your understanding

Communicating

6. **Explain** why environmental, social and economic criteria must be applied to manage a coastal area such as that shown in **FIGURE 2**.
7. **Predict** what might happen to the Great Barrier Reef if it wasn't listed on the World Heritage List.

Questioning and researching using geographical methods

8. Draw and label a sketch of coastal depositional forms such as those shown in **FIGURE 4**. **Identify** what role transportation of materials by longshore drift has had in the development of these features.
9. a. Refer to the photograph of Tasman Arch in **FIGURE 11**. **Predict** what will happen to this coastal feature in the future. **Explain** how this change will occur.
   b. **Explain** what happens over millions of years to eroded material that falls into the sea.
10. Refer to the **FIGURE 9** wave refraction diagram. **Discuss** why headlands are more vulnerable to erosion than bays.

LESSON
5.3 What are the challenges to coastal environments?

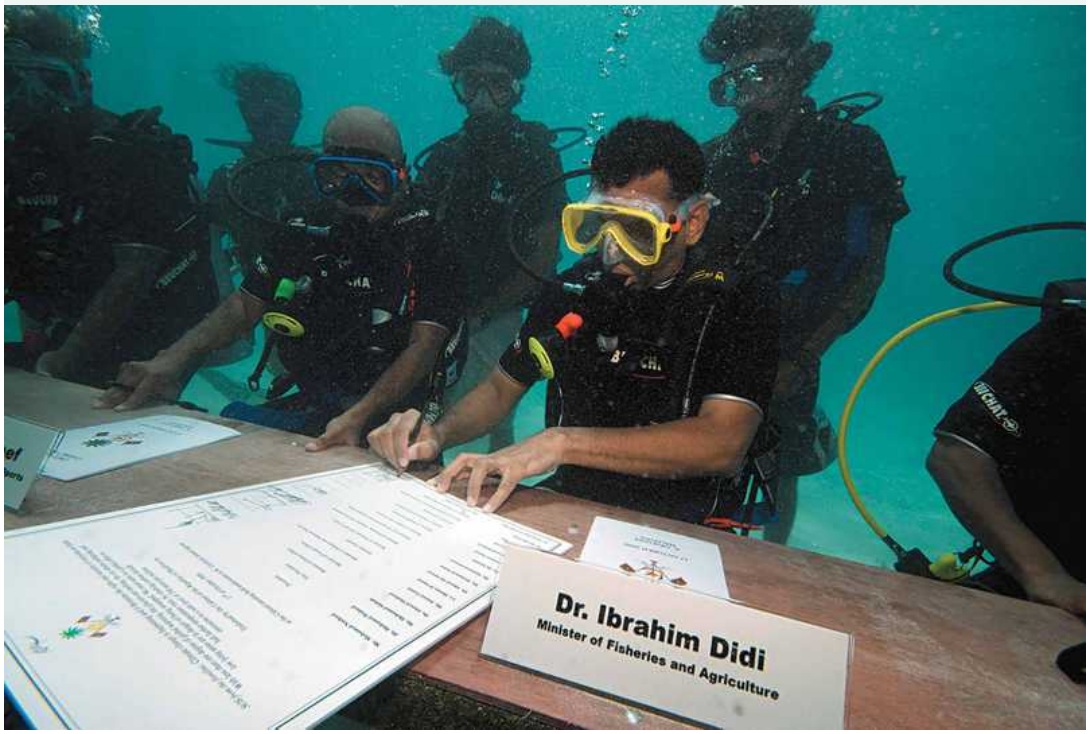
LEARNING INTENTION

By the end of this lesson you should be able to explain the human impacts on coasts, identify the threat posed by rising sea levels due to global warming and evaluate the impact on island nations.

TUNE IN

The many ecosystem services rendered by the coast are under increasing threat. A major one of these is rising sea levels, which may lead to the built environment of coasts being inundated by the sea. In addition, low-lying islands could be completely lost to the sea.

FIGURE 1 To bring attention to issues of global warming, in particular rising sea levels, a meeting was held on the sea floor by government representatives of the Republic of the Maldives.



1. What reasons can you suggest to explain why these government representatives from low-lying islands are signing documents under the sea?
2. Can you think of any management strategies that could help people who live on low-lying islands survive rising sea levels?

5.3.1 Human impacts on coasts

Human activities along the coast can interfere with natural coastal processes, resulting in significant changes to coastal environments. Our day-to-day lives across the globe contribute to global warming and sea-level rise, which in turn also affect our coastlines.

Human impacts on coastlines include the construction of ports, boat marinas and sea walls; changes in land use — for example, from a natural environment to agricultural or urban environments — and the disposal of waste from coastal and other settlements.

World Ocean Review

The 2021 *World Ocean Review* and others dating back to 2015 describe biodiversity as being under attack, as climate-induced changes in the ocean are now affecting marine biological communities at all levels. As a result, many marine creatures are being forced to abandon their traditional territories. Predator–prey relationships are changing, and ocean productivity is falling. The *World Ocean Review* series is published by a not-for-profit company that seeks to raise awareness of issues relating to marine science and sustainable use of our oceans. The 2015 Review suggested that for oceans and coasts to be sustainably managed into the future, new environmental policies must be implemented. The issues identified in the review that need to be addressed include the following.

FIGURE 2 Destruction of mangrove habitats has enormous impacts on biodiversity

Source: *World Ocean Review* 2015.

- **Marine pollution**
  - Toxic substances and heavy metals from industrial plants (liquid effluent and gaseous emissions)
  - Nutrients, in particular phosphate and nitrogen, from agricultural sources and untreated wastewater (eutrophication of coastal waters)
  - Ocean noise pollution from shipping and from growing offshore industry (exploitation of oil and natural gas reserves, construction of wind turbines, future mineral extraction)
- **Growing demand for resources**
  - Exploitation of oil and natural gas reserves in inshore areas and increasingly in deep-sea areas, resulting in smaller or greater amounts of oil being released into the sea
  - Extraction of sand, gravel and rock for construction purposes
  - For the development of new pharmaceuticals: extraction of genetic resources from marine life such as bacteria, sponges and other life forms, the removal of which may result in damage to sea floor habitats
  - Future ocean mining (ore mining at the sea floor), which may damage deep-sea habitats
  - Aquaculture (release of nutrients, pharmaceuticals and pathogens)
- **Overfishing**
  - Industrial-scale fishing and overexploitation of fish stocks; illegal fishing
- **Habitat destruction**
  - Building projects such as port extensions or hotels
  - Clear-felling of mangrove forests
  - Destruction of coral reefs as a result of fishing or tourism
- **Bioinvasion**
  - Inward movement of non-indigenous species as a result of shipping transport or shellfish farming; changes in characteristic habitats
- **Climate change**
  - Ocean warming
  - Sea-level rise
  - Ocean acidification

The focus of the 2017 *World Ocean Review* explores the coastal habitat and the diverse demands on this habitat. It illustrates how the varied ecosystem services of the coasts are under increasing pressure. It outlines measures

necessary in the future to respond effectively to the threats from both climate change and natural disasters. The 2021 Review looks into climate change, food from the sea, marine management and many other topics.

Changing worldviews

Coastal environments have not always been managed sustainably. In the past, decision makers generally had less understanding of the delicately balanced nature of many coastal ecosystems and they had limited anthropocentric worldviews 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 apartment blocks and tourist resorts on sand dunes seemed like a good idea — little thought was given to the fragility of the coastline and the long-term suitability of such development in an environment subject to coastal storm erosion and, in more recent times, rising sea levels.

Over time, people developed a stewardship worldview with an emphasis on sustainable coastal management, including:

- 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 government in managing coastal issues.

For example, in Queensland, the Indigenous Land and Sea Ranger Program assists First Nations Australian organisations to work together on management plans that reflect Traditional Custodian, local community and Queensland Government priorities.

Their conservation services successfully combine traditional knowledge of Country and science using environmental, economic and social criteria. An example is using drones to view areas of inaccessible terrain and map Country to monitor change over time. Rangers are skilled in conservation work and bring experience, inter-generational knowledge sharing and formal conservation qualifications to managing Country.

Activities include a wide range of conservation services including cultural burns, feral animal and pest plant control, soil conservation, cultural heritage site protection and biodiversity monitoring.

5.3.2 The threat of global warming

Perhaps the greatest threat to coasts today is rising sea levels. It is recognised that global warming is a result of the **enhanced greenhouse effect**, which is a human-induced phenomenon that is leading to the melting of polar ice caps and glaciers. Some of the changes to coastal environments that will result due to global warming include:

- increased intensity and frequency of storm surges and coastal flooding
- increased salinity of rivers and groundwaters 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.

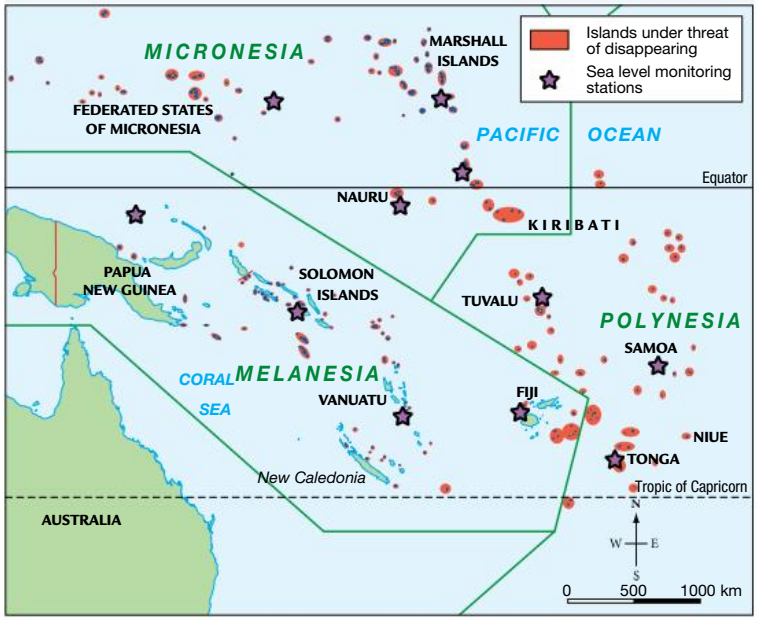
5.3.3 Our disappearing islands

As a result of climate change, it is currently anticipated that many low-lying islands will be flooded by the sea. 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. At current rates, many island groups in the Pacific and Indian oceans will be almost completely inundated by 2050.

enhanced greenhouse effect increasing concentrations of greenhouse gases in the Earth's atmosphere, contributing to global warming and climate change

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 3** and **TABLE 1**).

FIGURE 3 Low-lying islands in the Pacific under threat of disappearing due to climate change



Source: MAPgraphics Pty Ltd, Brisbane.

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 (masl*)
Kiribati	717	3 550 000	116 398	4280	80
Marshall Islands	181	2 131 000	53 127	5590	10
Tuvalu	26	900 000	11 192	5780	5
Australia	7 690 000	7 690 000	25 464 116	47 160	2229

*Metres above sea level.

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.

5.3.4 Rising sea levels in the Pacific

Many of the Pacific Islands are small and can in some cases be described as **atolls**. Their national boundaries, which include the waters and economic zones they control, extend over vast distances, but their land area is limited. Islands such as 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.

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. Although rainfall can be plentiful, not much water can be retained, due

atoll a coral island that encircles a lagoon

to sandy soils and low altitudes; streams are few and groundwater is scarce. Hence, any incursion by sea water can be devastating for agricultural produce (see **FIGURE 4**), the urban environment and tourism, which has more recently become a money earner for these islands.

Apart from the predicted rise in sea levels due to global warming, a secondary impact on the life of Pacific Islanders will be increases in the temperature of the sea, which will affect coral reefs and fish stocks that live in that environment. As is occurring on 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 4 Poulaka crops killed by salt water due to rising sea levels

What can be done?

If food crops are destroyed by rising sea levels, **storm surges** and saltwater pollution, the Pacific Islander Peoples 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. Clearly, this is an outcome that no-one wants to see. The task falls to the global community to instigate change to combat this impending humanitarian and ecological disaster.

The Pacific Islander Peoples are strong advocates for the policies of the **Kyoto Protocol** and the subsequent **Paris Agreement** on climate change. Under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC), these agreements have established 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. One hundred and eighty-nine countries have **ratified** the Paris Agreement, which came into effect in November 2016. Signatories have agreed to ambitious targets for the reduction of greenhouse gas emissions, with an aim of keeping global temperature rise below 2 °C, and attempting to limit it further still, to just 1.5 °C. All parties are required to report regularly on their progress towards emissions targets. It is hoped that through these measures, the low-lying Pacific Islands can be saved.

The leaders of the Pacific nations have spoken at the United Nations and many international climate change forums to raise awareness of their perilous situation and vulnerability to rising sea levels. They have also approached nations such as Australia and New Zealand to discuss the establishment of a future migration policy if global efforts to stem sea-level rise do not succeed.

storm surge a temporary increase in sea level from storm activity

Kyoto Protocol an internationally agreed set of rules developed by the United Nations aimed at reducing climate change through the stabilisation of greenhouse gas emissions into the atmosphere

Paris Agreement United Nations Framework Convention on Climate Change (UNFCCC) agreement outlining steps to reduce greenhouse gas emissions and tackle global warming

ratify to formally consent to and agree to be bound by a treaty, contract or agreement

DISCUSS

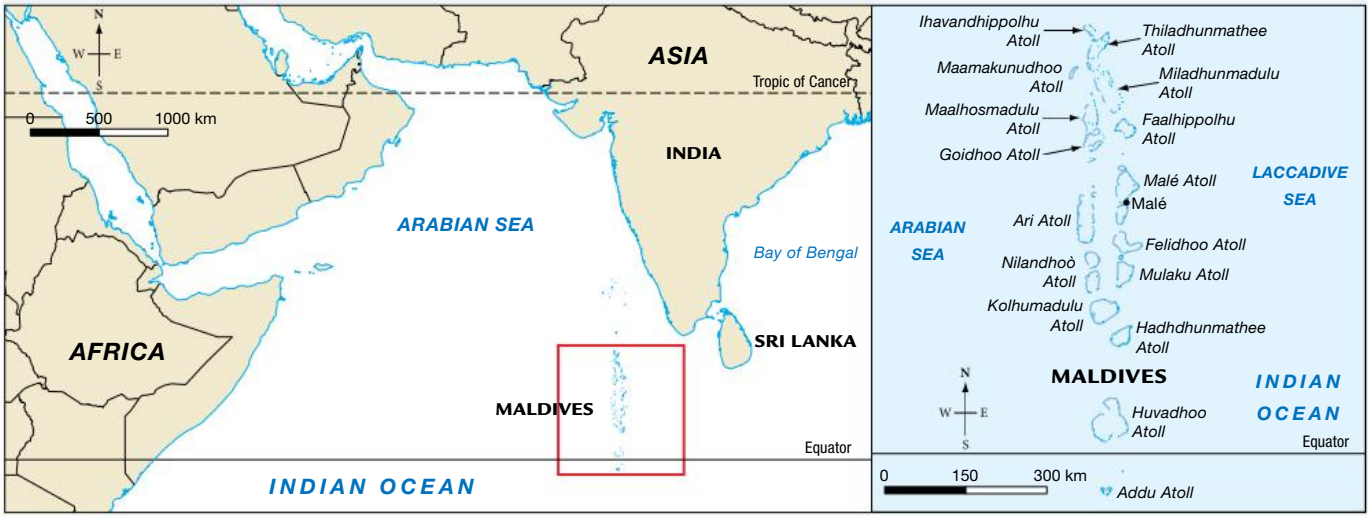
In small groups, consider the following statement.

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.

5.3.5 Rising sea levels in the Maldives

The Maldive Islands are located in the Indian Ocean, to the south-west of India (see **FIGURE 5**). There are about 1200 coral islands, grouped into 26 atolls. The average elevation across the islands is around 1.5 metres 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.

FIGURE 5 Location of the Maldive Islands



Source: Map by Spatial Vision.

The Boxing Day tsunami of 2004 showed how vulnerable the Maldives are, when the wave swept across many low-lying islands, causing widespread destruction of their fruit plantations. Eighty-two people died, while at least another 26 were reported missing, presumed dead. The number of deaths could undoubtedly have been much higher if not for the fact that most of the population lives in Malé, which is protected by a huge sea wall (see **FIGURE 6**).

FIGURE 6 Malé, the capital of the Maldives, occupies an entire island of its own.

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 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 country's **gross domestic product (GDP)**.

The impact of climate change

The long-term threat to the Maldives, however, as with the Pacific Island nations, is posed by global warming and the associated rise in sea levels. In 2013, the United Nations Intergovernmental Panel on Climate Change (IPCC) predicted that by 2100 sea levels would rise by up to one metre. A further study in 2019 by leading ice scientists suggested that the rise could actually be as high as 2 metres. Even using the more conservative estimate, many areas of the Maldives face significant threat. In the worst case, almost the entire nation of the Maldives would be effectively submerged. The latest Report, named 'Climate Change 2022: Impacts, Adaptation and Vulnerability', assesses the impacts of climate change by looking at ecosystems, biodiversity and human communities at global and regional levels. Many recommendations are presented to manage the impacts of climate change on all elements of the biophysical environment.

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 long-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 and subsequent Paris Agreement, which the government ratified on the same day as signing.

Unless the international community agrees to an environmental worldview that incorporates changes to make large cuts in emissions, the problems facing the Islanders will worsen. Thousands will be forced to seek refuge in other countries. Without global action, eventually the Islanders will lose their country.

FIGURE 7 Sandbags protecting a home on the Maldives island Medu Fushi, damaged by the 2004 tsunami

5.3.6 Tiwi Islands coastal management challenges

The Tiwi Islands are located approximately 80 kilometres north of Darwin in the Arafura Sea (see **FIGURE 8**). They consist of two large, inhabited islands, Melville and Bathurst, and numerous smaller uninhabited islands.

There has been an unbroken history of occupation, ownership and environmental management of the Tiwi Islands by Tiwi people, and the population of just over 3000 is more than 90 per cent Tiwi.

The Tiwi Islands have a distinct biodiversity environment, supporting a very high diversity of plant and animal species including many not recorded anywhere else in the world. The islands have healthy populations of small mammal species that have undergone recent dramatic declines on the Australian mainland.

gross domestic product (GDP) the value of all the goods and services produced within a country in a given period, usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

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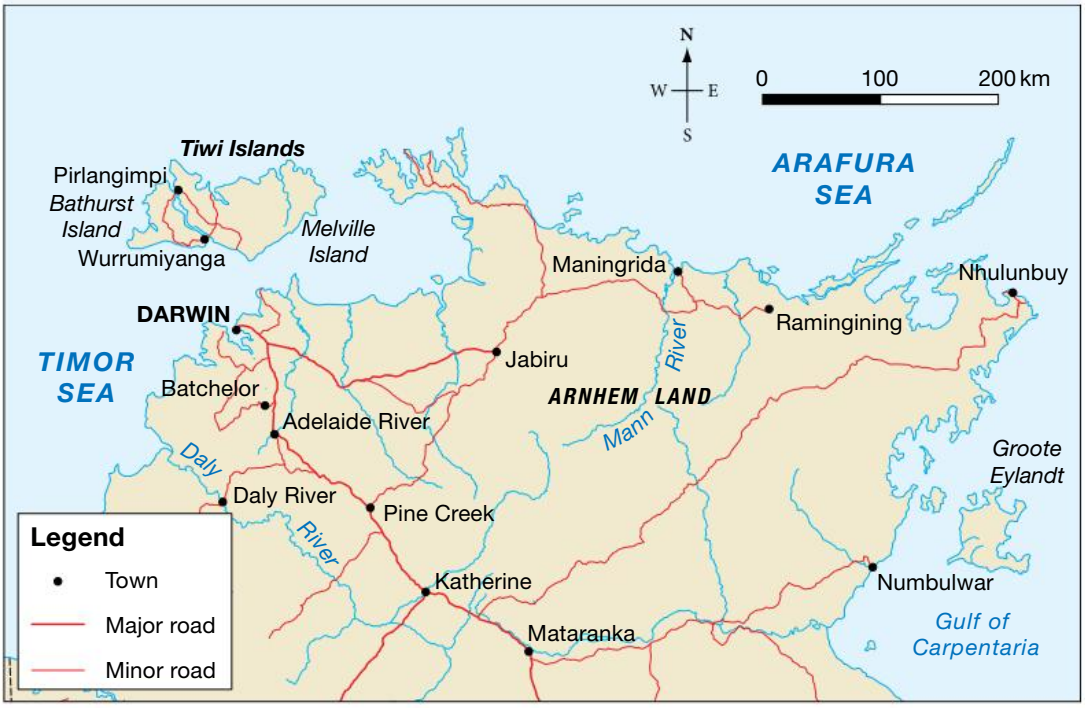
FIGURE 8 The Tiwi Islands off the coast of Darwin



Source: Map drawn by Spatial Vision.

Traditional environmental management, which focused on cultural values through custodial responsibilities for Country, is now changing, and Tiwi people seek to develop a range of mechanisms for enhancing the productive use of at least some of their lands.

Tiwi Marine Ranger Program

The coastal area holds strong cultural significance to Tiwi people and historically has been a major focus of activity and contact. Most of the significant sites identified in Tiwi history are located on the coast, including residential, hunting and ceremonial campsites. Mangrove and estuarine areas are particularly important for traditional food resources.

The Tiwi Marine Ranger Program commenced in 2001 and was the first Indigenous Marine Ranger Program in the Northern Territory. It focused on cultural knowledge and practices in the management of Country and environments. The program was developed in response to traditional owners wanting a more active role in sea country management. There were concerns about illegal fishing, the arrival of foreign vessels, and management of the internationally significant nesting sites for sea turtles, seabird rookeries and shorebird populations on the islands.

FIGURE 9 Several sea turtle species nest on the beaches of the Tiwi Islands.

Marine Ranger activities include coastal surveillance patrols, marine debris surveys, monitoring of sea turtle nesting (see **FIGURE 9**) and Crested Tern rookeries, visitor site management and raising community awareness about marine debris. The rangers provide input on coastal and marine

management issues that reflect traditional owner, local community and government priorities to protect the high natural and cultural values of the region.

Their conservation services successfully combine knowledge of Country and science. The rangers' skills and experience reflect both formal conservation training and the sharing of inter-generational knowledge.

Climate change

Climate change is another significant coastal management concern for Tiwi leaders, with sea levels in northern Australia rising from between 7 and 11 mm annually over the past 20 years.

Tiwi Islanders have a long history of strong ties to ancestral lands, habitats and wildlife, and Tiwi livelihoods are highly dependent on natural resources. Climate change is likely to change the resources available to support Tiwi people. Rising temperatures will affect the seasonal availability of bush tucker, as plant flowering and fruiting times change. Rising sea levels and more big storms will cause many coastal freshwater places to become saltier in the future. For communities living close by the sea, even moderate sea-level rises may mean people will have to move to higher ground.

Tiwi people have strong cultural and subsistence links to sea turtles. Sea turtles are predicted to be severely threatened by rapid climate change. Rising sea levels may affect their return to nesting sites, and increased nest temperatures and moisture from rising sea levels may affect the sex and development of hatchlings. This raises the question about the future of the islands with the threat of climate change impacting on lifestyle and management of Country.

5.3.7 The interconnection of coast and inland waters

Bangladesh's Sundarbans

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.

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. At current rates, the IPCC predicts rising sea levels will overtake 17 per cent of Bangladesh by 2050, displacing at least 20 million people.

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 and the biodiversity within. 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 and creates a **biodiversity hotspot**.

alluvial plain an area where rich sediments are deposited by flooding

deltaic plain flat area where a river(s) empties into a basin

biodiversity hotspot a biodiversity region with significant levels of biodiversity that is threatened by human habitation

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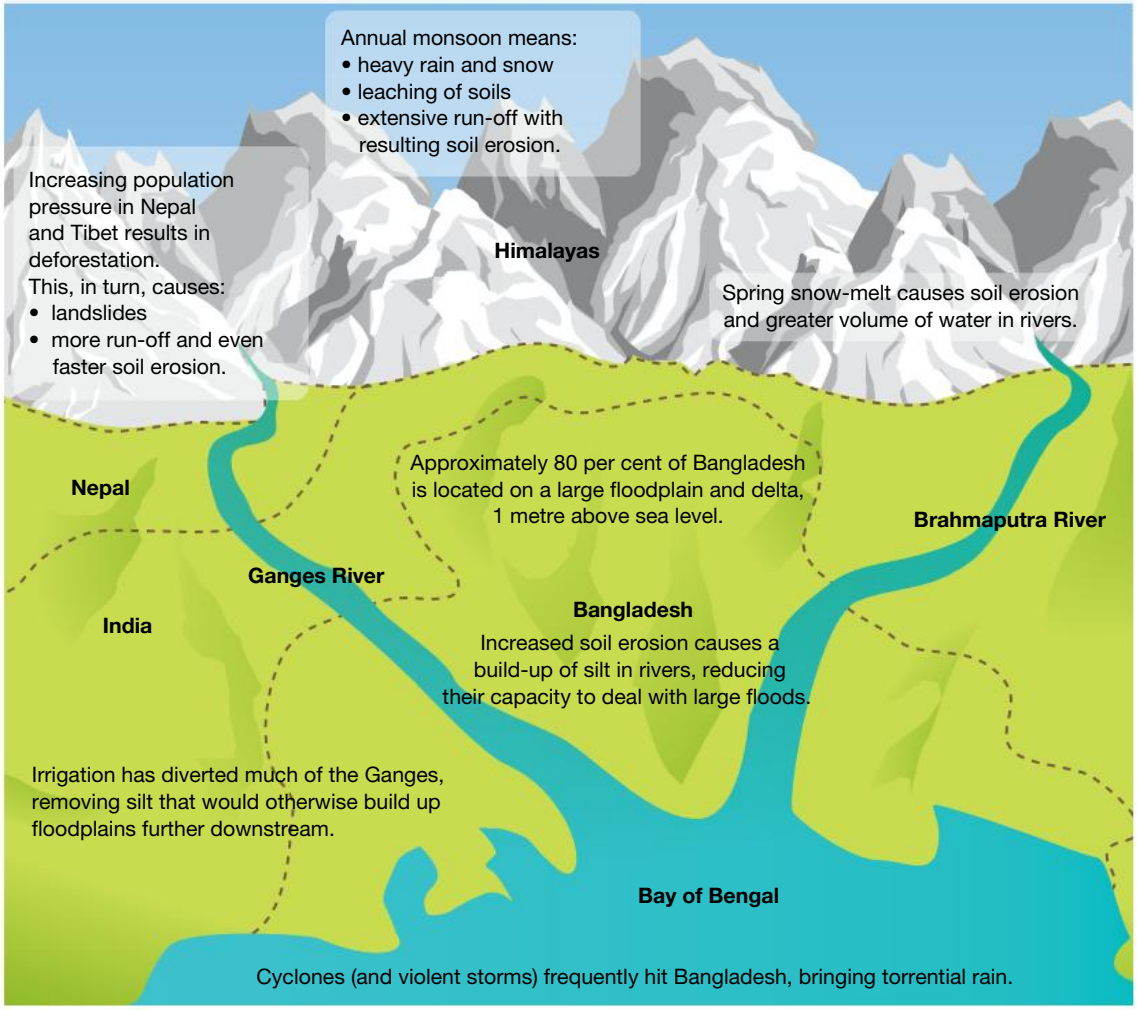
FIGURE 10 Flooding in Bangladesh — some causes



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 unseasonal snow-melt, flooding would occur on a scale never before seen, especially with the event of tropical cyclones. Land would be lost and people displaced. Many islands fringing the Bay of Bengal are already under water, producing 'climate refugees' — people who have to seek refuge, fleeing their uninhabitable lands.

In addition to rising sea levels and shifting weather patterns, the enhanced greenhouse effect is also predicted to increase the intensity of cyclones and storms. For low-lying countries that are already flood-prone, such storms can be devastating. One of the deadliest cyclones on record hit Bangladesh in 1991, killing almost 140 000 people and making around 10 million homeless. The cyclone made landfall in the south-eastern part of Bangladesh with wind speeds between 240 and 250 km/h. The resulting six-metre storm surge flooded the coastline, contaminating water supplies and destroying farming land and stock. Again in 2020, a third of Bangladesh was under water after some of the heaviest rains in a decade.

Bangladesh has regularly experienced severe flooding in recent years. In 1988, 1998 and 2004, flood waters inundated between two-thirds and three-quarters of the country. While the height of the floods was lower in 1999, parts of the country were underwater for over 60 days. In 2017, flooding in some areas of the country lasted from April until August.

Because of these risks, Bangladesh needs to plan and implement management strategies based on an understanding 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 new standards relating to vehicle emissions have been set. A proposed economic solution is ecotourism, as it attracts foreign currency while preserving the natural ecosystems and promoting sustainable development and responsible management of its vital environmental resources. This reflects a stewardship worldview.

FIGURE 11 Village houses are seen surrounded by the floodwater in Savar near Dhaka, Bangladesh, on 7 August 2020

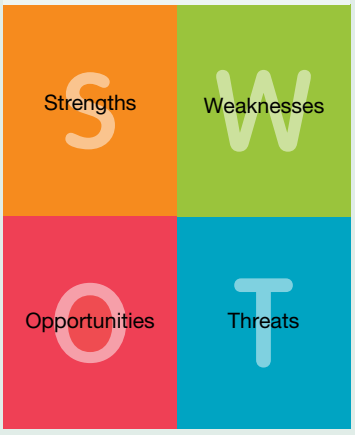
DISCUSS

To what extent do you think economic goals and objectives are important with respect to environmental goals (such as societal change and reducing greenhouse gas emissions)? What policy direction would you push if you were in a position of influence in government?

5.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. In groups, **discuss** the following statements concerning the impacts of climate change in the Pacific and Indian oceans using environmental, economic and social criteria.
2. Alternatively, you may wish to use a SWOT analysis to help **evaluate** each statement.
   - Australia and New Zealand should be prepared to resettle the 100 000 people of the islands of Kiribati if sea level rises create a 'climate refugee' problem.
   - 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 12 SWOT analysis



on Resources

Google Earth The Sundarbans

5.3 Exercise

learnon

5.3 Exercise

Learning pathways

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

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Check your understanding

1. Which of the following is not an impact that people have on coastal areas?
   - A. Growing demand for resources and habitat destruction
   - B. Marine pollution and bioinvasion
   - C. Aquaculture and creating marine reserves
   - D. Overfishing and climate change
2. **Determine** whether the following statements are true or false.
   - a. Many islands in the Pacific and Indian oceans are under threat from rising sea levels due to global warming.
   - b. The two reasons for mangroves being cleared in the Sundarbans are for firewood and fish ponds.
   - c. Predator–prey relationships in the ocean are not affected by climate-induced changes.
3. **Select** one of the impacts of rising sea levels on coasts identified in this lesson and **explain** why this would be a problem for a selected coastal settlement in Australia.
4. Governments and Pacific Islander Peoples can do a few things to solve the problems they will face due to climate change.
   Identify the correct option to classify each action as '*short-term*' or '*long-term*' solutions, or '*both*'.
   - a. Move to nearby islands that are part of their nation. _____
   - b. Advocate for policies to reduce greenhouse gas emissions that are causing climate change. _____
   - c. Build barriers against the rising sea. _____
   - d. Migrate to other countries (this will require residency visas). _____
   - e. Move inland. _____
5. **Identify** the effects you think climate change might have on the Tiwi Islands' high diversity of plant and animal species.

Apply your understanding

Concluding and decision-making

6. Refer to **FIGURE 10**. **Explain** how the geography of Bangladesh makes it so vulnerable to the threat posed by climate change.
7. **Consider** how ecotourism can play a role in preserving Bangladesh's ecosystems.

Interpreting and analysing geographical data and information

8. **Identify** other parts of the world you think might also be threatened if sea levels were to rise by about 1 metre over the next 100 years. **Justify** your views.
9. Refer to **FIGURE 10**.
   - a. **Discuss** how cyclones can contribute to flooding in Bangladesh.
   - b. **State** 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 **outline** the consequences of flooding for each category.

Communicating

10. **Discuss** what value the Tiwi Marine Ranger Program brings to the Tiwi Islands.

LESSON
5.4 How do we manage coastal change?

LEARNING INTENTION

By the end of this lesson you should be able to explain the range of coastal management solutions available to deal with the impacts of erosion and rising sea levels, and analyse a case study of Australian coastal developments.

TUNE IN

Waves generated by storm conditions contain great amounts of energy that can be very destructive to any built environment along the coast.

FIGURE 1 Storm waves hit the coastline of Cornwall, UK

Refer to **FIGURE 1**.

1. Describe what will happen to the landscape, in particular the beach and the housing, if storm waves of this size regularly impact on the coastline.
2. What built structures along this coastline could help in the management of storm conditions as seen in the image?

5.4.1 Changing coastlines

Coastal areas are not static or fixed places, and as such they are subject to two main agents of change. These can be defined as natural environmental processes and human-induced processes. In terms of natural environmental processes, where deposition processes dominate, coasts have been growing. However, where erosion processes dominate, coastal land is lost to the sea. Wherever people have imposed their structures, in the form of housing, harbour works and the like on coasts, there is a need to manage or at least moderate the processes of coastal change in a sustainable manner (see **FIGURE 1**).

In 2020, 41 per cent of the world's population, or some 3 billion people, lived within 100 kilometres of the coast. Most of the world's megacities are located on the coast. According to predictions made by the *World Ocean Review,* at least 1 billion people who live in low-lying coastal areas could experience inundation and/or erosion of their lands into the future. This change to coasts is seen as stemming essentially from climate change. As a largely human-induced event it is leading to rising seas, associated flooding in major delta regions, and more frequent severe storm events, such as hurricanes (see **FIGURE 2**). A consequence will be an increase in people who will have to relocate due to coastal changes (see lesson 5.3).

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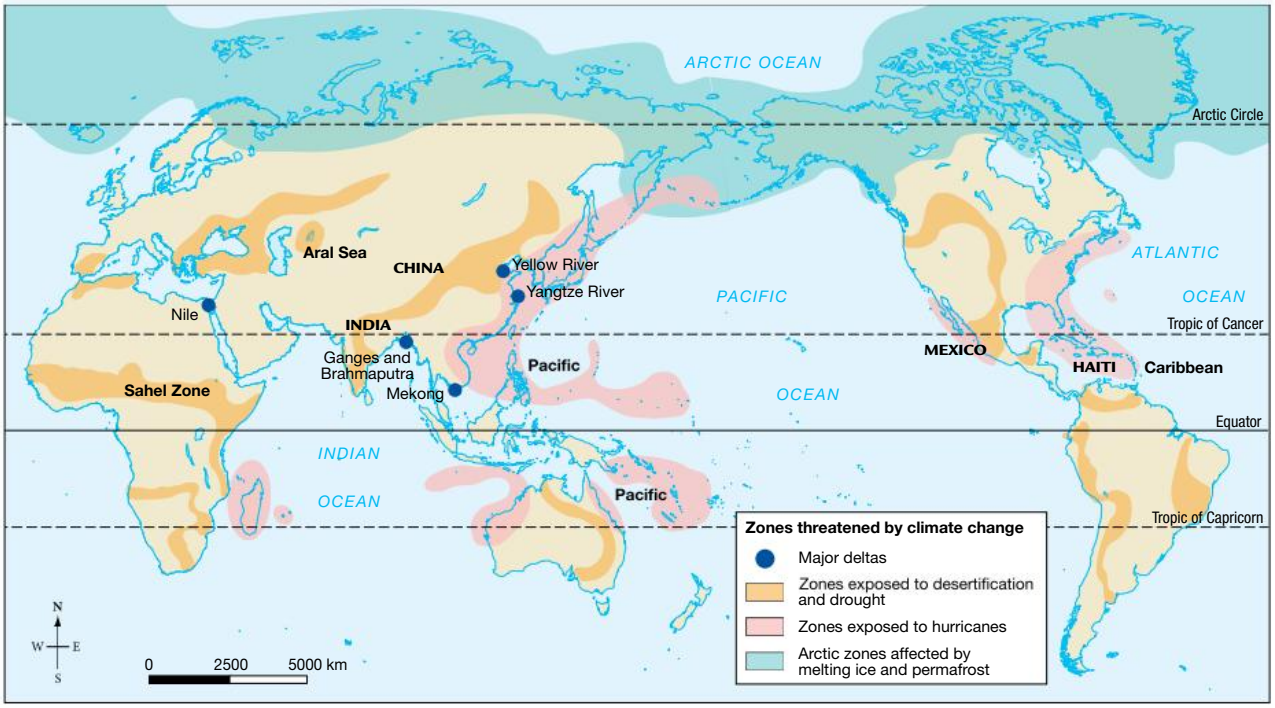
FIGURE 2 Zones across the world subject to threats associated with climate change



Source: UNEP (United Nations Environment Programme).

5.4.2 Protecting the coast

The protection of the coast through management programs is a costly business that aims to overcome problems associated with land loss, waterlogging and incursions of **groundwater salinity**.

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 3**).

FIGURE 3 Floating settlements anchored to the embankments along the waterfront at Maasbommel, the Netherlands

5.4.3 Coastal management in Australia

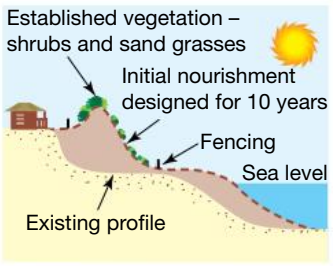
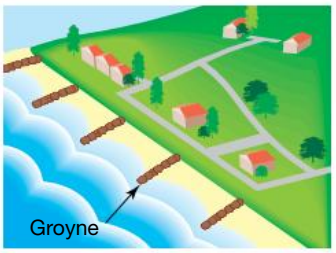
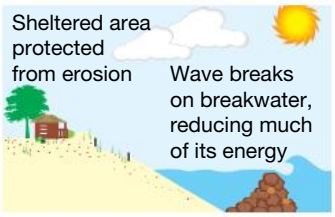
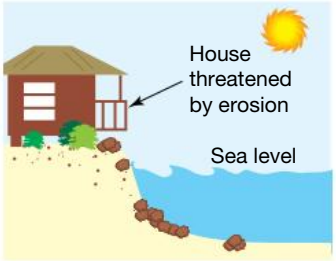
If coastlines are to be protected, a wide range of strategies must be employed to combat changes to the coastline and, in particular, flooding of low-lying areas and increased erosion of beaches and bluffs. The techniques shown in **TABLE 1** are used in Australia.

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 settlements anchored buildings that float on water and are able to move up and down with the tides

TABLE 1 Possible management solutions to reduce the impacts of rising sea levels and erosion

Solution	Description	Diagram	Advantages	Disadvantages
Beach nourishment	The artificial placement of sand on a beach, which is then spread along the beach by natural processes		Uses sand that best matches the natural beach material. There is 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; 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. Are a 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. Is a visual eyesore. Will need a sand nourishment program as well. Has a high initial cost. Involves 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.
Property purchase	The purchase of buildings and removal of 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. May cause possible social problems for residents who must move. Exposes the back dune area, which will need protection. Cost would be extremely high. Does not solve sand loss.

5.4.4 CASE STUDY: Shifting sands 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 the dynamic equilibrium of these natural processes, often creating long-term problems. One such example is the Gold Coast in Queensland where a human-centred — that is, a technical 'we can fix it' — viewpoint was taken.

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 4**) 400 metres out to sea, to keep the mouth open.

These, however, effectively interrupted the longshore drift current (see lesson 5.2), which moves sand along the coast.

training walls a pair of rock walls built at a river's mouth to force the water into a deeper and more stable channel. The walls improve navigation and reduce sand blockages.

FIGURE 4 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 5**).

The sand destined for the beach was effectively trapped at the southern end of the training wall, where it built out the Letitia Spit by 250 metres (see **FIGURE 6**).

FIGURE 5 The effect of storm waves on Duranbah Beach

How was the problem solved?

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 6**). It pumped sand from the build-up on the southern end of the training walls and piped it north to the eroded beaches. 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 6 Sand bypass system

Source: Spatial Vision.

Coastal protection works such as groynes, sea walls and training walls are usually built to protect human-built 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.

on Resources

Interactivity Pumping sand (int-3295)

SkillBuilders to support skill development

- 1.13 Evaluating alternative responses

5.4 SKILL ACTIVITY: Concluding and decision-making

1. In the US state of North Carolina, it is now illegal to build coastal structures to protect houses 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. i. **Determine** whether this approach is fair to those whose houses are threatened by storms and rising sea-levels.
      ii. **Outline** why or why not.
   b. **Contrast** 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. **Analyse** if it is equitable for all people who use the coast.
2. Write a page **outlining** and **explaining** your views.

5.4 Exercise

learnon

5.4 Exercise

Learning pathways

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

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Check your understanding

1. Determine whether the following statements are true or false.
   a. Training walls at a river mouth serve the purpose of keeping the mouth open.
   b. The Netherlands spends money on coastal protection in order to hold back the sea.
2. The various ways that sand can be moved naturally in a coastal region are:
   A. by waves.
   B. by current action.
   C. by wind.
   D. All of the above.
3. Refer to **FIGURE 2**. **Describe** the particular climate change-related threats faced by various nations and regions of the world.
4. Study **FIGURE 4**. **Identify** what effect these training walls have had on preventing a sand build-up in the Tweed River mouth.
5. **Examine FIGURE 6**. **Identify** the direction of the longshore drift in this region.

Apply your understanding

Communicating

6. **Explain** how a coastal defence system such as a dyke works.
7. **Consider** what impact rising sea levels and erosion could have on future food security.
8. **Consider** what the impact of rising sea levels and coastal erosion might be on the tourist industries of the Gold Coast. **Identify** what strategies of coastal protection mentioned in this topic could help solve the problems, and how they might work.

Concluding and decision-making

9. **Evaluate** the strengths and weaknesses of two of the management strategies shown in **TABLE 1**.
   a. Which strategy would have the least environmental impact?
   b. Which strategy would have the greatest economic impact or be the most costly to maintain?
   c. Which strategies could improve social amenities such as tourism and recreation in coastal areas? **Justify** your answer.
10. **Refer** to **FIGURES 4** and **6**. **Propose** what changes you would expect to see along this section of coast if the training walls on the Tweed River were removed.

LESSON
5.5 Investigating topographic maps: Consequences of coastal change in Merimbula

LEARNING INTENTION

By the end of this lesson you should be able to use a map and aerial photograph to investigate coastal change.

5.5.1 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. Tensions between conflicting perspectives by conservationists, who wish to preserve the natural environment, and developers, who wish to develop housing estates for economic benefit, need to be managed applying worldviews.

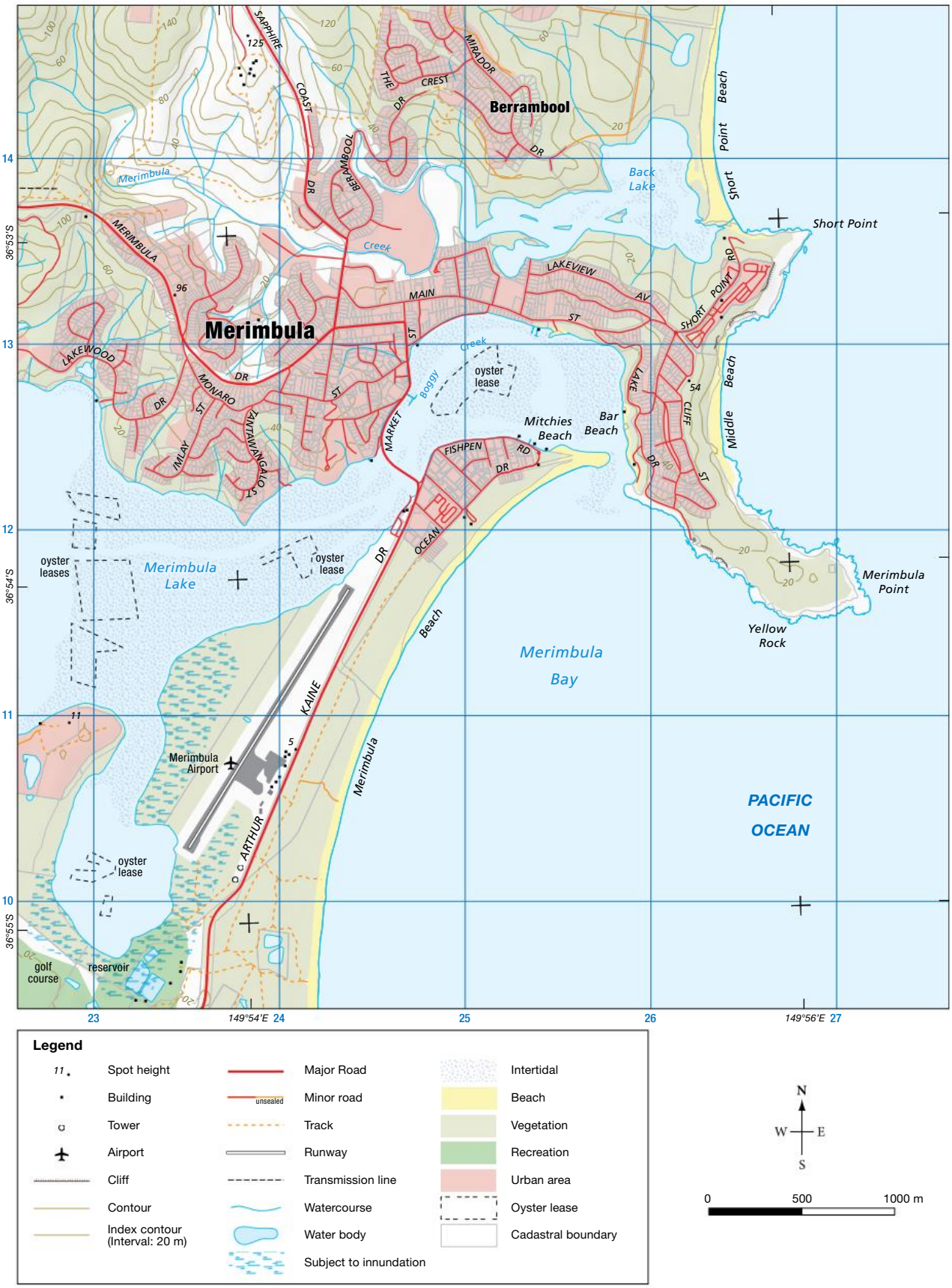
The natural landform features along this coastline include a series of headlands separated by bay head beaches. Merimbula Lake has formed from a slow and gradual build up of a sand barrier, leaving only a narrow channel for salt water to enter and fresh water to exit (see **FIGURE 1**). The shallow and sheltered waters of the lake provide an ideal environment for oyster farming and recreation.

FIGURE 1 Aerial view over Merimbula Lake

on Resources

eWorkbook	Investigating topographic maps — Consequences of coastal change in Merimbula (ewbk-10205)
Digital document	Topographic map of Merimbula (doc-36370)
Video eLesson	Investigating topographic maps — Consequences of coastal change in Merimbula (eles-5270)
Interactivity	Investigating topographic maps — Consequences of coastal change in Merimbula (int-8688)
Google Earth	Merimbula (gogl-0075)

FIGURE 2 Topographic map extract of Merimbula



Source: Data based on Spatial Services 2019.

5.5 Exercise

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5.5 Exercise

Learning pathways

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

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Check your understanding

1. **Describe** why Merimbula is a popular tourist location.
2. **Identify** the main pressure on the coastal system of Merimbula.
3. **Analyse** if poor management has resulted in the destruction of the Merimbula coastline.
4. a. **Identify** and provide the grid references for three natural landforms that feature along the Merimbula coastline.
   b. **Identify** what is located at the following grid references.
      i. GR574146
      ii. GR604127
      iii. GR615118

Apply your understanding

Communicating

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 Lake to be fresh or salty? Use evidence from the map.

LESSON
5.6 INQUIRY: Threats to the Great Barrier Reef

LEARNING INTENTION

By the end of this lesson you should be able to interpret and analyse information about why the Great Barrier Reef is under threat and communicate this in a speech

Background

In this inquiry you will **investigate** why the Great Barrier Reef is under threat. You can start with the images supplied in **FIGURE 1** and should find further images to support your findings.

FIGURE 1 The Great Barrier Reef

Before you begin

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

Inquiry questions

These example inquiry questions can be used or adapted to focus the development of your geographical knowledge, understandings and skills.

- How can the spatial variation between places and changes in environments be explained?
- What management options exist for sustaining human and natural systems into the future?
- How do worldviews influence decisions on how to manage environmental and social change?

Inquiry steps

Step 1: Questioning and researching using geographical methods

Discuss the following with members of your class:

- What do you know about the Great Barrier Reef?
- How has human activity affected the Great Barrier Reef and what can be done to sustainably manage the reef?

a. **Write down your inquiry question**

b. **Investigate your inquiry question**

- **Conduct research** into the current issues surrounding the Great Barrier Reef.
- Provide relevant data in table or graph form associated with reef death.
- Provide annotated images and maps to illustrate different aspects of the reef.

Step 2: Interpreting and analysing geographical data and information

- **Create** a table which **summarises** social, economic and environmental impacts of human activity on the reef.
- Give details and explain what actual damage has occurred to the reef.

Step 3: Concluding and decision-making

- **Conclude** your inquiry with potential strategies to help protect and maintain the reef.

Step 4: Communicating

- Prepare a brief speech based on your findings and be prepared to deliver it to your class.

Complete your self-assessment using the **Inquiry rubric** document or access the 5.6 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-40157)

LESSON
5.7 Review

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

Review your results

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5.7.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

5.2 How are coasts formed and changed?

- A large percentage of the world's population lives adjacent to the coast, causing major changes to marine and terrestrial-based biophysical environments.
- The coastal zone is where the land meets the sea, and comprises the coastal waters and hinterland.
- Coasts are dynamic systems that are always changing though the process of building up and wearing down by agents such as wind and water.

5.3 What are the challenges to coastal environments?

- Rising sea levels due to climatic change and global warming will have dramatic effects on coastal built and natural environments.
- Places close to the coast that are low lying are affected by natural elements such as storms and are vulnerable to rising sea levels that will be the consequence of global warming.
- Some islands will eventually be submerged by rising sea levels, leading to people becoming climate change refugees.
- Delta areas of the South Asia region are home to large populations.
- Settlements and farming lands in areas such as Bangladesh are subject to flooding caused by severe weather events such as cyclones. This flooding will become more likely as sea levels rise and severe weather events increase due to global warming.

5.4 How do we manage coastal change?

- Rises in sea levels associated with global warming will have significant impacts on people who live and work in the coastal zone.
- Governments have responded to coastal erosion and deposition problems through a range of management solutions, such as dredging and building coastal protection structures, including groynes and sea walls.
- Coastal management programs will need to be extended to cope with even higher sea levels due to global warming.
- Beaches along areas such as the New South Wales and Queensland coasts are prone to storm conditions, affecting built environments.
- Storms, with consequent high sea levels, must be viewed as part of the natural cycle of erosion and deposition. These natural events can create ongoing management issues.
- Coastal locations are highly attractive places for human settlement.
- People in coastal areas are developing strategies to manage natural and human-induced changes so that their livelihood can be secured.

5.5 Investigating topographic maps: Consequences of coastal change in Merimbula

- Merimbula is a coastal resort town on the south-east coast of New South Wales.
- The main pressures on this coastal system are the impact of 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.

5.6 INQUIRY: Threats to the Great Barrier Reef

- Human activity has negatively affected the reef.
- There are potential strategies to help protect and maintain the reef.

5.7.2 Key terms

alluvial plain an area where rich sediments are deposited by flooding

atoll a coral island that encircles a lagoon

biodiversity hotspot a biodiversity region with significant levels of biodiversity that is threatened by human habitation

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

deltaic plain flat area where a river(s) empties into a basin

dyke an embankment constructed to prevent flooding by the sea or a river

dynamic equilibrium when the input of a coastal system such as winds and waves moving sediments onshore is equal to the output that moves sediments offshore, the system is said to be in a steady state. It is therefore not unstable and it has a dynamic equilibrium.

ecosystems systems formed by the interactions between the living organisms (plants, animals, humans) and the physical elements of an environment

enhanced greenhouse effect increasing concentrations of greenhouse gases in the Earth's atmosphere, contributing to global warming and climate change

floating settlements anchored buildings that float on water and are able to move up and down with the tides

gross domestic product (GDP) the value of all the goods and services produced within a country in a given period, usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

groundwater salinity presence of salty water that has replaced fresh water in the subsurface layers of soil

hinterland the land behind a coast or shoreline extending a few kilometres inland

Kyoto Protocol an internationally agreed set of rules developed by the United Nations aimed at reducing climate change through the stabilisation of greenhouse gas emissions into the atmosphere

mass wasting the movement of rock and other debris downslope in bulk, due to a destabilising force such as undermining compounded by the pull of gravity

Paris Agreement United Nations Framework Convention on Climate Change (UNFCCC) agreement outlining steps to reduce greenhouse gas emissions and tackle global warming

ratify to formally consent to and agree to be bound by a treaty, contract or agreement

storm surge a temporary increase in sea level from storm activity

training walls a pair of rock walls built at a river's mouth to force the water into a deeper and more stable channel. The walls improve navigation and reduce sand blockages.

5.7.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

Although it may not be obvious, coasts are constantly changing. How do natural and human processes contribute to this?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-11504)
Reflection (ewbk-12521)
Crossword (ewbk-12522)

Interactivity Coastal change and management crossword (int-7672)

5.7 Review exercise

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Multiple choice

1. What is a hinterland?
   - A. The coastal waters up to 5 kilometres offshore
   - B. The land behind a shoreline
   - C. Treeless, wide plains that are not affected by coastal changes
   - D. Areas prone to cyclone damage
2. Define the term ‘dynamic equilibrium’.
   - A. When the inputs to a coastal system are equal to the outputs
   - B. When an ecosystem does not suffer negative effects of human interaction
   - C. Implementing traditional coast management techniques
   - D. When the natural environment changes quickly rather than slowly
3. Which of these human interventions will help dunes to form?
   - A. Vegetation removal
   - B. Vegetation planting and protection
   - C. Constructing groynes
   - D. Removing mangroves
4. What kind of waves strip the sand from beaches?
   - A. Constructive
   - B. Constrictive
   - C. Destructive
   - D. Denuding
5. Which natural process creates bays and headlands?
   - A. Fast vegetation growth
   - B. Constructive waves
   - C. Deposition and transportation
   - D. Differential erosion
6. Which of the following is *not* a reason that the sea level rises when the climate warms?
   - A. There is increased evaporation from landforms.
   - B. Glaciers melt, releasing water into the ocean.
   - C. Polar ice caps melt.
   - D. The volume of water increases when it warms.
7. What mitigation strategies might people use to prevent a low-lying island from being inundated by sea water?
   - A. Building sea walls
   - B. Moving to another island
   - C. Building groynes
   - D. Moving further inland

8. Which of the following is *not* a factor that makes Bangladesh flood prone?
   - **A.** Rivers fed by Himalayan snow melts
   - **B.** Its warm climate
   - **C.** That it is in a cyclone-prone area
   - **D.** Nepalese and Tibetan deforestation
9. What is an advantage of an offshore breakwater?
   - **A.** Waves break in deeper water, reducing erosion of the shore
   - **B.** Better surf breaks
   - **C.** Inexpensive to create
   - **D.** Allows for easier dune management
10. How might rock walls and groynes make beach erosion worse?
   - **A.** They can block river entrances.
   - **B.** They can interfere with longshore drift and accelerate erosion.
   - **C.** They can prevent sand relocation efforts by humans.
   - **D.** They encourage more beach users to visit.

Short answer

Questioning and researching using geographical methods

11. **Identify** the changes sea levels rising could bring to a coastal area. **Consider** both environmental and human changes. **Consider** how this would relate to the First Nations Peoples of the Tiwi Islands.
12. **Discuss** what changes need to be made to the interconnection of natural processes and human activities to reduce the destruction of the Sundarbans.

Concluding and decision-making

13. **Evaluate** the economic and environmental benefits of floating settlements such as those in **FIGURE 3** in section 5.4.2.

Communicating

14. With the use of specific examples, **discuss** the ways in which human-induced changes can challenge the sustainability of our coastlines.
15. **Describe** one way that rising sea levels might affect one industry in Australia (e.g. tourism, fishing).

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6 Marine environments change and management

LESSON SEQUENCE

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LESSON
6.1 Overview

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How are marine environments threatened and how can they be sustainably managed into the future?

6.1.1 Introduction

Imagine you are on a beach. You are looking out 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 with the oceans, which provide or regulate our water, oxygen, weather, food, minerals and resources. Oceans also provide a surface for transport and trade and a habitat for 80 per cent of all life on Earth. Our oceans are under threat because we use them to extract resources and dump waste, destroying habitats and biodiversity at a rapid rate. **FIGURE 1** shows just a tiny fraction of the many thousands of tonnes of marine debris floating at sea. The health of our oceans is at risk. In this topic, we look at this problem in more detail.

FIGURE 1 So much rubbish and marine debris can be found floating in the world's oceans.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11506)

Video eLesson Thrown overboard (eles-1711)

LESSON
6.2 What is so special about marine environments?

LEARNING INTENTION

By the end of this lesson you should be able to explain the environmental benefits of marine environments and the threats posed to them.

TUNE IN

The marine environment includes seas and oceans and all living things within them.

FIGURE 1 What can you see in this marine environment?

1. What five things come to mind when you think of oceans?
2. Compare your list with another student. Do they differ, if so how?
3. How important do you think marine environments are to you?

6.2.1 What are marine environments?

Marine environments cover all seas and oceans, stretching from the high tide mark along the coast to open water, including the surface and interconnection with the atmosphere and land.

Marine biodiversity plays an important role in providing the ecosystem functions and services that humans derive from the oceans.

- Oceans are critical for the planet's survival, holding 96.5 per cent of the planet's water. They produce over half of the world's oxygen and absorb 50 per cent more carbon dioxide than the atmosphere.
- Covering 70 per cent of the Earth's surface, oceans play a pivotal role in maintaining temperatures and influencing weather patterns.
- Fish provide the main protein source for more than one billion people, while 590 million people rely on the fishing industry for employment.
- Oceans are important for spiritual and cultural benefits, as well as recreation and tourism.
- Humans rely on marine waters to move goods and people from place to place.

Our oceans are rich in biodiversity. Coastal biodiverse 'hot spots' are well known, but those in the open ocean are less so, even if they do make up two-thirds of the high seas.

Ten regions in the open ocean around the world have been suggested by scientists as 'special places' (see **FIGURE 2**). This recognises where there are high numbers of **endemic** species and the threat to them is high. There are unique habitats such as **sea mounts** and **hydrothermal vents**, where changes in elevation and temperatures encourage rich biodiversity.

When selecting the special places, scientists avoided high-use fishing grounds due to the possible socioeconomic impacts of creating conservation areas in the same place. Being recognised as a biodiversity hotspot ensures that these special places can be recommended as marine protected areas. This means resources could be focused to reduce species extinction or loss of habitat.

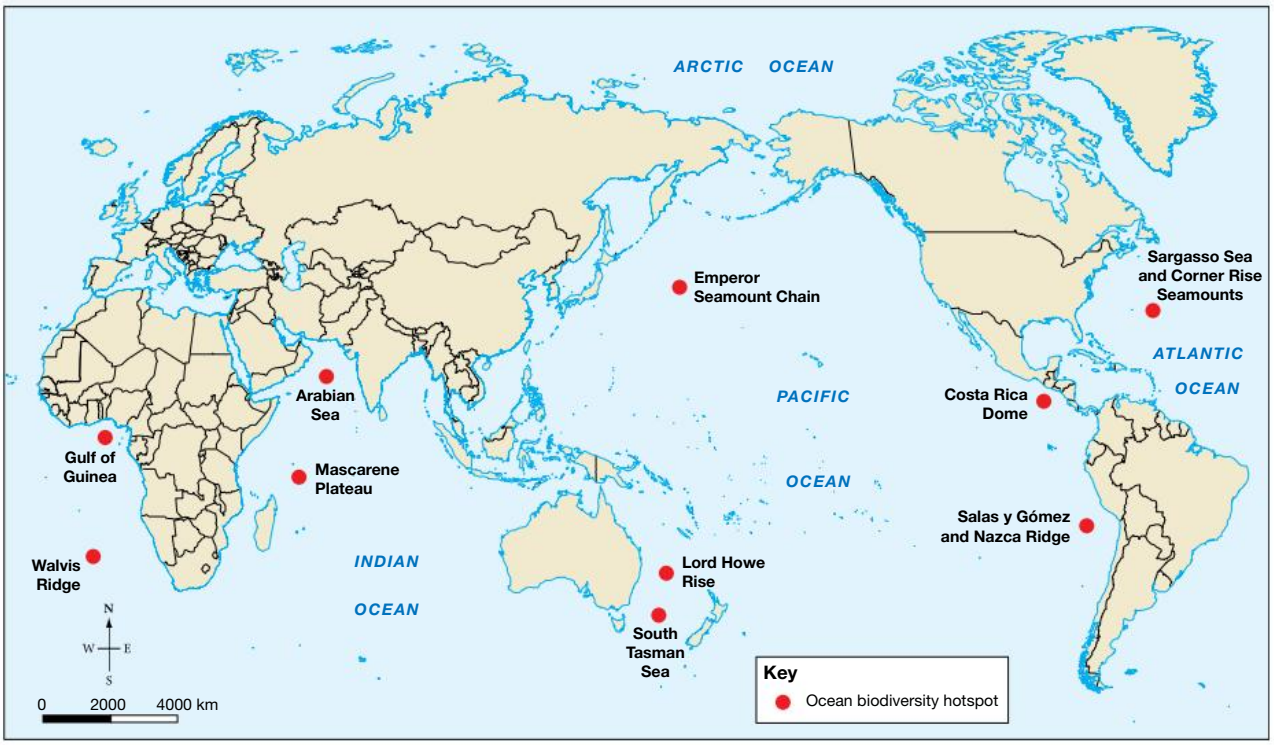
endemic a plant or animal restricted to a certain place

sea mount under-sea mountains, usually formed from volcanic activity on the seabed. They are known for their rich biodiversity.

hydrothermal vent an opening on the seafloor from which geothermally heated water is released. They are commonly found near volcanically active places.

tlvd-10775

FIGURE 2 Open ocean biodiversity hotspots

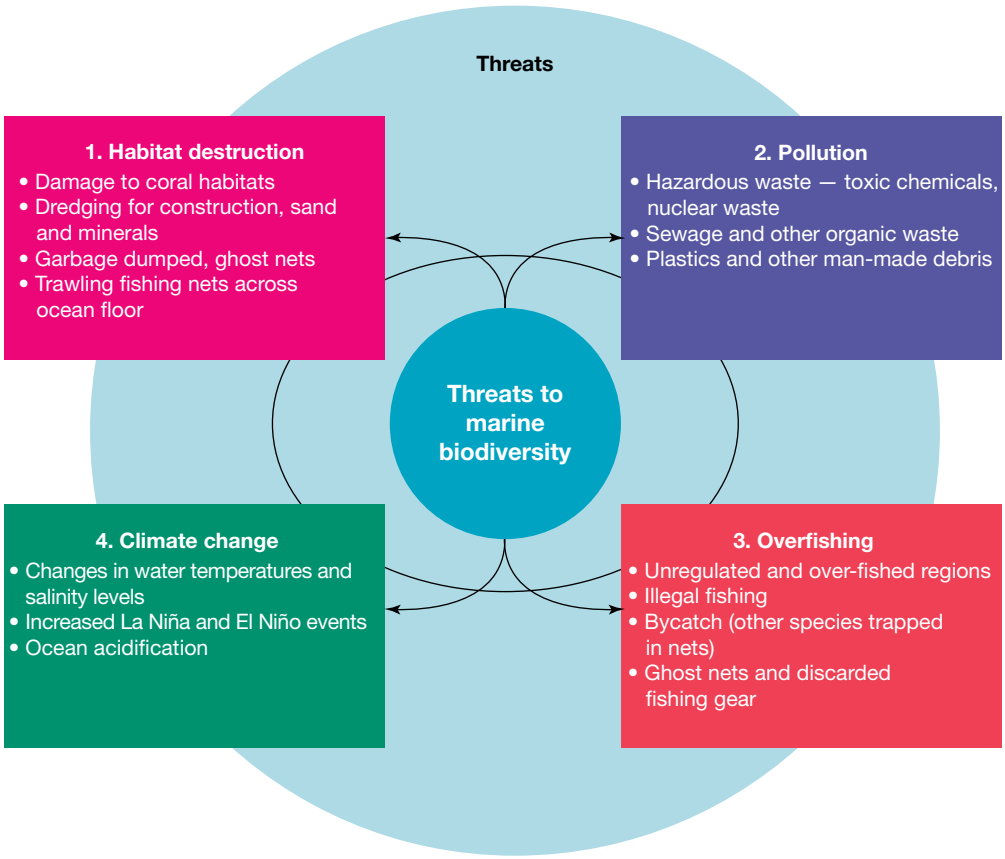


Source: Map drawn by Spatial Vision based on information © 2022 World Economic Forum.

6.2.2 What changes do humans make to marine environments?

Like terrestrial environments, marine environments, biodiversity and habitats are susceptible to change, especially as a result of unsustainable human activity (see **FIGURE 3**). Changes in the populations of fauna, flora and habitats, especially around coastal regions, have been contributing to a loss of biodiversity and food security. They also lead to the degradation of unique coral reefs and wetlands, and pollution of waters. These changes are now extending into open waters.

FIGURE 3 Major threats to marine biodiversity



6.2.3 What are two worldviews on marine environments?

For centuries, the oceans were viewed as a boundless food source due to their sheer size. Fish resources were seen as never-ending and, while coastal waters are within a nation's boundaries, the open ocean was there for everyone to use and abuse.

The whaling industry of the nineteenth century led to the death to hundreds of thousands of whales; more recently, new technology allowed fishers in the 1980s to extract fish from deeper open oceans. This led to the discovery of huge populations of the orange roughy fish at depths of 1000 metres around sea mounts off the coast of Australia and New Zealand. The orange roughy were easily caught and became very popular at markets.

Orange roughy catches increased dramatically (see **TABLE 1**) and then dropped to less than 10 per cent of the 1970's catches because the fishing industry was catching faster than the fish could breed and grow.

This is an **anthropogenic** worldview, a type of 'boom and bust' mentality, where one species is targeted and hunted (boom) until it is no longer sustainable to harvest (bust) and then another species is targeted. These days, fishing for orange roughy is highly regulated and strictly managed.

anthropogenic caused by humans or their activity

TABLE 1 Fish catches of orange roughy

Year	Number of fishing boats	Size of catch (metric tons)
1980	10	5000
1993	756	340 000
1999	200	20 000

Ocean waters have also been used as a dumping ground for all types of waste, from human sewage to discarded nuclear submarines. This was very much an anthropogenic worldview, reflecting a belief that the volume of water would dilute dangerous substances and depths could make things disappear.

In more recent times we have developed into a 'throwaway society' where the Earth's resources are no longer considered important or valuable; they are just turned into a single-use product and then discarded. Eighty per cent of the 8 million tonnes of rubbish that enters the seas each year is made up of single-use plastics such as drink bottles and shopping bags.

6.2.4 What is the worldview of First Nations Australians on marine environments?

First Nations Australians hold a central belief of 'caring for Country' and have a custodial responsibility to safeguard all for future generations. There is no distinction between land and oceans; rather, there is an interconnection between human beings and non-human beings such as plants, animals, land, rivers and oceans.

This **holistic** view contrasts with a Western worldview, which sees different types of environments managed by different groups, organisations and government departments. First Nations Australians have extensive knowledge of their environments and manage their resources with an emphasis on sustainable practices and environmental ethics, which can then be passed on to future generations.

This viewpoint is shared by many other Indigenous Peoples around the world, which place humans within the environment, and they are actively part of it. Some Western viewpoints place humans outside of the environment and view it as something to control and change; this is commonly seen as an anthropocentric worldview. This has led to a conflict of interest and a lack of inclusion for Indigenous Peoples in environmental management, both in Australia and in other places around the world.

holistic relating to the whole of something or to the total system instead of just to its parts. The environment is made up of many parts, all interconnected.

SkillBuilders to support skill development

- 1.8 SkillBuilder: Using geographic information systems (GIS)

6.2 SKILL ACTIVITY: Questioning and researching using geographical methods

1. **Select** one of the proposed biodiversity hotspots shown on the map in **FIGURE 2**. **Conduct research** and prepare a short, illustrated report on why this site was chosen as a biodiverse hotspot. Consider:
   - location (map showing location relative to nearest countries)
   - environmental features that make the site unique
   - possible human threats to ecosystem
   - any current management of the place.
2. Do you think the site is suitable to become a special deep sea biodiverse hotspot? **Justify** your response.
3. **Identify** the difficulties that might occur from creating a marine protected area in the open ocean compared to coastal locations.

Resources

Interactivity Motion in the ocean (int-3298)

6.2 Exercise

learnon

6.2 Exercise

Learning pathways

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

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Check your understanding

1. Sea mounts can best be described as:
   - A. old volcanoes on the seabed that are exposed above the sea as islands (for example, the Hawaiian Islands).
   - B. underwater volcanic activity linked to tsunamis.
   - C. steep cliffs that form off the continental shelves of continents.
   - D. underwater mountains formed through volcanic activity.
2. Which of the following would *not* be considered a threat to marine environments?
   - A. The establishment of marine protected areas
   - B. The use of trawling nets for fishing
   - C. Climate change increasing water temperatures
   - D. Release of hot clean water from power stations into the sea
3. Study **FIGURE 2**. **Match** each of the following biodiversity hotspots with the name of the ocean in which they are located.
   - a. Emperor Seamount Chain
   - b. Walvis Ridge
   - c. Sargasso Sea and Corner Rise Seamounts
4. **Explain** why viewing marine resources with a 'boom and bust' worldview is considered non-sustainable.
5. **Identify** two ways in which humans depend on the marine environment to break down, recycle or safely store the waste they produce. This is part of the 'sink' component of ecosystem functions.

Apply your understanding

Communicating

6. **Consider** the factors that may explain why we have less knowledge and environmental protection for the open ocean compared to coastal regions.
7. **Construct** a Venn diagram to illustrate the differences between an First Nations and Western worldview on marine environments. **Select** the most appropriate terms from the following list.
   Human-centred, Earth-centred, holistic, conservative, compartmentalised, knowledge passed on in written form, exploitative, individual focus, knowledge passed on orally, community focus
8. How might the worldview of a 'throwaway society' contribute to changes in the marine environment? **Justify** your response with examples.

LESSON
6.3 Why is there plastic in the ocean?

LEARNING INTENTION

By the end of this lesson you should be able to describe ocean pollution, especially marine debris, and identify its sources, distribution and movements.

TUNE IN

Many rivers in the Philippines are choked by litter.

FIGURE 1 A coastal creek in the Philippines

1. Have you ever stopped to think about what happens to any litter you might accidentally drop?
2. Describe what you see in **FIGURE 1**.
3. Why do you think there is so much litter in the creek?
4. What do you think is going to happen to this litter?
5. Could this be happening anywhere else in the world?
6. What would be the consequences?

6.3.1 What is marine pollution?

Directly or indirectly, the oceans receive millions of tonnes of human-made pollutants each year, which are collected in currents and swirl around.

Marine pollution includes any harmful substance or product that enters the ocean. Most are human pollutants such as fertilisers, chemicals, sewage, plastics and other solids, including more than 3000 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. Even industrial air pollution can be returned to the Earth's surface via rainfall (see **FIGURE 2**).

int-5596

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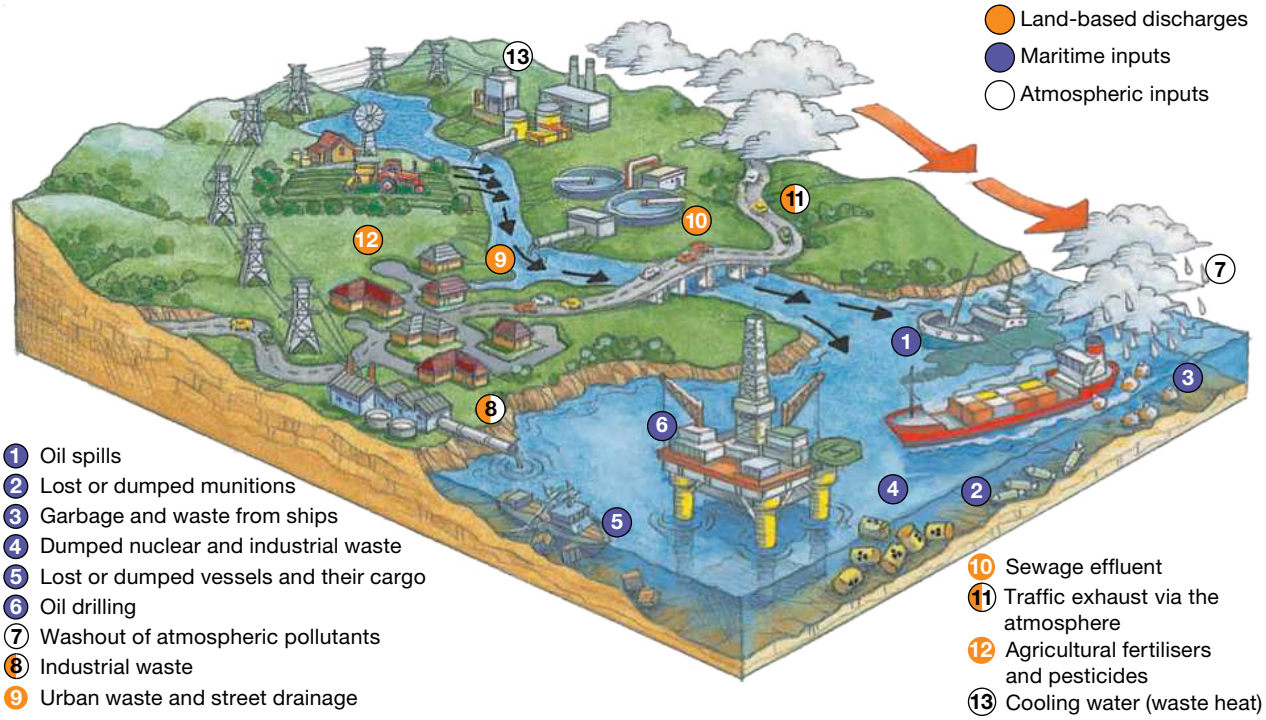
FIGURE 2 The sources of marine pollution



6.3.2 What is marine debris?

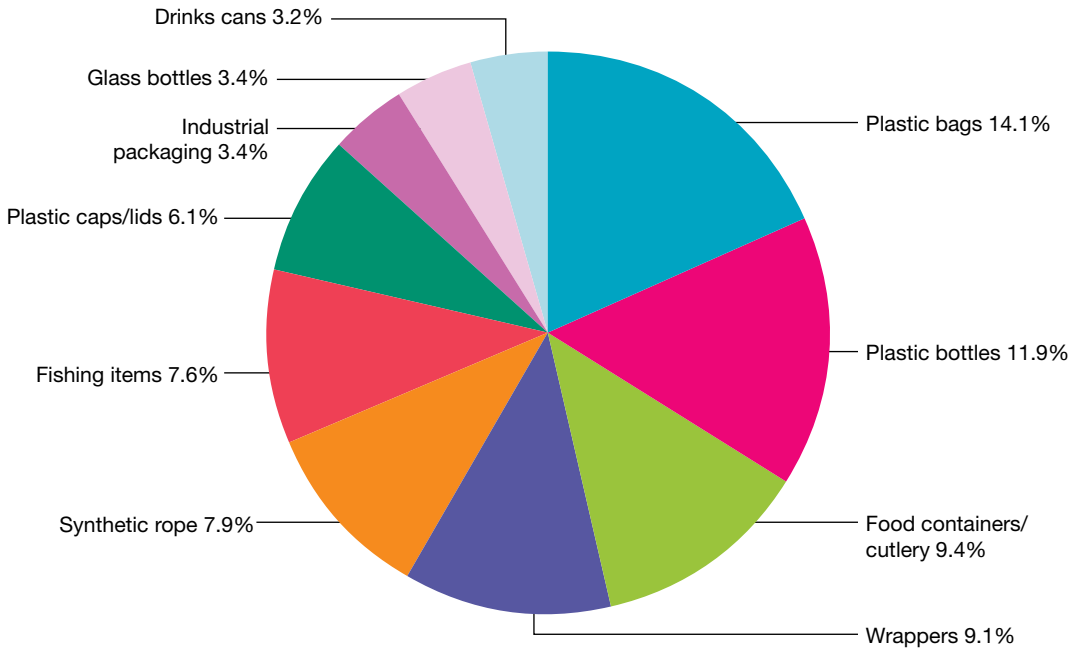
What happens to that empty drink can or plastic bag that misses the bin? There's a good chance it might wash down the gutter, into the drain and out to sea, never to be seen again. The world's largest rubbish dump is not on land, it is in the ocean.

Marine debris, the most prolific form of marine pollution, is litter and other solid material that washes or is dumped into the oceans. Much of it is plastic (see **FIGURE 3**). The special features of plastic that make it such a useful product — it is light, cheap to produce and disposable — also make it responsible for environmental changes in marine and coastal environments.

Plastics have revolutionised almost every aspect of society; more than 380 million tonnes of plastic (nearly the weight of the entire human population) are produced each year. On a global scale, only 13 per cent of all plastic is recycled. In Australia in 2020, only 16 per cent was recycled; the rest was either shipped overseas or ended up in landfill. Much is unaccounted for, lost in the environment and eventually washed out to sea, often ending up in the gut of or wrapped around the neck of marine creatures, or even buried in Arctic ice. Marine pollution is not confined to one place; it easily moves and crosses from national to international waters. Thus it can be an issue at a local, regional, national and international scale.

Researchers estimate that 8 million tonnes of plastic end up in the oceans each year — imagine a garbage truck dumping a load of plastic in the ocean every minute of every day of every year. Sixty per cent of plastic is less dense than sea water. When washed or dumped into the ocean, the buoyant material is easily moved by wind and surface currents, degraded into smaller and smaller pieces, or finally loses buoyancy and sinks. Surface currents and wind can also move debris back on to the coast, where it can become buried in sand or swept out to sea again. A survey of Australia's coastline found that plastics made up 84 per cent of marine litter.

FIGURE 3 Top ten marine debris items



Unlike most other litter, plastics are generally not biodegradable. The technological features of plastic mean that when it is exposed to constant wind, waves, salt and sunlight, it breaks down into tiny fragments known as microplastics (20–50 microns in diameter, thinner than a human hair), which can float or sink to the seabed.

Samples taken from selected sites in the Mediterranean Sea and the Atlantic and Indian Oceans have shown microplastics as deep as 3000 metres and in concentrations 1000 times higher than those found floating on the surface. Microplastics make up 85 per cent of plastic wastes along shorelines. Marine debris has also been discovered buried in sediments on the seafloor, in quantities 35 times greater in weight than that on the surface.

As well as microplastics, we also have microbeads and microfibres. Microbeads are tiny solid plastic fragments, less than 5mm in diameter, intentionally added to exfoliate and cleanse in rinse-off personal care products such as toothpaste, body wash and cleansers. The beads, as many as 100 000 per shower, flow straight down the bathroom drain and into the sewer. Wastewater treatment plants cannot filter such fine particles and so they ultimately end up out at sea. They are easily ingested by even the smallest sea creatures and are passed up through the food chain. Microbeads are not biodegradable and are impossible to remove from the marine environment.

Synthetic textiles pose a similar problem. When clothes made of microfibres such as lycra, acrylic, polar fleece or nylon are washed, between 600 000 and 17.7 million microfibres per wash are shed and end up in wastewater.

6.3.3 Where do we find the most marine debris?

Marine debris can be found in all seas and oceans and along most coastlines, from the isolation of the Arctic to heavily populated coastlines. Three regional places of concern are:

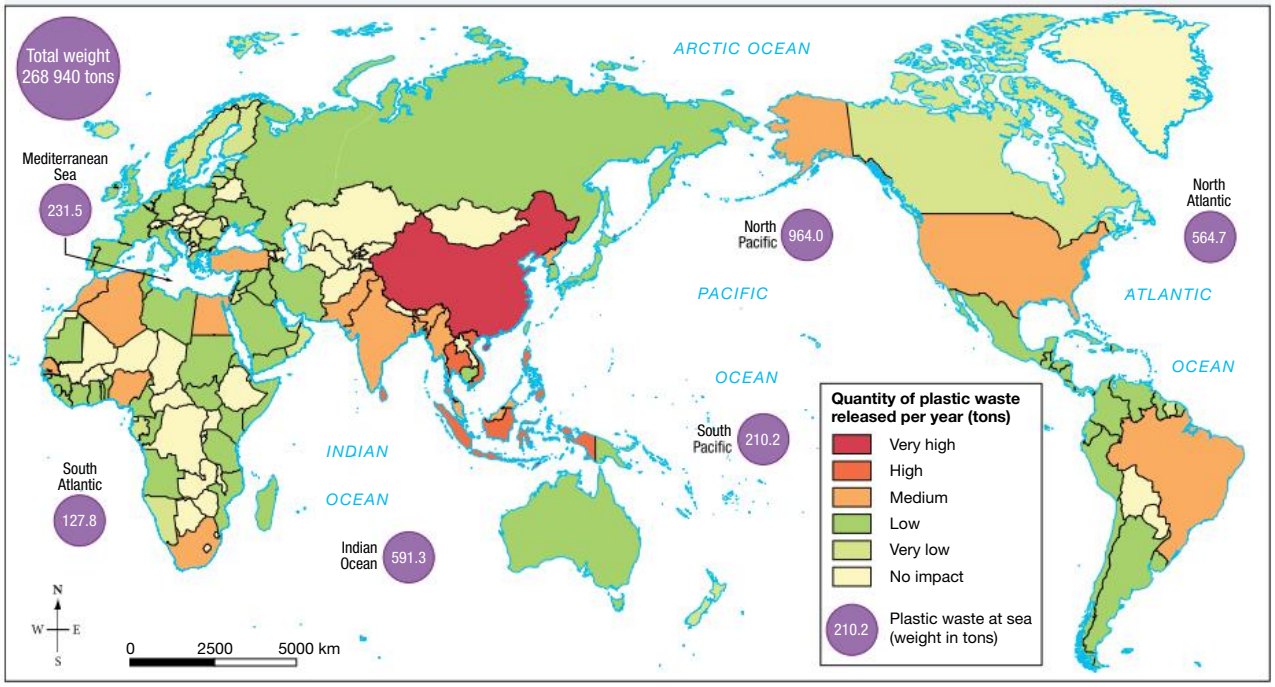
- the Mediterranean Sea, due to being geographically enclosed and proximity to large populations
- the Arctic Ocean, due to its pristine environment and the impacts on Indigenous communities
- East Asia, due to extensive coastlines (especially around island countries such as Indonesia) and close proximity to large populations dependent on marine environments for survival and inadequate waste disposal systems.

FIGURE 4 shows the major sources of plastic from land-based and fishing activities.

int-7963

tlvd-10777

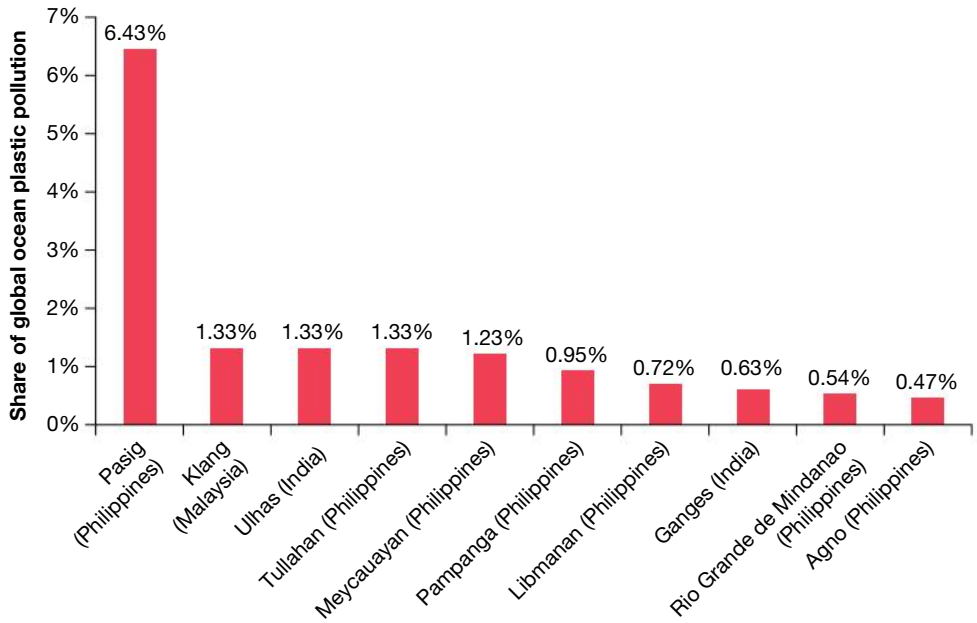
FIGURE 4 Quantity of plastic released into the ocean for selected countries



Source: Ministry of Environment & World Economic Forum; Statista.

It is estimated that 81 per cent of ocean plastics come from Asian rivers. The Philippines alone contributes around one-third of the global total (see **FIGURE 5**). These rivers all support high populations in their catchment areas and do not necessarily have the infrastructure to collect, recycle and dispose of plastic waste before it enters the sea.

FIGURE 5 River systems producing the most plastic marine litter



6.3.4 How is debris moved?

Why doesn't ocean water at the equator get hotter and hotter, and water at the poles get colder and colder? The answer is 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.

Ocean currents form part of the human–environmental interconnection. They are a natural environmental process that humans interfere with as they dispose of waste into the oceans. The waste can be swept up and carried by currents over long distances, often washing up on coastlines in places far from the source.

In January 1992, a ship sailing from Hong Kong to the United States lost a shipping crate containing 28 000 plastic bath ducks at sea during a storm. The toys drifted off in the currents, the first ones eventually reaching the Alaskan coast in November of that year. Nearly 30 years later, many are still floating! Tracking these toys has enabled scientists to improve their understanding of ocean currents.

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. There are also vertical currents operating in the oceans, responsible for stirring up the water and distributing heat, gases and nutrients.

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. Caused by the rotation of the Earth, the **Coriolis force** deflects currents into large circular patterns called gyres, which flow clockwise in the northern hemisphere and anticlockwise in the southern hemisphere (see **FIGURE 6**). Surface currents make up about 10 per cent of water movements in the ocean; deep water currents powered by **thermohaline** circulation make up the other 90 per cent.

Deep water currents

The Global Ocean Conveyor Belt (also known as the Great Ocean Conveyor Belt) is the largest of the thermohaline-driven ocean currents (see **FIGURE 6**). Warm water, which holds less salt and is less dense than cold water, travels from near the surface at the equator 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 that moves at a rate of 100 millimetres per second 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.

6.3.5 The Great Pacific Garbage Patch

A swirling mass of plastic waste, microplastics and other rubbish has been 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 Asia and west coast of the United States gets swept up in the North Pacific gyre. Within the marine environment, the slow-moving currents and winds push material into the calmer centre of the gyre, where it accumulates.

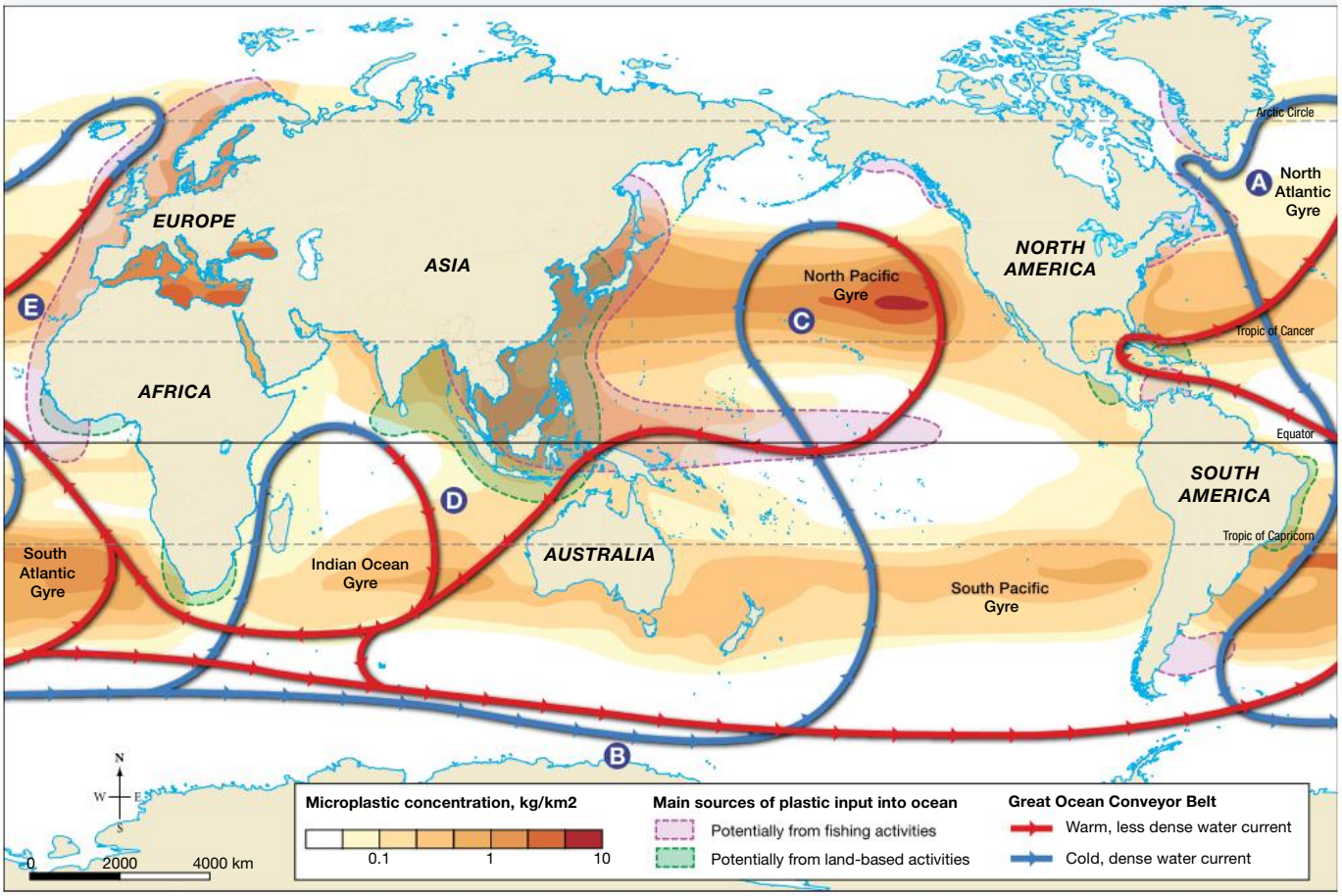
It can take a year for material to reach the centre of the gyre from Japan and five years from the United States. The accumulation of debris has earned this region the name the 'Great Pacific Garbage Patch' (see **FIGURE 7**). It is the largest of the five offshore plastic accumulation zones in the world's oceans, all corresponding with the major gyres. Very

Coriolis force a 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.

thermohaline relating to the combined influence of temperature and salinity

int-9133

FIGURE 6 The Global Ocean Conveyor Belt and the five main ocean gyres



Source: Map drawn by Spatial Vision, based on data from Schoolmeester, T., Gjerdi, H.L., Crump, J., Alfthan, B., Fabres, J., Johnsen, K., Puikkonen, L., Kurvits, T. and Baker, E., 2019. Global Linkages – A graphic look at the changing Arctic (rev.1). UN Environment and GRID-Aren dal, Nairobi and Arendal. www.grida.no

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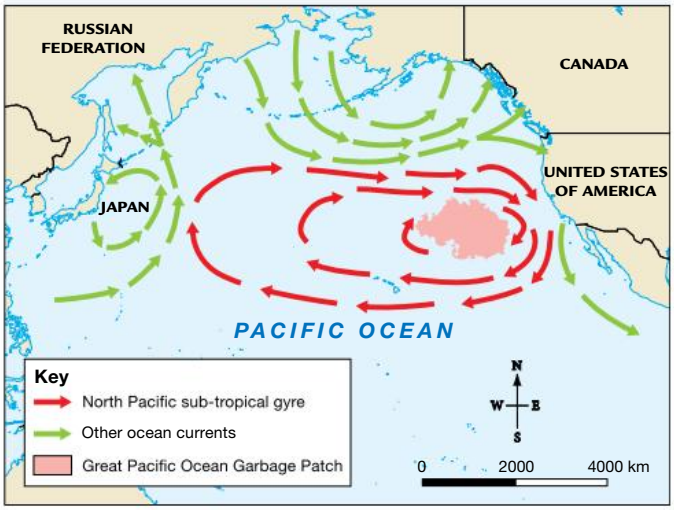
FIGURE 7 Location of the Great Pacific Garbage Patch



Source: The Ocean Cleanup.

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 extent of the patch in 2021 was around 1.6 million square kilometres. This is an area almost three times the size of France. Suspended within the patch are an estimated 1.8 trillion plastic pieces — around 250 pieces for every person on Earth!

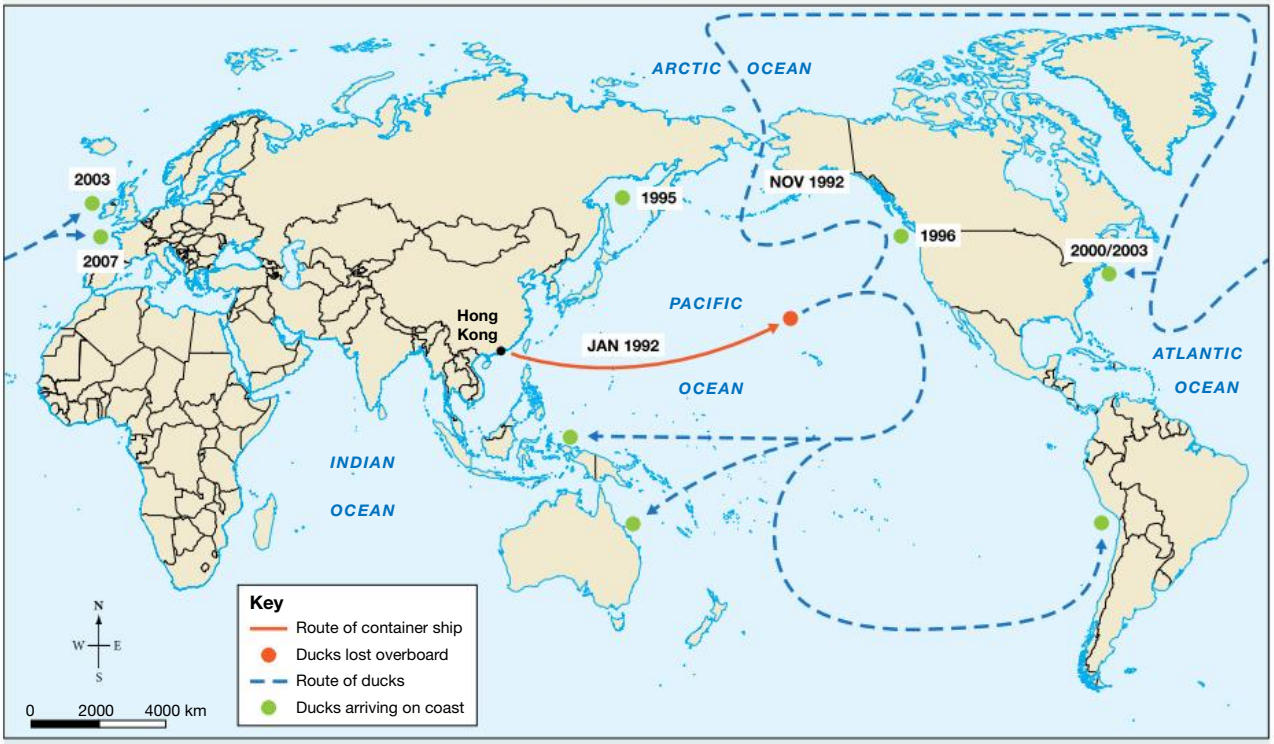
6.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

Refer to **FIGURE 6** and a map of the world in an atlas.

1. **Describe** the route taken by the Global Ocean Conveyor Belt. At each of the locations marked A–E:
   - name the ocean
   - mark the direction the current is taking
   - name the continent it is passing
   - **identify** the thermohaline features (warm, cold, higher salt content, lower salt content).
2. **Locate** the Great Pacific Garbage Patch on **FIGURE 6** and **identify** possible source countries/regions for marine litter arriving at the North Pacific Gyre. **State** if they are based on fishing or land-based activities.
3. How important is an understanding of ocean currents for dealing with marine pollution? **Explain**.

int-9134

FIGURE 8 The movement of the plastic ducks along the ocean currents



Source: Map drawn by Spatial Vision based on article by Patrick Knox for The Sun, 21 November 2017.

4. **FIGURE 8** shows the movement of the plastic ducks that went overboard in 1992.
   a. **Create** a timeline to demonstrate the distances, directions and countries where the ducks landed.
   b. **Explain** how this information helps our understanding about how we might manage marine pollution.

6.3 Exercise

learnon

6.3 Exercise

Learning pathways

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

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Check your understanding

1. Close to _____ per cent of marine pollutants originate on land (including atmospheric fallout), with the remainder coming from the ocean.
   Of marine debris, cigarette butts and food wrappers comprise nearly _____ per cent of rubbish found in the ocean.
2. **FIGURE 2** shows the sources of marine pollution. **Identify** the correct type of each of the pollutants below.

	Atmospheric-based	Land-based	Marine-based
Traffic exhaust			
Sewage effluent			
Oil drilling			
Shipping waste			
Industrial air pollutants			
Street drainage			

3. Answer the following questions about ocean currents.
   a. Ocean currents form in response to the uneven heating of the world's oceans. True or false?
   b. What is the driving force behind surface currents?
      A. Wind
      B. Movements of sea creatures
      C. Differences in temperature and salinity levels
      D. Rubbish
4. **Analyse 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?
5. Refer to **FIGURE 4**. **Describe** the distribution of those countries that produce medium to high (orange–red) quantities of plastic marine waste.

Apply your understanding

Communicating

6. **Explain** why water at the equator doesn't keep getting hotter and why water at the poles doesn't keep getting colder. Use your knowledge of currents to write an explanation for a younger student.
7. **Clarify** why ocean currents are described as 'conveyor belts'. **Suggest** what changes might happen to the Global Ocean Conveyor Belt if there was a significant melting of the polar ice caps.
8. **Explain** how a plastic bag discarded after a picnic in Los Angeles can end up in the middle of the Pacific Ocean Garbage Patch.
9. **Discuss** the environmental, economic and technological factors that have created the Great Pacific Garbage Patch.

Concluding and decision-making

10. Is our use of plastic a sustainable practice? **Justify** your answer.

LESSON
6.4 How does debris change marine environments?

LEARNING INTENTION

By the end of this lesson you should be able to describe the environmental, economic and social impacts of plastic litter in the marine environment.

TUNE IN

Much of the litter that is found in the ocean can end up being eaten by birds or sea creatures.

FIGURE 1 Foreign objects found in the stomach of a sea bird

1. How many different items can you identify in **FIGURE 1**?
2. How do you think all these objects ended up in the bird's stomach?
3. What could happen to sea creatures that eat marine litter?

6.4.1 What are the impacts of marine debris?

The amount of marine litter has been growing rapidly due to largely unsustainable production and consumption patterns and the inability to manage the waste. The amount of waste being dumped into the oceans is predicted to double from 23 million tonnes per year in 2016 to around 53 million tonnes per year by 2030. This has been compounded by the COVID-19 pandemic. It is believed that more than 25 900 tonnes of single-use plastic personal protective equipment and gloves has ended up out at sea. The sheer volume was more than any country could process or recycle.

6.4.2 What are the impacts on the environment?

Plastics can take between 500 and 1000 years to completely degrade. As a result, all of the plastic ever made or used still exists in one form or another.

FIGURE 2 gives estimates of the length of time some marine debris takes to decompose. Most plastics undergo photodegradation, which is the process of degradation aided by sunlight and oxygen. This happens more slowly in water than on land because of the cooler temperatures and reduced exposure to the sun. As the plastics break down into smaller particles, they 'thicken' the water and can release toxins. If the particles are less than 5 millimetres in diameter, sea creatures can consume them. In turn, these creatures are eaten by bigger creatures and so on up the food chain; this is called bioaccumulation. Marine animals such as mussels, which filter seawater, take up the microplastics, 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 1**).

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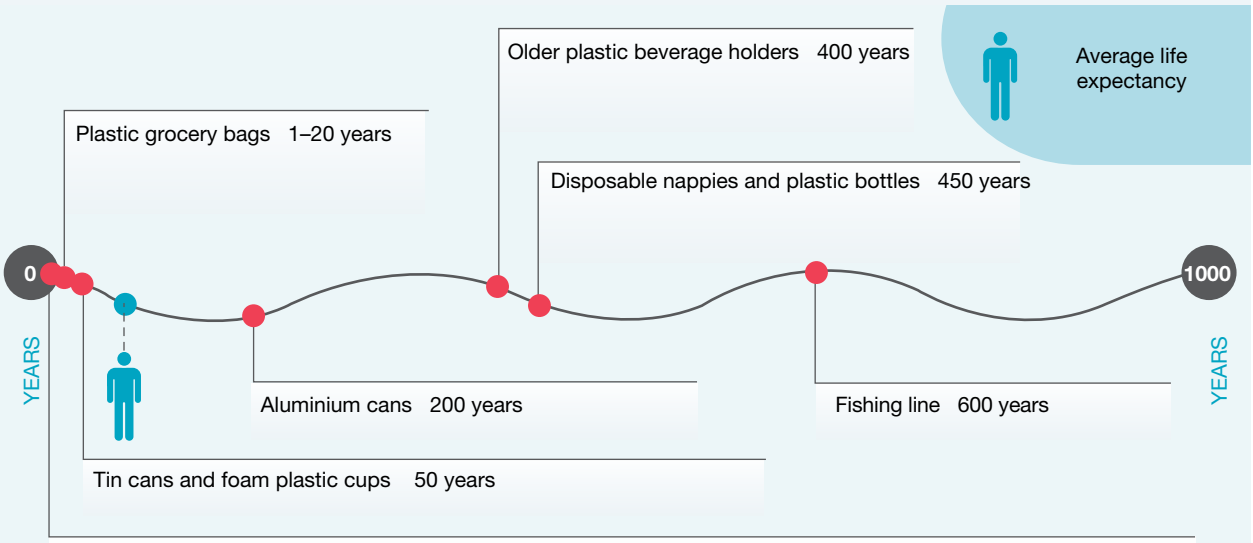
FIGURE 2 Time periods for the decomposition of marine litter



Paper towels	2–4 weeks	Waxed milk cartons	3 months
Newspapers	6 weeks	New photodegradable beverage holders	< 6 months
Cotton ropes	1–5 months	Plywood	1–3 years
Apple cores	2 months	Wool socks	1–3 years
Cardboard boxes	2 months		

Note: Estimated individual item timelines depend on product composition and environmental conditions.

Source: South Carolina Sea Grant Consortium, South Carolina Department of Health and Environmental Control (DFHC) — Ocean and Coastal Resource Management, Centers for Ocean Sciences Education Excellence (COSEE) — Southeast and NOAA 2008.

Plastic pollution is believed to affect at least 800 marine species, with estimates of up to 100 000 marine mammal deaths, including whales, dolphins, porpoises, seals and sea lions, and one million seabird deaths each year. Deaths are mostly caused by eating plastic, starvation, suffocation, infection or drowning due to becoming tangled.

Twelve out of 25 of the most important species of fish for human consumption have been discovered to have consumed microplastics. These tend to lodge in the gut rather than being found in the muscle tissue that humans consume.

FIGURE 3 Discarded plastic bags floating in the ocean are mistaken for jellyfish and eaten by hundreds of marine species.

It has been a common practice by many countries to pay other countries to take care of their unwanted waste, with large quantities being shipped to less developed nations. These countries lack the correct methods to break down and deal with the waste and it is instead burnt or buried, creating environmental problems for the local people.

Plastics are made from non-sustainable fossil fuels and both manufacturing and burning it releases emissions into the environment.

CASE STUDY: An environmental disaster in Sri Lanka

In May 2021, Sri Lanka experienced its worst maritime disaster when a container ship caught fire and sank. The disaster was neither the fire or threat of an oil spill, but rather the release of 87 container loads, holding 1680 tonnes of rice-sized plastic pellets or 'nurdles' (the raw materials for manufacturing plastic products). Since the disaster, millions of nurdles have been washing up along the Sri Lankan coastline, in some places up to two metres deep. They are expected to drift in the currents around the Indian Ocean from Somalia to Indonesia for the next few decades.

FIGURE 4 Nurdles collected from a beach

Nurdles can act as 'toxic sponges', attracting pollutants to their surface, which then enter the food chain. Mistaken as food, the nurdles are eaten by birds, fish and other marine life. Despite the environmental damages caused by nurdles, they are not considered a hazardous shipping item like diesel or petrol, which require special handling and storage.

Around 230 000 tonnes of nurdles end up in the ocean each year. Previous spills have occurred in the North Sea, impacting on the coastlines of Denmark, Sweden and Norway. Another spill off the coast of South Africa affected 2000 km of coastline. Only 23 per cent of 49 tonnes were recovered.

Impacts on people

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 fishers had continual problems with marine debris in their nets, snagging nets on rubbish, and that they avoided some fishing grounds because of their high litter concentrations. A recent study found that commercial fishing in Norway contributes 400 tonnes of plastic from lost fishing gear and ghost nets. (See lesson 6.5.)

Rafting also has an impact on aquaculture. Rafting is a natural phenomenon. Small marine creatures, such as barnacles, which normally spend their lives attached to rock, coral or coconut shells, can 'hitch a ride' on marine debris. The arrival of invasive or pest species in new locations can seriously affect ecosystems as they compete with native species for food or habitat. As well, invasive species can increase the risk of extinction for some species, reduce biodiversity and affect ecosystem function. Of the 455 marine pests in the eastern Mediterranean Sea, most have arrived on plastic rafts via the Suez Canal and the prevailing north-flowing current. If invasive species are introduced into fish farms, it can lead to the spread of disease or loss of fish stock.

Because of 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. People can consume plastic through eating seafood and microplastics can be eaten, absorbed through the skin or inhaled and they can then accumulate in organs. Scientists estimate that each person on earth consumes the equivalent of a credit card worth of microplastics weekly. This poses a threat to the health of communities who consume seafood as their main source of food.

rafting when small marine creatures attach themselves to floating objects and are moved around by wave and current action

DISCUSS

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?

6.4 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Use the following data to construct a bar graph to show the places where the largest sources of COVID-19 waste comes from (such as masks, gloves and testing kit materials). Finish your graph with full BALTSS (Border, Axes labelled, Legend, Title, Scale and Source).

Source region	Percentage of total COVID-19 waste
North America	6
Asia	46
South America	16
Africa	8

2. **Describe**, with the use of data, your observations from the graph.
3. **Suggest** reasons why the Asian region had such a large percentage of discarded waste.
4. **Discuss** in what ways discarded COVID-19 waste could impact on the marine environment.
5. **Identify** what countries could have done with the COVID-19 waste, given the speed at which the virus spread around the world.

Resources

Interactivity Garbage patch (int-3299)

6.4 Exercise

learnon

6.4 Exercise

Learning pathways

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

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Check your understanding

1. **Select** the best **explanation** of rafting in the context of marine litter.
   - A. The ability of marine organisms to create a raft-type structure out of marine litter
   - B. The ability of marine organisms to attach themselves to floating material and move with wave and current action
   - C. Objects floating in the Great Pacific Garbage Patch
   - D. The formation of large mats of seaweed during a storm
2. **Select** all the statements below that are false.
   - A. All plastic waste that enters the ocean will eventually decompose within a few years.
   - B. Microplastics can only enter the food chain at the producer stage.
   - C. Drowning is a major cause of death for fish entangled in nets.
   - D. Humans can only take in microplastics by swallowing them.
3. The environmental concern over nurdles is that:
   - A. they are not considered a hazardous shipping item.
   - B. that once in the environment they easily sink to the seabed and decompose.
   - C. that once in the environment they can be consumed by marine creatures or litter beaches.
   - D. they are easily lost in containers that fall overboard.
4. **Elaborate** on the impact of the COVID-19 pandemic on marine environments.

Apply your understanding

Communicating

5. **Suggest** why environmentalists are keen to have nurdles declared a hazardous shipping item.
6. **Examine FIGURE 4**.
   - a. **Describe** how you feel when viewing this beach.
   - b. **Consider** how the appearance of this beach could impact on (i) tourists and (ii) local people.
7. **Explain** how rafting can impact on both people and environments.
8. **Identify** the environmental changes that marine plastic brings to oceans.

Interpreting and analysing geographical data and information

9. Refer to **FIGURE 2**. **Compare** the decomposition changes for natural materials and man-made materials as seen in this timeline. What does this indicate to the packaging industry and consumers?

Concluding and decision-making

10. Is our use of plastic a sustainable practice? **Justify** your answer.

LESSON
6.5 How do ghost nets create environmental change?

LEARNING INTENTION

By the end of this lesson you should be able to explain the role that ghost nets play in changing marine environments and the way in which First Nations Australians are managing the problem in the Gulf of Carpentaria.

TUNE IN

Nets discarded or lost from fishing vessels cause damage to the marine environment.

1. What is happening in **FIGURE 1**? Why?
2. Would you consider this to be a small-scale or large-scale issue?
3. Where in the world do you think this is happening?
4. What influenced your decision?
5. How could people and governments deal with this problem?

FIGURE 1 What are these fish trapped in?

6.5.1 What are ghost nets?

Ghost nets are lost or discarded fishing nets and fishing gear that can drift in the oceans for many years. It is estimated that there are 640 000 tonnes of ghost nets discarded in the oceans annually, contributing to 46 per cent of the plastics found in the Great Pacific Garbage Patch.

Ghost nets are a threat to marine life because they are designed to capture fish but end up trapping and killing unintended species such as seals, dolphins, whales, turtles and birds that become tangled in the nets, unable to rise to the surface for air or untangle themselves. Thirty per cent of the decline in some fish species and more than 70 per cent of tangled marine animals is attributed to lost nets.

Ghost nets can also smother coral reefs, blocking sunlight and breaking corals. Discarded nets threaten biodiversity across all oceans. Economically, an estimated 90 per cent of species tangled in nets would have had commercial value, thus depriving people with income.

Traditionally, fishing nets were made of more eco-friendly materials, such as flax or hemp, but now they are usually made of nylon or another plastic compound, which makes them stronger, cheaper and more buoyant. However, this means they take a very long time to break down. Nets can also range in size from 30 cm to 6 km long!

TABLE 1 outlines several factors responsible for the loss of fishing gear at sea.

TABLE 1 Factors contributing to the loss of fishing gear

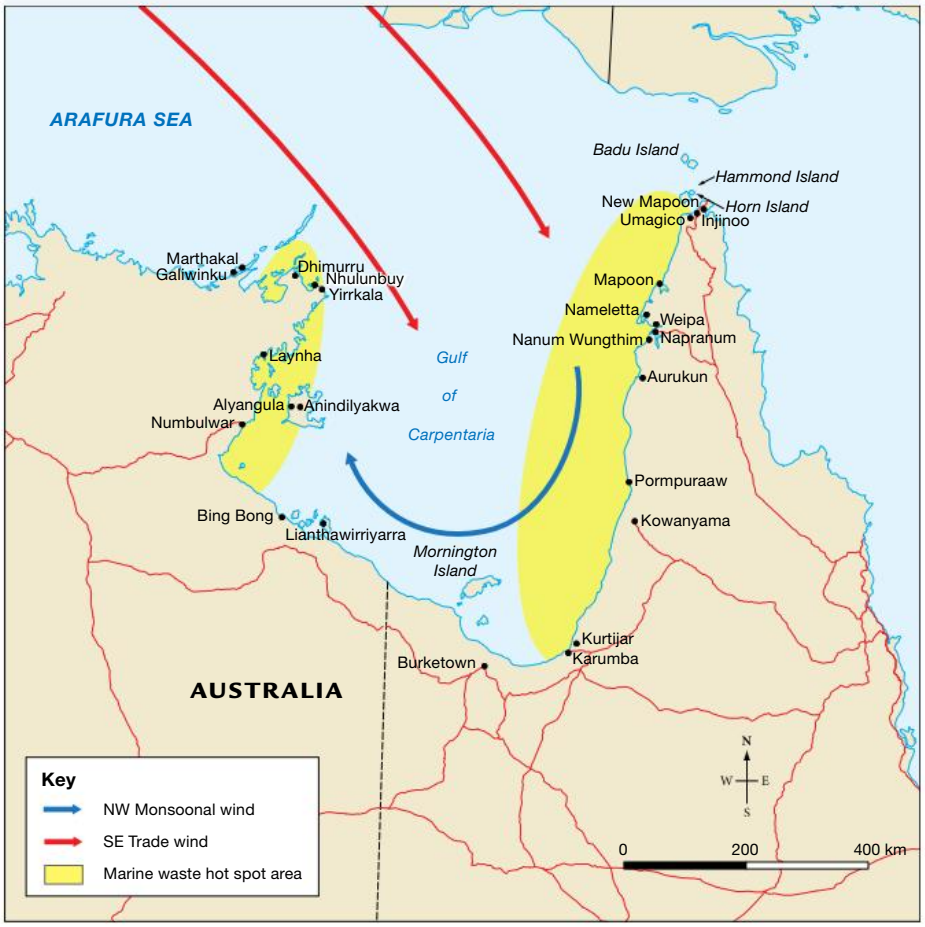
Social factors	Environmental factors	Economic factors
• Illegal fishing vessels, when threatened with capture from authorities, may cut nets or throw them overboard. • Gear deliberately dumped if no longer effective • Crew are often ill trained or unaware of the issue of ghost nets	• Stormy weather or rough seas may cause fishing gear to be washed overboard • Trawl nets dragged behind boats may get tangled on reefs or other obstacles and tear off • Nets anchored to the seabed can be torn off their mounts by strong seas and drift off	• It can be very expensive to dispose of old nets correctly or facilities may not exist. Dumping is the easiest option. • In times of good fish catches, nets may be thrown overboard to make room for the catch.

6.5.2 Where are ghost nets a problem around Australia?

Fishing debris is a global problem, found in every ocean and sea, even in isolated places such as the Midway Islands in the Hawaii archipelago, thousands of kilometres from any port or major fishing grounds. Discarded fishing nets accumulate on beaches, coral reefs and mangrove swamps or drift with ocean currents in large rafts, trapping marine life. It is a major problem in tropical northern Australia, particularly in the Gulf of Carpentaria.

The Gulf is a shallow sea located between Australia, Indonesia and Papua New Guinea; it represents 10 per cent of Australia's coastline. Around the Gulf, densities of abandoned nets can reach up to three tonnes per kilometre per year, among the highest densities in the world. The coastlines in this region are pristine environments and support six of the world's seven marine turtle species. Turtles make up 96 per cent of marine creatures captured in the nets. Over 90 per cent of the debris that collects is derived from the fishing industry, with 85 per cent of the nets originating from outside of Australia's territorial waters. Most of the nets come from the Arafura Sea (see **FIGURE 2**), an important fishing ground, especially for Indonesia, Taiwan and Japan.

FIGURE 2 Distribution of ghost net hot spots around northern Australia



Source: © Commonwealth of Australia Geoscience Australia 2013. Ghost Nets Australia, www.ghostnets.com.au/index.html.

Under the influence of the south-east trade winds and north-west monsoon winds (see **FIGURE 2**), a circular gyre current develops, which creates a build-up of ghost nets, like the Great Pacific Garbage Patch.

6.5.3 How can the ghost nets be dealt with sustainably?

In Australia, the issue of ghost nets is being tackled by GhostNets Australia, an alliance that supports the Indigenous Rangers Programme. Specially trained First Nations Australian rangers from 40 clan groups in remote coastal places of Western Australia, Queensland and the Northern Territory, have been responsible for capturing up to 15 000 ghost nets in the past 15 years.

FIGURE 3 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.

1. **R**emove ghost nets from waters and the 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 First Nations Australians' customary lands and seas.

6.5.4 What can be done with the debris?

There are three main stages to dealing with ghost nets:

- locating and retrieving
- cleaning them and removing them
- disposal

An evaluation of some of the strategies used is outlined in **TABLE 2**.

There are three options for disposing of the waste: burning, placing in landfill, or recycling. Some methods are more sustainable than others and all require the difficult task of collecting the waste.

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:

- the expense of transporting the waste over large distances to a landfill site
- waste is often burned in tips, and these tips are close to settlements.

Disadvantages of recycling or reusing fishing nets include:

- the remoteness of and distances to recycling plants (South Australia and Taiwan have plants big enough to cope with fishing nets)
- the 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.

Recent analysis from aerial surveys has noted that despite the clean-up methods being employed and the banning of the use of trawl and seine nets in Indonesia, the number and density of ghost nets has continued to increase around the Gulf.

TABLE 2 Evaluation of strategies to manage ghost nets using three criteria

Strategy	Economic criteria	Environmental criteria	Social criteria
Tracking/retrieval			
Radio frequency tagging of nets	Cost 50 cents each	Can work in remote areas and can work at local scale. Can be tracked and retrieved when suits	Indirect benefit — improved data collection
Use of drones	Cost $230	Can work in remote areas and at local and regional scales.	Makes clean up more efficient
Use of satellite imagery	Cost $5000 per 100 km^2	Can work in remote areas and at local and regional scales. Allows a larger area to be examined compared to a drone	Indirect benefit — may allow tracking and prevention of nets reaching coast
Clean up and removal			
4WD, Ute road vehicles	Second hand $60 000 plus running and maintenance costs Small loads only	Can drive on sand and in harsh terrain, though needs tracks or roads	Opportunities for local businesses to maintain Only driving license required
Helicopter to lift and carry items	$1400/hour to use	Can work in remote locations, increased clean-up efficiency	Opportunities for local businesses to maintain Requires special training
Boat/barge to ship out waste	$50 000+ to purchase	Can work in remote locations, increased clean-up efficiency	Opportunities for local businesses to maintain Requires special training
Responsible disposal			
Manufactured into another product	Machinery up to $1 million	May be sustainable depending on what products made	Requires skilled workers more suited to regional town
Incineration — material to be burnt and left over compacted	Approx. $400 000	Reduces amount that would go to landfill Risk of air pollution	Scale of operation May not be large enough More suited to regional urban location
Small-scale conversion of plastics to diesel fuel	Mobile unit $1.7 million Insufficient nets to allow continual processing	Some environmental risks if leak or spill	Requires skilled operators More feasible for urban locations

6.5.5 What else is being done?

International scale

Clearing the oceans of ghost nets will require global innovation, commitment and cooperation. Presently, there is no international law for ghost nets; instead it is up to volunteer groups and environmental organisations to clear the seas.

The United Nations have suggested practical methods aimed at the fishing industry to help educate and provide incentives for reporting and retrieving lost nets. The World Wildlife Fund (WWF) is actively working with local fishers and governments to identify and target hotspot areas to remove nets. They are also promoting ways to trace nets back to their owners, using sonar reflectors to make the nets easier to find and encouraging more sustainable fishing practices. Other small-scale strategies being used are:

- In Britain and Alaska, ghost gear is being turned into plastic tokens for supermarkets or local craft.
- In Chile, collected nets are recycled into sunglasses, chairs and skateboards.
- In Europe, a new nylon fibre has been created from recycled nets to be used in swimwear, sports clothing and carpets.

Instead of being discarded, the nets have value and can be sold. Jobs are created and an environmental threat averted.

Local scale

The Australian Government committed $14.8 million in 2021 to address the challenge of ghost nets and plastic litter around the Gulf coastline. The GhostNets Initiative will work with First Nations organisations, Parks Australia and other agencies to build on past and present efforts with the focus on three main strategies.

- Supplying new technology to better detect, collect and dispose of ghost nets and plastic litter. These could include tracking databases, the use of satellite and drones for tracking and mobile recycling plants.
- First Nations Australian ranger groups collecting data on the source of nets and coordinate retrievals of nets and debris.
- Trials to attach GPS tracking devices to floating nets that cannot be safely retrieved initially, but can be tracked and picked up later.

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 4**). This type of sustainable cottage industry brings economic and social benefits as well as raising awareness of the problem of marine debris.

FIGURE 4 Woven basket made of recycled fishing nets

6.5 SKILL ACTIVITY: Questioning and researching using geographical methods

1. **Research** information on the different types of fishing nets used: gill, purse, seine and trawl nets. Briefly **explain** how they work. I**llustrate** with clearly labelled sketches or images.
2. **Construct** a table to list the advantages and disadvantages of each type of net from a fishing and an environmental perspective.
3. **Identify** which net design might prove to be the most damaging to the environment if lost or discarded.
4. Many countries have now banned the use of trawl nets. **Discuss** if you think this decision was influenced more by economic or environmental factors. **Explain** your reasoning.

FIGURE 5 A fishing trawler dragging nets near the Netherlands

6.5 Exercise

learnon

6.5 Exercise

Learning pathways

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

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Check your understanding

1. **Explain** why ghost nets are a problem in northern Australia.
2. Why are fishing nets an environmental problem?
   - A. They cost a lot of money to remove.
   - B. They are a waste of good fishing nets.
   - C. They can trap marine creatures and birds.
   - D. They are not an environmental problem.
3. Refer to **FIGURE 2** to complete the following sentences.
   - a. You would expect ghost nets to predominantly build up on the east coast of the Gulf during the _____ season.
   - b. You would expect ghost nets to predominantly build up on the west coast of the Gulf during the _____ season.
4. **Explain** why an understanding of local wind patterns is useful to GhostNets rangers.
5. **Discuss** why transporting ghost nets to South Australia for recycling is not a viable option.

Apply your understanding

Concluding and decision-making

6. **Evaluate** the environmental, economic and social aspects of the GhostNets program.
7. The Ghost Net Initiative hopes that by 2030 the amount of fishing gear lost in the ocean each year will be smaller than the amount that is recovered, recycled and re-used. **Reflect** on whether you think this is a realistic goal and **explain** your reasoning.

Communicating

8. **Clarify** how the cultural values of First Nations Australians has influenced their partnership with the Ghosts Nets program.
9. The Gulf of Carpentaria is a hotspot for discarded fishing nets. **Explain** how the detection, retrieval and disposal of nets might be different if there was a hotspot along the coast of a major Australian city.
10. **Consider** what would be involved in establishing a global law on the issue of discarded fishing gear. What would be required and how best would it be managed? **Justify** your viewpoint and reasoning.

LESSON
6.6 How is marine debris being dealt with in different places?

LEARNING INTENTION

By the end of this lesson you should be able to compare different strategies for dealing with marine pollution.

TUNE IN

Marine pollution can negatively affect even the most isolated islands.

FIGURE 1 A pristine beach on one of Australia's most remote islands

1. Have you ever wanted to live or holiday on a tropical coral island? What features in **FIGURE 1** appeal to you?
2. How would you feel if you knew this was more than 2000 km from the Australian coastline, but still part of Australia? Do you know where this is?
3. What is your reaction to the fact that many of the beaches here are covered in marine litter?

6.6.1 How is litter removed from oceans?

CASE STUDY: Cleaning up the Great Pacific Garbage Patch

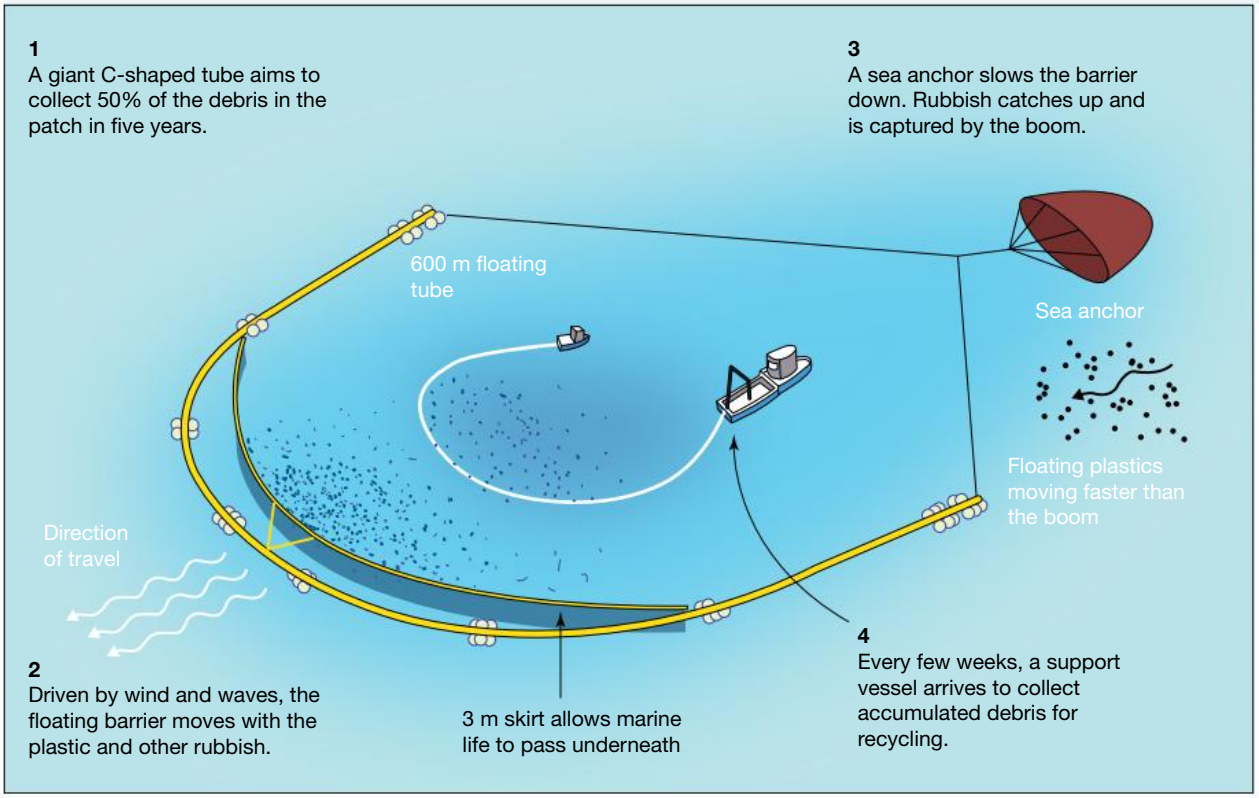
Ocean Cleanup, a not-for-profit organisation set up by 17-year-old Boyan Slat in 2013, is endeavouring to clean up the Great Pacific Garbage Patch, the world's largest accumulation of marine rubbish in the middle of the Pacific Ocean. The organisation is designing a device that can be towed behind ships and literally scoop up debris while still allowing marine life to swim beneath (see **FIGURE 2**).

Winds and waves propel the device forward at a faster rate than the current-driven debris, allowing it to be collected. The debris can then be brought back to land for processing and recycling. Their third design is now being tested and it is hoped that they could deploy 10–15 collectors, powered by 20–30 ships to operate 24 hours a day. Over 12 months they could collect up to 20 000 tonnes of plastic. Much of the plastic they capture is being recycled into new products such as sunglasses.

There are drawbacks to the scheme, such as:

- a reliance on fossil fuel-burning ships for collecting and transporting the waste
- 20 000 tonnes collected each year is only a very small proportion of the 11 million tonnes that enter the marine environment annually
- the cost of hundreds of millions dollars to operate and staff so many ships
- the fact that much of the plastic is not floating on the surface but suspended through the water
- the debris in the patch is constantly moving in response to wind, waves and currents.

FIGURE 2 The design of the Ocean Cleanup debris collector



Note: The project's original design had the boom travelling in the opposite direction and catching up with debris in the ocean.
Source: The Ocean Cleanup.

6.6.2 How is litter removed from coastlines?

Australia is an island continent with an ocean territory twice the size of our landmass. Eighty-five per cent of the population lives within 50 kilometres of the sea.

Despite the uneven distribution of our population, marine pollution is evident around the entire coastline. Fifty per cent of the debris was related to land-based sources, and 7 per cent is dumped in the ocean. The highest densities tend to correlate with urban areas. Human littering and land-dumping are the most important causes, while rivers, storm water drains and wind help move the rubbish into the marine ecosystem.

The worldview of First Nations Australians is that our oceans and land are interconnected and Caring for Country is central to their beliefs.

CASE STUDY: Beach litter on the Cocos Keeling Islands, Australia

More than 2000 kilometres off the north-west coast of Australia, in the Indian Ocean, lie two coral **atolls** (see **FIGURE 3**) made up of 27 islands of the Cocos Keeling Islands (part of Australia's external territory). With a maximum elevation of nine metres and a population of less than 500 people on the only two inhabitable islands, the islands and beaches are considered some of the most beautiful in the world. They are also home to more than 400 million pieces of marine plastic litter.

The islands lie south of Indonesia and in the path of the Indonesian Throughflow Current, which moves water from the Pacific Ocean to the Indian Ocean (**FIGURE 4**). A tracking survey in 2020 indicated that 100 per cent of litter ending up on the island's beaches came from river sources in Indonesia transported by this current.

Plastic debris from neighbouring Indian Ocean islands or the mainland was only a small proportion of the 238 tonnes of litter arriving. It would take 4000 years for the population of the island to generate the same amount of plastic waste in their marine environment.

Such remote islands, which don't have large populations or river systems discarding litter, are an indication of the scale of human-induced environmental change in our marine environments.

atoll a ring-shaped coral reef or string of small coral islands surrounding a shallow lagoon

FIGURE 3 The Cocos Keeling Islands

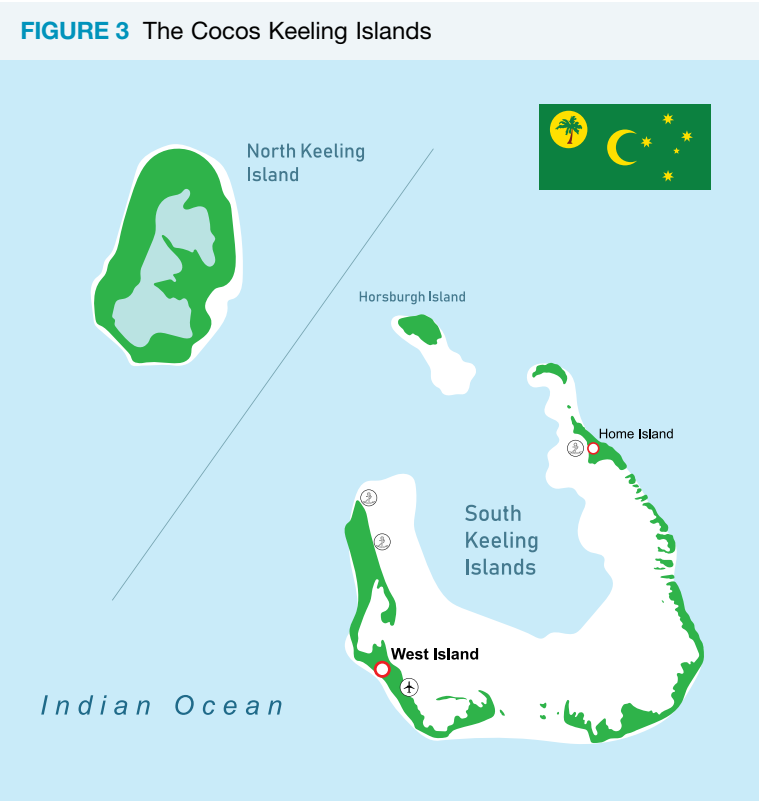


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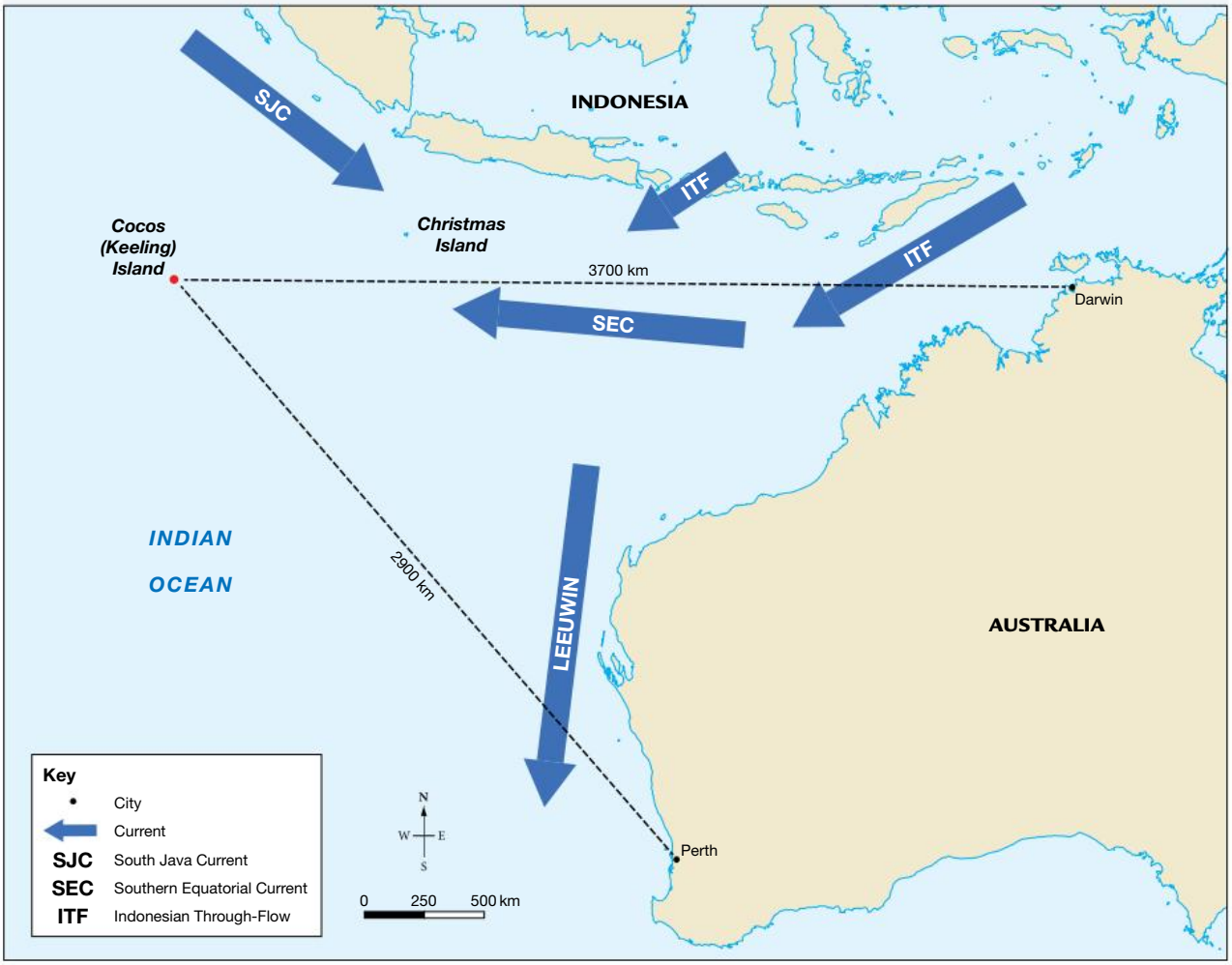
FIGURE 4 Location of Cocos Keeling Islands and local currents



Recent litter surveys discovered some interesting facts. All were anthropogenic (caused by humans or their activity) and, of the identifiable items:

- 25 per cent were classified as disposable items — straws, plastic bags, toothbrushes, food packaging
- 93 per cent of all debris was buried up to 10 cm in the sand
- 4.5 tonnes of discarded fishing nets were collected from one small island
- microplastics were in such concentrations that they could be scooped up by hand. One square metre of beach produced 5302 plastic pieces with a total weight of 3.2 kilograms.

What clean-up strategy is being used?

The only method available for reducing marine litter on the Cocos Keeling Islands is hand collecting. Not-for-profit organisations, such as Sea Shepherd and the Tangaroa Blue Foundation (TBF), have volunteered for data and litter collection over the years and even the Navy has done clean-up work. The rubbish is then incinerated at high temperatures. Burying the rubbish is not an option for fear of polluting groundwater, the main source of drinking water. Hence there has had to be a 'trade off', removing the rubbish by hand and incinerating it to help reduce the plastic pollution problem without the extreme economic impact of paying for it to be shipped to a major city on the mainland for correct disposal.

The Australian and Indonesian Governments are working together in the Australia-Indonesia Plastic Innovation Hub (The Hub) to work with the plastic industry in Indonesia to identify how technology can help achieve improvements in the plastic pollution issue. This case study is an example of human-environmental interconnection, where the impacts of human behaviour in one place creates environmental changes in another place.

6.6.3 How is litter stopped from entering the ocean?

Indonesia is the world's second largest contributor of marine plastic in the world, contributing 625 000 tonnes of plastic annually to the surrounding seas, and it is growing at an unsustainable rate. By 2025 it is expected to reach 800 000 tonnes.

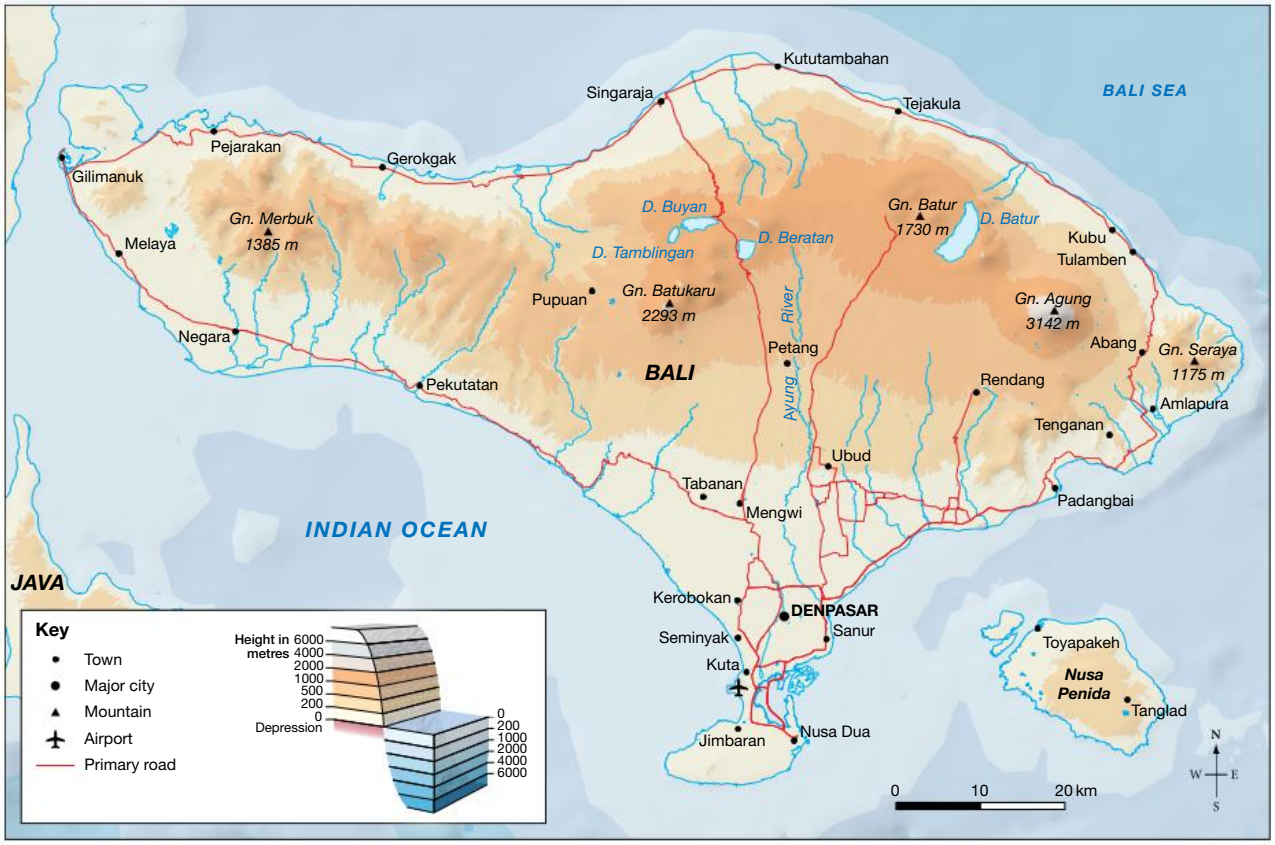
The country has some of the most biodiverse and important coral reefs in the world, which support livelihoods and food security for millions of people. Over the past decades, the seas around Indonesia have experienced large-scale environmental change due to human activities: plastic pollution, over-fishing, illegal fishing and coastal development.

CASE STUDY: Bali

Bali is a small southern island of Indonesia (smaller than Tasmania) with a population of 4.2 million people (Tasmania has 517 000). Ninety per cent of the population lives within one kilometre of Bali's 372 rivers.

The island is a popular tourist destination, with 6.3 million international tourists and 10 million domestic tourists visiting annually (pre-COVID-19). Tourism contributes 70–80 per cent of Bali's income. This places enormous stress on both the land and marine environment. It has been calculated that one tourist uses 3.5 times more plastic than a local resident.

FIGURE 5 The island of Bali



Source: Map drawn by Spatial Vision.

The famous beaches at Kuta and Legian (see **FIGURE 6**) are subject to massive plastic pollution, accumulating up to 60 tonnes of rubbish daily. Rivers deliver inland garbage to the coast, while seasonal monsoons bring in westerly winds and currents that drag plastic litter from the nearby island of Java. Coupled with the influx of tourists, an inefficient garbage disposal system and low levels of community education, the island is literally being buried in waste. Confusion arises because the island is divided into eight different regions, each with

its own policies, waste disposal methods and landfills (dumps). There is minimal household sorting, recycling or collection. The river is the bin.

In 2019, Bali became the first province in Indonesia to ban plastic bags, straws and polystyrene takeaway containers. The Government has also introduced a US$10 fee on every visitor to the island as a waste levy. However, 40 per cent of the garbage created in Bali is still either burnt or dumped.

FIGURE 6 Marine litter on Kuta Beach, Bali

Sungai River Watch

The increasing problem of plastic garbage has instigated numerous organisations and residents to battle the clean-up. Sungai (river) Watch was set up in 2019 by Sam Bencheghib, a local with a goal of 'stopping the endless flow of plastics from going into the sea and prevent our coastline from being so polluted'.

He started by creating a river barrier to trap garbage in a Balinese River. He collected, hand sorted and delivered the waste to a recycling centre (see **FIGURE 7**).

With support from the World Wildlife Fund, Sam started employing people and paying above-base wages. Fifty-five people are now employed to set up barriers, remove the waste daily and then sort and process two tonnes of rubbish daily. **FIGURE 8** shows the results of fourteen months of collection of recyclable material.

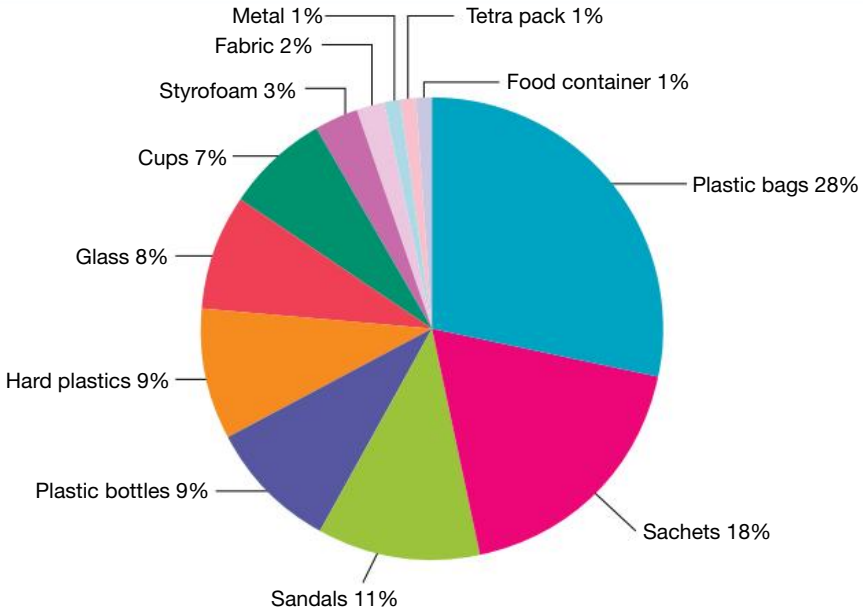
Sungai Watch has now installed 105 barriers across rivers in Bali. The barriers have been designed to allow free movement of fish and cater for rising waters during the monsoon season. There has already been considerable success.

- 333 000 kg of litter has been captured, preventing it from entering the seas.
- Rivers are now visibly cleaner and the volume of garbage trapped by the barriers is reducing, particularly in those villages where Sungai Watch works closely with and educates community leaders.
- The barriers become conversation starters in villages, helping people to realise the importance of clean rivers.
- Analysis of litter collected helps build a data bank for further research.
- Any organic matter (branches, leaves) sorted is converted to compost and sold.
- Any illegal dumping grounds along the rivers with barriers are cleaned up.
- Waste plastics are either sent for recycling or compressed into sheets for re-purposing.

Changing people's views and practices is a slow process, with the ultimate goal not to merely prevent plastic accumulation in the seas but also to change the mindset that put it there.

FIGURE 7 A river barrier collecting litter in Bali

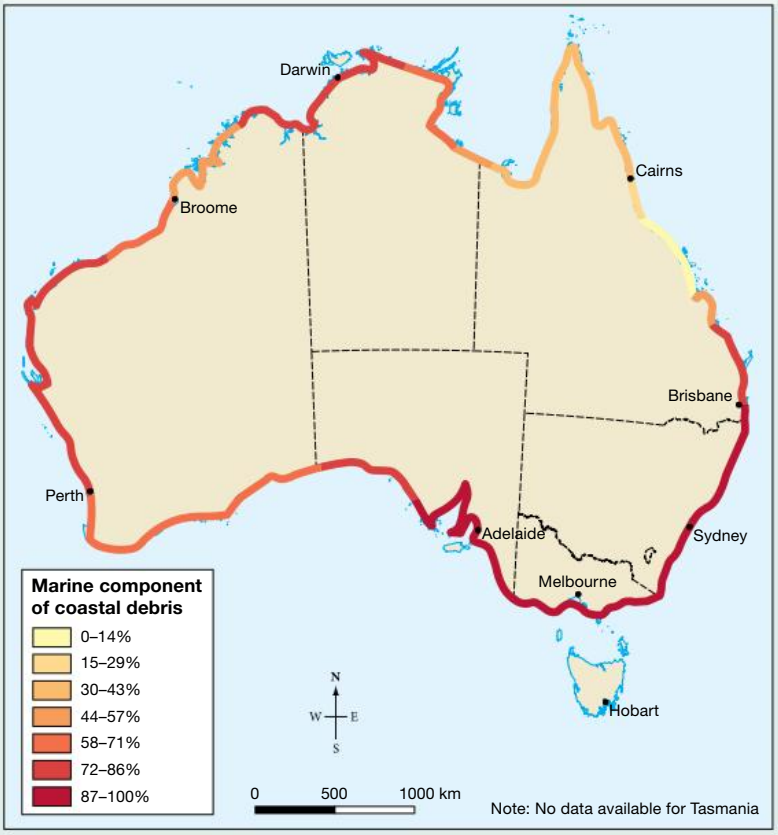
FIGURE 8 Types of recyclable material collected by Sungai Watch



6.6 SKILL ACTIVITY: Interpreting and analysing geographical data and information

Study the map of Australia, which shows the distribution and concentration of marine litter around the coastline.

FIGURE 9 Marine litter distribution



Source: Map redrawn by Spatial Vision © Copyright Commonwealth of Australia 2022, Bureau of Meteorology.

1. Complete the following table to **determine** the percentage of marine litter for each major city.
2. **Identify** the places in Australia that have the highest component of marine litter.
3. Using the knowledge that you gained in this lesson, **suggest** a reason why the highest concentration is found in this region.
4. **Identify** if the regions with the highest concentrations of marine litter are associated with major cities. **Explain** why or why not.
5. **Propose** the factors that seem to influence the degree to which a place might receive marine- or land-based pollution.

City	Percentage components coming from marine litter
Darwin	
Cairns	
Brisbane	
Sydney	
Melbourne	
Adelaide	
Perth	

6.6 Exercise

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6.6 Exercise

Learning pathways

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

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Check your understanding

1. An atoll is best described as:
   - **A.** an area of fringing reef in the open ocean.
   - **B.** an area of shallow water surrounded by deeper water.
   - **C.** a continuous ring of coral reef.
   - **D.** a ring-shaped coral reef or string of islands surrounding a shallow lagoon.
2. Complete the following statement by **selecting** the correct word.
   The Great Pacific Garbage Patch is located in a **moving** / **fixed** position close to the **east** / **west** coast of the U.S.A. The Pacific Gyre current moves in a / an **clockwise** / **anticlockwise** direction.
3. Which of the following would *not* be regarded as an anthropogenic cause for declining marine environments?
   - **A.** Over-fishing
   - **B.** Trampling of coral reefs
   - **C.** An El Niño event in the Pacific Ocean
   - **D.** Sewage disposal into coastal waters
4. Many of the schemes to reduce marine pollution rely on volunteer groups and not-for-profit organisations rather than governments. **Consider** why this might be the case.
5. a. **Identify** an example of a social, environmental and economic factor that has contributed to the build-up of plastic litter in Bali.
   b. **Reflect** on the factor that you think is the most important in explaining the litter problem.

Apply your understanding

Communicating

6. The Balinese Government has installed a US$10 levy on every tourist as a waste levy. **Discuss** the advantages and disadvantages of such a tax.
7. Sungai Watch is attracting sponsorship from businesses such as Bintang Beer, who pay an annual fee of US 210 to have a section of a river barrier branded in their name. **Outline** the benefits this might bring to Sungai Watch.

8. **Consider** how the worldviews of Balinese communities might influence the way in which litter is dealt with in Bali.
9. **Compare** the strategies for managing marine pollution in Bali and the Cocos Keeling Islands using the criteria of success and sustainability. You might like to do this in table form.
10. 'The scale of the problem means cleaning up our oceans is currently not possible, and cleaning beaches once they are polluted with plastic is time consuming, costly, and needs to be regularly repeated as thousands of new pieces of plastic wash up each day.' **Judge** this statement with reference to Cocos Keeling Islands.

LESSON
6.7 What strategies are in place to deal with marine litter?

LEARNING INTENTION

By the end of this lesson you should be able to identify the various ways organisations and community groups are trying to tackle the issue of marine pollution at a range of scales.

TUNE IN

What a mess. Marine litter can end up covering beaches with debris.

FIGURE 1 The sand can't even be seen on this polluted beach.

1. How does **FIGURE 1** make you feel?
2. How do you think this rubbish ended up here?
3. If you and your class were given the task, how would you go about cleaning this up?
4. What could you do, as an individual, to avoid this happening on your favourite beach?

6.7.1 Think global…

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! Doug Woodring, a co-founder of the ocean clean-up charity Project Kaisei, says, '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'.

The problem of marine pollution continues to grow and is harmful not only to marine environments and creatures, but humans as well. A variety of strategies are being used to tackle the issue at a range of scales in different places around the world.

Marine debris might start as a local issue but it can contribute to a global problem as debris may travel great distances from its original source, crossing both geographic and political boundaries. We will only significantly reduce marine debris if we control its land-based sources. Communities and governments need to develop effective waste reduction schemes if we want to manage our oceans sustainably.

It has been suggested that if no action is taken, pieces of plastic in the ocean will outnumber fish by 2050! Every year, people around the world use 5 trillion plastic bags — over 700 a year for every single person on the planet. On average, a person uses a plastic bag for just 12 minutes, but it may then take many, many years for it to decompose, if ever. The scale of the waste issue is huge.

The economic cost of marine litter was estimated in 2021 at US$21.3 billion annually, and this was just related to industries such as the marine tourism industry, fishing/aquaculture and shipping, not the environment.

A recent survey predicted that by 2050, 95 per cent of all sea birds will have plastic in their gut. The environmental changes created by the human–marine interconnection are not going to go away. The anthropogenic worldview of a throwaway culture needs to change to focus on the health of marine environments. Furthermore, many of the 'solutions' focus on plastics as a waste issue rather than a production issue. We need to reduce the amount of plastic being produced and consumed.

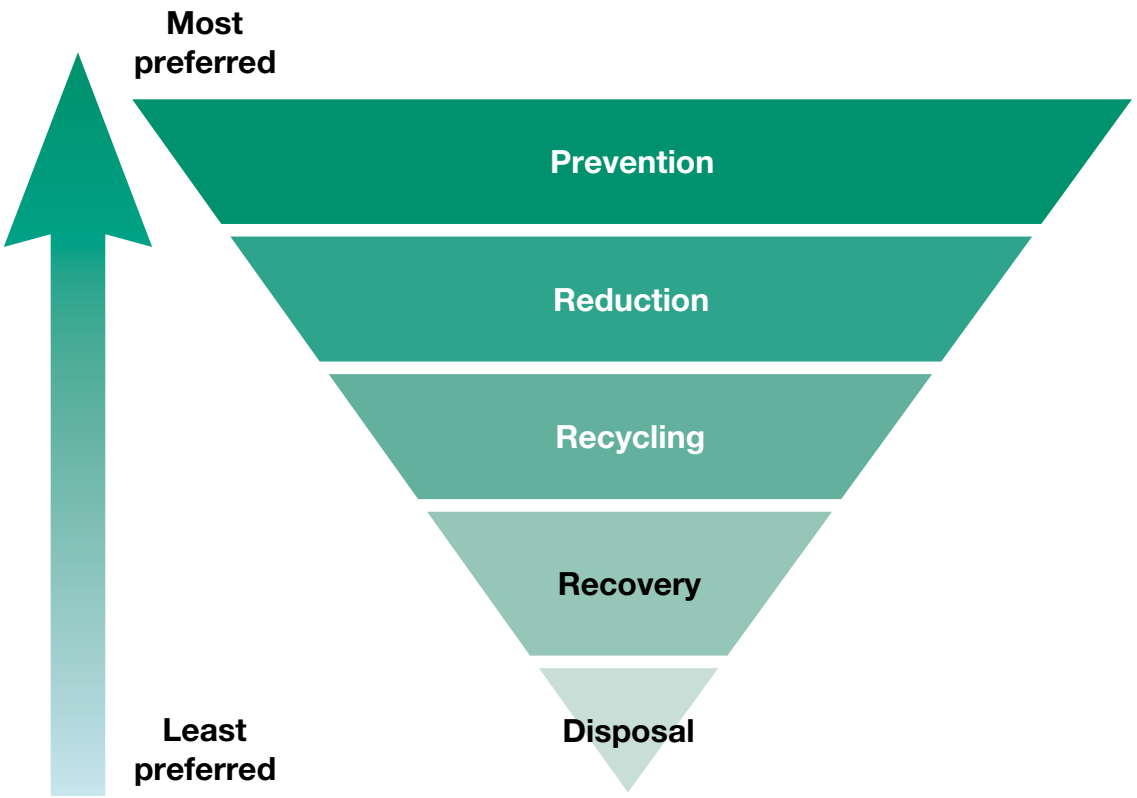
FIGURE 2 What message is this advertisement sending?

6.7.2 What can be done at the national and international scale?

The current law that governs the high seas, The United Nations Convention on the Law of the Sea, was introduced in 1982. Since then, plastic pollution has increased 100-fold and one-third of fish stocks are being overharvested. Technological developments have increased prospecting for natural resources beneath the seabed and climate change is bringing even more threats to marine environments. As not one nation has control over the seas, international cooperation and treaties are very much needed.

The UN 2030 Agenda for Sustainable Development calls for action to 'Conserve and sustainably use the oceans, seas and marine resources' (Goal 14) and 'By 2025, [to] prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution' (Target 14.1). **FIGURE 3** shows a hierarchy of preferred waste management actions.

FIGURE 3 Hierarchy of preferred action on plastics



Marine Protected Areas (MPAs) cover just 7.5 per cent of the oceans, mostly in national waters, while scientists have suggested that at least 30 per cent of the ocean needs to be protected. They are calling for an international treaty to protect places of high biodiversity in 'wilderness' areas of the oceans. Protecting a global network of MPAs could cost anywhere from US$5–19 billion per year. The benefits would include economic benefits from employment, development of ecotourism and restored fisheries.

A unanimous decision was made at a United Nations conference in 2022 and 175 countries agreed to develop an international legal agreement on plastic pollution by 2024. It will include binding and voluntary measures and set targets, and will develop ways to track a country's progress in meeting targets. It should cover:

- limits on plastic production (expected to reach 600 million tonnes by 2040)
- the phasing out of single-use products
- requirements to recycle
- supplying financial assistance to help poorer countries take action.

Marine Protected Areas
areas of the oceans set aside to be conserved for biodiversity conservation, species protection or to protect economic resources. There are strict guidelines on what is permitted in these zones.

Although this has yet to become a legally binding treaty, there are now 80 countries that have a partial or full ban on single-use plastics and microplastics (see **FIGURE 4**).

When Ireland first introduced a plastic bag levy back in 2002, bag usage dropped by 90 per cent. Kenya has gone to extremes, with up to four years in jail or fines of US$40 000 for anyone producing, selling or even just carrying a plastic bag. This has been successful in terms of creating a cleaner environment, but manufacturers and retailers are struggling to adapt and find affordable and environmentally suitable alternatives.

Currently only the United Kingdom, the United States and Canada have banned the use of microplastics, while several other countries such as Australia, India, New Zealand and China are considering a similar action. The United Nations recommend a worldwide ban.

In 2020, Australia banned the export of unprocessed plastics. In 2022, we initiated a new international treaty that would ban the export of plastic waste to other countries. Countries that have traditionally accepted waste often lack regulations and the infrastructure to correctly treat and dispose of waste and it is burnt or discarded instead.

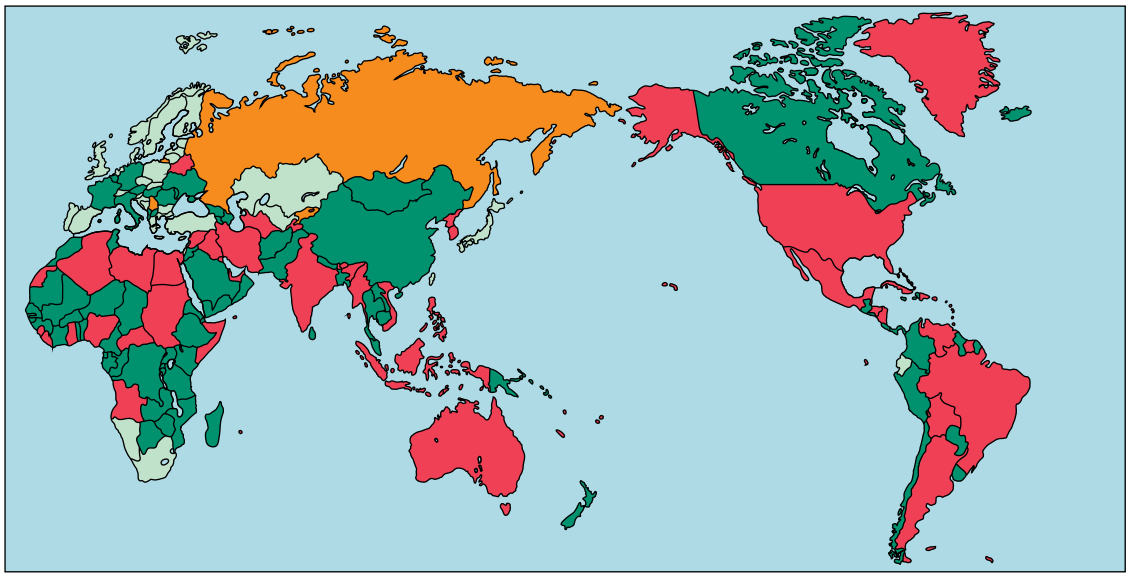
Several countries, such as Great Britain, Canada, the United States and the Netherlands, have now banned the use of microbeads in many products, particularly body scrubs and toothpaste. Other products such as sunscreens and lipsticks have not been included in the ban.

International agreements such as the International Convention for the Prevention of Pollution from Ships (known as MARPOL) forbid ships from disposing plastic into the sea and disposing food waste within 12 nautical miles of land. Although such regulations are an important step in tackling the issue of marine pollution, they are extremely difficult to police and have no impact on the amount of waste entering the ocean from land-based sources.

int-9135

FIGURE 4 Plastic bag bans around the world

The countries banning plastic bags
National-level regulation to ban/limit the use of plastic bags (2021)



* Can also include charges. Some bans not in effect yet
Sources: United Nations, media reports.

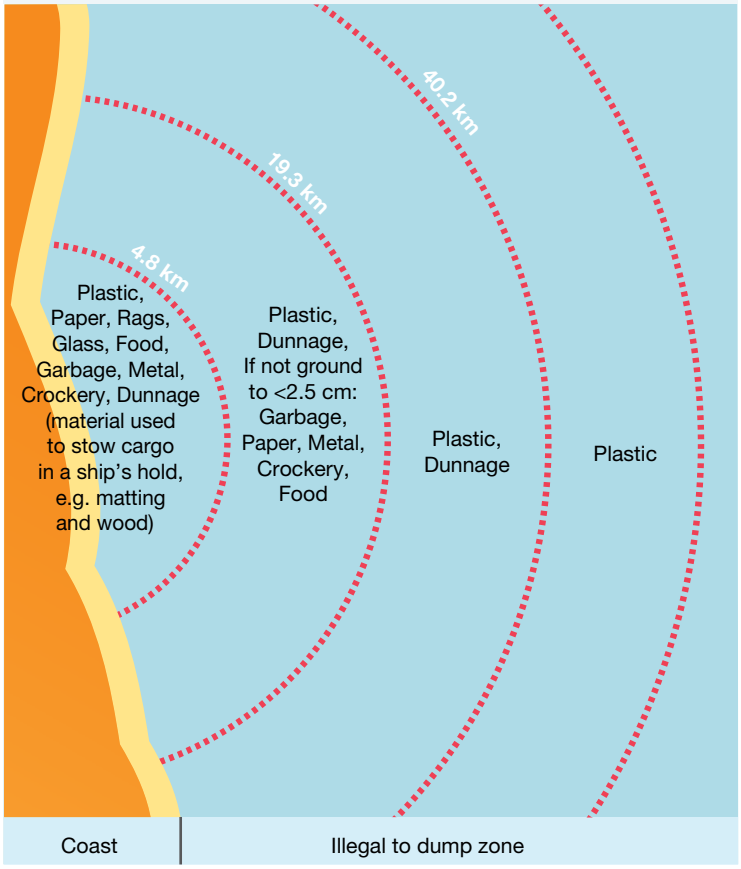
6.7.3 What can communities and organisations do?

Numerous organisations are dedicated to improving our marine environment, working at a range of scales. Much of this is focused on cleaning up marine litter.

International coastal clean-up

A 2021 report highlighted the results of a 2020 clean-up campaign in the United States: 221 589 volunteers collected over 2 million kilograms of litter (8 million total items) along 79 000 kilometres of coastline. The data collected over the years has contributed to new littering laws (see **FIGURE 5**).

FIGURE 5 Marine pollution restrictions in the United States



What can manufacturers do?

In recent years, manufacturers have become much more environmentally aware, with new biodegradable packaging materials and improved recycling methods developed. Several of the large beauty and personal toiletry companies have voluntarily removed plastic microbeads from their products, replacing them with natural, biodegradable 'beads' made from products such as jojoba, coffee, salt and oats.

Examples of individual companies, progress

McDonalds (Australia) is committed to becoming a sustainable industry leader and has phased out plastic cutlery and 500 million single-use plastics straws have been removed from circulation. Plastic lids on dessert cups, drinks and salad bowls, are to be replaced with fibre-based ones, saving 250 tonnes of plastic.

IKEA has pledged to phase out plastic consumer packaging between 2025 and 2028. Today, less than 10 per cent of the total volume of packaging material used annually by IKEA consists of plastics. The company is committed to continuing the movement towards only using renewable or recycled materials.

Volvo is replacing 60 kg of plastic components in their new XC60 SUV car with products made from recycled materials. The centre console is made from renewable fibres and plastics from recycled fishing nets, while the carpets are made from recycled PET bottles.

As an international company, Coca Cola is a target for consumer and environmental groups concerned over single-use plastic containers. It has been regarded as the world's worst plastic polluter for four years running. However, it is actively reducing its use of plastics and today 70 per cent of plastic bottles are made entirely from recycled plastic and 100 per cent of bottles and cans are recycled.

6.7.4 What can we do?

As Australians we all help to consume 3 million tonnes of plastic produced in the country each year. Of that 130 000 tonnes end up in the ocean each year! State governments and local councils are encouraging households to separate their weekly rubbish and recycling bins are provided everywhere. However, there is still a lot of education needed on classifying recycling material. This includes the one million disposable coffee cups that Australians use annually. The cardboard cups are lined with a plastic film. Soft plastic, which you can scrunch easily in your hands, such as food wrap, cannot be recycled via the household bin; you can help cut down on soft-plastic waste by choosing products without it and avoiding use of this type of packaging.

While no one person, organisation or government can stop marine litter, everyone can help reduce it. There are several very effective and simple methods to reduce your plastic footprint. Simply, follow the 4R guide.

Refuse – all single-use disposable plastic (straws, plastic bags, cutlery, drink cups); you might only use it for a few minutes but it is going to stay in the environment for hundreds of years

Reduce – buy products with the least packaging and look for biodegradable options instead. Avoid clothing with plastic microfibres (synthetic fabrics) and bathroom products with microbeads.

FIGURE 6 Plastic bottles awaiting recycling

Reuse – wash and reuse plastic takeaway containers or repurpose them as storage containers. Select lunchboxes and drink bottles that can be used daily.

Recycle – buy products that are made of recyclable material or use the correct bins for recycling (rinse first to avoid contamination).

6.7 SKILL ACTIVITY: Questioning and researching using geographical methods

1. Each student in class is to undertake a plastic container survey at home. Have a class **discussion** to devise a survey sheet that everyone can use. You might consider what constitutes a plastic container and which rooms you will investigate (don't forget places like laundries, bathrooms, garages and garden sheds). It might also be possible to do a plastic survey within the school grounds.
2. Complete your survey and then collate results with the rest of the class to produce final figures.
3. **Create** a suitable graph to display your findings.
4. **Analyse** your completed graph and write a summary paragraph. You might like to consider:
   - which three items were the most common
   - which rooms of the house had the most plastic items.
5. As a class, **determine** how you can promote the idea of reducing plastic use and ultimately plastic marine litter. You may like to **create** a slogan and poster, address a school group or assembly, or write a proposal to the school administration.

6.7 Exercise

learnon

6.7 Exercise

Learning pathways

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

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Check your understanding

1. It is illegal to dump plastic, paper, rags, glass, food, garbage, metal, crockery and dunnage within _____ km of the coast of the US.
2. Which of the following statements best **describes** the map in **FIGURE 4**?
   - **A.** Countries that have fully banned plastic bags are mostly located in Europe and Asia.
   - **B.** Countries that have taxed the use of plastic bags are distributed across all continents with the exception of North America and Asia.
   - **C.** Countries that have banned plastic bags are distributed across all continents except for Australia.
   - **D.** Countries that are considering banning plastic bags are located in Europe.
3. **Determine** whether the following statements are true or false.
   - **a.** The main aim of Marine Protected Areas is to create conservation areas in places of high biodiversity.
   - **b.** International treaties are the most effective way of managing marine environments in territorial waters.
   - **c.** One way in which Australia deals with excess plastic waste is to sell it off to other countries for them to process, recycle and sell on.
   - **d.** Individual companies cannot play any significant role in reducing marine litter.
4. **Identify** four ways that you *personally* can reduce your plastic footprint.
5. **Suggest** ways in which you could encourage others to reduce their plastic footprint.

Apply your understanding

Interpreting and analysing geographical data and information

6. **Analyse FIGURE 4.**
   Consider those countries that have banned the use of plastic bags. **Identify** some of the benefits to both the environment (land and marine) and people of such a ban.

Communicating

7. Study **FIGURE 3. Describe** and **explain** the pyramid.
8. **Consider** how people's worldviews might influence their attitude towards adopting more Marine Protected Areas in the oceans.
9. **Determine** how successful an international agreement where all countries decide to reduce land-based marine pollution would be. **Identify** the advantages and disadvantages.
10. Is the saying, 'Think global, act local' applicable to marine pollution? **Justify** your answer.

LESSON
6.8 Investigating topographic maps: Coral bleaching on Lizard Island

LEARNING INTENTION

By the end of this lesson you should be able to describe how the Lizard Island marine environment has been affected by coral bleaching and give examples from a topographic map.

6.8.1 Lizard Island

int-9136

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 2 Green turtle, Great Barrier Reef

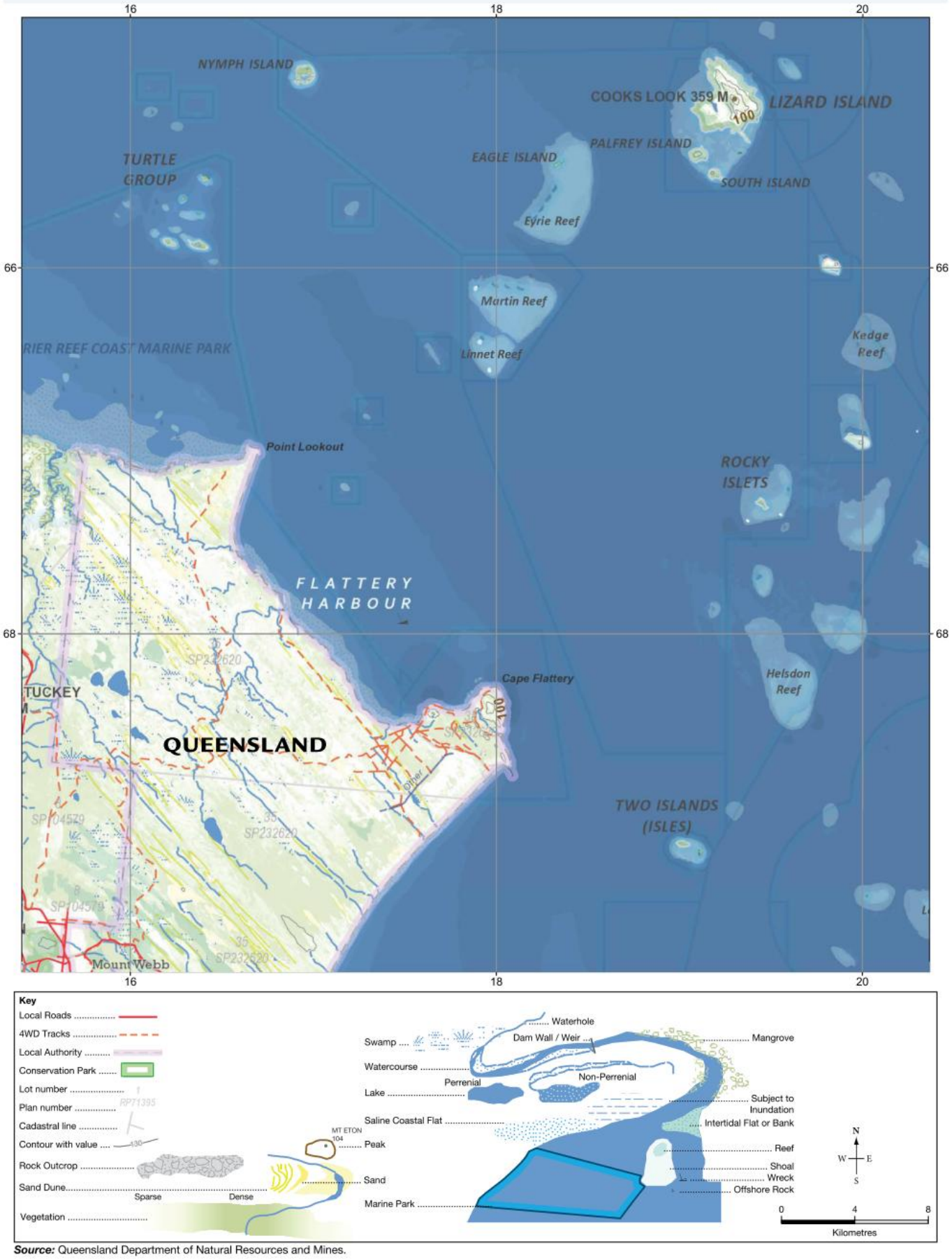
FIGURE 1 Lizard Island zoning

Source: © The State of Queensland

Resources

eWorkbook	Investigating topographic maps — Coral bleaching on Lizard Island (ewbk-10237)
Digital document	Topographic map of Lizard Island (doc-20456)
Video eLesson	Investigating topographic maps — Coral bleaching on Lizard Island — Key concepts (eles-6138)
Google Earth	Lizard Island (gogl-0106)

FIGURE 3 Topographic map of Lizard Island and the Queensland coastline



Source: Queensland Department of Natural Resources and Mines.

6.8 Exercise

learnon

6.8 Exercise

Learning pathways

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

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Check your understanding

1. Refer to **FIGURE 3**. **Identify** the quadrant of the map that Lizard Island is found in.
2. Refer to **FIGURE 3**. **Identify** the direction of Lizard Island from:
   a. Cape Flattery
   b. Nymph Island
   c. Linnet Reef
   d. Helsdon Reef
   e. Point Lookout.
3. **Describe** the relative location of Lizard Island.

Apply your understanding

Interpreting and analysing geographical data and information

4. Examine **FIGURES 1** and **3**. **Explain** why Crystal Beach and North Point on the north-eastern side of Lizard Island might have different zoning to other parts of the Great Barrier Reef and Lizard Island.
5. Refer to **FIGURES 1** and **3**. **Suggest** reasons for the location of the resort on the island.
6. **Identify** how the location of the research station might impact on the activities of tourists in the area.

LESSON
6.9 INQUIRY: 'Plastic-not-so-fantastic' media campaign

LEARNING INTENTION

By the end of this lesson you should be able to identify, describe and communicate information about the issue of plastic waste in our oceans.

Background

It has been estimated that by the year 2050 there will be more plastic than fish in the world's oceans. In less than a century, the wonderfully versatile product that is plastic has become an integral part of our daily lives — from plastic toothbrush to the components in a car. However, its versatility and widespread use have created environmental changes to our marine environments.

The sheer volume of discarded plastic and inappropriate methods of disposal have meant that each year eight million tonnes end up swirling around the world's oceans, threatening marine life and polluting the water and coastlines, and affecting

FIGURE 1 Plastic is life-threatening to wildlife.

industries such as fisheries and tourism. Microplastics, microfibres and microbeads, so small they are nearly invisible, also wash through drains and rivers entering the oceans.

While many countries have stringent rules on plastic waste and efficient disposal and recycling methods, there are still two billion people globally who don't have access to such systems but who still purchase, use and discard plastic items daily.

FIGURE 2 Cleaning up the waste that reaches oceans and beaches is a costly task.

Before you begin

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

Inquiry steps

As a film producer, you have been asked to produce a 2 -to 3-minute media advertisement to raise *public awareness* about the issue of plastic waste in our oceans. The advertisement will be shown on prime-time television and across social media platforms. (An alternative would be to create a PowerPoint presentation.)

Discuss the following:

a. What do you know about marine pollution?
b. How does plastic rubbish change marine environments?
c. How can people/organisations/governments help reduce plastics in the ocean?

Step 1: Questioning and researching using geographical methods

Write your **inquiry question**, based on the focus of the topic.

Discuss with your group (if doing a group presentation) and **decide** on the main points that you want to communicate in your media campaign. Allocate the required tasks among members of your group. Responsibility for researching the different sections should be shared so that all students help in finding the information.

Different group members could be responsible for sourcing images, scriptwriting, preparing the voiceover, editing and background music.

You might like to think about the following:

- What is plastic litter? Where does it come from? How does it end up in the ocean? What happens to plastic in the ocean? What are the impacts of plastics?
- A possible case study that could be included from a specific location (you could either use one of the case studies from the lessons or select a place that has a marine litter problem)
- What is being done about plastic pollution in your case study area or in Australia, and at different scales.

Conduct research so that your advertisement is accurate and factual. Look for data to support your case, such as graphs and maps. Images or short video clips would also be useful.

Make notes of your research and remember to record details of your sources so you can create a bibliography to include in the credits at the end of your advertisement.

Depending on the focus of your advertisement, it could include some of the following:

- Several images that identify the problem of plastic pollution in the ocean
- Several images and/or diagrams or maps that explain how plastics are moved via wind/rivers/waves and ocean currents
- A map to show either the pattern of ocean currents or the distribution of plastic patches, or the countries most responsible for plastic ocean pollution
- An explanation/description of the map(s), diagrams and so on — using data where possible
- Images that highlight some of the impacts of ocean plastic pollution
- Images that can show how people in their everyday life can help reduce the problem of plastic pollution
- A voiceover explaining the issue (as well as a hard copy of the script)
- Background music (optional)
- Closing credits acknowledging members of the production team and their responsibilities/roles, as well as sources of data, images and so on.

Step 2: Interpreting and analysing geographical data and information

Work through your notes and data and **create** a script for your advertisement. Remember that you are trying to educate and raise public awareness about the issue. Support your points with data.

Consider which statistics are going to support your viewpoint clearly and powerfully.

Step 3: Concluding and decision-making

Remember you need to create an informative and visually exciting advertisement that will *provoke thought and promote action by the audience.*

Decide on the language that you wish to use: emotional, factual or entertaining. Finish with a strong **summarising** statement.

Step 4: Communicating

Once you have compiled all the elements for your advertisement, conduct your filming (or create your PowerPoint) and edit.

Check that it meets the aim of educating the viewer and that it flows smoothly within a timeframe of 2–3 minutes.

Complete your self-assessment using the **Inquiry rubric** or access the 6.9 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-40156)

LESSON
6.10 Review

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

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

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6.10.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

6.2 What is so special about marine environments?

- Marine environments cover all seas and oceans, stretching from the high tide mark along the coast to open water, including the surface and interconnection with the atmosphere and land.
- Marine biodiversity plays an important role in providing the ecosystem functions and services that humans derive from the oceans.
- Our oceans are rich in biodiversity; coastal biodiverse 'hotspots' are well known, but open ocean less so, even if they do make up two-thirds of the high seas.
- Like terrestrial environments, marine environments, biodiversity and habitats are susceptible to change, especially as a result of unsustainable human activity.
- Two worldviews on marine environments are 'boom and bust' and 'out of sight, out of mind'.
- A worldview of First Nations Australians is 'Caring for Country', in which oceans and land and all living creatures and interconnected.

6.3 Why is there plastic in the ocean?

- Marine pollution is any harmful product or substance that enters the ocean; most are human pollutants and 80 per cent start off on land.
- Debris is largely solid material that ends up in the sea, the most common material being plastic.
- Marine debris is easily moved around the oceans via currents, and tends to accumulate in large ocean gyres in the centre of the main oceans, or it is washed ashore to litter coastlines.
- Understanding the causes and movement of currents is important for shipping and tracking the movement of nutrients, water temperature and pollutants.
- Countries in Asia are the largest supplier of marine debris, and much of this comes from just eight river systems.

6.4 How does debris change marine environments?

- The marine environment is changed because of human activities.
- Plastics do not biodegrade and only slowly break down into minute particles that can stay suspended or sink. Some plastics take hundreds of years to slowly break down.
- Ocean plastic litter has a detrimental effect on most living marine creatures.
- Humans and human activities such as fish and tourism can be negatively affected by marine plastic pollution.

6.5 How do ghost nets create environmental change?

- Ghost nets are a form of marine pollution that create vast rafts of fishing debris entrapping marine creatures.
- The Gulf of Carpentaria, while isolated from large urban areas, is a major collection region for ghost nets, usually originating from other places.
- Indigenous groups living in the areas where ghost nets are a problem have taken on the responsibility of collecting and dealing with ghost net debris.

- There are a range of different strategies for tracking, retrieving and processing ghost nets.
- Clearing the oceans of ghost nets will require global innovation, commitment and cooperation. Presently there is no international law for ghost nets; instead, it is up to volunteer groups and environmental organisations to clear the seas.

6.6 How is marine debris being dealt with in different places?

- Removing marine litter from oceans, such as the Great Pacific Garbage Patch, is not economically viable and cannot remove as much as is accumulating.
- Coastal plastic litter on the Cocos Keeling Islands has largely been transferred long distances from Indonesia via ocean currents.
- The only practical method of clearing debris from the islands is hand collection and then incineration.
- Even remote, almost unpopulated islands in the ocean are suffering the impacts of marine pollution.
- Indonesia is the second largest contributor to ocean pollution in the world.
- Marine litter on the island of Bali mostly comes from waste dumped inland and carried to the coast via rivers.
- Litter booms across rivers can be effective in reducing marine pollution

6.7 What strategies are in place to deal with marine litter?

- To reduce the amount of marine debris in the world we need to reduce land-based sources.
- This can be done by changing people's mindset and behaviour.
- At international and national scales there is a need to introduce treaties that commit countries to reducing their plastic consumption and finding more sustainable alternatives.
- The industrial and retail sectors also need to reduce their waste and promote recycling and alternative products.
- While no one person, organisation or government can stop marine litter, everyone can help reduce it by following the 4R guide.

6.8 Investigating topographic maps: Coral bleaching on Lizard Island

- Lizard Island marine environment has been affected by coral bleaching. Topographic maps can be used to further understand this.

6.9 INQUIRY: 'Plastic-not-so-fantastic' media campaign

- Plastic litter is a huge problem for oceans and there are different approaches to this globally.

6.10.2 Key terms

anthropogenic caused by humans or their activity

atoll a ring-shaped coral reef or string of small coral islands surrounding a shallow lagoon

Coriolis force a 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.

endemic a plant or animal restricted to a certain place

holistic relating to the whole of something or to the total system instead of just to its parts. The environment is made up of many parts, all interconnected.

hydrothermal vent an opening on the seafloor from which geothermally heated water is released. They are commonly found near volcanically active places.

Marine Protected Areas areas of the oceans set aside to be conserved for biodiversity conservation, species protection or to protect economic resources. There are strict guidelines on what is permitted in these zones.

rafting when small marine creatures attach themselves to floating objects and are moved around by wave and current action

sea mount under-sea mountains, usually formed from volcanic activity on the seabed. They are known for their rich biodiversity.

thermohaline relating to the combined influence of temperature and salinity

6.10.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

How are marine environments threatened and how can they be sustainably managed into the future?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customised worksheets for this topic (ewbk-11502)
Reflection (ewbk-12518)
Crossword (ewbk-12519)

Interactivity Marine environments: change and management crossword (int-7673)

6.10 Review exercise

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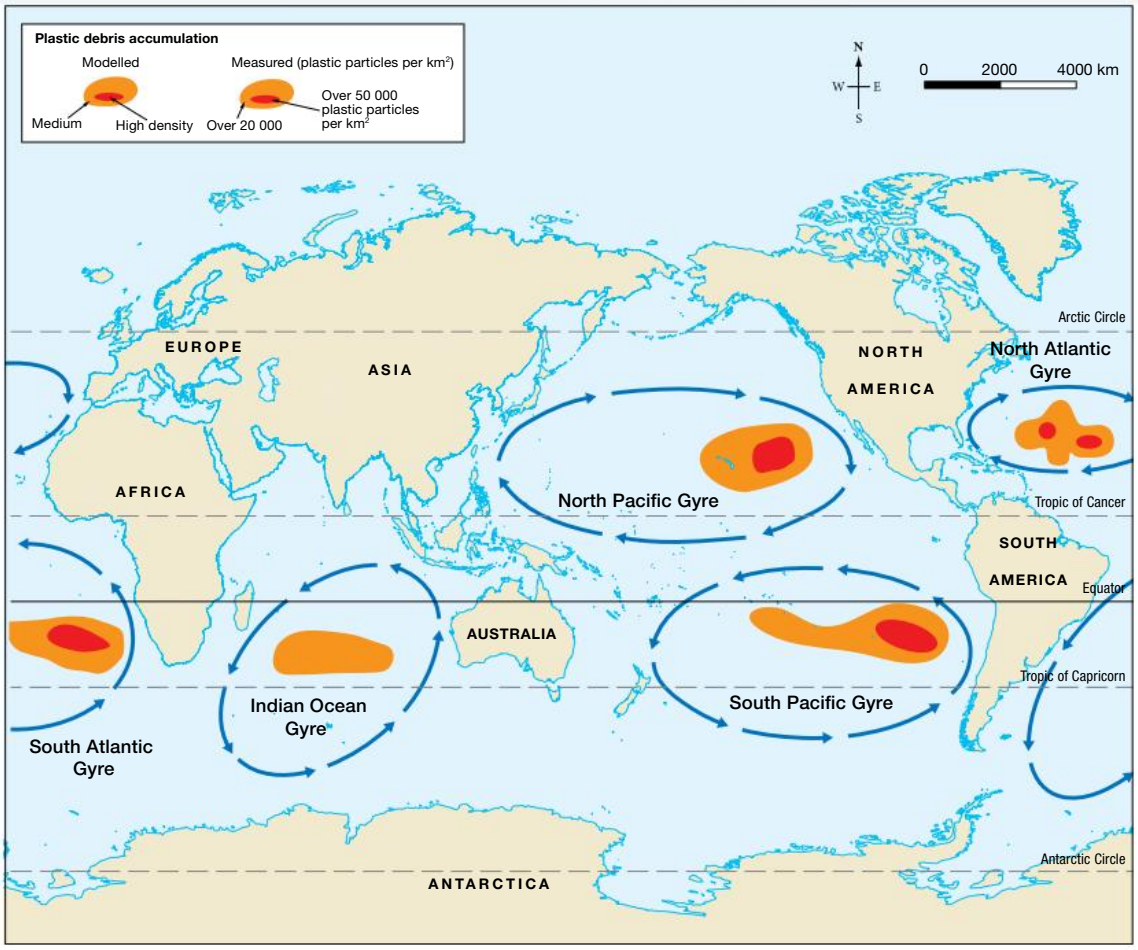
Multiple choice

1. Ocean currents are caused by the
   - A. uneven heating of the world's oceans.
   - B. even heating of the world's oceans.
   - C. movement of shipping channels.
   - D. force of the wind.
2. Which one of the following is NOT a function of an ocean current?
   - A. Distributing water
   - B. Heat
   - C. Nutrients
   - D. Making waves
3. Identify the features of plastic that make it a problem in the ocean.
   - A. It is widely used, light, floats easily, is not biodegradable and can easily be eaten by sea creatures.
   - B. It sinks to the bottom and pollutes the sea floor.
   - C. It is heavy and can knock sea animals over.
4. Select the *three* options that are ways for plastic to enter the food chain.
   - A. It breaks down into micro-fragments.
   - B. Sea creatures mistake the micro-fragments for food.
   - C. Smaller animals eat larger animals and transfer the plastic through the food chain.
   - D. Larger animals eat smaller animals, transferring the chemicals from plastic up the food chain.
5. What is one advantage of dealing with issues of marine debris at an international level?
   - A. It creates global cooperation and could reduce the amount of and impacts of marine litter across all oceans.
   - B. It is difficult to police and enforce.
   - C. It requires a great deal of international cooperation.
   - D. The problem would be greatly reduced if all citizens took more care with their waste.
6. Select the best *two* options to describe ghost nets.
   - A. White-coloured nets that are hard to see in the ocean
   - B. Lost or discarded fishing nets and fishing gear that can drift in the oceans for many years
   - C. Blue-coloured nets that are hard to see in the ocean
   - D. Discarded fishing equipment adrift in the ocean
7. The marine litter that has the longest decomposition period is
   - A. a paper towel.
   - B. a fishing line.
   - C. a plastic bag.
   - D. wool socks.

Refer to **FIGURE 1** to answer questions **8** and **9**.

FIGURE 1 Plastic debris accumulation in the world's oceans



Source: GRID-Arendal. Map by Spatial Vision.

8. Which ocean gyres have the highest concentrations of plastic debris?
   - **A.** North Atlantic and Indian Ocean
   - **B.** South Pacific, North Pacific and South Atlantic
   - **C.** North Pacific and North Atlantic
   - **D.** South Pacific, Indian Ocean and North Atlantic
9. Which ocean gyre has the largest area of plastic debris?
   - **A.** North Atlantic
   - **B.** North Pacific
   - **C.** South Pacific
   - **D.** Indian Ocean
10. The accumulation of plastic litter on the Cocos Keeling Islands is mostly due to:
   - **A.** the Indian Ocean Gyre pushing debris from the coast of Western Australia towards the islands.
   - **B.** the action of currents moving debris from Indonesia in a south-west direction.
   - **C.** debris being moved via the river system to the coast.
   - **D.** littering, particularly by tourists attracted to the coral atoll.

Short answer

Concluding and decision-making

11. 'It is the activities of humans 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 this topic.
12. 'The most effective ways of reducing marine pollution have to start on land.' **Reflect** on our obligations and duties as global citizens to reduce waste and pollution.
13. **Evaluate** the Ocean Cleanup campaign using environmental and economic sustainability criteria.

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7 Urban change and management

LESSON SEQUENCE

7.1 Overview 275
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LESSON
7.1 Overview

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How far can our urban environments spread before they become unsustainable?

7.1.1 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 who seek a better life through the social and economic opportunities available in the big cities.

The complexity of urban environments can be seen in a modern city such as Shanghai, with its high-rise 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 viability into the future, sustainable solutions to the wide range of problems that exist in big cities must be found.

FIGURE 1 Modern cities are complex urban environments.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11508)

Video eLesson Sprawling cities (eles-1712)

LESSON
7.2 How do cities impact the environment?

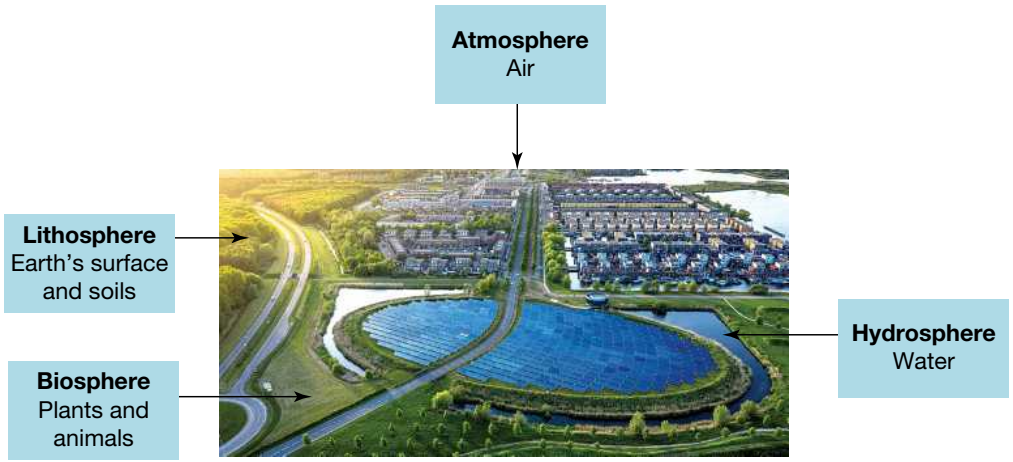
LEARNING INTENTION

By the end of this lesson you should be able to describe the four spheres that comprise the Earth's biophysical environment, and explain the ways in which urban environments interconnect with these elements.

TUNE IN

FIGURE 1 shows a modern sustainable neighbourhood, Almere, in the Netherlands. Note the interaction of the elements of atmosphere, hydrosphere, lithosphere and biosphere.

FIGURE 1 Interaction between the urban physical, human and biophysical environments



1. What do you see in this image that suggests this city in the Netherlands has a good understanding of sustainability with respect to the atmosphere, hydrosphere, lithosphere and biosphere?
2. Do you know of any examples on this scale in an Australian city? If so, name them and give some details.

7.2.1 Interconnections between urban and biophysical environments

The earliest forms of 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.

All forms of urban environment 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.

The biophysical elements impose limits on the development and sustainability of all forms of urban environment. Conversely, 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.

urban environment the human-made or built structures and spaces in which people live, work and recreate on a day-to-day basis

biophysical environment all elements or features of the natural or physical and the human or urban environment, including the interaction of these elements

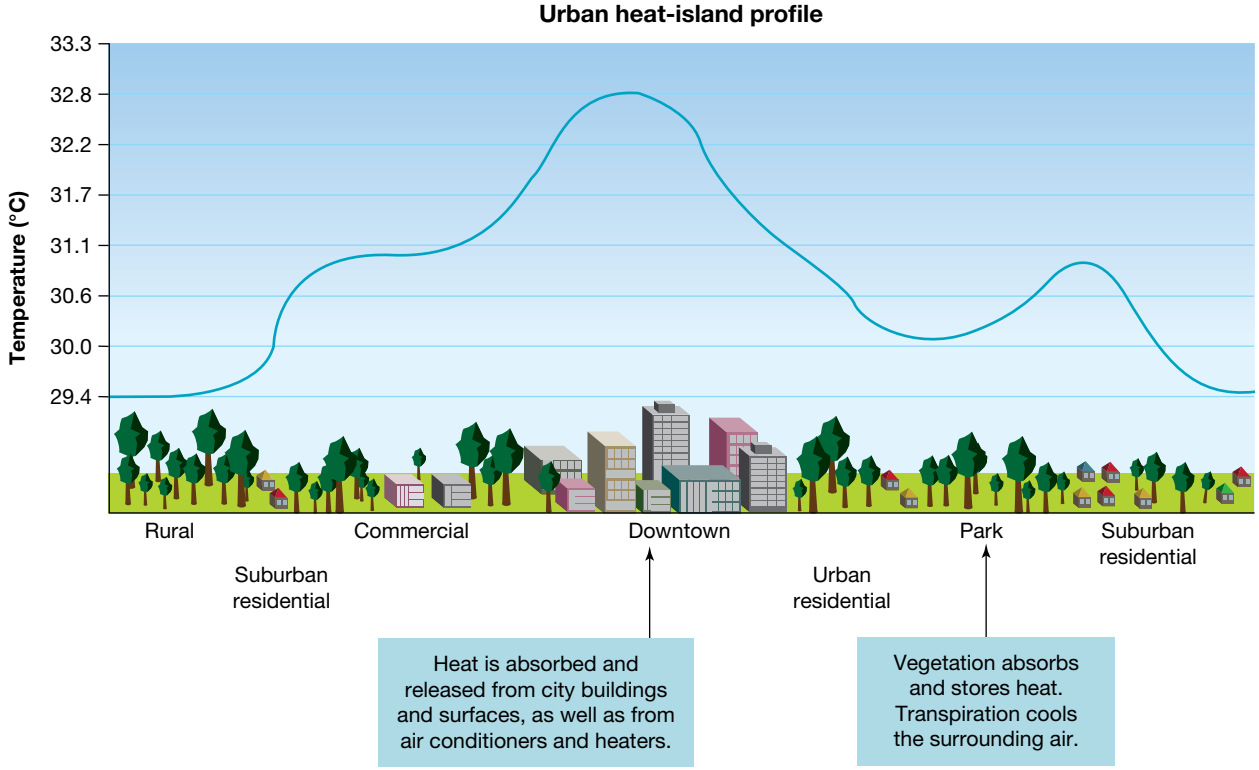
7.2.2 Effects on the atmosphere

Atmospheric pollution can be a problem in urban environments. This occurs when sources of potentially dangerous gaseous emissions are high, such as from buildings, transport systems and industry. Examples of this pollution (such as hazy conditions, photochemical smogs, light and noise pollution, and acid rain) are significant problems. The development of clean-air policies controlling emissions of gases into the atmosphere is important to help combat this. Examples of such measures include the introduction of lead-free petrol, banning the burning of household waste and emission-control systems on factory furnaces.

Cities and industries have huge energy demands, and the by-product of this is heat. When urban environment structures, such as buildings and roads, absorb heat from the sun, this raises the temperature of the city environment compared to rural surrounds (see **FIGURE 2**). This is called the 'heat-island effect'.

The production of greenhouse gases such as carbon dioxide and methane by urban environments is a serious contemporary climate issue. Global warming leading to climate change is largely the result of emissions of these gases into the atmosphere, particularly in large urban centres.

FIGURE 2 The 'heat-island effect' of cities



7.2.3 Effects on the hydrosphere

As the urban environment is closely dependent on the hydrosphere, it is not surprising that **water security** and **water rights** are important objectives for a sustainable future. One of the most important aims for urban planners is to ensure the supply of clean water and to manage the waste water from cities.

In general, all urban centres seek increasing supplies of water for domestic and industrial consumption from rivers, groundwater and, more recently, desalination sources.

water security the reliable availability of acceptable quality water to sustain a population

water rights refers to the right to use water from a water source such as a river, stream, pond or groundwater source

FIGURE 3 Like those of many rivers in the world, the banks and channel of the Brisbane River have been heavily modified by people.

Infrastructure in the form of dams, pipelines and 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 important to monitor, 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.

7.2.4 Effects on the lithosphere

The 'tar and cement' structures that are our cities often cover vast areas of land (the built-up areas of greater Brisbane, for instance, cover more than 15 000 square kilometres).

The associated problems include the disposal of the enormous amount of waste that cities produce, and the impacts on agriculture, plants and animal life in adjacent habitats and ecosystems.

Urban environment surfaces, such as footpaths, roads and carparks, generate two to six times more run-off than a natural surface. Rain that falls on roads and carparks can be contaminated with petroleum residues and other pollutants, which can then find their way into waterways.

FIGURE 4 Dubai International Airport's Terminal 3 is the largest airport terminal in the world; its carpark offers space for 100 000 cars. Consider the run-off generated by this surface.

7.2 SKILL ACTIVITY: Concluding and decision-making

1. **Select** a capital city in Australia.
2. **List** some impacts of rising sea levels on suburbs close to the coast. Some sources to **consider** include government reports, websites and local news articles.
3. **Outline** the social and economic impacts on these suburbs. These include potential property damage and displacement of residents.
4. **Identify** what measures are being taken or proposed to manage the effects of rising sea levels. For example, is there coastal protection infrastructure or restrictions on land use planning?
5. **Summarise** your findings.
6. **Explain** how the social and economic impacts of rising sea levels might be managed.

on Resources

Interactivity Urban impacts on the environment (int-3301)

7.2 Exercise

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7.2 Exercise

Learning pathways

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

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Check your understanding

1. What is the 'bio' part of the biophysical environment?
   - A. Bioscience
   - B. Biological
   - C. Biome
   - D. Biography
2. It is the case that water supplies are a problem for large cities. True or false?
3. Most of the large urban centres of the world have high-rise buildings. True or false?
4. **Outline** what is meant by the 'heat-island effect'.
5. **Give reasons** why urban environments can have such a major impact on the Earth's atmosphere.

Apply your understanding

Questioning and researching using geographical methods

6. **Explain** how rising sea levels, predicted to increase as a result of global warming, might affect the place and space of a city such as New York.

Concluding and decision-making

7. **Predict** how the supply of fresh water will affect the development of cities in the future.

Interpreting and analysing geographical data and information

8. **Consider** how the development of extensive public transport systems affects the environment. How can such systems lead to a more sustainable urban environment?
9. **Investigate** and contrast the sustainability of car use with public transport in terms of positive and negative effects on the environment.

Concluding and decision-making

10. **Determine** ways that the biodiversity of plant species might be increased in an urban area.

LESSON
7.3 How do urban environments develop?

LEARNING INTENTION

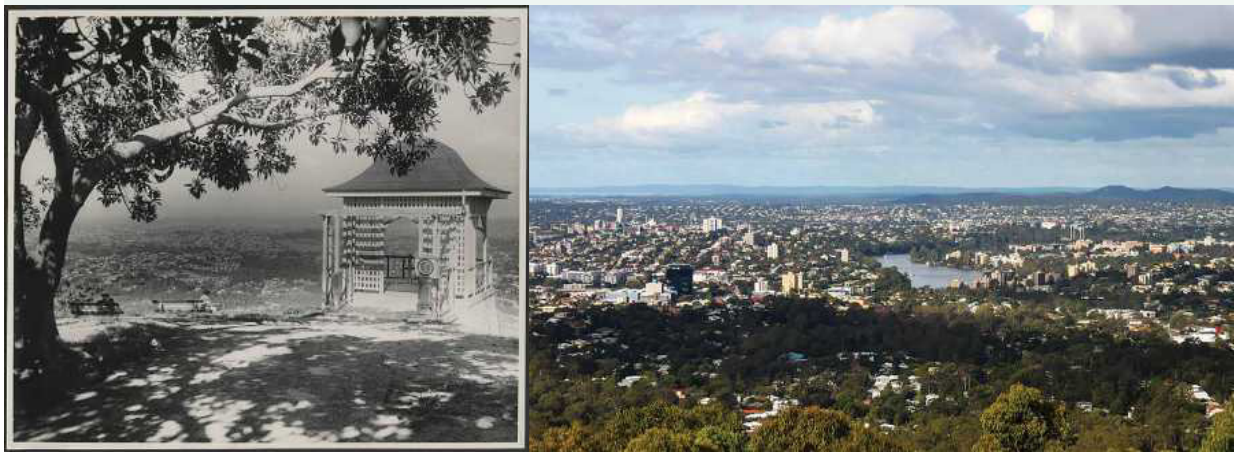
By the end of this lesson you should be able to describe how cities have developed over time, identify where the world's biggest cities and the regions with a high proportion of urban dwellers are and explain some of the impacts of urban growth.

TUNE IN

Cities develop over periods of time, and this is the case for Brisbane, which was established as a town in 1823, and has developed into a significant metropolis.

Compare the two photographs of Brisbane. What changes do you notice?

FIGURE 1 Development of the city of Brisbane as seen from Mt Coot-tha, 1937 and today



7.3.1 Expansion 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, traders, government officials and craftspeople, and were dependent on agriculture and domesticated animals from surrounding rural areas. Over time, cities change; some will grow and others will decline.

Before 1800, over 90 per cent of the world's population lived in rural agriculture-based societies. With the **Industrial Revolution**, people began to move from rural areas to find employment in the factories of the rapidly expanding industrialised cities. In 1850, only two cities in the world — London and Paris — had a population above 1 million. By 1900 there were 12, by 1950 there were 83 and by 1990 there were 286. In 2022, more than 570 cities had populations of a million or more people; over half the global population now lives in urban areas.

Industrial Revolution the period from the mid 1700s into the 1800s that saw major technological changes in agriculture, manufacturing, mining and transportation, with far-reaching social and economic impacts

megacity a settlement with 10 million or more inhabitants

Megacities

The term '**megacity**' commonly refers to urban settlements of 10 million inhabitants or more. Currently, about 530 million people live in 33 megacities across the world. By 2030, the world is projected to have 43 megacities that will be home to more than 750 million people.

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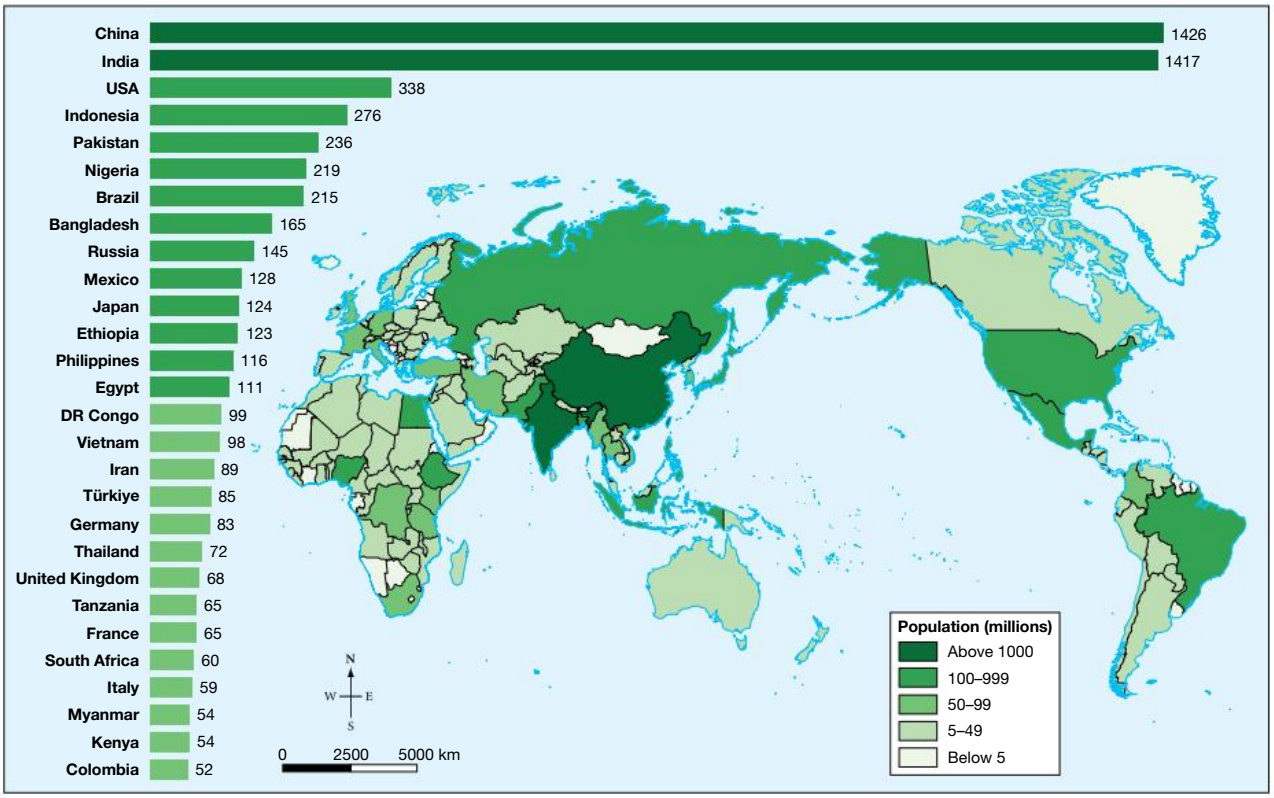
FIGURE 2 Distribution of the world's population, 2022



Source: Map redrawn by Spatial Vision, based on information taken from United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects: The 2022 Revision, Medium Variant.

Of the 20 largest megacities, only six are located in highly developed industrialised countries: Tokyo–Yokohama, Seoul–Incheon, New York, Osaka–Kobe–Kyoto, Moscow and Los Angeles. Three-quarters of the world's megacities are in developing countries; they include gigantic **conurbations** such as Jakarta, Manila and Karachi (see **FIGURES 3** and **4**).

Asia has by far the greatest proportion of the world's large urban area population. Regions such as Oceania and Africa are less urbanised (see **FIGURES 3, 4** and **5**). For example, in Papua New Guinea (Oceania) and Burundi (East Africa) only 10 per cent of the population is urbanised, whereas in Singapore this figure is 100 per cent.

7.3.2 Impacts of the growth of urban environments

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. 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 from rising sea levels. The application of **human–environment systems thinking** will be the key to evaluating and solving these economic and social issues.

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

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

urban sprawl the spreading of urban developments into areas on the city boundary

infrastructure the basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society

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

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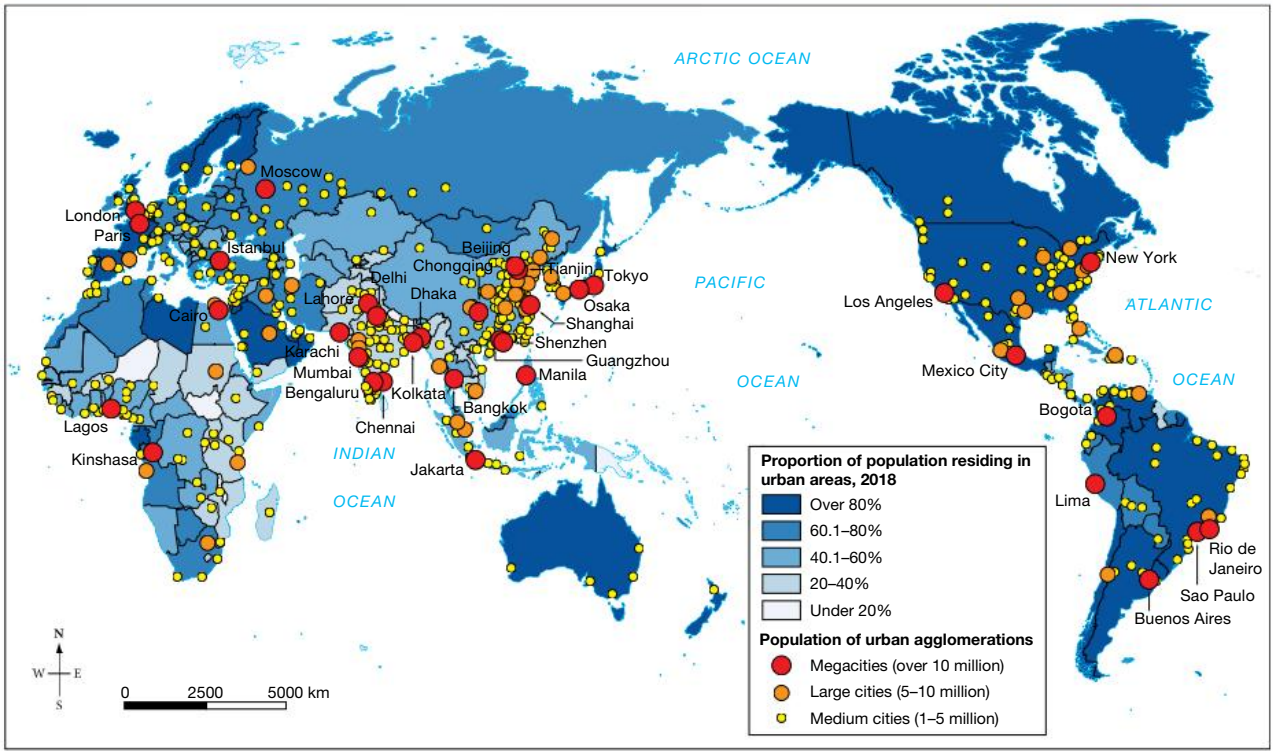
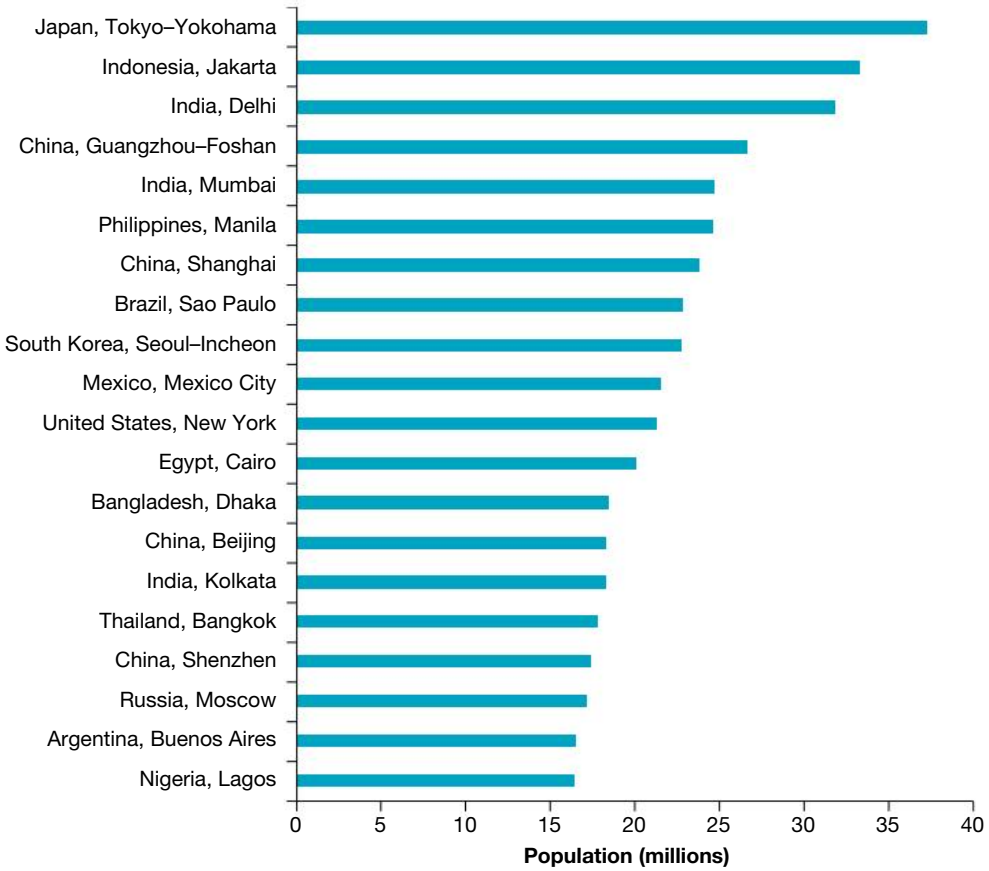
FIGURE 3 Percentage of urban population and urban agglomerations, 2018



Source: United Nations Department of Economic and Social Affairs; Worldatlas.com.

int-9137

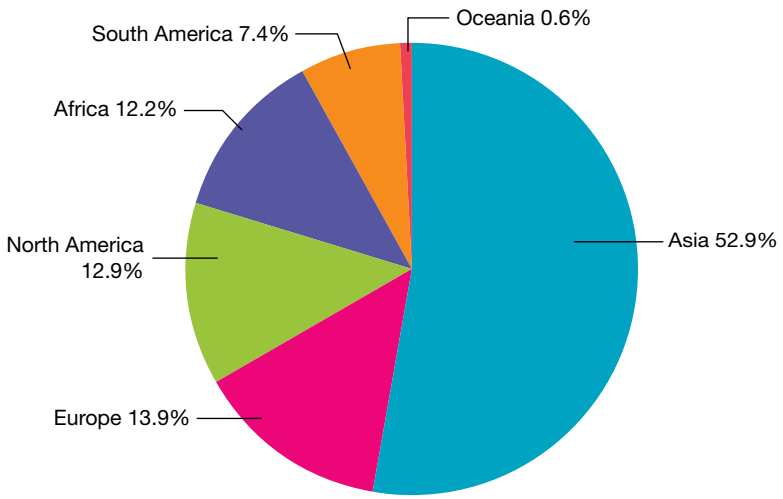
FIGURE 4 Urban areas with more than 16 million population, 2022



Source: Demographia World Urban Areas http://www.demographia.com/db-worldua.pdf

The United Nations estimates that a staggering 90 per cent of the world's population growth is taking place in the cities of developing nations. For many people in these countries, pressures such as extreme poverty, famine and civil unrest often 'push' them away from rural areas towards cities, to which they are 'pulled' by the promise of jobs, shelter and protection.

FIGURE 5 Proportion of global built-up urban area population, by region, 2022



***Source**:* Demographia World Urban Areas http://www.demographia.com/db-worldua.pdf

FIGURE 6 Contrasts in urban development in the capital of the Philippines, Manila

7.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

Find out more about the natural and human influences on the development of cities.

- Natural factors include climate, topography, and access to resources like water and land.
- Human factors that influence the development of cities include population growth, economic development, culture and religion, and technological advancements.

Examples for research could include: Canberra, Australia (a planned city); Cape Town, South Africa (a port city); Rothenburg, 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).

1. **Identify** one city for further research.
2. **Select** pictures or videos of the city and **create** a presentation or a poster that shows the natural or human influence on the development of your chosen city.
3. **Explain,** in a presentation, the natural and human influences on the development of your city. Use examples and visuals from your poster or presentation as evidence.

7.3 Exercise

learnon

7.3 Exercise

Learning pathways

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

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Check your understanding

1. The first cities developed where? **Select** all options that apply.
   A. America **B.** Mesopotamia **C.** Egypt **D.** China
2. Which regions of the world are urbanising most quickly?
   A. Africa **B.** America **C.** Asia **D.** Europe
3. **Determine** whether the following statements are true or false.
   a. After the Industrial Revolution, cities experienced rapid decline.
   b. A conurbation is an urban area formed when two or more towns or cities spread into and merge with each other.
4. **Identify** the factors driving the process of urbanisation in the world.
5. **Discuss** some of the major economic and social issues facing rapidly developing cities in the world.

Apply your understanding

Questioning and researching using geographical methods

6. Refer to **FIGURE 2**. **Name** the world's two most populous nations.

Interpreting and analysing geographical data and information

7. Study **FIGURE 3**. **Identify** what proportion of the Australian population lives in urban areas. **Explain** why this is so, despite the fact that Australia has no megacities.
8. **Identify** what impact you think global warming and rising sea levels will have on coastal cities around the world.
9. **Determine** some other urban problems, besides those mentioned in this lesson, that arise as cities develop.

Communicating

10. **Discuss** what 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?

LESSON
7.4 Case studies in urban growth: Melbourne and Mumbai

LEARNING INTENTION

By the end of this lesson you should be able to identify the issues associated with urban growth by looking at two case studies — one in Australia (a developed country) and the other in India (a rapidly developing country).

TUNE IN

High rise living is popular in the megacities of the world. Melbourne is a prime example of a megacity that relies heavily on high rise living to accommodate such a concentrated populated.

The apartments shown in **FIGURE 1** are an example of high-rise housing in a large-scale urban renewal project at Docklands in Melbourne.

1. What are the advantages and disadvantages of living in a high-rise building?
2. Would you like to live in a high-rise building? Give your reasons why or why not.

FIGURE 1 Apartments at Docklands in Melbourne

7.4.1 CASE STUDY: Ever-sprawling Melbourne

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?

Today, the Melbourne metropolitan area sprawls over just under 10 000 square kilometres and has a population of over 5.1 million. It is one of the fastest growing Australian capital cities, increasing at a rate of 150 000 people per year or an average annual growth rate of 3 per cent. Although this was slowed by the impacts of the COVID-19 pandemic, in 2019–20, Melbourne still had the largest growth (80 100 people) of any Australian city, while Brisbane had the fastest growth rate that year of 1.9 per cent.

By the year 2050, Melbourne's population will increase to over 8 million, with a need for more than 500 000 additional households. To house this number, urban planners essentially have two choices. One option is the **urban infilling** of land in the inner and middle suburbs. This can be done by dividing older larger blocks into smaller new blocks, by the **urban renewal** of old industrial sites, or by building up

urban infilling the division of larger house sites into multiple sites for new homes

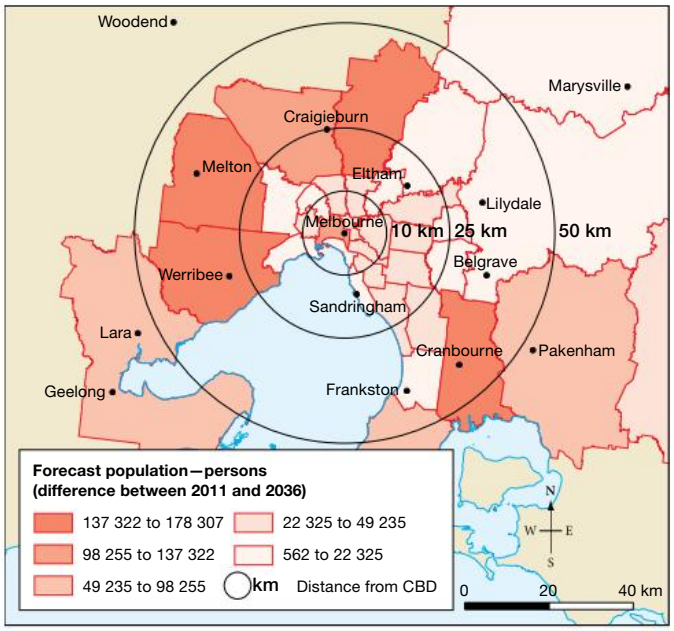
urban renewal redevelopment of old urban areas, including the modernisation of household interiors

and increasing population density with medium- or 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.

int-9138

FIGURE 2 Future population growth for Melbourne



***Source**: © The State of Victoria, Department of Environment and Primary Industries 2013 © Commonwealth of Australia Geoscience Australia 2013.*

Increasing 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 apartments (three to five storeys) built along main transport routes.

Impacts of changes 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, is 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.

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. In recent years, new suburbs planned for Melbourne have included Diggers Rest, near Sunbury; Lockerbie, near Greenvale; Manor Lakes, in Wyndham; Merrifield West, in the city of Hume; and Rockbank North, near Melton. In 2019, the Victorian government rezoned more land to enable 50 000 new homes to be built in new suburbs across Melbourne's north, north-west and south-east. These new suburbs require the development of infrastructure such as shopping complexes, medical centres, open spaces, schools and recreation facilities.

Loss of fertile farmlands

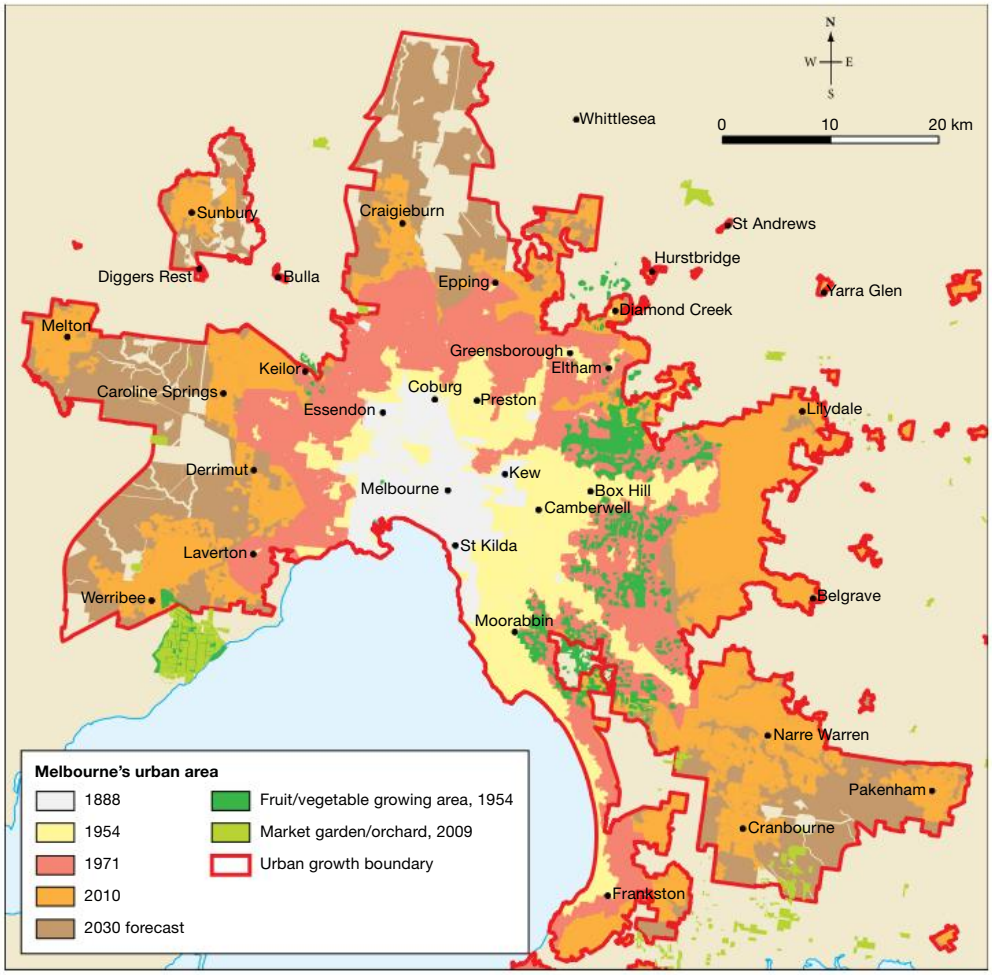
Arguably the largest issue associated with urban sprawl is the loss of fertile farmlands. The Casey Council, 48 kilometres south-east of Melbourne's city centre, initially resisted moves for subdivision of farmlands at Clyde, arguing that the sandy loam soils that produce most of Melbourne's fruit and vegetables should be set aside for growing food, not houses (see **FIGURE 3**).

As one newspaper article 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?'

rural–urban fringe the transition zone where rural (country) and urban (city) areas meet

int-9139

FIGURE 3 Growing over our food



Source: © The State of Victoria, Department of Environment and Primary Industries 2013.

Some local farmers had different viewpoints on this matter because rezoning their properties into the urban boundary immediately boosted the value of their land. These farmers preferred to relocate further out and reap the financial gains from the sale of the land for housing.

Inevitably, the pressure of population and the expansion of nearby suburban development has meant that many of the farms are now gone.

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. As such, planners now 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.

The benefits of wetlands include:

- acting as flood retention basins and receiving and purifying stormwater run-off from residential areas
- providing habitats that can increase plant and animal biodiversity
- providing recreational opportunities.

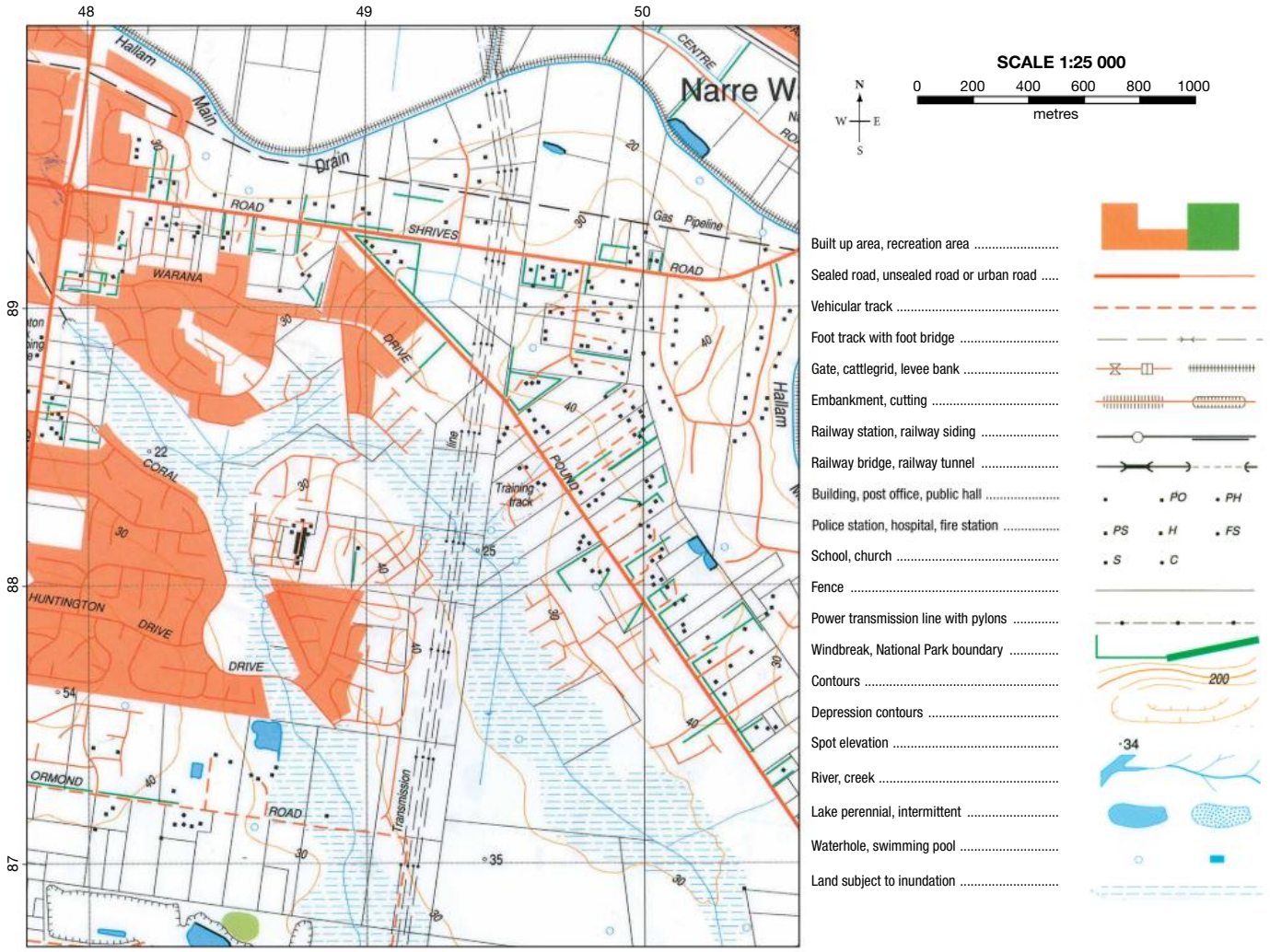
A recent development in the city of Casey is the establishment of a green zone at the Royal Botanic Gardens, Cranbourne which features plants and ecosystems of south-eastern Australia. Certain ideas for these gardens were inspired by the Royal Botanic Gardens Melbourne Aboriginal Heritage Walk. This walk displays traditional plant uses, customs and ongoing connection to Country of the Kulin Nation and is escorted by First Nations guides.

FIGURE 4 Royal Botanic Gardens, Cranbourne

Rural–urban fringe change: Narre Warren

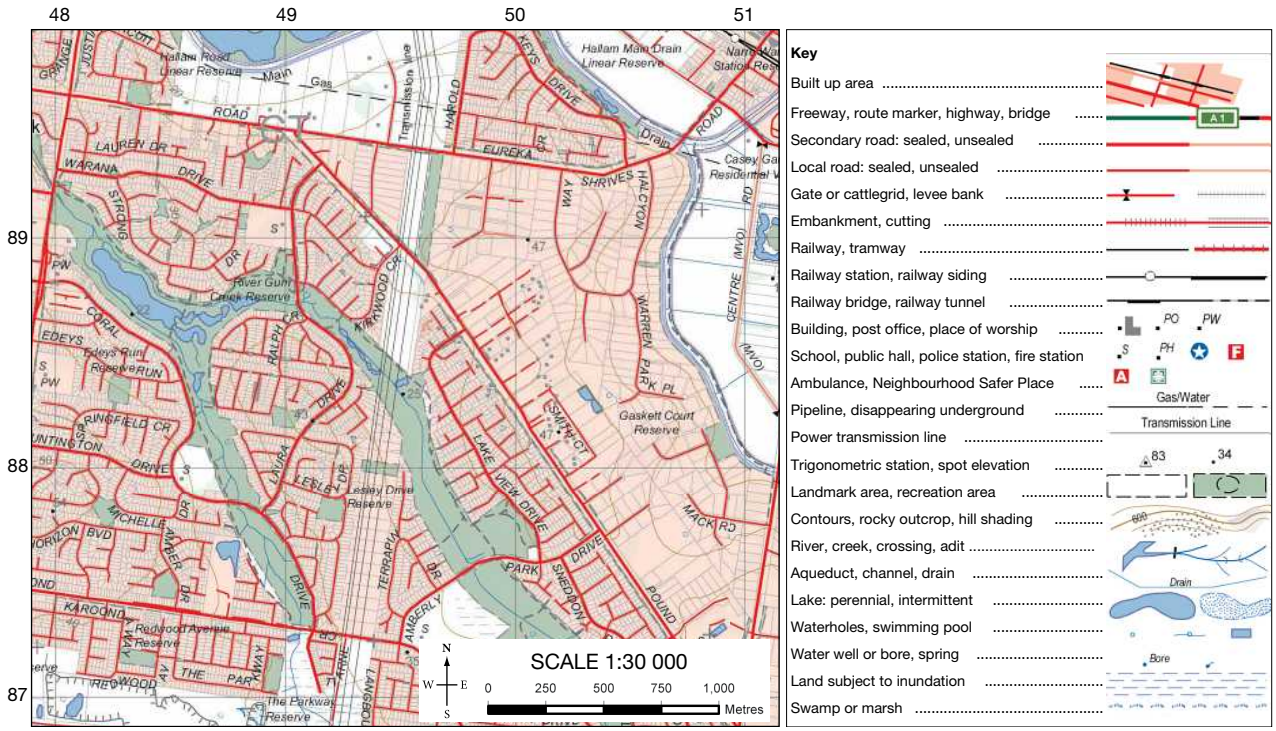
Narre Warren is a Melbourne suburb located some 40 kilometres south-east of the city centre (shown in **FIGURE 5**).

FIGURE 5(a) Topographic map extract of Narre Warren, 1966



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

FIGURE 5(b) Topographic map extract of Narre Warren, 2020



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The suburb is an example of urban-fringe development, where blocks vary in size and are more affordable for first-home buyers and young families. This area has seen what was a semi-rural town become part of a major growth corridor to the south-east of Melbourne. The development of this suburb, along with other nearby urban developments, led to the loss of farmlands over the years. This loss has been counteracted to an extent by the 'Green Zone' of the Cranbourne Botanic Gardens.

Narre Warren has a population of around 27 750, with an average age of 35 years. According to 2021 Census data, there are over 7400 families and 9500 private dwellings in the suburb. Narre Warren sits within the local government area of the City of Casey. This growing municipality was home to around 358 000 people in 2021, but this figure is expected to grow to more than 549 000 by the year 2041. **FIGURES 5(a)** and **(b)** show the changes to the Narre Warren environment between 1966 and 2020.

7.4.2 CASE STUDY: The growth of Mumbai

Located in the western Indian state of Maharashtra, Mumbai is the most populous city in India and the seventh-most populous city in the world, with a metropolitan population of over 20 million in 2023. 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 of its residents live in squalor.

gross domestic product (GDP) the value of all goods and services produced within a country in a given period, 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, and its potential to offer a higher standard of living, attract migrants from all over India seeking employment and a better way of life. In turn, this has made the city a melting pot of many communities and cultures. In 2020,

the metropolitan density was estimated to be around 5603 persons per square kilometre, and the living space just 10 square metres per person.

TABLE 1 Population growth in Mumbai

Census	Population	% change
1971	6 655 771	–
1981	9 513 848	40
1991	12 708 725	32
2001	16 496 409	29
2011	18 464 334	13
2021	20 667 656	12

Source: Based on Government of India Census, conducted every 10 years.

Despite government attempts to discourage the influx of people, the city's population grew by more than 13 per cent between 2001 and 2011, and by 12 per cent between 2011 and 2021 (see **TABLE 1**). The number of migrants to Mumbai from outside Maharashtra during the ten-year period from 2001 to 2011 was over 1 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. As of 2017, an estimated 62 per cent of the city's inhabitants lived in slum conditions. Some areas of Mumbai city have population densities of around 46 000 per square kilometre — among the highest in the world.

slum rundown area of a city with substandard housing

Challenges

FIGURE 6 Mumbai train rush hour

Mumbai suffers from the same major urbanisation problems that are 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 or clogged roadways (see **FIGURE 6**). Although many live in close proximity to bus or train stations, suburban residents spend a significant amount of time travelling southwards to the main commercial district.

The Dharavi slum

FIGURE 7 Dharavi in central Mumbai

Dharavi, Asia's second-largest slum, is located in central Mumbai. Stretching across 2.2 square kilometres of land, it is home to more than 1 million people (see **FIGURE 7**). In Dharavi, it is estimated that there is only one toilet for every 200 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 significantly higher in Mumbai's slums than in upper- and middle-class areas.

Dharavi's recycling entrepreneurs

Hidden amid Dharavi's labyrinth of ramshackle huts and squalid open sewers are an estimated 20 000 single-room factories, employing around a quarter of a million people and turning over a staggering US$1 billion each year through recycling and other trades, such as the production of pottery, textiles and leather goods.

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 rather a necessity of life.

FIGURE 8 Ragpickers in Dharavi, Mumbai

In India, it is estimated that anywhere between 1.5 million and 4 million people make their living by recycling waste. At least 300 000 of these live and work in Mumbai. These people are known as 'ragpickers' and are made up of India's poorest and most marginalised groups (see **FIGURE 8**). 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 even be collected, let alone sorted or recycled. 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.

An uncertain future

There are plans to demolish and redevelop Dharavi, 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.

However, many Dharavi residents do not support 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 a redeveloped life.

DISCUSS

Most Australians would probably perceive slums negatively. Comment on whether the role of ragpickers and the recycling that takes place in Dharavi support a more positive perception of slums.

on Resources

Interactivity Changes on the rural–urban fringe (int-3302)

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

Search for and watch some of the YouTube videos about Dharavi. **Create** a one-page infographic detailing life in the slum. **Consider** questions such as:

- How many people live here and what are living conditions like?
- What work is done here?
- What are the risks to health and what could be done to improve the situation?

7.4 Exercise

learnon

7.4 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 3, 4, 6	2, 5, 8	7, 9, 10, 11, 12

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Check your understanding

1. **Identify** the two main ways that additional housing can be established in an expanding city.
   - A. Urban infilling
   - B. Urban renewal
   - C. Urban planning
   - D. Urban sprawl
2. **Classify** each of the following impacts of expansion into the rural–urban fringe as either environmental, social or economic factors.
   - Ensuring access to recreation facilities such as playgrounds, parks and gardens.
   - Providing green zones such as parks and gardens for native wildlife and recreation purposes.
   - Providing housing assistance schemes for young families to encourage building and make housing more affordable.
   - Encouraging a feeling of community by developing schools, community and service centres.
   - Developing rapid and inexpensive public transport systems and roadways to avoid congestion during peak transport times.
   - Developing wetlands to manage stormwater run-off and provide aquatic environments for native water birds, fish and crustaceans.
3. **Analyse FIGURE 3**.
   - a. **Clarify** 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. **Identify** what would be the advantage of market gardens being located close to urban areas.
   - c. **Predict** the future location of this land use in Melbourne in 2030.
4. Study **FIGURE 2. Describe** the location of the suburbs of Melbourne that are expected to show the greatest increase. What is the average distance of these suburbs from Melbourne's CBD?
5. **Study FIGURE 5(a)**. There is evidence to suggest that this area is part of the urban–rural fringe. True or false?
6. **Identify** the various challenges that Mumbai faces.

Apply your understanding

Interpreting and analysing geographical data and information

7. **Create** a table to compare the social, environmental and economic impacts of urban sprawl with those of urban infilling and increased high-density living.
8. **Examine FIGURE 5(b)**.
   - a. The area at GR485880 is subject to flooding (inundation). **Suggest** two pieces of evidence from the map that explain why this is the case.
   - b. **Identify** how planners have used the flood-prone land when designing the housing estate.
9. Study **FIGURE 5(b).** List and give any new forms of infrastructure established. **Consider** schools, shopping centres, parks and transport.

Concluding and decision-making

10. **Suggest** one human and one environmental factor that would make Narre Warren suitable for a housing estate.
11. **State** what you believe are the economic, social and environmental benefits of ragpickers.

Communicating

12. **Discuss** the advantages and disadvantages of replacing slums with high-rise low-income housing.

LESSON
7.5 What factors contribute to urban decline?

LEARNING INTENTION

By the end of this lesson you should be able to explain the environmental and human factors that can lead to the decline of urban environments.

TUNE IN

Gary, Indiana was established in 1907 by US Steel and once had a population of close to 200 000. The population in 2014 had declined to 78 000 and 13 000 properties were said to suffer 'urban blight' as they were abandoned.

1. Would it be possible to renovate this cathedral? How much money do you think you would need and where would you get it from?
2. Do you know of any towns that have suffered decline or are being abandoned?
3. What reasons could explain the decline of a city or town?

FIGURE 1 The abandoned remains of the once majestic Gary Cathedral, Indiana, USA

7.5.1 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. Some cities such as Gary, which was a major steel-producing city in the United States, have gone into decline due to changes in economic circumstances. Gary, the hometown of Michael Jackson, has been referred to as being in the 'rust belt' of the USA (see **FIGURE 1**). Longer-term events, such as **desertification** and climate change, can also have negative impacts.

Movements of the Earth, such as those due to earthquakes and volcanic eruptions, can also destroy urban environments. One well-documented example is the eruption of Mt Vesuvius in Italy in 79 CE, which completely buried the cities of Pompeii and Herculaneum under volcanic ash.

Tsunamis are also a significant hazard that can lead to the destruction of settlements. On 22 December 2018, for example, the coastline regions of Banten

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

and Lampung in Indonesia were devastated by a 3-metre tsunami triggered by an underwater landslide following the volcanic eruption of Anak Krakatau.

Hundreds of lives were lost and many villages were destroyed. Residents were forced to relocate until restoration works could be completed. Similarly, as a result of a massive earthquake and resultant tsunami in Japan in 2011, towns such as Otsuchi underwent significant change. Thousands of people simply left the region — the lack of employment opportunities and the risk associated with living in a disaster-prone region combining to drive people to move elsewhere.

7.5.2 Human factors

Human factors, which include changes in the social, economic and political elements of a region, can also be a cause of the decline of cities and their urban environment. The destructive effects of war on the social fabric and economy of a nation, which have significant impacts on urban environments, are one example.

Angkor, the capital 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. The destruction of its economy, which was based on management of water and rice production, meant the city was no longer viable. The elaborate Khmer temples constructed in the twelfth century (see **FIGURE 2**) have now become popular tourist attractions; more than 2 million people visit these sites each year.

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, and **economic downturn**. An example of an urban project that failed due a downturn in the Turkish economy is that of Burg Al Babas. The residential housing project started in 2014 but halted when the developers went into bankruptcy in 2018; the chateau-style houses remained unoccupied in 2023 (see **FIGURE 3**).

economic downturn a recession or downturn in economic activity that includes increased unemployment and decreased consumer spending

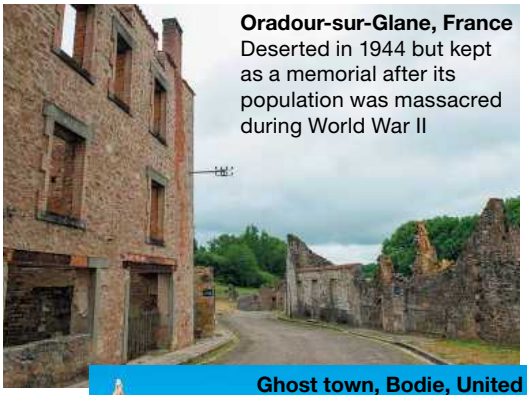
Other examples of urban environments that have declined due to human-induced factors can be seen in **FIGURE 4**.

FIGURE 2 Main temple complex, Angkor Wat, Cambodia

FIGURE 3 Burj Al Babas, Türkiye, is a ghost town due to a downturn in the economy.

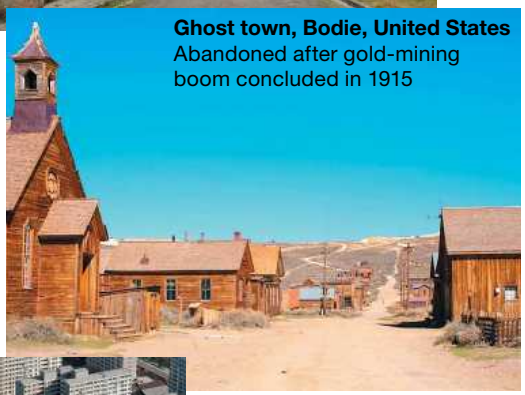
FIGURE 4 Cities abandoned due to changing human and physical factors

Wittenoom, Australia
Abandoned in 2006 after asbestos in the area caused major human 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.

7.5.3 CASE STUDY: Venice, a sinking city

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.

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

Storms and high tides, when combined, can lead to destructive surges that cause erosion and damage to cities. The prospect of rising sea levels as a result of global warming-induced ice cap melting 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 5** and **6**). Although Venice has a population of only around 270 000, its **historical architecture**, life on the canals and cultural events such as Carnevale attract around 20 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.

Why is Venice sinking?

When Venice was established almost 2000 years ago, the sea level was 2 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 artesian wells near Venice in the 1950s. This practice, which fortunately has stopped, led to building subsidence.

Floods or *aqua alta*

Venetians refer to floods as *aqua alta* or 'high water'. Flooding events occur each year, usually between autumn and spring, and their intensity varies. In October 2018, high sea waters with a depth of 1.56 metres above average sea levels submerged nearly two-thirds of the city. A combination of high tides and winds forced waters over the canal banks and into buildings and public areas (see **FIGURE 7**). These types of flooding events

FIGURE 5 Venice and surrounding areas

Source: © OpenStreetMap contributors.

FIGURE 6 Aerial view of Venice showing the built area in the lagoons and the canals

make life difficult for locals and tourists as buildings and public areas are flooded and transport is restricted, with some boats unable to fit under bridges. The actual number of tourists is another significant problem for Venice — in the busy season, tourist numbers can reach 60 000 per day. Management plans and limits to tourist numbers are now under consideration.

FIGURE 7 Flooding in Venice

Reducing the impact of floods

Completed in 2018, the MOSE (MOdulo Sperimentale Elettromeccanico) or Experimental Electromechanical Module Project aims 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 above 110 centimetres (to a maximum of 3 metres). The project has been criticised by some who say that flushing of the canals would be reduced and the huge cost of the project cannot be justified as it may only be effective for a few years if sea levels continue to rise.

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

Use the internet to **research** and learn more about the MOSE project in Venice. **Create** a labelled diagram to show how it will work.

7.5 Exercise

learnon

7.5 Exercise

Learning pathways

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

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Check your understanding

1. What environmental hazards can lead to destruction or damage of urban environments? **Select** all options that apply.
   - A. Cyclones
   - B. Hurricanes
   - C. Downturn in the economy
   - D. Climate change
2. Water was essential to the survival of the city of Angkor because it:
   - A. was good to drink.
   - B. helped with the building of the city.
   - C. supported the agriculture and fishing practices of the city.
   - D. All of the above
3. **Determine** whether the following statements are true or false.
   - a. Venice is located in the Adriatic Sea.
   - b. Longer-term events, such as desertification and climate change, can have negative impacts on urban environments.
   - c. Kowloon was a 'shanty town' in Hong Kong that was abandoned and then demolished in 1993.
4. **State** why the town of Pripyat near Chernobyl in the Ukraine was abandoned.
5. **Identify** aspects of its landscape that make the city of Venice vulnerable to flooding.

Apply your understanding

Questioning and researching using geographical methods

6. **Reflect on** how you would employ human–environment systems thinking to solve the flooding of Venice. (Hint: Make a list of environmental impacts and human management responses.)
7. **Identify** what impact a rise in the sea level might have on a city such as Venice.
8. **Consider** if ore bodies are depleted in the mining town of Broken Hill, how might the town sustain its existence into the future?

Concluding and decision-making

9. **Judge** if there is a future for ghost towns. Explain your view.
10. **Outline** the MOSE Project in Venice and **predict** how it is expected to work in holding back the sea.
11. **Evaluate** the MOSE Project in terms of its:
    - a. environmental impact
    - b. social impact (i.e. its value in preserving a unique city with a long history).

LESSON
7.6 What are the future challenges of sustainable urban environments?

LEARNING INTENTION

By the end of this lesson you should be able to describe the projected urban growth of the future, explain the challenges that this growth presents and recommend sustainable approaches to development that aim to tackle these challenges.

TUNE IN

A sustainable city might include parks, high-rise green zones and waterways.

1. What would be your plans for a model new city of the future? What three things would you include?
2. What changes could you make to your city or town to make it more sustainable?

FIGURE 1 A high-rise building covered in plants

7.6.1 The influence of technology

Throughout human history, cities have changed as new forms of technology have developed. For instance, high-rise buildings such as skyscrapers could not exist without the modern cement-and-steel methods of construction and 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 develop and be managed in a fair and sustainable manner?

7.6.2 Managing urbanisation

The United Nations (UN) Sustainable Development Goals (SDGs) have been developed as a set of ambitious aims to achieving an improved and sustainable future for everyone on the planet. The SDGs inform bodies that have an interest in urban development, including UN-Habitat, ComHabitat (Commonwealth Habitat), the Cities Alliance and the World Bank. These agencies aim to address the urban challenges of the twenty-first century with a focus on social and economic management criteria. The SDGs are shown in **FIGURE 2**. (These are explored in more detail in section 9.2.2.)

It has been estimated by UN studies that the global urban population, which is currently around 55 per cent (4.2 billion), will increase to about 5.1 billion in 2030, meaning that over 60 per cent of the world's total population will be living in cities. This increase means that another 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 (see **FIGURE 3**).

FIGURE 2 The 17 Sustainable Development Goals

7.6.3 What are the challenges for cities?

Many cities in the world face environmental, social and economic challenges. Issues such as extensive areas of slum housing and a general lack of infrastructure to support what may be called a socially and economically just lifestyle undermine the sustainability of these environments. Particularly in the poorest or least developed countries, there are significant environmental management issues associated with large cities. Some of these are detailed in **TABLE 1**. Note that there are issues even in cities that could be called wealthy or most developed.

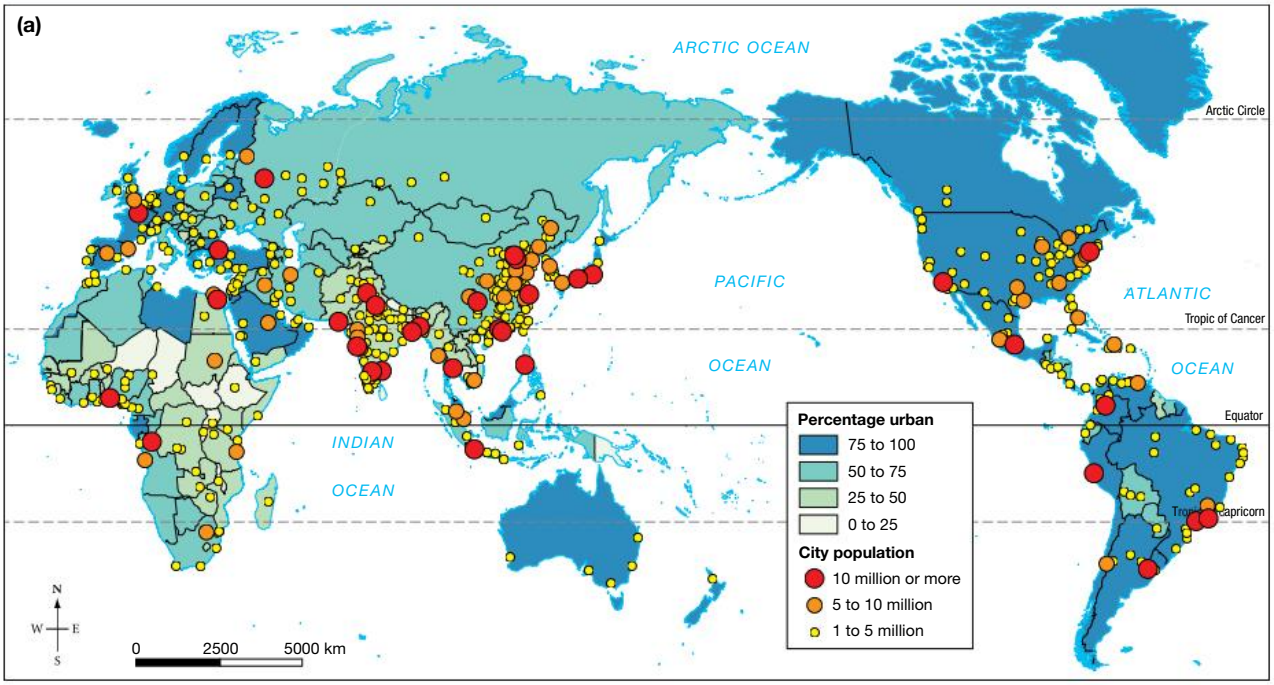
TABLE 1 Urban challenges

Level	Challenges to be addressed to ensure a sustainable urban environment
Less economically 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
More economically 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

int-7670

tlvd-10783

FIGURE 3 Urban population (a) 2018 and (b) projected for 2030



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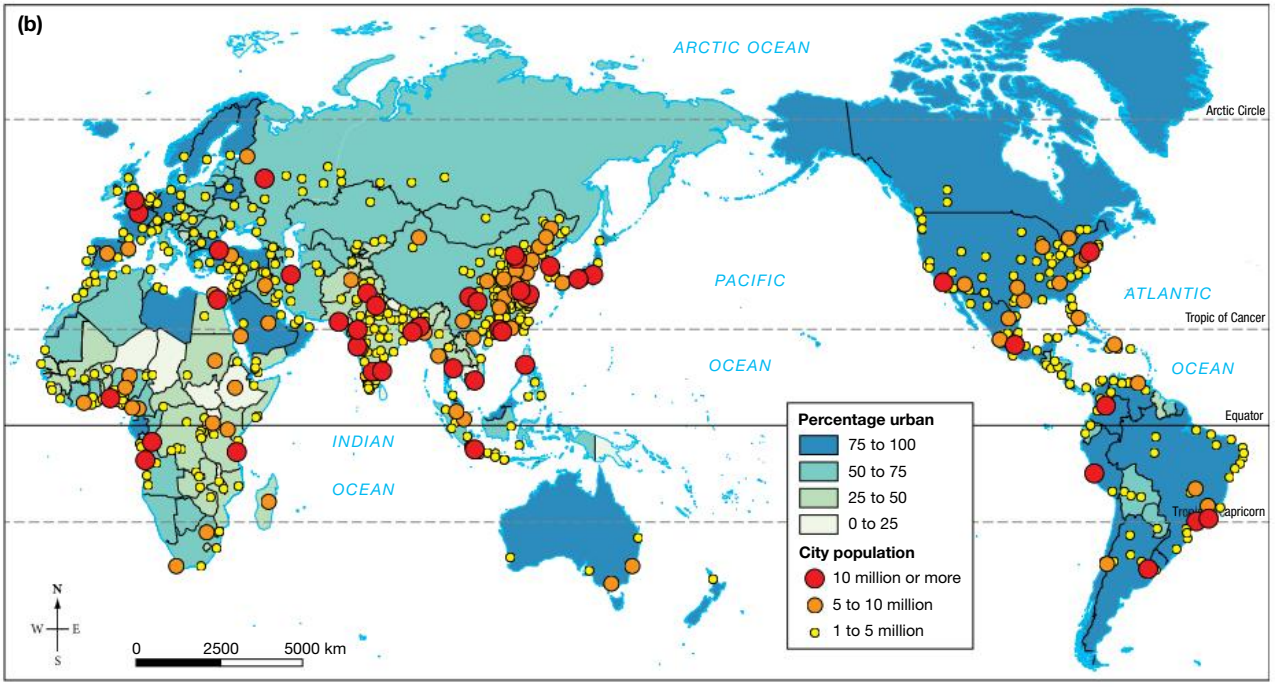

Source: United Nations, Department of Economic and Social Affairs, Population Division 2018. World Urbanization Prospects: The 2018 Revision.

7.6.4 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 socially, economically and environmentally sustainable urban environments include:

- building energy-efficient houses using 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 a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person in the world for food, water, transport, housing, waste management and other purposes

medium-density housing a form of residential development such as detached, semi-attached and multi-unit housing that can range from about 25 to 80 dwellings per hectare

FIGURE 4 Vertical gardens can be used to add green spaces to medium- and high-density housing developments.

SkillBuilders to support skill development

- 1.17 SkillBuilder: Building a map with geographic information systems (GIS)

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

Use the internet to **research** the decline of the cities of Gary and Detroit in the United States. Write a list of reasons why these cities have declined. Make conclusions to **suggest** how they might be reinvigorated. **Identify** any efforts to revive the local economy, attract new residents and businesses, or improve public services.

on Resources

Interactivity Where am I? (int-3303)

7.6 Exercise

learnon

7.6 Exercise

Learning pathways

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

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Check your understanding

1. How many people in the world will need new housing in 2030, based on current predictions of urbanisation?
   - A. 2000
   - B. 200 000
   - C. 2 million
   - D. 2 billion
2. **Determine** whether the following statements are true or false.
   - a. Refer to **FIGURE 2**. The SDGs aim to achieve an improved and sustainable future for everyone on the planet.
   - b. The United Nations (UN) Sustainable Development Goals (SDGs) aim to achieve an improved and sustainable future for everyone on the planet, including addressing urban challenges.
   - c. A major challenge faced by cities around the world is slum housing and a lack of infrastructure.
3. The SDGs were developed to:
   - A. inform bodies that have an interest in urban development.
   - B. address the urban challenges of the twenty-first century.
   - C. focus on social and economic management criteria.
   - D. All of the above
4. Refer to **FIGURE 2**. Which of the SDGs do you think relate to the issue of sustainable urbanisation? **Explain** your view.
5. **Identify** three management strategies for sustaining urban environments and **outline** the contribution that each of these would make.

Apply your understanding

Questioning and researching using geographical methods

6. **Discuss** how migration would help solve the problems of ageing populations in developed Western cities.
7. Using **TABLE 1**, **explain** why the urban challenges are different for least developed, transition and developed countries.

Concluding and decision-making

8. It has been said that if all nations had the same ecological footprint as the developed countries (e.g. the United States, Australia and most European nations), we would need four new worlds the size of planet Earth to accommodate the growth in resource consumption. **Propose** ways we can achieve energy, food and water security with an aim of sustainability into the future.
9. **Identify** which of the SDGs will directly improve social conditions in urban environments. Give reasons for your answer.
10. **Identify** which of the SDGs will directly improve environmental conditions in urban environments. Give reasons for your answer.

LESSON
7.7 Investigating topographic maps: Examining the city of São Paulo

LEARNING INTENTION

By the end of this lesson you should be able to identify key features and landforms in the São Paulo area from a topographic map, and suggest how these features affect the liveability and sustainability of the city.

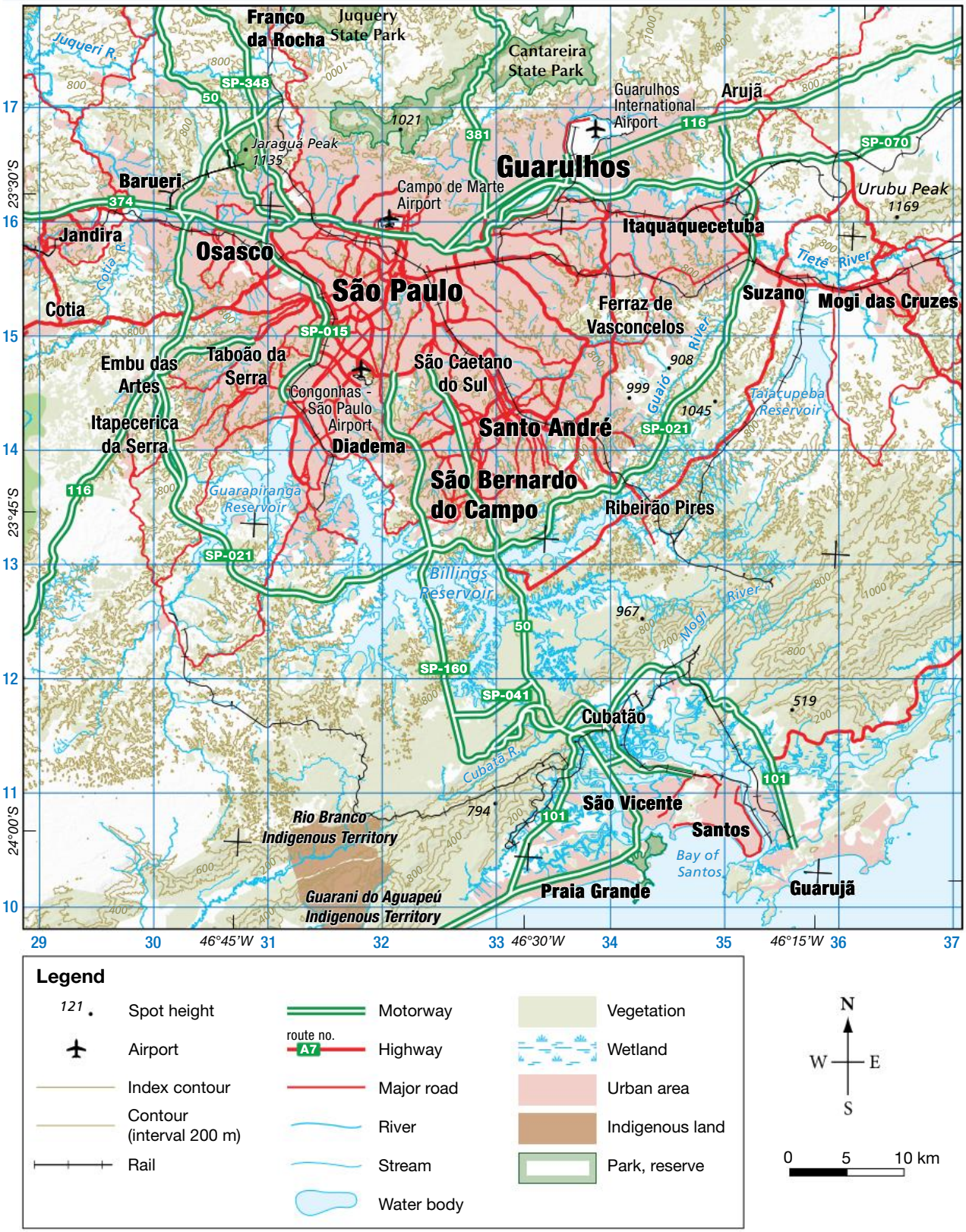
7.7.1 The biggest city in the southern hemisphere

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.

FIGURE 2 A topographic map of São Paulo, Brazil



Source: Map data © OpenStreetMap contributors, https://openstreetmap.org. Data is available under the Open Database Licence, https://opendatacommons.org/licenses/odbl/; elevation data sourced from USGS.

Resources

eWorkbook	Investigating topographic maps — Examining the city of São Paulo (ewbk-9927)
Digital document	Topographic map of São Paulo (doc-36320)
Video eLesson	Investigating topographic maps — Examining the city of São Paulo — Key concepts (eles-5231)
Interactivity	Investigating topographic maps — Examining the city of São Paulo (int-8659)
Google Earth	São Paulo (gogl-0139)

7.7 Exercise

learnon

7.7 Exercise

Learning pathways

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

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- Receive immediate feedback
- Access sample responses
- Track results and progress

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Check your understanding

1. Give the area reference for Guarulhos International Airport.
   - **A.** AR 1934
   - **B.** AR 3316
   - **C.** AR 1935
   - **D.** AR 3417
2. **Match** the relevant area references to each of the four following locations on the map.
   - **a.** AR3013
   - **b.** AR3616
   - **c.** AR3117
   - **d.** AR3317

   Cantareira State Park, Guarapiranga Reservoir Urubu Peak Juquery State Park
3. **Record** the highest and lowest elevations shown.

Apply your understanding

Interpreting and analysing geographical data and information

4. **Describe** where the steepest land is located on this map.
5. **Describe** the rail and road routes from the coast to São Paulo. How can you explain the pattern shown?
6. Based on the topography and features of São Paulo shown in **FIGURE 2**, **suggest** where you expect the poorest neighbourhoods of the city would be located. Provide grid or area references to support your answer.

LESSON
7.8 INQUIRY: Life in a Mumbai slum

LEARNING INTENTION

By the end of this lesson you should be able to describe why slums exist and outline elements of daily life.

Background

In this inquiry you will investigate why slums exist and what life would be like living in a slum. Begin by examining the images supplied in **FIGURE 1** and then endeavour to find further images to support your findings.

FIGURE 1 Life in a Mumbai slum

Before you begin

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

Inquiry steps

Step 1: Questioning and researching using geographical methods

Discuss the following:

a. What do you know about life in a slum and how do the images in **FIGURE 1** help you understand the conditions in a Mumbai slum?
b. How could life be improved for these people living in the slums in Mumbai?

1. Write down your selected **inquiry question**, based on the focus of this topic.
2. **Research** your inquiry question
   - **Conduct research** into living conditions in the Mumbai slums.
   - Provide relevant data in table or graph form.
   - Provide annotated images where appropriate to illustrate areas of concern.

Step 2: Interpreting and analysing geographical data and information

- **Create** a **summary** table outlining the social, economic and environmental issues that are matters of concern in the Mumbai slums.
- Study the SDGs and identify the three (minimum) goals that you will focus on in tackling these concerns.
- **Identify** a range of strategies to overcome slum life problems.

Step 3: Concluding and decision-making

- **Evaluate** which of your suggested strategies would be most effective based on:
  - economic viability (affordability)
  - social justice (fairness for all people)
  - environmental benefit (minimal negative environmental impact and with future sustainability).

Step 4: Communicating

- **Decide** how you will **communicate** your findings, whether it be in the form of a written report, multimedia presentation, poster or PowerPoint presentation.

Complete your self-assessment using the **Inquiry rubric** or access the 7.8 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-40159)

FIGURE 2 Children living in a Mumbai slum

LESSON
7.9 Review

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7.9.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

7.2 How do cities impact the environment?

- Urbanisation has led to significant changes to the natural environment, including changes to the atmosphere, hydrosphere and lithosphere.

7.3 How do urban environments develop?

- Large urban complexes are a recent phenomenon in the world's history.
- The modern trend is for people to move to urban complexes seeking improvement in lifestyle, but this means having to cope with socioeconomic and environmental challenges in the urban environment, such as congestion, crime, pollution and social isolation.
- Megacities, while offering opportunities for work and access to multiple services, can have issues such as slums and poor waste management.
- Dealing with the impacts of cities on air and water quality is a major issue.
- Urban sprawl in large urban complexes is a major problem for city planners.

7.4 Case studies in urban growth: Melbourne and Mumbai

- Urban infilling and increasing density are two methods of creating more living space in existing urban areas.
- Expansion into the rural–urban fringe leads to urban sprawl, which has economic and environmental impacts.
- Rapid urban growth in Mumbai has created challenges relating to human wellbeing, urban sprawl, traffic congestion and infrastructure needs.

7.5 What factors contribute to urban decline?

- Natural and human-induced changes can lead to processes that build up and lead to the decline of urban complexes.
- Events such as natural and human-induced disasters have large impacts on urban complexes.
- The depletion of resources can lead to urban decline.
- Low-lying coastal cities can be subject to the destructive forces of storms, and this can affect tourism if the city is a popular holiday destination.
- Rising sea levels caused by global warming are an additional problem requiring new directions in management and urban planning.

7.6 What are the future challenges of sustainable urban environments?

- Urban populations are predicted to continue to grow, with megacities being a magnet for rural dwellers.
- Careful management of urban complexes is required so that they may be sustained and offer a good quality of life for their inhabitants.
- The management of sustainable cities must draw inspiration from the Sustainable Development Goals established by the United Nations.

7.7 Investigating topographic maps: Examining the city of São Paulo

- Key features and landforms in the São Paulo area affect the liveability and sustainability of the city.

7.8 INQUIRY: Life in a Mumbai slum

- Investigate how and why slums exist in urban areas.

7.9.2 Key terms

biophysical environment all elements or features of the natural or physical and the human or urban environment, including the interaction of these elements

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

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

economic downturn a recession or downturn in economic activity that includes increased unemployment and decreased consumer spending

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person in the world for food, water, transport, housing, waste management and other purposes

gross domestic product (GDP) the value of all goods and services produced within a country in a given period, usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

historical architecture urban environment that has significant value due to its unique form and history of development

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

Industrial Revolution the period from the mid 1700s into the 1800s that saw major technological changes in agriculture, manufacturing, mining and transportation, with far-reaching social and economic impacts

infrastructure the basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society

lagoon a shallow body of water separated from the sea by a sand barrier or coral reef

medium-density housing a form of residential development such as detached, semi-attached and multi-unit housing that can range from about 25 to 80 dwellings per hectare

megacity a settlement with 10 million or more inhabitants

river delta a landform composed of deposited sediments at the mouth of a river where it flows into the sea

rural–urban fringe the transition zone where rural (country) and urban (city) areas meet

slum rundown area of a city with substandard housing

urban environment the human-made or built structures and spaces in which people live, work and recreate on a day-to-day basis

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

urban sprawl the spreading of urban developments into areas on the city boundary

water rights refers to the right to use water from a water source such as a river, stream, pond or groundwater source

water security the reliable availability of acceptable quality water to sustain a population

7.9.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

How far can our urban environments spread before they become unsustainable?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

Resources

eWorkbooks Customisable worksheets for this topic (ewbk-11508)
Reflection (ewbk-12527)
Crossword (ewbk-12528)

Interactivity Urban change and management crossword (int-7674)

7.9 Review exercise

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Multiple choice

1. The biophysical environment consists of which four elements?
   - A. Atmosphere, hydrosphere, lithosphere, biosphere
   - B. Earth, wind, fire, water
   - C. Atmosphere, aquasphere, lithosphere, biosphere
   - D. Atmosphere, hydrosphere, lithosphere, earthsphere
2. How many inhabitants does a city need to be classified as a megacity?
   - A. At least 20 million
   - B. At least 10 million
   - C. At least 5 million
   - D. At least 12 million
3. Which region has the highest proportion of global built-up urban area population?
   - A. North America
   - B. Asia
   - C. Europe
   - D. Africa
4. Which is Australia's fastest growing capital city?
   - A. Melbourne
   - B. Sydney
   - C. Gold Coast
   - D. Perth
5. What practice does 'urban infilling' refer to?
   - A. The infilling of former waste sites into parklands
   - B. The infilling of former industrial areas into small sites for new homes
   - C. The division of larger house sites into multiple sites for new homes
   - D. The division of larger house sites into new schools
6. Which organisation is responsible for the Sustainable Development Goals?
   - A. United Nations
   - B. UNICEF
   - C. World Bank
   - D. World Trade Organization

7. By promoting sustainable urban environments at all levels of scale, problems can be overcome. Which options describe the levels of scale?
   - **A.** Large scale and local scale
   - **B.** Local, regional, national and global
   - **C.** National and global
   - **D.** Local and regional
8. Strategies for sustainable urban environment include which options?
   - **A.** Building energy-efficient houses
   - **B.** Increasing waste by expanding landfill
   - **C.** Improving public transport systems to reduce reliance on cars
   - **D.** Redeveloping to include medium-density housing to reduce urban sprawl

Refer to TABLE 1 to answer questions 9 and 10.

TABLE 1 Population of the 10 largest cities, 1950 to 2025

Rank	1950 population	2015 population	2025 population
1	New York (12.3)	Tokyo (37.8)	Tokyo (35.2)
2	London (8.7)	Jakarta (30.5)	Mumbai (26.4)
3	Tokyo (6.9)	Delhi (24.9)	Delhi (22.5)
4	Paris (5.4)	Manila (24.0)	Dhaka (22.0)
5	Moscow (5.4)	Seoul (23.4)	Sao Paulo (21.4)
6	Shanghai (5.3)	Shanghai (23.4)	Mexico City (21.0)
7	Essen (5.3)	Karachi (22.1)	New York (20.6)
8	Buenos Aires (5.0)	Beijing (21.0)	Kolkata (20.6)
9	Chicago (4.9)	New York (20.6)	Shanghai (19.4)
10	Kolkata (4.4)	Guangzhou (20.6)	Karachi (19.1)

Note: All population figures are in millions.
Source: United Nations (1950 & 2025); Demographia (2015).

9. Which city has the same population in the 2015 and 2025 figures?
   - **A.** Tokyo
   - **B.** Delhi
   - **C.** Shanghai
   - **D.** New York
10. Which city, not seen in either the 1950 or 2015 figures, is expected to jump to within the top three highest populations in 2025?
   - **A.** Mumbai
   - **B.** New York
   - **C.** Tokyo
   - **D.** Dhaka

Short answer

Questioning and researching using geographical methods

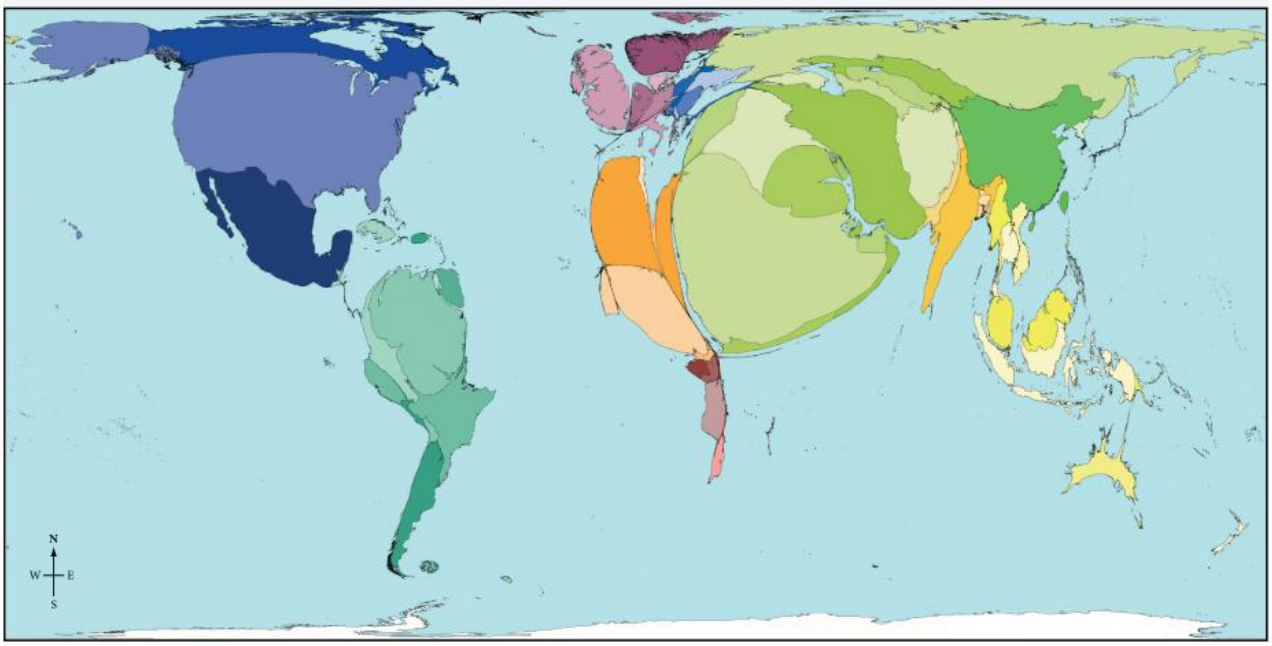
11. Desalination plants have been built in a number of Australia's main cities to solve water resource problems.
   - **a.** **Investigate** how a desalination plants operates.
   - **b.** **Explain** how desalination plants may solve the problem of water supply to capital cities.

12. Most Australians would perceive slums negatively. Refer to the case study of Dharavi, India, in lesson 7.4. **Investigate** how each of the following supports a more positive perception of slums.
    - The role of ragpickers
    - Recycling

Communicating

13. 'Let it sink. Venice is not worth saving.' **Develop** an argument that supports and then an argument that would challenge this viewpoint.
14. 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. **Identify** what aspects of urban environments and their infrastructure can be used to encourage sustainable energy use in various nations.
    c. **Identify** 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.

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8 Measuring and improving wellbeing

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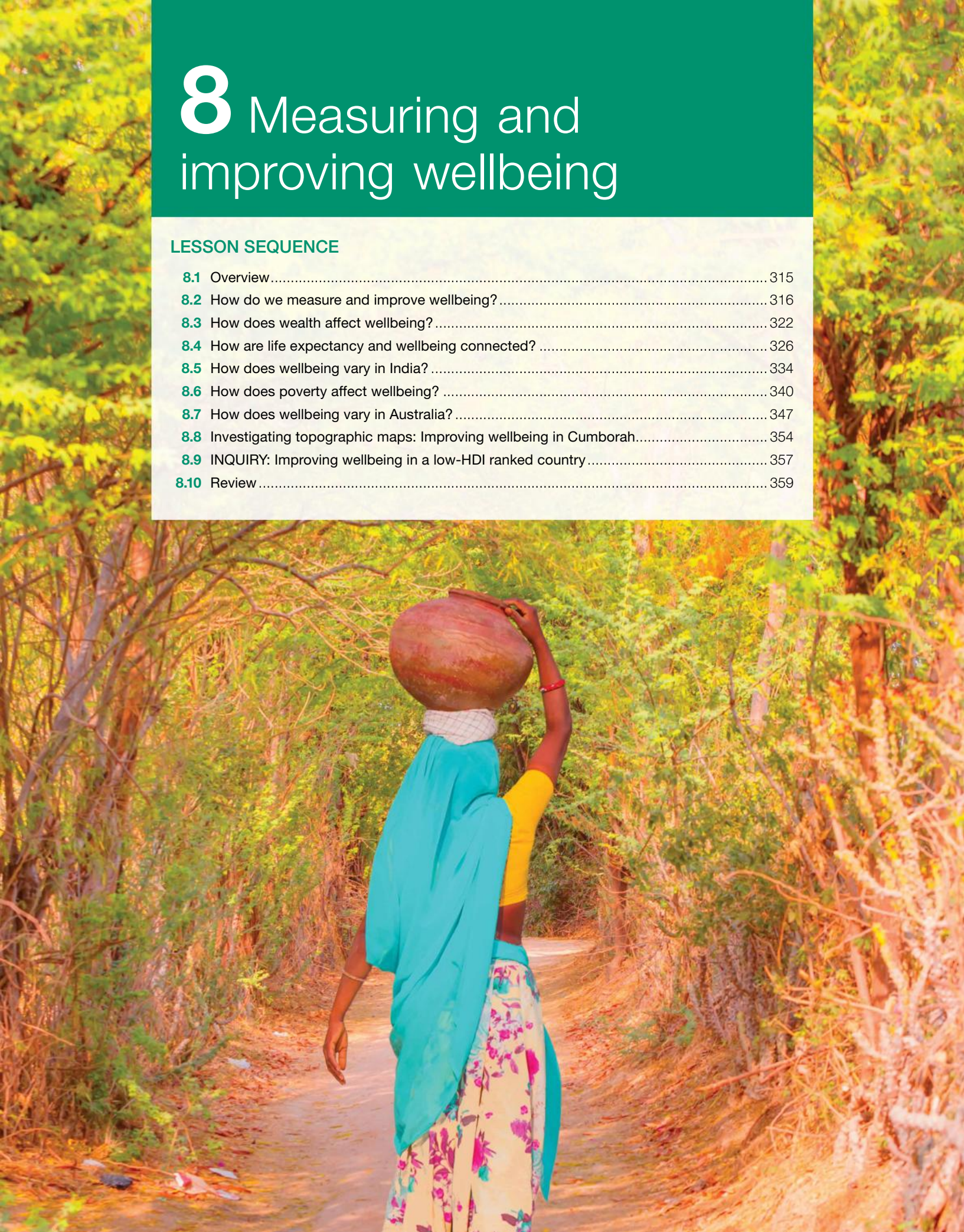

LESSON
8.1 Overview

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Everyone wants a good life, but what does that mean for different people? Can wellbeing actually be measured and how can we improve it if it's not measuring up?

8.1.1 Introduction

We all want a better life for ourselves, our families and our children, no matter where we live. We care about the wellbeing and progress of our communities, our country and our world. But how can we measure these things? What does wellbeing really mean, and what do we count when we measure progress? How do we know if we are succeeding in our efforts to create a better life for everyone?

FIGURE 1 Our wellbeing and the wellbeing of our community, country and world are all linked.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11510)

Video eLesson The good life? (eles-1713)

LESSON
8.2 How do we measure and improve wellbeing?

LEARNING INTENTION

By the end of this lesson you should be able to describe the tools, known as indicators, that allow us to gauge what makes a good life and measure wellbeing, and explain the ways of describing levels of development and how we define poverty.

TUNE IN

Wellbeing means different things to different people. But in a changing world where modern technology is readily available, people around the world are seeing the lifestyle of wealthy nations and want to participate in that lifestyle.

FIGURE 1 Wellbeing is more than being physically healthy; wellbeing includes health, happiness, prosperity and welfare.

Look at **FIGURE 1**.

1. What do you see in this image about the physical condition and dress of these children that suggests that they have a lifestyle where wellbeing is important?
2. How does the type of housing seen in the background compare to the place where you live and how does your housing support you in achieving a sense of wellbeing?

8.2.1 A good life

A county's progress can no longer be accurately measured by income. The concept of **wellbeing** offers us a new perspective on what matters in our lives.

Wellbeing is the experience of having what you need for life to be good. But how do we measure a good life? We can use a variety of **quantitative indicators** and **qualitative indicators** to help us (see **FIGURE 2**). **Indicators** are important and useful tools for monitoring and evaluating progress, or lack of it.

FIGURE 2 Examples of quantitative and qualitative wellbeing data

Quantitative indicators	Qualitative indicators
• Gross national income (GNI)	• Happy Planet Index
• Gross domestic product (GDP)	• Freedom of speech
• Literacy and numeracy rates	• Safety
• Human Development Index (HDI)	• Sustainability
• Life expectancy	

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)**.

Using indicators

A wellbeing-centred approach to development takes into account a variety of quantitative and qualitative indicators. Quantitative indicators, based on numerical values, are commonly used because it is easy to compare changes over time and between places. Qualitative indicators, which measure quality of life, are harder to quantify and compare as the data collection can be subjective and time consuming. Indicators can be classified into a range of broad categories (see **FIGURE 3**). 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. Wellbeing can also be influenced by technological indicators in fields such as transport, industry, agriculture, mining and communications.

Geographers use data from various indicators to identify the spatial distribution patterns and explain why these patterns exist. Data may be used to look at the spatial distribution of wellbeing at a local, national or global scale.

wellbeing a good or satisfactory condition of existence; a state characterised by health, happiness, prosperity and welfare

quantitative indicators objective indices that are easily measured and can be stated numerically, such as annual income or the number of doctors in a country

qualitative indicators subjective measures that cannot easily be calculated or measured; e.g. indices that measure a particular aspect of quality of life or that describe living conditions, such as freedom or security

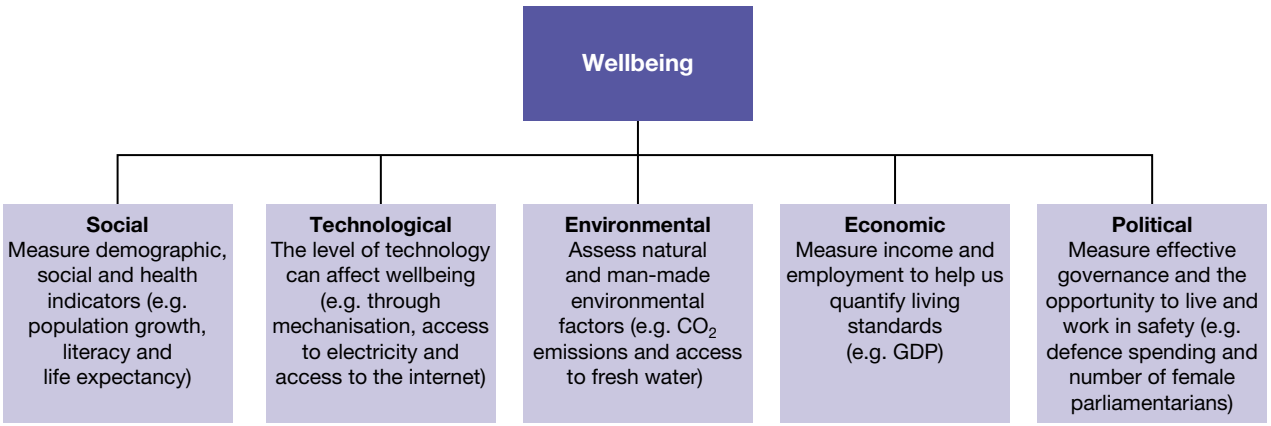
indicator a value that informs us of a condition or progress. It can be defined as something that helps us to understand where we are, where we are going and how far we are from the goal.

development 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' according to the United Nations

gross domestic product (GDP) the value of all goods and services produced within a country in a given period, usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

standard of living a level of material comfort in terms of goods and services available. This is often measured on a continuum; for example, a 'high' or 'excellent' standard of living compared to a 'low' or 'poor' standard of living.

FIGURE 3 Categories of wellbeing indicators



8.2.2 Describing development

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' (previously often referred to as 'undeveloped'). These terms assume that development is a linear process of growth, so each country can 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 West 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, roughly following the line of the equator. The developed North included the United States, Canada, Europe, the USSR, Australia and Japan. The undeveloped 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 and 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.

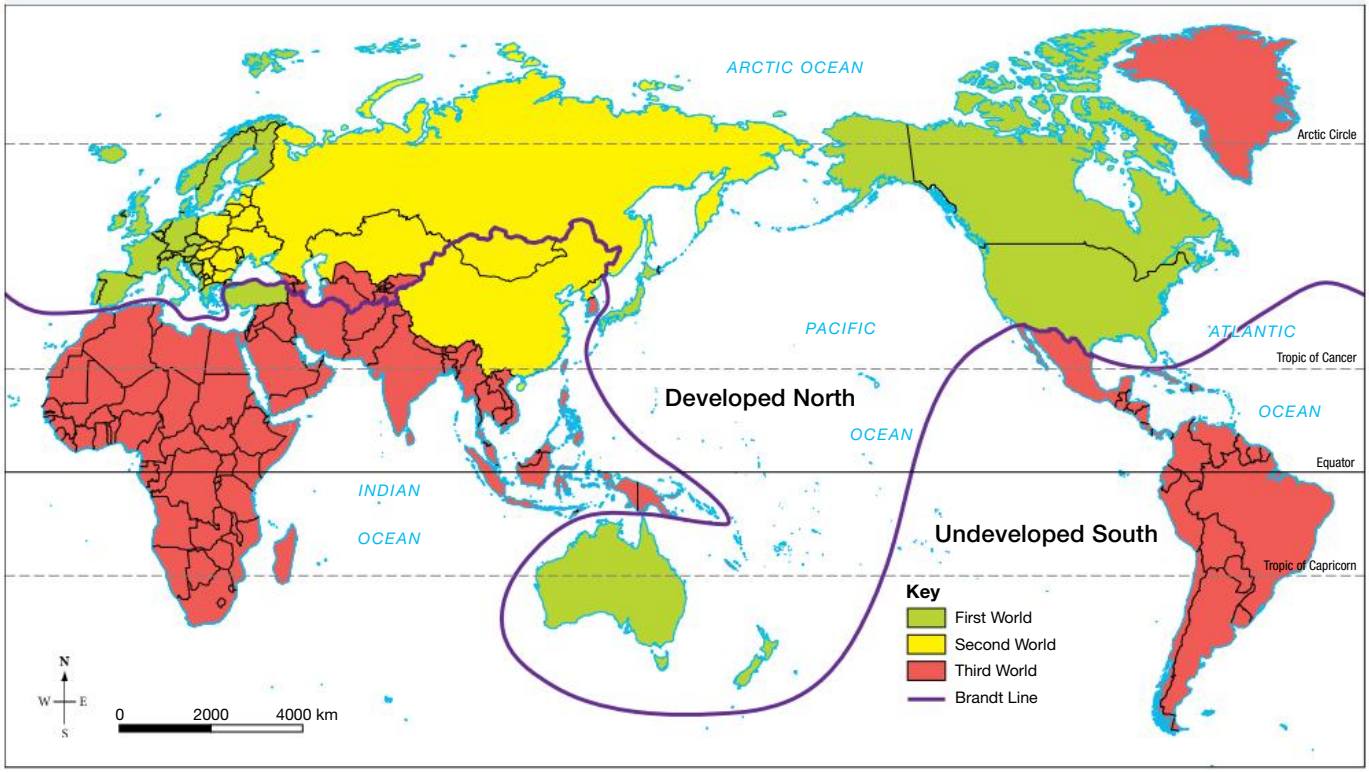
Whichever method of measuring development or wellbeing we choose, it is important to understand the terms that have been used, the values that underpin it, and what perspective (often Western) we take. With an overwhelming amount of data available to us, the world is often divided simplistically into extremes such as 'rich' or 'poor'. Is this the best way? The annotated classifications in **FIGURE 4** 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

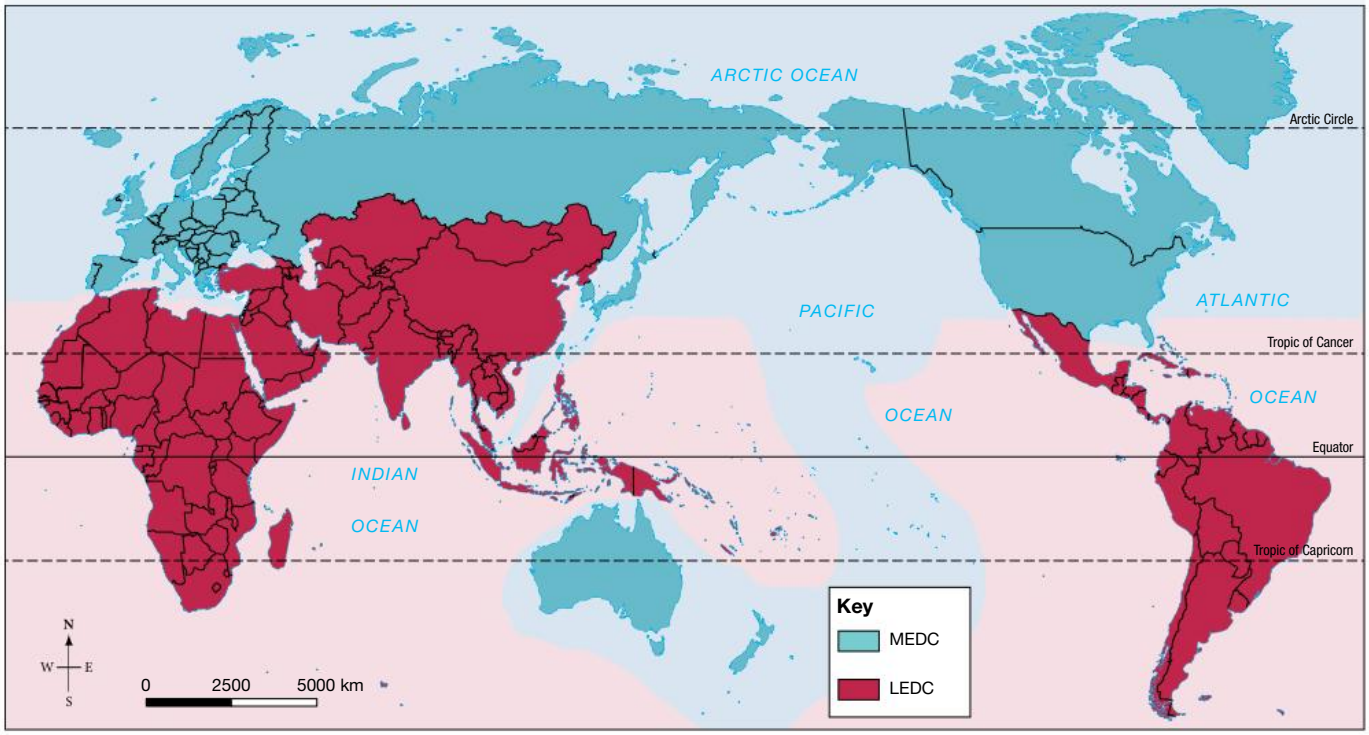
int-9140

FIGURE 4 World map showing various definitions of development



Source: United Nations Development Report.

FIGURE 5 World map showing MEDCs and LEDCs



Source: CantGeoBlog.

8.2 SKILL ACTIVITY: Concluding and decision-making

1. **Select** one of the indicator categories: social, economic or environmental.
2. In pairs or small groups, brainstorm the various indicators that you think might be used to measure the category.
3. **Create** a short list of at least five before checking the World Statistics section of your atlas to see which indicators are commonly used.

8.2 Exercise

learnon

8.2 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** from the list examples of nations that are classified as 'developed North'.
   - **A.** Japan
   - **B.** Singapore
   - **C.** Rwanda
   - **D.** Australia
2. Australia is always labelled as a part of the 'developed North'. True or false?
3. Although indicators measure 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. **Discuss** this matter using examples (a flow chart may be useful to step out your thinking).
4. Complete **TABLE 1** to **compare** the differences between MEDCs and LEDCs (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

Apply your understanding

Communicating

5. Refer to **FIGURE 2**.
   a. Using the figure as a guide, **create** a table to **classify** each of the following as either a quantitative or qualitative indicator.
      - Motor vehicle ownership rates
      - Unemployment
      - Forest area
      - Incidence of obesity
      - Freedom of speech
      - Proportion of seats held by women in national parliaments
      - Electric power consumption
      - Quality of teaching at your school
      - How safe you feel walking in the city at night
      - How much you trust your neighbours
      - Access to public transport
   b. Qualitative indicators are the only ones that need be taken into account to define wellbeing. True or false?

Interpreting and analysing geographical data and information

6. Refer back to the indicators in **FIGURE 2**. Indicators can also suggest further information about a country's progress, rate of change or development. **Consider** whether these indicators are clues to the factors affecting the development of a country. If so, what else do they tell you?
7. Does your pet dog or cat have a good life? What indicators would you use to measure this? Write a **summary** selection of five quantitative and five qualitative indicators to help **determine** the wellbeing of your pet.
8. The concept of wellbeing is relative to who you are and the place where you live. **Discuss** the following statements. Does the term 'wellbeing' have any relevance to these people? Does wellbeing hold any relevance for people in the direst poverty? Write a paragraph to **explain** your view.
   - 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.'
9. How do you compare? 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 2** by evaluating the data. What reasons could account for these differences?

TABLE 2 Australia versus the world — a selection of quantitative indicators, 2018

Life expectancy (years)	Australia	83.64	Sierra Leone (Africa)	55.18
Mobile phones (subscriptions per 100 people)	Australia	126	Eritrea (Africa)	21
Adolescent fertility rate (births per 1000 women 15–19 years of age)	Australia	10.50	Denmark (Europe)	4
Proportion of seats held by women in national parliament (%)	Australia	31.10	Rwanda (Africa)	61.25
Gross National Income per capita (US$)	Australia	56 100	Qatar (West Asia)	61 940
Literacy rate (% of youth aged 15–24)	Australia	99.00	Mozambique (Africa)	60.00

LESSON
8.3 How does wealth affect wellbeing?

LEARNING INTENTION

By the end of this lesson you should be able to explain some of the different ways of discussing and measuring wellbeing.

TUNE IN

Wellbeing and happiness are closely related concepts. You may be surprised to note that Australia does not rate highly in terms of the Happy Planet Index!

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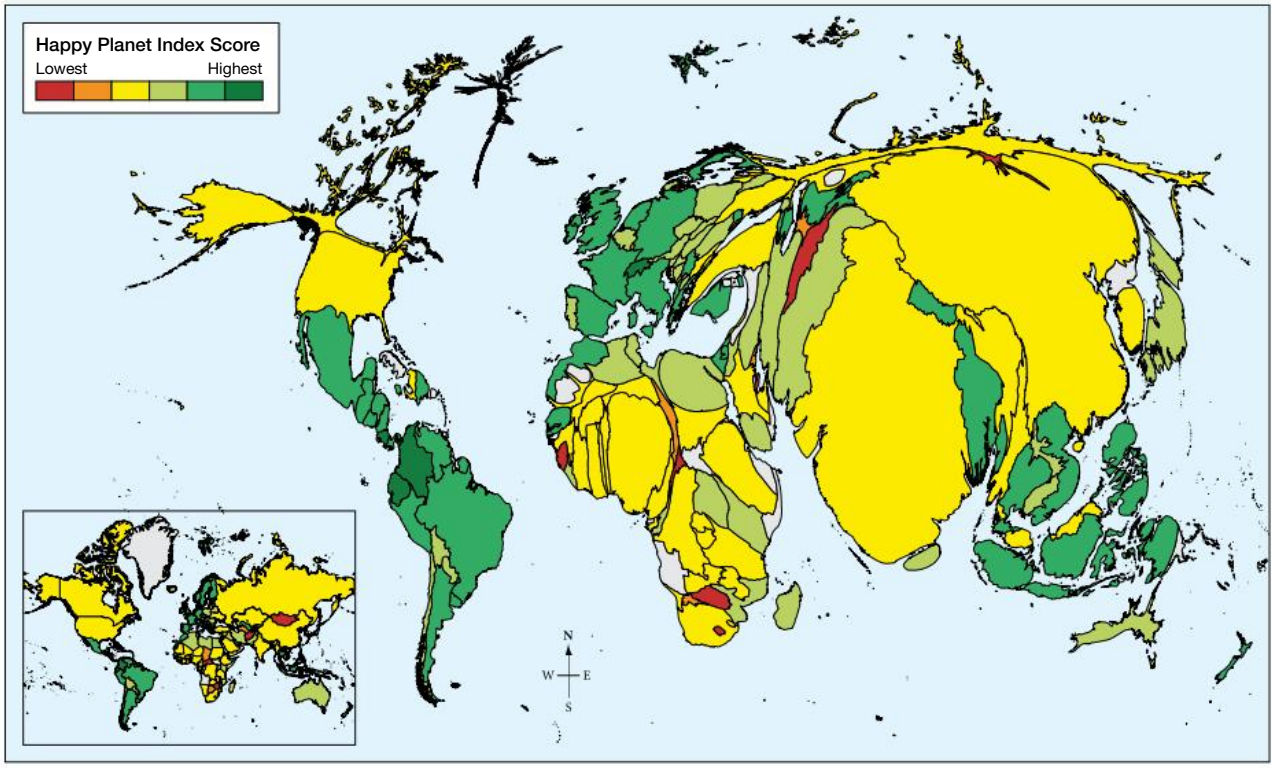
tlvd-10784

FIGURE 1 Cartogram showing relative global populations and Happy Planet Index scores, 2021



Source: Map drawn by Spatial Vision based on the information from Wellbeing Economy Alliance (WEALL) www.happyplanetindex.org.

1. Are you happy with your lifestyle? What do you think are the social and economic elements of your lifestyle that make you happy?
2. How might this contrast with a person in a nation with a very low Happiness Index?

8.3.1 The multiple component index

A wellbeing approach to development takes into account a variety of quantitative and qualitative indicators. Some of these are a little more difficult to measure, such as the idea of happiness. Before you read on, make a list of 10 indicators that you think would give an accurate measure of a teenager's happiness in their country of residence.

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.

GLOBAL WEALTH

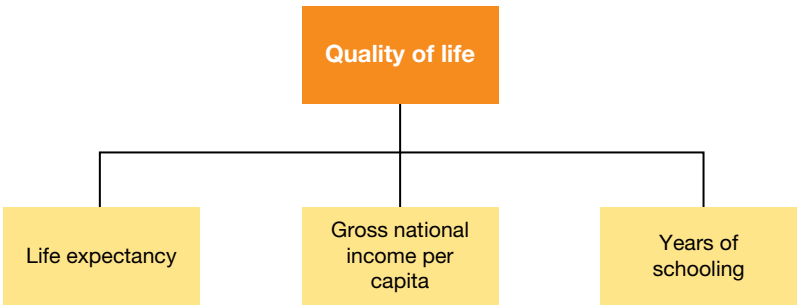
The richest one per cent of adults worldwide owned 47 per cent of global assets in the year 2018, and the richest 10 per cent of adults accounted for 85 per cent of the world total. In contrast, the bottom half of the world adult population owned less than one per cent of global wealth. These figures have remained much the same for the last 20 years and will be as such into the foreseeable future.

Wealth is heavily concentrated in North America, western Europe and high-income Asia–Pacific countries (excluding China). People in these countries collectively hold 78 per cent of total world wealth.

Source: Credit Suisse Wealth Report, 2018.

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 and measures wellbeing according to three key indicators (see **FIGURE 2**).

FIGURE 2 The HDI measures quality of life according to three key factors.



8.3.2 Other measures of wellbeing

Over thousands of years, 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.

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

Human Development Index (HDI) measures the standard of living and wellbeing by measuring life expectancy, education and income

Measuring twenty-first century wellbeing

The new Happy Planet Index (HPI) results map the extent to which 151 countries across the globe produce long, happy and sustainable lives for the people that live in them. The coloured shading in the **FIGURE 1** cartogram represents each country's HPI score, while the relative sizes and shapes of countries are determined by their population size (see 1.10 SkillBuilder — Interpreting a cartogram).

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.

$$\text{Happy Planet Index} = \frac{\text{experienced wellbeing} \times \text{life expectancy}}{\text{ecological footprint}}$$

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 nations to do the same. Former UN Secretary-General Ban Ki-moon supported this innovation: 'Gross 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.'

According to the last GNH Survey conducted by the Centre for Bhutan Studies and Gross National Happiness in 2015, on a scale of zero to one, the happiness of the Bhutanese has increased from 0.743 in 2010 to 0.756 in 2015. This translates into an overall increase of 1.8 per cent.

Australia currently stands at number 10, just achieving a position in the top 10 countries with a score of 7.227 out of 10. The top country is Finland with 7.632, followed by Norway, Denmark, Iceland, Switzerland, the Netherlands, Canada, New Zealand and Sweden (based on 2015–17 data).

Australia's assessment of wellbeing

The Australian National Development Index (ANDI), which was approved in 2015, incorporates 12 indicators measuring elements of progress including health, education, justice and First Nations Australians' wellbeing. Measures such as this demonstrate a new direction in articulating wellbeing, recognising that happiness is not directly proportional 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. It will allow Australians to measure the future we want.

experienced wellbeing an individual's subjective perception of personal wellbeing

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person for food, water, transport, housing, waste management and other purposes

8.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. Use the **HPI** weblink in your online Resources to learn more about the HPI and explore the results.
2. List three results that surprised you.
3. **Explain** why those results surprised you.
4. **Compare** your list with that of a partner.
5. What similarities or differences did you find?

on Resources

Weblink HPI

8.3 Exercise

learnon

8.3 Exercise

Learning pathways

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

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Check your understanding

1. Complete the following definition of the wellbeing approach using the terms provided.

multiple	indicators	income	quantitative

A wellbeing approach takes into account a variety of _____ and qualitative _____ — that is, '_____ components' of what comprises wellbeing, such as life expectancy, education and _____.

2. **Determine** whether the following statements are true or false.
   a. A multiple component index is the only determinant of wellbeing.
   b. The measurement of happiness has become important in the twenty-first century.
3. **Analyse** each of the indicators used to calculate the HDI. Is the HDI the best indicator of a country's development? Give reasons for your answer.
4. Without referring to **FIGURE 1**, **identify** from the options the three places you would expect to have a high Happy Planet Index score. Check your predictions on the map. Were you correct?
   a. Mexico
   b. Japan
   c. Australia
   d. Iraq

Apply your understanding

Interpreting and analysing geographical data and information

5. **State** what the Credit Suisse Wealth Report of 2018 says about the inequality of wealth across the world.
6. Using the Happy Planet Index and **FIGURE 1**, **discuss** what wellbeing conditions you might find in:
   a. South Africa
   b. France
   c. the United States.
7. **Decide** why a range of indices are being developed in the twenty-first century to measure wellbeing.
8. **Identify** two indicators that might be used in the ANDI.
9. **Evaluate** the distribution of the happiest and unhappiest countries across the world according to the data in **FIGURE 1**. What do you think would make a country unhappy?

LESSON
8.4 How are life expectancy and wellbeing connected?

LEARNING INTENTION

By the end of this lesson you should be able to explain the reasons for variations in life expectancy across the world and make connections between life expectancy and child mortality. You should also be able to explain the interconnection between life expectancy and wellbeing, and define key terms such as 'fertility rate', 'natural increase', 'replacement rate' and 'child mortality'.

TUNE IN

Life expectancy varies greatly in different nations around the world due to social and economic factors.

FIGURE 1 A homeless Australian man

1. What reasons can you suggest as to why this man is in this situation?
2. How would the impact of social and economic factors affect the life expectancy of the homeless man?

8.4.1 Life expectancy

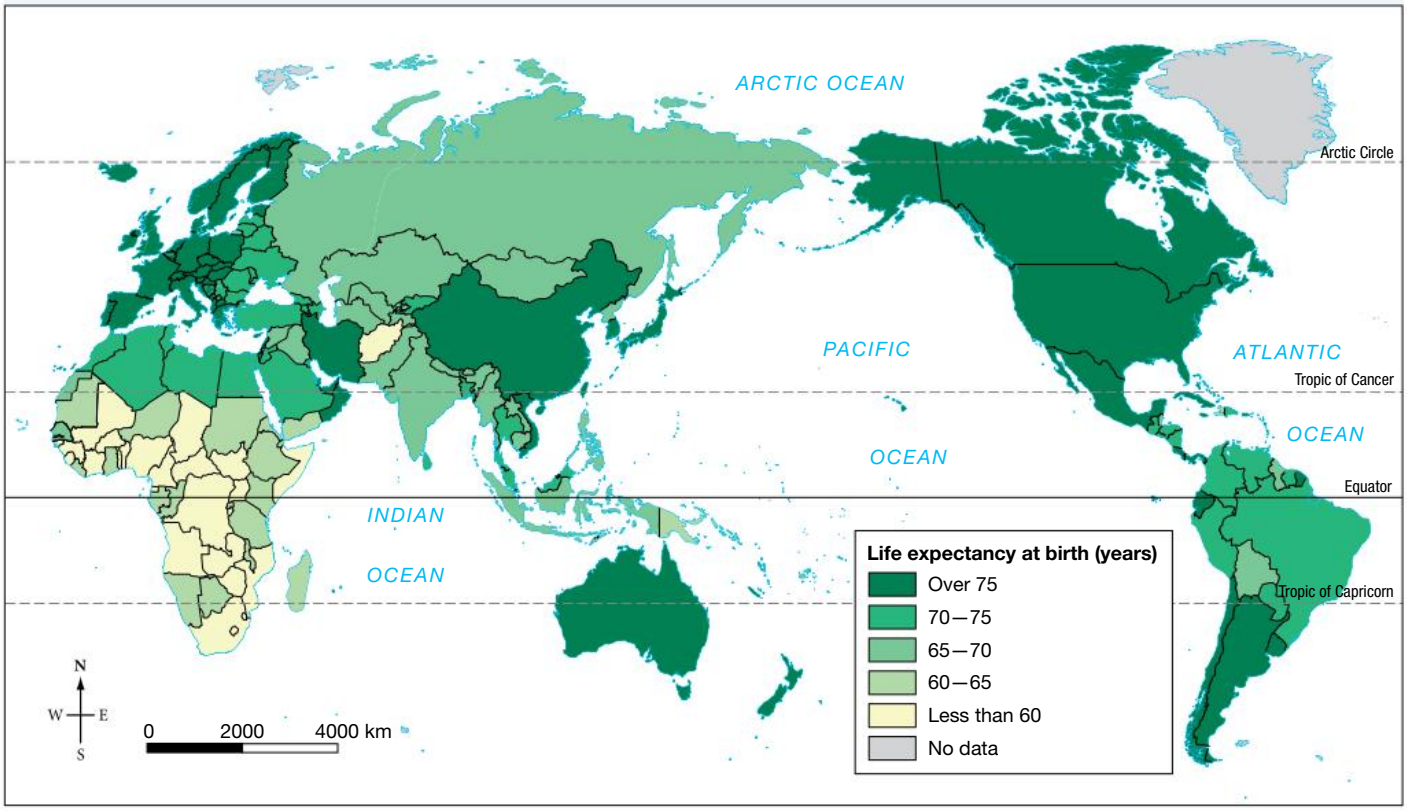
How long we can expect to live when we are born is referred to as our life expectancy and is calculated according to the conditions in a particular country in that year. Life expectancy is one of the major indicators of wellbeing. Globally, on average, people are expected to live longer than at any previous time in history. Sayings such as '60 is the new 50' reflect our changing expectations in Australia as to how long we expect to lead active lives. However, with the variation in living conditions around the world, the answer to the question 'how long can we expect to live?' also varies considerably.

Worldwide, a child born in 2022 can expect to live, on average, 73.20 years. If this child is born in Japan, they can expect to live 84 years, while one born in the African country of Somalia can expect to live only 58.34 years. **FIGURE 2** shows variations in life expectancy worldwide.

int-5603

tlvd-10785

FIGURE 2 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.

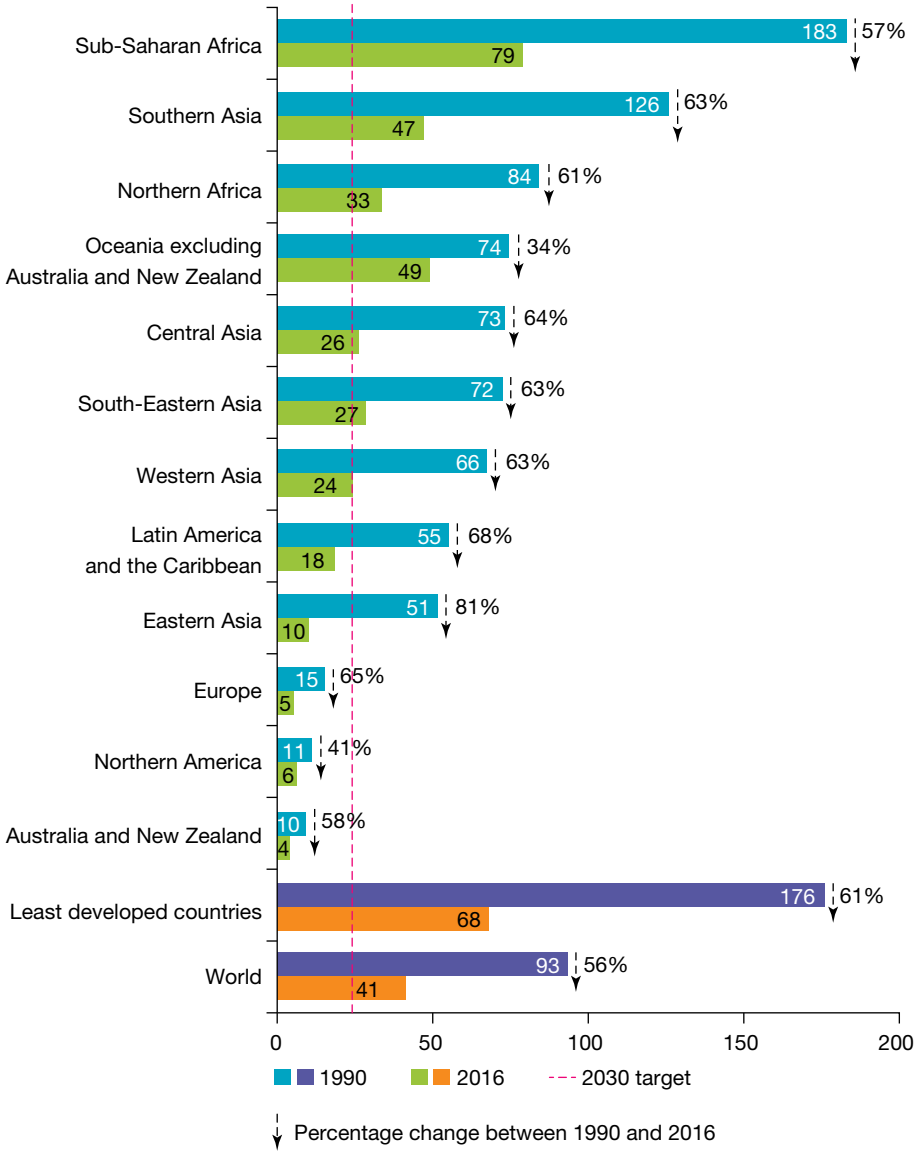
However, improvements that have led to increased life expectancy have not been uniform across the world. Regions where life expectancy continues to be low have a higher prevalence of infectious diseases. For example, 72 per cent of people worldwide living with HIV and AIDS are in sub-Saharan Africa, and the number of deaths in this region from AIDS is the highest in the world. In 2017, 25 per cent of new infections were in South Africa and Nigeria, with the latter also recording the highest rate of new infections among children under 14.

8.4.2 Child mortality

Life expectancy is closely interconnected with child mortality: countries with high death rates for children under five years of age have low life expectancy. The highest rates are recorded in countries in sub-Saharan Africa, with a rate of mortality of 74 deaths per 1000 live births. This is 14 times the rate expected for children in Europe and North America. These rates are well above the United Nations Sustainable Development Goal 3 target of 25 deaths per 1000 by 2030 (see **FIGURE 3**). 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 more likely to have better nutrition and to be immunised, and parents are more likely to be educated and aware of how to prevent disease.

Under the United Nations' Millennium Development Goals program, which operated from 1990 to 2015, child mortality was 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 17 000 fewer children dying each day. The greatest success occurred in northern Africa and eastern Asia.

FIGURE 3 Under-five mortality rate (deaths per 1000 live births) and percentage change, 1990–2016

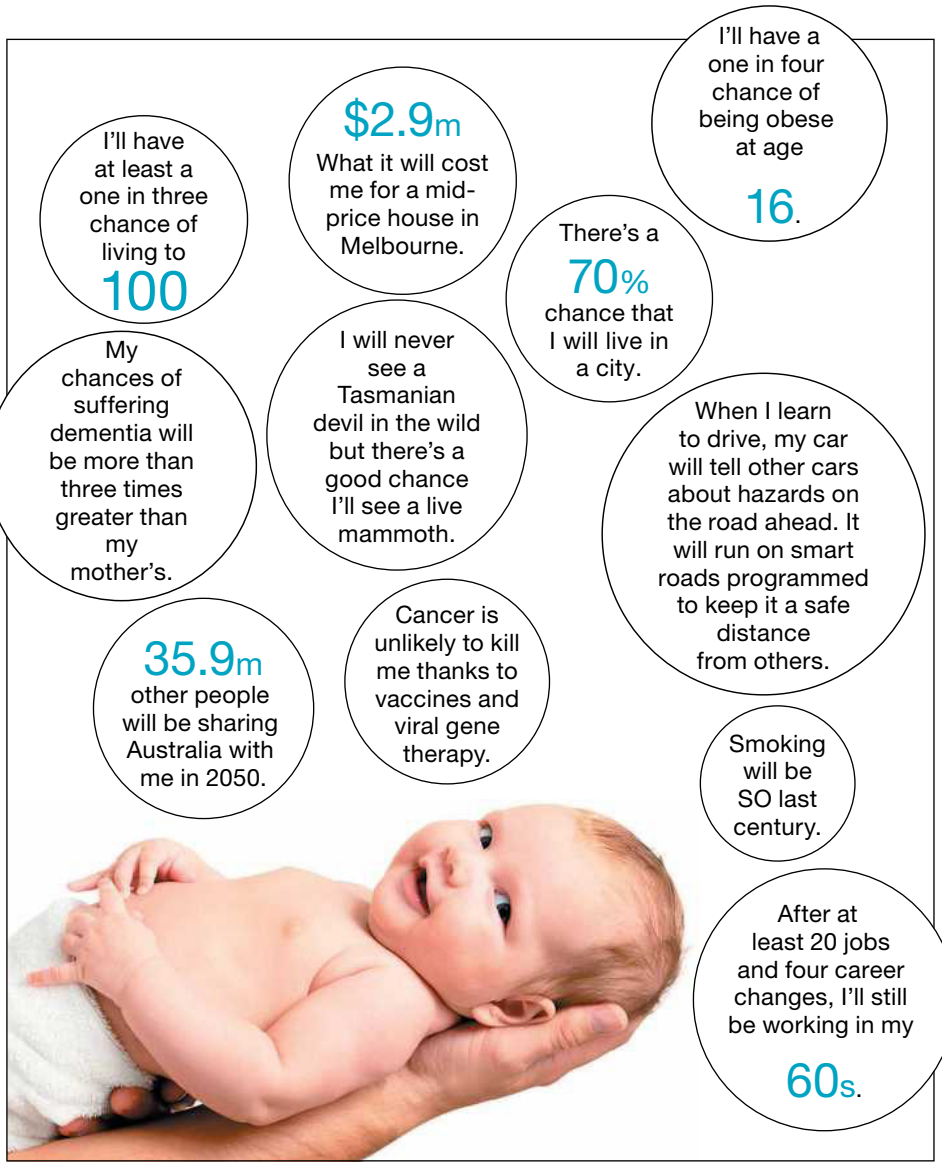


Note: Most recent data available at time of publication. Percentage change calculations are based on unrounded numbers.

Substantial improvements have been made in the area of preventable childhood diseases. For example, before the introduction of a measles vaccine in 1963, major epidemics occurred every two to three years, resulting in 2.6 million deaths each year. In 2020, 83 per cent of the world's children received the measles vaccine before their first birthday, up from 72 per cent in 2000. The World Health Organization reports an 80 per cent drop in measles-related childhood deaths, thus preventing 23.2 million deaths. Despite this reduction, in 2020 there were still 207 500 deaths globally due to measles. (The COVID-19 pandemic has set back vaccination efforts.)

Life expectancy and child mortality allow us to measure and compare human wellbeing in different places.

FIGURE 4 What will her future be like?



8.4.3 Births and deaths

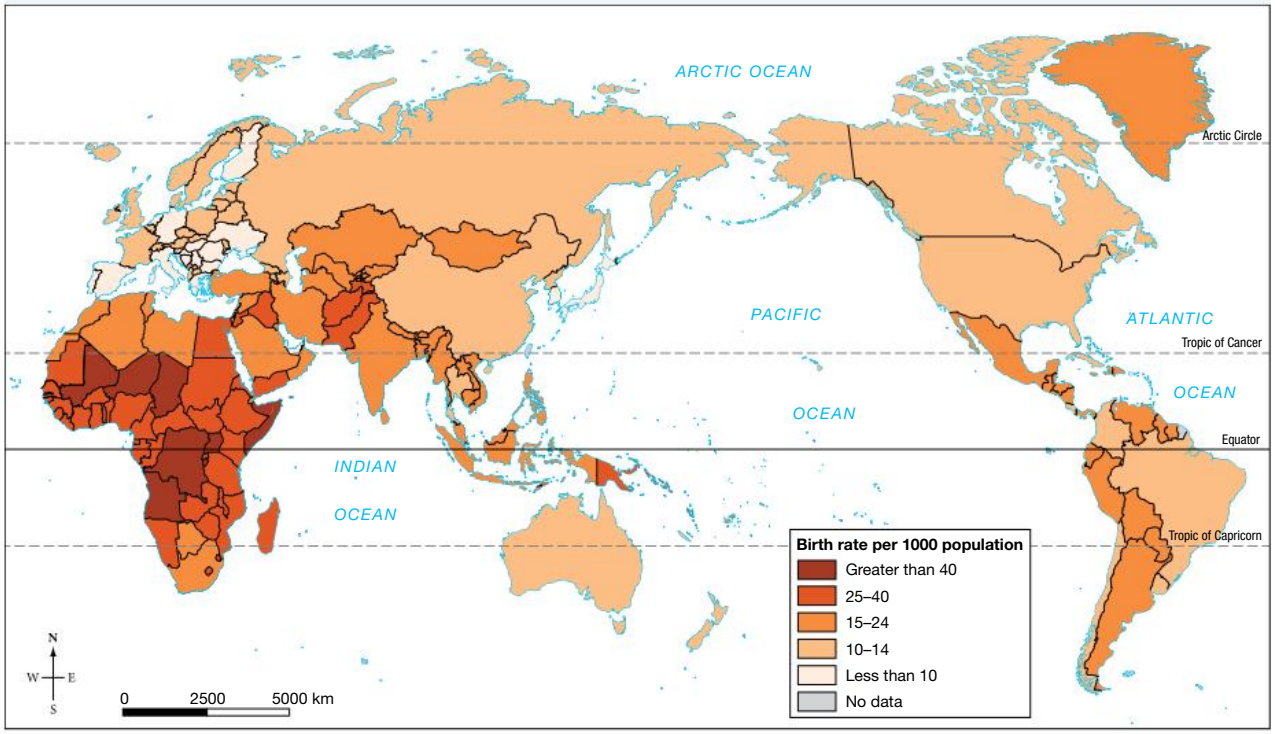
Every minute there are an estimated 250 births and 105 deaths worldwide. This natural increase equates to an extra 145 people at a global scale every minute. However, the rate of population change varies considerably across the world, with some places experiencing a decline rather than an increase in numbers of people. Rates of population change have an impact on wellbeing, both now and in the future.

FIGURE 5 shows the global distribution of birth rates. The continent of Africa clearly stands out here with the highest figures. In 2010, Africa had a population of one billion; the United Nations projects that by 2050 the African population will be 2.5 billion — three times that of Europe. The majority of this growth will occur in sub-Saharan Africa, where the average **fertility rate** in 2019 was five children per woman. Countries such as Niger and Somalia have fertility rates as high as 6.8 and 6 respectively, while Tunisia has the lowest fertility rate in Africa with 2.2 births per woman. Europe has very low birth rates with a fertility rate of 1.6. France is slightly higher than this average with fertility rates of 1.9. Taiwan recorded the lowest fertility rate in the world in 2020 with 1.2 births per woman. Australia's fertility rate is 1.6.

fertility rate the number of live births per 1000 women of childbearing age (usually 15–44) in a given year

int-7976

FIGURE 5 Global distribution of birth rates



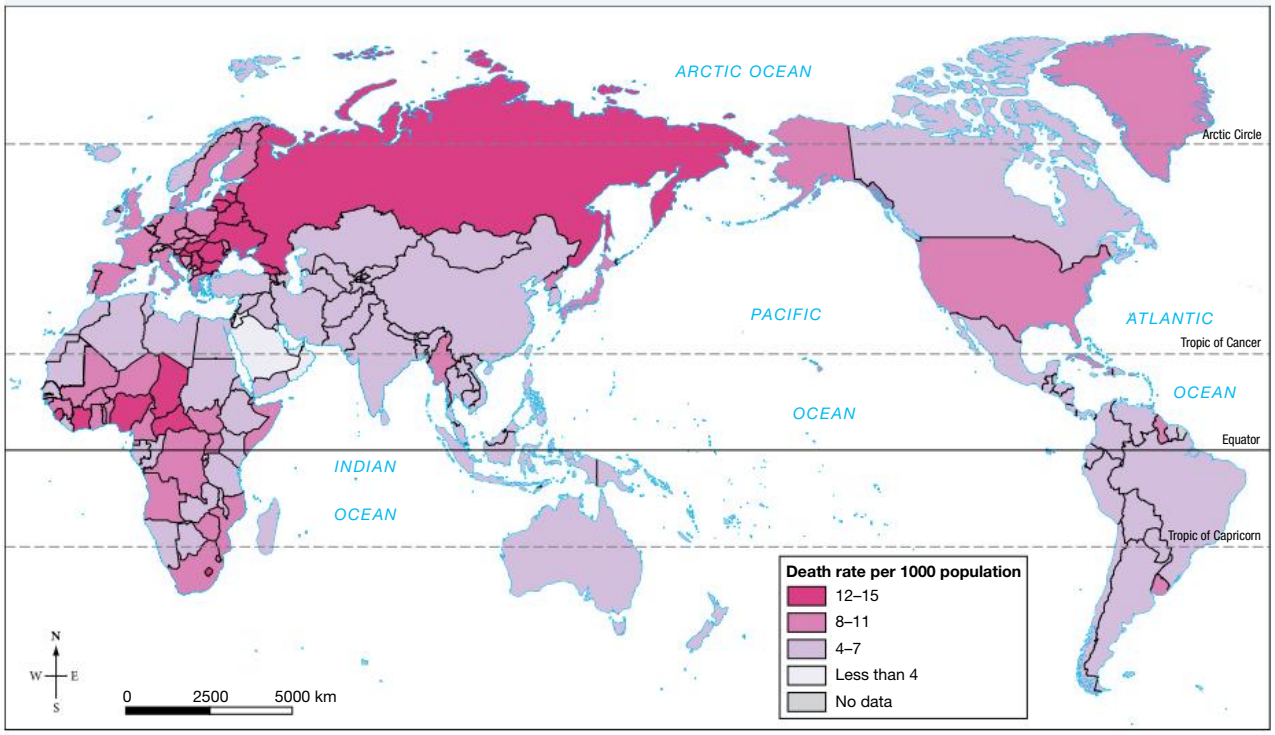
Source: © United Nations Publications; The World Bank.

For death rates, as **FIGURE 6** illustrates, sub-Saharan Africa is again at the high end of the spectrum, with many places in that region experiencing death rates above 10 per 1000. However, high death rates are more dispersed, with many European countries, such as Bulgaria and Ukraine, included. Low death rates are widely distributed across the regions of the Americas, much of Asia and Oceania.

int-7977

tlvd-10786

FIGURE 6 Global death rates

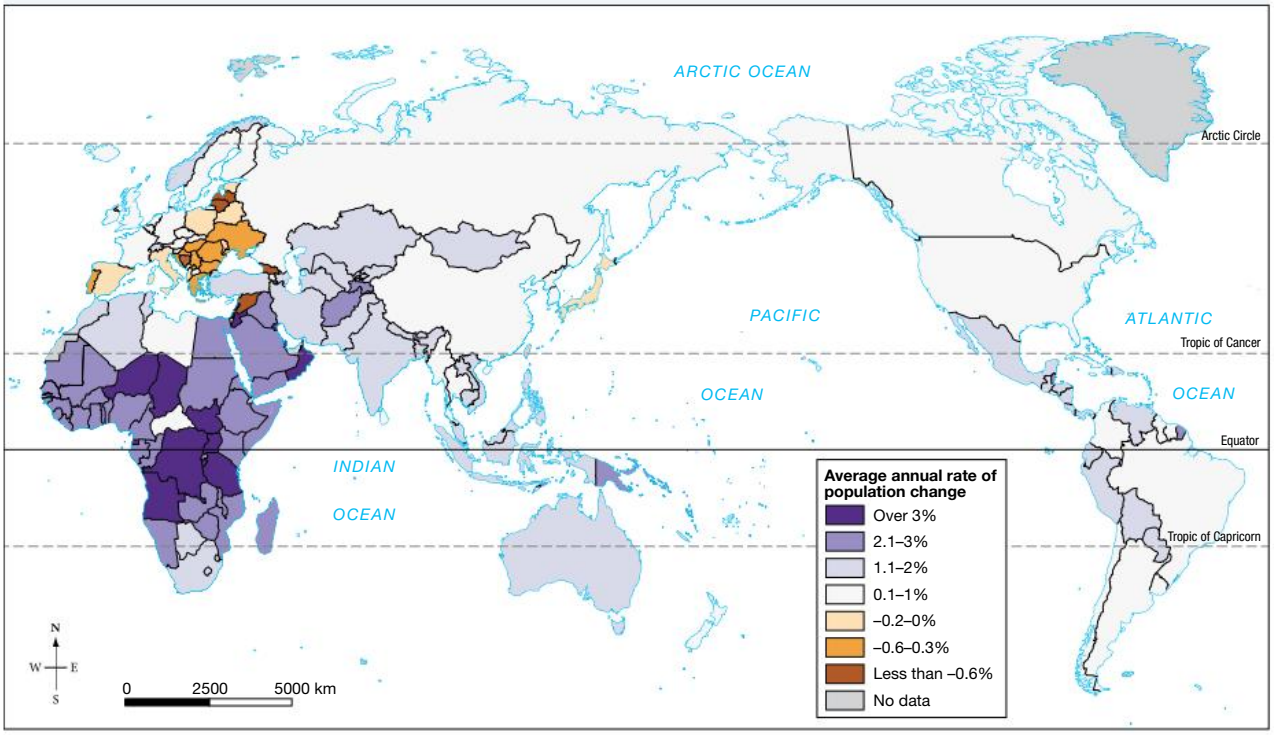


Source: © United Nations Publications; The World Bank.

Whether a population increases or decreases is largely dependent on variations in births and deaths producing a **natural increase.** Where a fertility level is well above the **replacement rate** of 2.1 children, population growth will occur. Conversely, fewer births over a period of time will ultimately result in a declining population. **FIGURE 7** indicates the rate of natural population change, which ranges from over 3 per cent growth primarily in African nations (this would result in a doubling of population in approximately 23 years) to negative growth primarily in Europe. It should be noted that on a national scale, population change is also affected by migration.

int-7978

FIGURE 7 Population change



Source: © United Nations Publications.

8.4.4 Maternal mortality

Rarely would women in Australia consider that pregnancy and giving birth could pose a risk of death. For most women in Australia and other developed countries, childbirth is something that occurs without significant health complications for either the mother or the baby. Unfortunately, for a huge number of women around the world this is not the case, and child-bearing can have a negative impact on their health and wellbeing.

Less economically developed countries (LEDCs) generally experience worse human wellbeing than more economically developed countries (MEDCs). For example, women in low-income countries have a 1 in 36 lifetime risk of **maternal mortality**, whereas this risk for women in high income countries is 1 in 3300. It is also true that within LEDCs, the health and wellbeing of women is generally worse than that of their male counterparts across most age groups. For this reason, ending gender discrimination, achieving gender equality and empowering women and girls are key elements of the United Nations' **Sustainable Development Goals** (SDGs). SDGs 3 and 5 clearly outline targets related to the health and wellbeing of women. Reducing maternal mortality rates is key among these aims. (See section 8.2.2 for the Sustainable Development Goals.)

Every day approximately 830 women die from complications related to pregnancy or childbirth. Most of these deaths are from preventable complications: severe bleeding,

natural increase the difference between the birth rate (births per thousand) and the death rate (deaths per thousand). This does not include changes due to migration.

replacement rate the number of children each woman would need to have in order to ensure a stable population level — that is, to 'replace' the children's parents. This fertility rate is 2.1 children.

maternal mortality the death of a woman while pregnant or within 42 days of termination of pregnancy

Sustainable Development Goals (SDGs) a set of 17 goals established by the United Nations Development Programme, which aim to end poverty, protect the Earth and promote peace, equality and prosperity

infections and complications from unsafe abortions. The incidence of maternal mortality and related illness is interconnected with poverty and lack of accessible, affordable quality health care.

The spatial distribution of maternal mortality (see **FIGURE 8**) shows that LEDCs have higher rates of maternal mortality, with the regions of sub-Saharan Africa and southern Asia accounting for the majority.

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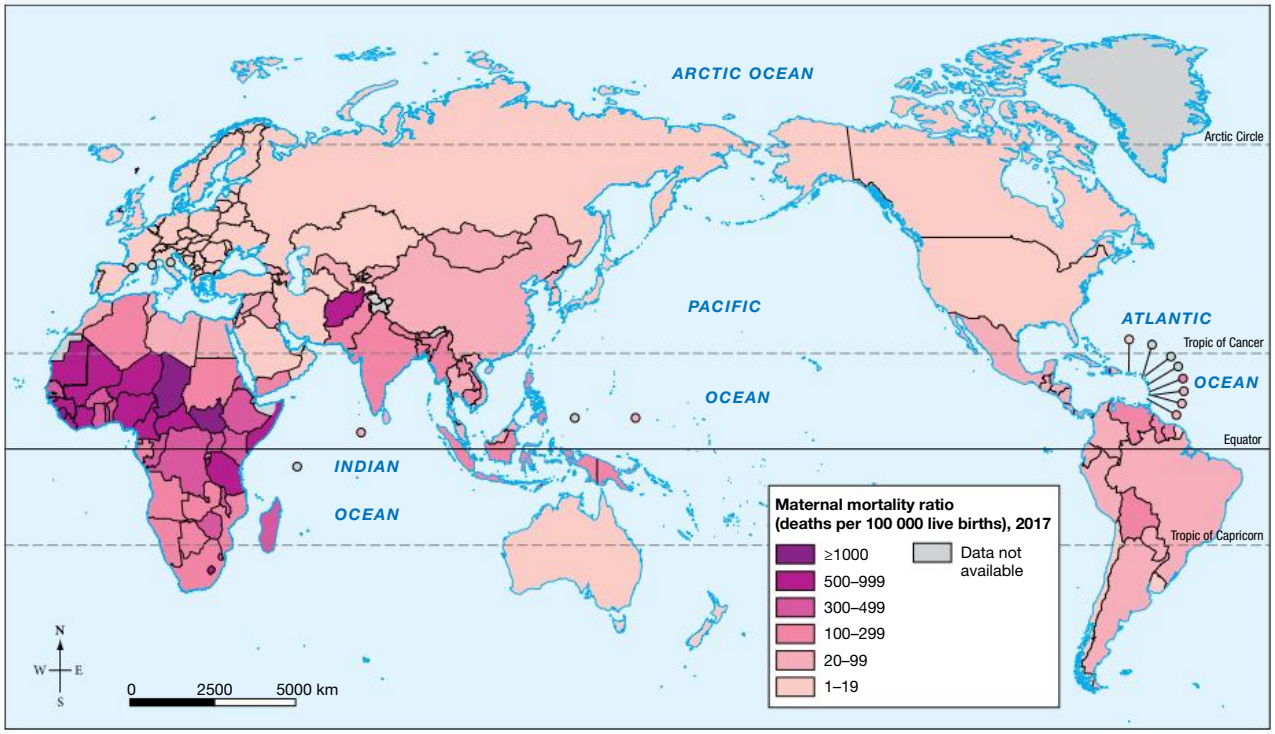
FIGURE 8 Global scale distribution of maternal mortality

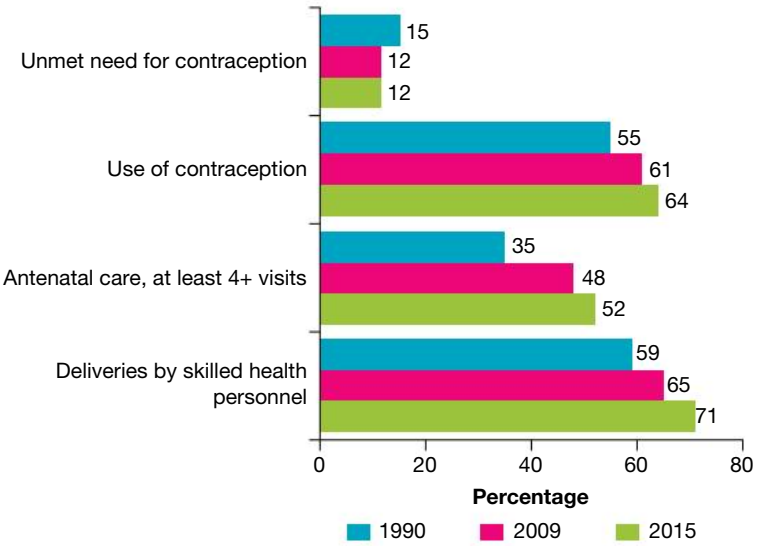


Source: World Health Organization, UNICEF, United Nations Population Fund and The World Bank, Trends in Maternal Mortality: 2000 to 2017 WHO, Geneva, 2019.

Eighty-six per cent of maternal deaths are in sub-Saharan Africa and southern Asia; sub-Saharan Africa accounts for two-thirds of all these deaths. Highest maternal mortality rates are recorded in Sierra Leone and Chad, where mothers have a 1 in 17 and 1 in 18 risk of dying, respectively. Two countries account for one-third of total global maternal deaths: Nigeria at 19 per cent (58 000), followed by India at 15 per cent (45 000).

The Millennium Development Goals (MDGs) — the forerunner to the SDGs — set a target of reducing the maternal mortality rate between 1990 and 2015 by three-quarters, and the achievement of universal access to reproductive health by 2015. While maternal mortality fell by 45 per cent during the MDG period, globally the 75 per cent target was not met, particularly in countries in sub-Saharan Africa.

FIGURE 9 Global reproductive health indicators, 1990–2015



Source: Data from *The Millennium Development Goals Report 2015*, United Nations, pp. 39, 41.

FIGURE 9 indicates progress in terms of access to reproductive health. Most indicators fell well short of universal access (considered to be 80 per cent). While use of contraception has increased, wealthier women continue to have the best access to contraception. The unmet need for contraception among poorer women remains at levels similar to 1990. In sub-Saharan Africa, for example, this figure was 28 per cent in 1990; in 2015 it remained high, at 24 per cent. Providing access to contraception is a means of empowering women to make choices about family size.

The SDGs have set a target of a maternal mortality rate below 70 per 100 000 by 2030. This will require an annual drop of 7.5 per cent — more than three times the reduction that occurred under the MDGs. However, Cambodia, Rwanda and Timor-Leste all achieved this type of reduction rate in the 15 years from 2000 to 2015, proving that this goal is achievable.

8.4 SKILL ACTIVITY: Communicating

Study **FIGURE 4**. **Create** your own version of this figure, depicting what you imagine your life will be like when you are 35 years old. Consider your daily life, the environment and social norms.

8.4 Exercise

learnon

8.4 Exercise

Learning pathways

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

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. **FIGURE 2** shows sub-Saharan Africa as having the lowest life expectancy.
   b. By 2020, over 80 per cent of the world's children were vaccinated against measles before their first birthday.
   c. Women in wealthier countries have the highest level of access to contraception.
2. LEDCs generally experience lower levels of human wellbeing than MEDCs due to:
   A. poor farming techniques and working conditions.
   B. lack of medicine.
   C. poor nutrition and hygiene.
   D. All of the above.
3. **Identify** the major contributors to population change at a national scale.
4. **Elaborate** on how a lack of education might contribute to increased rates of maternal mortality.
5. Using **FIGURES 5** and **6** and an atlas, **identify** countries that are exceptions to these patterns:
   a. high birth rates in Africa
   b. low birth rates in Europe
   c. low death rates in Asia
   d. low death rates in Europe.

Apply your understanding

Interpreting and analysing geographical data and information

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.
8. **Discuss** what implications an increase in life expectancy will have on the provision of health care.

LESSON
8.5 How does wellbeing vary in India?

LEARNING INTENTION

By the end of this lesson you should be able to describe India's changing population and explain the variation that exists in various measures of wellbeing across different regions of the country.

TUNE IN

In India and many Asian countries, child labour is an important part of a family's labour force.

FIGURE 1 Indian children assisting with rice planting

1. Consider why these children are working in the fields and see whether you can justify an argument as to why they should or should not be employed in this manner. How would this type of employment affect their wellbeing?
2. How does the situation for children in Australia differ from those shown in **FIGURE 1**?

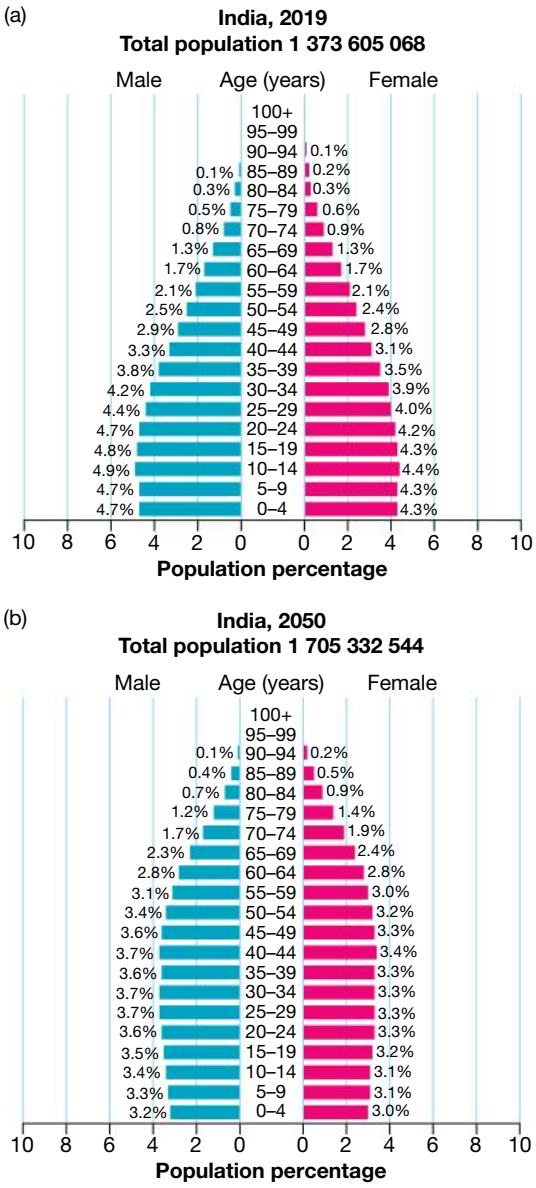
8.5.1 How and why is India's population changing?

China has the biggest population in the world, with a population of 1.4 billion in 2022; however, its population is expected to drop to 1.35 billion by 2050. The population of India, on the other hand, is expected to surpass that of China by 2025, rising from its current level of 1.37 to 1.46 billion. With a predicted population of 1.7 billion by 2050, what happens to India's population will have major implications in terms of the wellbeing of the people of that country.

Although the number of children per woman in India has declined substantially from 5 in the 1970s to 2.3 in 2018, there is considerable regional variation in this rate. Overall, India's population is growing at a rate of 1.1 per cent per year. 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. Of the entire population, 27 per cent is under 15 years of age, creating huge momentum for future growth (see **FIGURE 2**).

int-7991

FIGURE 2 Population pyramid for India (a) 2019 and (b) 2050



8.5.2 Regional variation in wellbeing

In addition to variations in population structure, the states of India show differences in other important wellbeing-related demographics. The levels of literacy and poverty shown in **FIGURES 5** and **6** reflect a varying distribution of wellbeing in India.

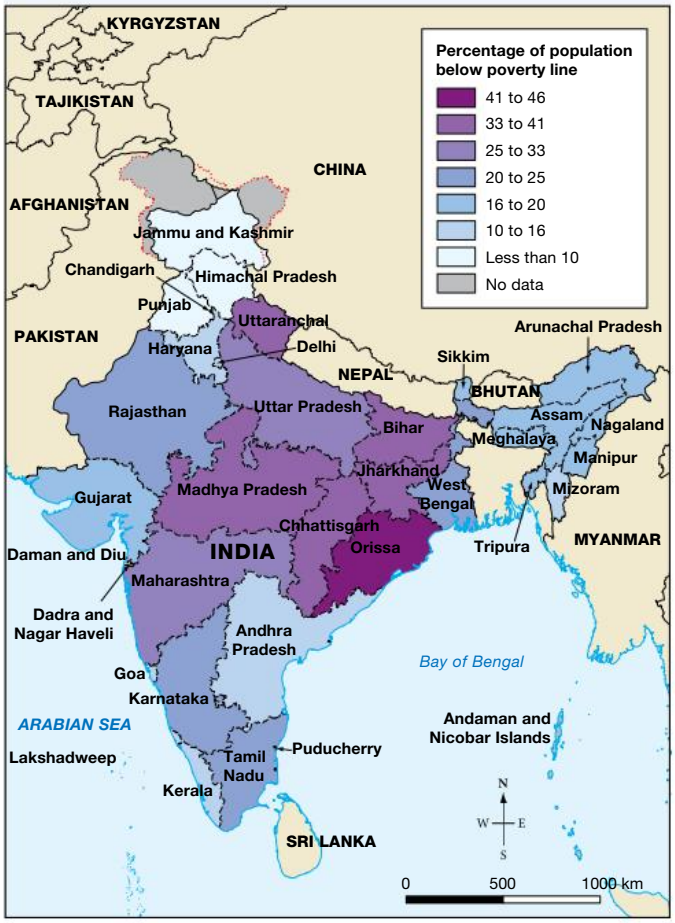
FIGURE 3 Proportion of children 0–6 years to total population, India, 2011

Note: Data drawn from 2011 census; next census due in 2023.
Source: Spatial Vision.

FIGURE 4 Poverty and literacy levels vary throughout India. States with both high levels of literacy and lower levels of poverty, such as Kerala and Mizoram, are rare.

int-7992

FIGURE 5 Poverty levels in India



Note: Data drawn from 2011 census; next census due in 2023.
Source: Spatial Vision.

FIGURE 6 Literacy rates (percentage) in India, 2011

int-7993

Note: Data drawn from 2011 census; next census due in 2023.
Source: Spatial Vision.

8.5.3 Maternal mortality in India

There is also a substantial variation of maternal mortality within India (see **FIGURE 7**). Maternal mortality is strongly interconnected with poverty in both rural areas and urban slums: places with poor **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 and less literate than males in a household, 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. This was reinforced in their 2013 Call to Action. 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 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 8**). By comparison, the natural human sex ratio at birth would see around 952 girls born per every 1000 boys.

sanitation facilities that safely dispose of human waste (urine, faeces and menstrual waste)
sex ratio the number of females per 1000 males

int-9141

FIGURE 7 Maternal mortality rates in India

Note: Data drawn from 2011 census; next census due in 2023
Source: Published and issued by Office of the Registrar General, India, Ministry of Home Affairs, www.censusindia.gov.in/vital_statistics/SRS_Bulletins/MMR_Bulletin-2010-12.pdf.

FIGURE 8 Variation in sex ratio within India

int-9142

Note: Data drawn from 2011 census; next census due in 2023
Source: Government of India, Ministry of Home Affairs, Office of the Registrar General. Map by Spatial Vision.

FIGURE 9 Son preference has resulted in an imbalance in India's sex ratio.

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 an estimated 500 000 girls aborted each year (although sex-selective abortion is also illegal). 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 7** and **8** suggest an 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

SkillBuilders to support skill development

- 1.11 SkillBuilder: Using multiple data formats

DISCUSS

How have cultural norms, religion and worldviews within Indian culture contributed to a lack of fairness and equality for females in Indian society?

8.5 SKILL ACTIVITY: Questioning and researching using geographical methods

A number of countries have already adopted a national measure of wellbeing. Either individually or in pairs, complete the following.

1. **Research** the history of one of the following indices:
   - Gross National Happiness (Bhutan)
   - Key National Indicator System (United States)
   - Canadian Index of Wellbeing (Canada).
2. **Identify** the indicators used to measure your chosen indicator of wellbeing.
3. **Evaluate** the success of your chosen measure of wellbeing.

8.5 Exercise

learnon

8.5 Exercise

Learning pathways

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

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Check your understanding

1. With reference to the **FIGURE 2** population pyramids, complete the sentence below to **summarise** India's changing population growth, using the words provided.

high	increase	increased
low	reduction	decreased

India's population growth remains _____ as the death rate has decreased due to improvements in water supply and a _____ in the rate of infectious diseases, while the birth rate has _____ to a lesser extent.

2. From **FIGURE 3**, **identify** the three regions of India that have the lowest proportion of children aged 0–6 years.
   - **A.** Bihar
   - **B.** Tamil Nadu
   - **C.** Meghalaya
   - **D.** Andhra Pradesh
   - **E.** Kerala
   - **F.** Goa
3. **Determine** whether the following statements are true or false.
   - **a.** Some people in India live below the poverty line (an official measure used by governments to define those living below this income level as living in poverty).
   - **b.** In India, males are often the desired gender of children as they are seen as the breadwinners and daughters are seen as an economic burden.
   - **c.** Poor sanitation is associated with high levels of maternal mortality.
4. Study **FIGURE 5**. **Describe** the distribution of the states with the highest percentage of the population living below the poverty line. (*Note:* Currently the World Bank's global poverty line indicator is less than US$1.90 per day.)
5. Look at **FIGURE 6**. **Identify** five Indian states that have a literacy rate above the national average.
   - **A.** Tripura
   - **B.** Jammu and Kashmir
   - **C.** Puducherry
   - **D.** Daman and Diu
   - **E.** Assam
   - **F.** Gujarat
   - **G.** Orissa
   - **H.** Delhi

Apply your understanding

Interpreting and analysing geographical data and information

6. Use **FIGURES 3, 5, 6, 7** and **8** to **identify** the average characteristics of the population in Uttar Pradesh.
7. **Describe** the characteristics of the state of Orissa in India.
8. Using the data provided throughout this lesson, **describe** and account for the variation in wellbeing in India.
9. In which state (or states) of India do you think wellbeing would be highest? **Explain** your response.
10. **Predict** the shape of India's population pyramid if the trends in India's sex ratio continue.
11. **Examine FIGURE 5** showing the distribution of poverty in India. To what extent is the interconnection between poverty and maternal mortality (as shown in **FIGURE 7**) evident?

LESSON
8.6 How does poverty affect wellbeing?

LEARNING INTENTION

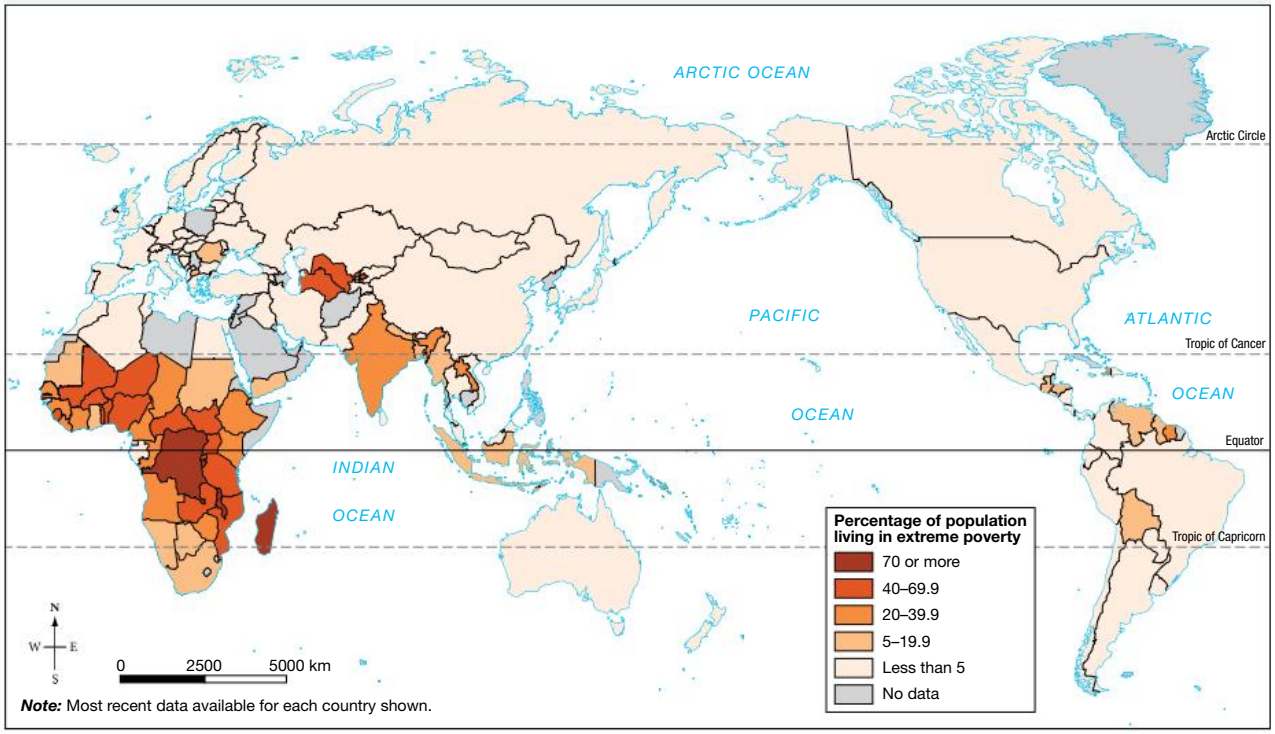
By the end of this lesson you should be able to explain the concept of economic inequality and describe how this affects individuals' wellbeing.

TUNE IN

Many people in the world have to live on less than $2.00 per day and this can have a great impact on their access to health and education services that many in Australia recognise as essential services for wellbeing and a high standard of living.

int-7972

FIGURE 1 The proportion of the world's population living on less than US$1.90 per day, the World Bank's global poverty line indicator



Source: World Bank – World Development Indicators.

1. Suggest reasons as to why much of Africa is living in extreme poverty.
2. What elements in your life, both social and economic, contribute to the high level of wellbeing seen in Australia?

8.6.1 Defining 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 one billion people live in **extreme poverty**, as represented in **FIGURE 1**.

8.6.2 The haves and have-nots of Rio

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 what life is like in a typical **favela** in Rio de Janeiro.

According to World Bank statistics, Brazil is the eighth-largest economy in the world. This ranking places Brazil ahead of Russia, South Korea and Australia. Yet, despite the strength of Brazil's economy, the benefits of economic growth have not trickled down to the poor, resulting in large differences in wellbeing across the nation.

In Brazil, some of the most overt inequality of wealth distribution in the world is evident. Almost 55 million Brazilians — a quarter of the population — live in poverty. Incredibly, the wealthiest 5 per cent of Brazil's population earns the same income as the remaining 95 per cent.

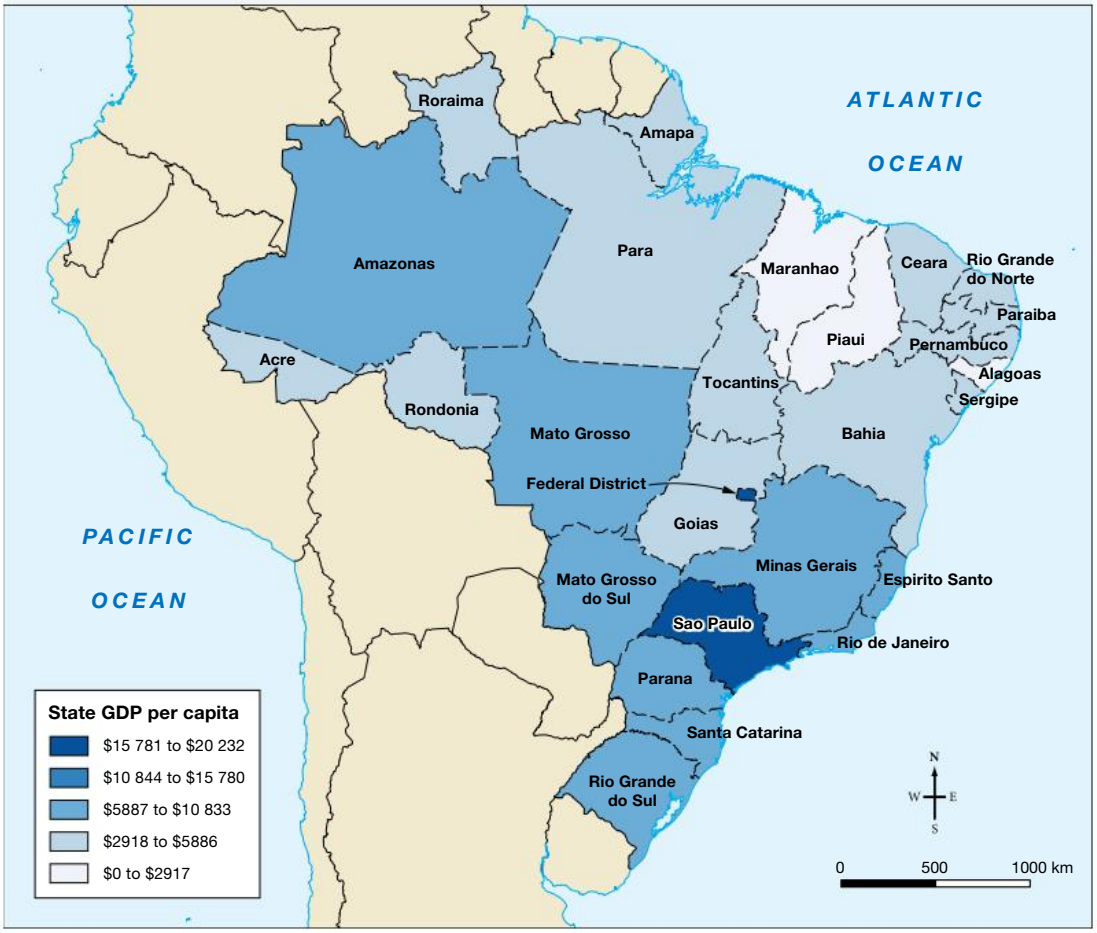
FIGURE 2 shows the variation in wealth experienced across Brazil's different regions, as measured by gross domestic product (GDP).

extreme poverty a state of living below the poverty line (US$1.90 per day), and lacking resources to meet basic life necessities (also known as absolute poverty)

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.

int-9143

FIGURE 2 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 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.

Impacts of Rio de Janeiro's development 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, these elements are far removed from their daily lives. Even within 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 in the eighteenth century when freed slaves who had 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 entire suburbs, known as 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 3**), while the wealthier tend to live on the more stable flatter land closer to the city centre.

Brazil conducts its census every ten years, although the latest has been delayed due to COVID-19. According to the census in 2010, 22 per cent of Rio de Janeiro's population of over 6.35 million people lived across some 763 favelas. Rocinha (shown in **FIGURE 4**) is considered Rio's largest favela, with its population estimated at between 150 000 and 300 000 people. It is located in the southern zone of the city, in close proximity to the famous beaches of Rio's Ipanema and Copacabana districts.

FIGURE 3 A favela located on a steep slope in Rio de Janeiro

FIGURE 4 Street view of Rocinha favela, Rio de Janeiro

The effect of favela-living on wellbeing

Living conditions in the favelas are extremely difficult as these areas have developed without any type of planning or government regulation and the housing is generally substandard. The resulting issues have an impact on the ongoing 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 4**).

spatial variation difference observed (in a particular measure) over an area of the Earth's surface

- *long commuting times*. The average time to travel into the city centre of Rio is 1.5 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*. The incidence of homicide and other crimes is high. This is linked to the influence of drug trafficking and criminal gangs who have established themselves within the relative safety of the favelas.
- *a sense of 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.

Improvements to wellbeing in the favelas

In order to reduce crime and drug traffickers' control over the favelas, and to improve safety, in 2008 the government introduced Pacifying Police Units (known in Portuguese as the *Unidade de Polícia Pacificadora*, or UPP). By 2014, 37 UPPs were in place. These have had mixed success, with ongoing violence still very much an issue in many areas.

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 2014 World Cup soccer tournament and the 2016 Olympic Games, the city expanded infrastructure and built new facilities. **FIGURE 5** highlights the major issue that many of the planned Olympic

FIGURE 5 Location of Rio's favelas and Olympic venues

Source: UNEP-WCMC 2012. Made with Natural Earth.

Zones were located on existing favela sites. Many residents were very unhappy at the prospect of being relocated to make way for new sporting venues. Over 3000 families were forcibly relocated. Favela residents claimed that the financial compensation offered was insufficient for a new home and that communities that had existed for generations were being destroyed.

Unfortunately, Brazil's ambitious plan to improve the wellbeing and living conditions of the favelas has been limited by recent economic uncertainty. After the hope provided by the Olympic Games upgrades, the futures of people living in the favelas are much more uncertain.

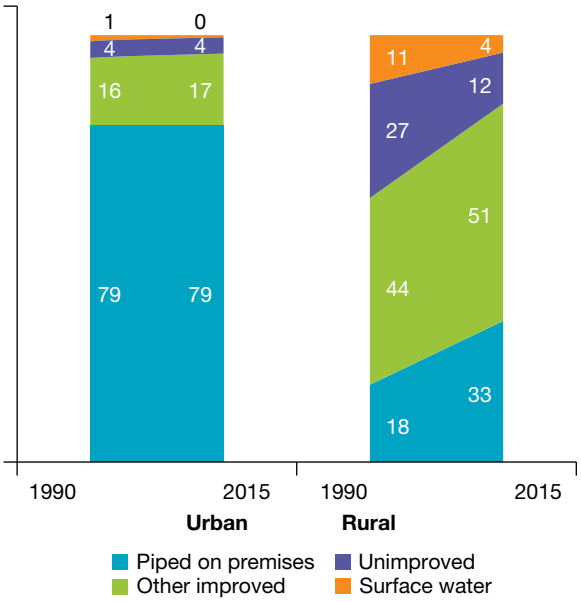
Preventing the continued growth of favelas by providing adequate low-income housing is the most cost-effective means of improving wellbeing. The cost of upgrading a favela with basic infrastructure is estimated to be two to three times as much as the cost of providing new high-rise housing estates. However, 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, it ultimately fell well short of its goal; extreme poverty remains, with rates back up to 4.8 per cent in 2017. The challenge of improving the lives of Rio's poor continues.

8.6.3 The interconnection between poverty, water supply, sanitation and wellbeing

For many people around the world, lack of access to clean water and lack of adequate sanitation has had a major impact on their health and therefore their wellbeing. Approximately 840 million people do not have access to clean, safe drinking water, and at least two billion people use a drinking water source contaminated with faeces. Over two billion lack basic sanitation. Safe drinking water and basic sanitation are of crucial importance to human health, especially for children. Water-related diseases are the most common cause of death among the poor in less developed countries — they kill an estimated 842 000 people each year, nearly half of whom are children under the age of five. Diseases such as cholera, typhoid, dysentery and worm infestations are directly attributable to contaminated water supplies.

FIGURE 6 Trends in drinking water coverage (%), by rural and urban residency



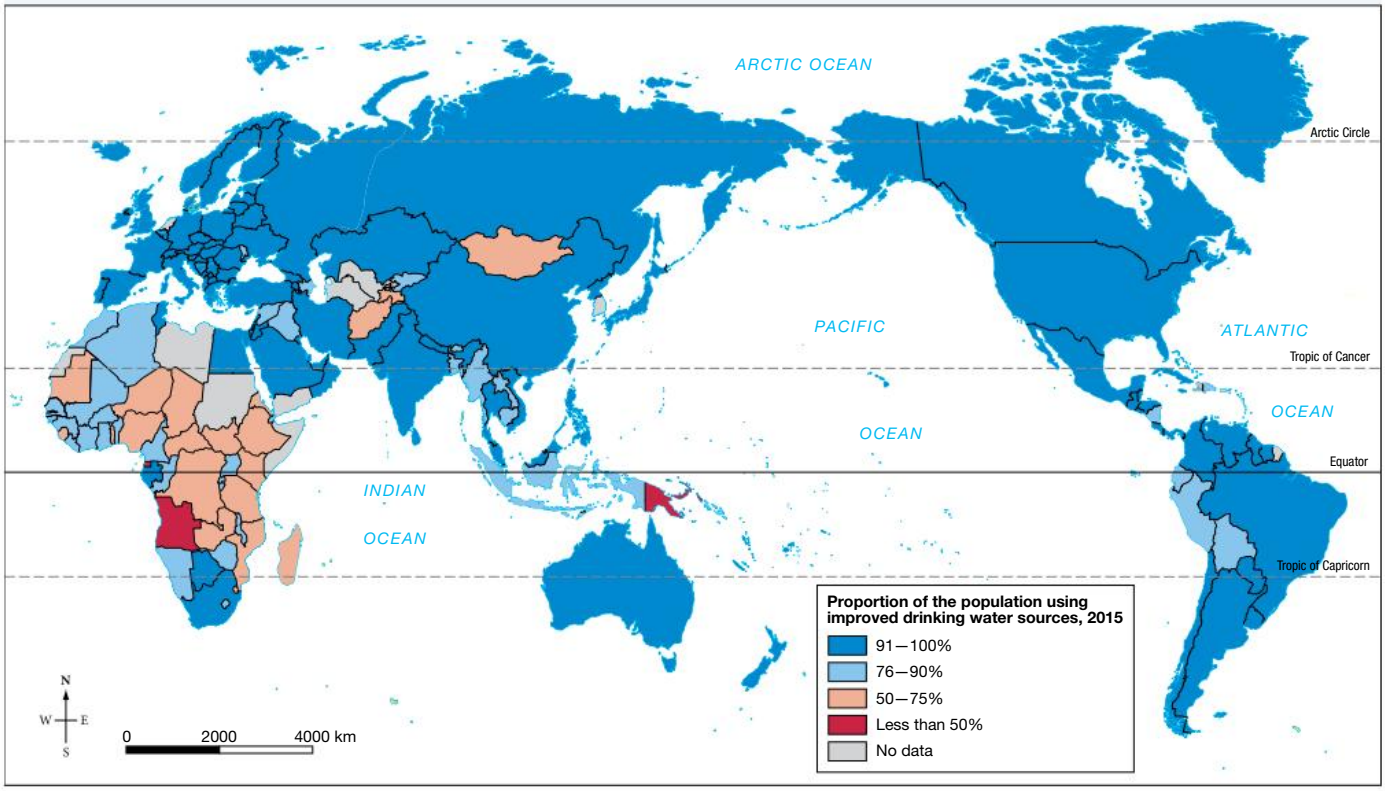
Global progress

Remarkable progress was made under Millennium Development Goal 7 — to halve the proportion of people without access to safe drinking water by 2015. The target was met more than five years ahead of schedule, with 91 per cent of the global population using an improved drinking water source in 2015 compared with 76 per cent in 1990. Fifty-eight per cent of the world's people now have access to piped drinking water. Rural and urban coverage does vary, however, as shown in **FIGURES 6** and **7**.

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

int-7984

FIGURE 7 Proportion of the population using improved drinking water sources, 2015



Source: © UNICEF.

Progress towards the MDG sanitation target of 75 per cent was much slower and was not met overall, although 95 countries did succeed. Only 68 per cent of the world's population has access to improved sanitation. New targets for improved access to clean water and sanitation have been set for 2030 under Sustainable Development Goal 6.

There are huge regional variations across the globe as well as within countries. For example, 90 per cent or more of people in Latin America, Northern Africa and much of Asia have improved water supply, in contrast to only 68 per cent in sub-Saharan Africa. In terms of sanitation, most people who lack access are again rural dwellers, even within locations where water supply has improved.

DISCUSS

'Access to adequate sanitation is increasingly a problem in urban places in the developing world.' Evaluate this statement in small groups.

Success stories

Many **non-government organisations (NGOs)** have been involved in successful projects to improve access to water supply and sanitation. The success of these projects hinges not just on provision of clean water and toilets, but also on community involvement and education. Agencies such as Oxfam and World Vision work within communities to provide access to water filters, safe and clean toilets, water pumps and rainwater harvesting systems for collecting and storing water. In addition to the health benefits that they provide, these facilities also free up women and girls from hours of work spent carrying water or finding additional firewood in order to boil unsafe drinking water. Mothers now have more time to work on their farms, potentially improving food availability and income, and girls have more time free from essential chores, so they can instead attend school.

non-government organisation (NGO) an organisation that operates independently of government, usually to deliver resources or serve some social or political purpose

8.6 SKILL ACTIVITY: Concluding and decision-making

Undertake **research** on one of the following to **determine** the role unclean water plays in its spread:

a. cholera
b. typhoid
c. dysentery
d. schistosomiasis
e. worm infestation.

Start by finding out how it spreads, how it affects people and where in the world it is most common.

on Resources

Weblink Favelas

8.6 Exercise

learnon

8.6 Exercise

Learning pathways

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

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Check your understanding

1. **Select** any answers that could be used to **describe** a typical favela.
   A. Formal housing
   B. Standard infrastructure
   C. Built by the residents
   D. Informal housing
   E. Occupied legally
   F. Rubbish disposal systems
2. Poor sanitation leads to higher rates of disease. True or false?
3. The development of Rio de Janeiro's favelas has had an impact on people's wellbeing through:
   A. lack of access and infrastructure.
   B. long commuting times and high crime rates.
   C. vulnerability to weather extremes.
   D. lower household incomes and a sense of insecurity.
   E. All of the above.
4. With reference to **FIGURE 5**, **describe** the spatial distribution of favelas in Brazil.
5. Refer to **FIGURE 2**.
   a. The average GDP for the state of Rio de Janeiro is $5887 to $10 833. True or false?
   b. **Describe** the distribution of Brazilian states with an average GDP per capita of more than $12 000.
   c. **Explain** your reasoning for this pattern.

Apply your understanding

Interpreting and analysing geographical data and information

6. **Elaborate** on the interconnection between the development of favelas and movement of people from rural areas into Rio de Janeiro.
7. Visiting favelas is increasingly popular among tourists. **Identify** some positive and negative impacts of tourist tours of favelas. Formulate your own opinion: is such tourism exploiting or helping locals?
8. **Explain** the impact poor sanitation has on the natural environment.
9. Which countries and regions do you expect to make greatest progress in terms of improving access to clean water and sanitation? **Justify** your answer.
10. What is the likely impact of improved water provision on literacy for girls? **Discuss**.

LESSON
8.7 How does wellbeing vary in Australia?

LEARNING INTENTION

By the end of this lesson you should be able to describe the changing nature of Australia's population, identify factors that influence Australia's population profile and be able to make and justify predictions about Australia's changing population profile. You should also be able to describe the wellbeing of First Nations Australian communities and explain variations between the wellbeing of Australians.

TUNE IN

Health and education services and access to good chances of employment are crucial factors in the level of wellbeing of a nation. These factors vary greatly in Australia, with capital cities and regional centres generally doing well.

1. Why would remote outback settlements, particularly for First Nations Australians, be considered as having a lower level of wellbeing?
2. Do you have any suggestions of how wellbeing in these remote centres could be improved? Put forward some of your ideas.

FIGURE 1 Innamincka: an outback town

8.7.1 Australia's population

According to the Australian Bureau of Statistics, Australia's population reached 25.9 million in September 2020. Statistically speaking, a typical Australian in that year would be female, born in Australia, aged 37 years and 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 2**). Seventy-one per cent of Australians live in major cities with a population of over 100 000; 29 per cent live in rural and remote areas, of whom around 2 per cent live in small towns with a population of less than 1000 people.

On average, Australians living in rural and remote areas have shorter lives, higher levels of disease and injury, and poorer access to and use of health services compared with people living in metropolitan areas. Poorer health outcomes in rural and remote areas may be due to multiple factors including lifestyle differences and a level of disadvantage related to education and employment opportunities, as well as access to health services.

These health inequalities may be due to factors including:

- challenges in accessing health care or health professionals, such as specialists
- social determinants such as income, education and employment opportunities
- higher rates of risky behaviours such as tobacco smoking and alcohol use
- higher rates of occupational and physical risk, for example from farming or mining work and transport-related accidents.

However, despite poorer health outcomes for some, the Household, Income and Labour Dynamics in Australia (HILDA) survey found that Australians living in small towns (fewer than 1000 people) and in non-urban areas

FIGURE 2 Australia's population distribution

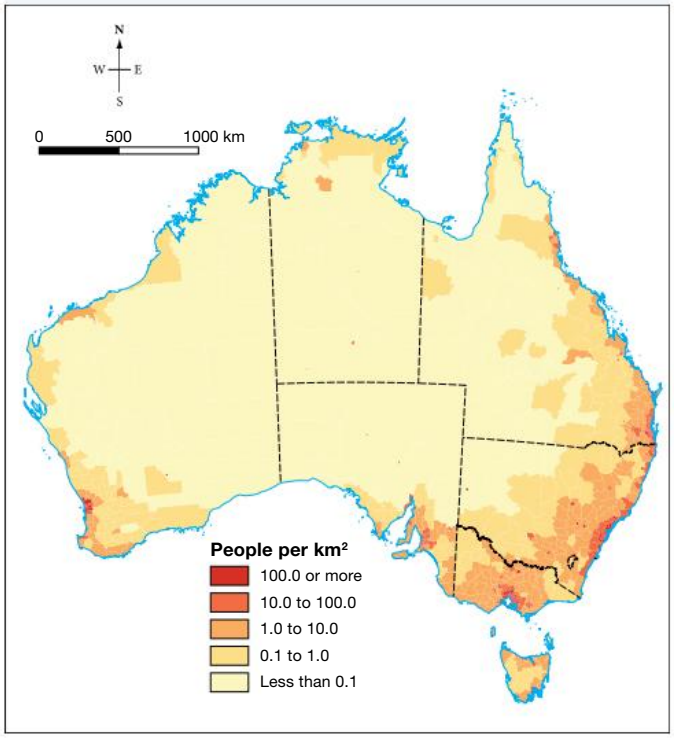


FIGURE 3 Brisbane is a typical urban environment

Source: Spatial Vision.

generally experienced higher levels of life satisfaction than those in urban areas. Rural and remote Australians also reported increased community interconnectedness and social cohesion, as well as higher levels of community participation, volunteering and informal support from their communities.

8.7.2 Are all Australians equal?

First Nations Peoples of Australia make up 3.3 per cent of the Australian population, with a median age of 23 years. With 65 per cent of the First Nations Australian population under 30 and only 3.4 per cent over the age of 65, they are a young population. The rest of the Australian population is ageing, with a median age of 37 years; 39 per cent of the population is under 13 and 14.1 per cent is over the age of 65.

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'. However, many First Nations Australians consistently experience lower levels of health, education, employment and economic independence than those experienced by other Australians. These **socioeconomic** factors inhibit the ability of First Nations Australians to contribute to and benefit from all that Australia has to offer.

socioeconomic of, relating to or involving a combination of social and economic factors

Why does disadvantage exist?

The inequalities may be attributed to the following main causes:

- the dispossession of land
- the displacement of people
- discrimination
- remoteness and isolation.

Many generations of First Nations Australians 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, First Nations Australians (as a group) remain disadvantaged (see **FIGURE 4**).

8.7.3 Improving wellbeing — closing the gap

In 2008, the Close the Gap program was launched with the aim of eliminating health and wellbeing differences between First Nations Australians and non-First Nations Australians. It set out six key targets:

1. to close the life expectancy gap within a generation
2. to halve the gap in mortality rates for First Nations Australian children under five within a decade
3. to ensure access to early childhood education for all First Nations Australian four-year-olds in remote communities within five years
4. to halve the gap in reading, writing and numeracy achievements for children within a decade
5. to halve the gap for First Nations Australian students in Year 12 attainment rates by 2020
6. to halve the gap in employment outcomes between First Nations Australians and other Australians within a decade.

FIGURE 4 Indicators of First Nations Australians wellbeing

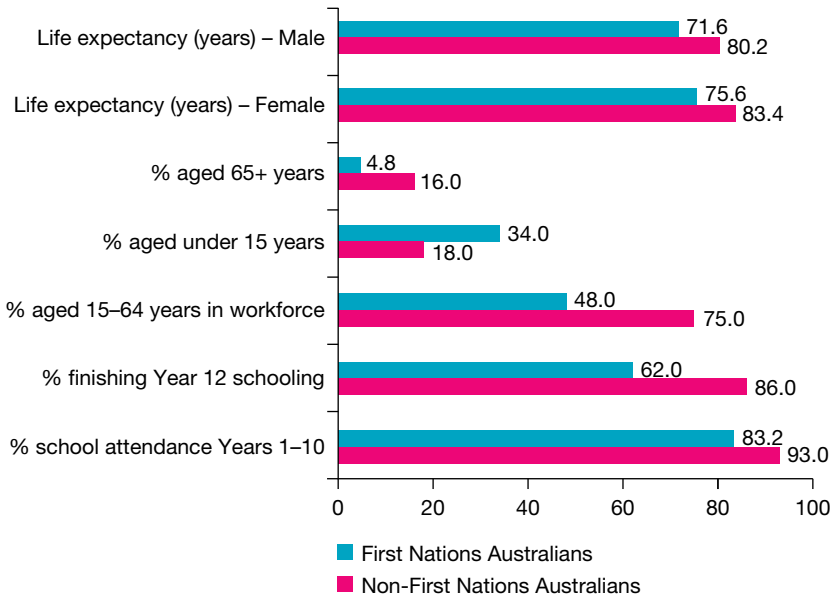


FIGURE 5 Closing the gap will take generations of commitment.

In the ten-year review of the program in 2018, it was noted that only two of the targets — early childhood education and Year 12 attainment — were on track to be met. The remaining target areas, although showing some improvements, were falling short of the desired levels. In the Closing the Gap Reset program outlined in 2020, targets were completely reset in all areas and a greater involvement of First Nations Australians in leading and measuring its progress was announced. Key areas of focus include:

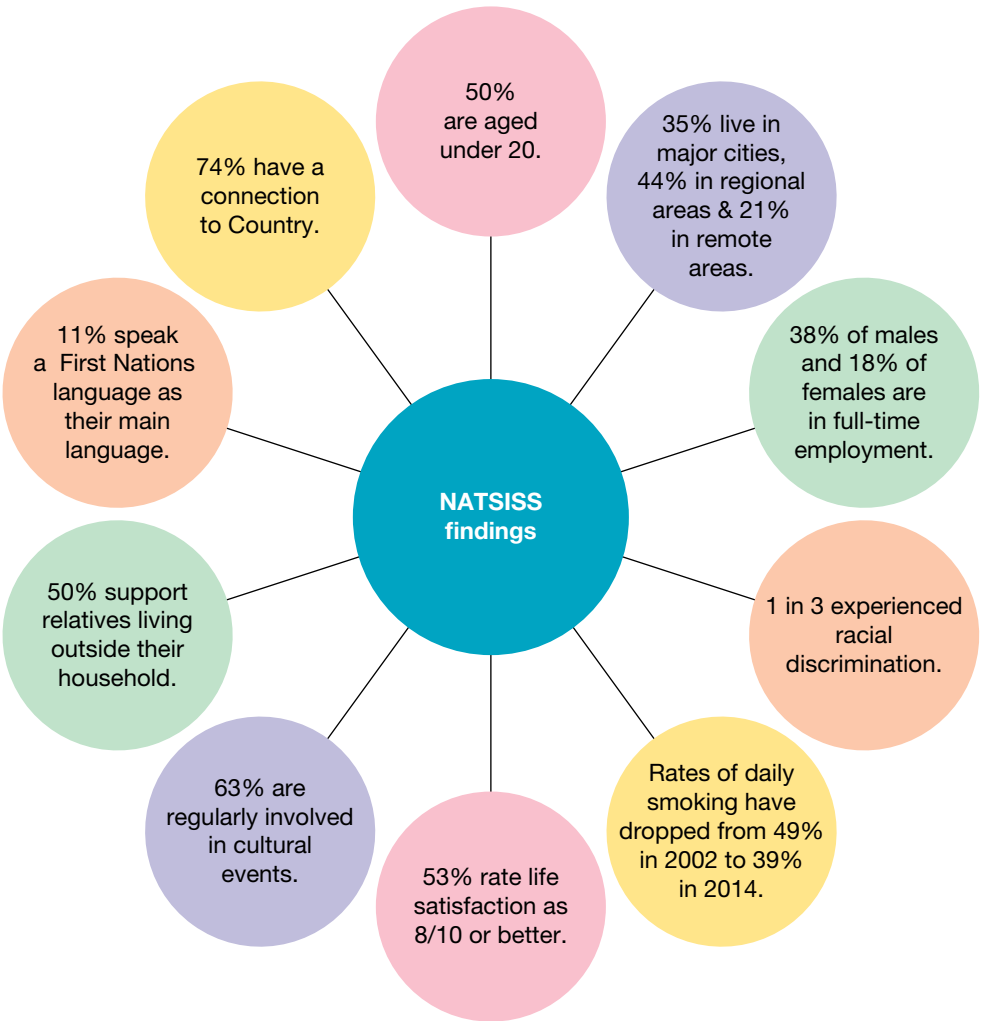
- families, children and youth
- housing and a reduction of children in out-of-home care
- justice, including youth justice
- health
- suicide prevention
- culture and language
- education
- land and sea rights
- eliminating racism and systemic discrimination.

How can we measure First Nations Australians' wellbeing?

First Nations Australians are culturally and linguistically diverse, but their cultures differ markedly from other Australian cultures. Traditions of family structure and community obligation, language, obligations to Country and the passing down of culture and knowledge are all viewed and practised very differently 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 by standards devised by other cultural traditions.

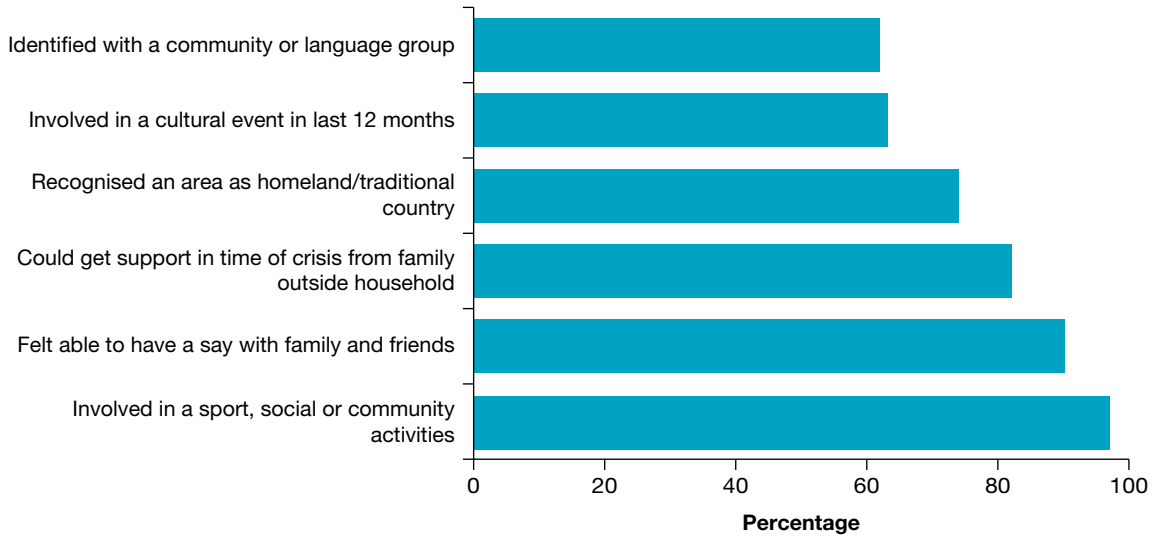
The National Aboriginal and Torres Strait Islander Social Survey (NATSISS) is a six-yearly survey conducted by the federal government. It aims to measure the health and wellbeing of First Nations Australian communities. Some of the data gathered from the survey are highlighted in **FIGURE 6**.

FIGURE 6 Some findings from the latest National Aboriginal and Torres Strait Islander Social Survey (NATSISS) 2014–15



The latest data reveals some of the key wellbeing issues facing First Nations Australians, but also highlights the cultural and community connections and the importance of these connections in relation to overall sense of life satisfaction and wellbeing. **FIGURE 7** summarises the extent of this participation in family and community life.

FIGURE 7 First Nations Australians' participation in aspects of family, community and cultural life



Programs to close the gap

Recognising the divides that exist at home, Australian governments and other agencies such as Oxfam are continuing to push initiatives aimed at tackling some of the problems that many First Nations Australian communities face. Ultimately, all Australians benefit from a united effort to address this disadvantage. When disadvantage is overcome, the need for government expenditure is decreased. At the same time, First Nations Australians will be better placed to fulfil their cultural, social and economic aspirations.

The following initiatives are examples of how both government and non-government agencies are working to improve the wellbeing of First Nations Australians.

- *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 ten Aboriginal-controlled health organisations that share resources and programs servicing 35 000 people.
- *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 communities often had little choice. Goods and food were of poor quality and basic consumer protection was lacking. More than 90 Northern Territory stores, such as the one pictured in **FIGURE 8**, are now licensed, with reported improvements in management, hygiene and employment of local staff.
- The *Wylak Project* builds the leadership capacity of First Nations Australian youth by offering grants in three key areas — cultural projects, advocacy/campaigning and learning events.

FIGURE 8 New food store at Ngukurr, Northern Territory

Lombadina Aboriginal community program

First Nations Australians are also working hard to improve their wellbeing. The Bardi people, who live in Lombadina, a community on the north-western coast of Western Australia (see **FIGURE 9**), are one example of this. Lombadina and the neighbouring Djarindjin community are home to approximately 200 Bardi 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 the Bardi people's 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.

FIGURE 9 Location of Lombadina, Western Australia

Lombadina is also involved in the EON Thriving Communities Project. EON is a non-government organisation operating by invitation in First Nations Australian 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.

8.7 SKILL ACTIVITY: Communicating

1. **Conduct** internet research into the Closing the Gap Reset.
   Consider the following:
   - What is it? What are the main focus areas?
   - When did it start?
   - Why did it happen?
   - Who are the main stakeholders involved?
2. **Create** an infographic poster outlining the new targets relating to each of the key focus areas.

Resources

Weblink Lombadina

8.7 Exercise

learnon

8.7 Exercise

Learning pathways

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

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Check your understanding

1. Refer to **FIGURE 4**.
   a. The average life expectancy for First Nations Australians is:
      A. 75.6 years.
      B. 71.6 years.
      C. 73.6 years.
   b. The average life expectancy for non-First Nations Australians is:
      A. 80.2 years.
      B. 81.8 years.
      C. 83.4 years.
   c. What is the difference (in years) between the average life expectancies in parts a and b?
      A. 2 years
      B. 8.2 years
      C. 3.2 years
2. **Name** the areas that are being addressed by the federal government's Close the Gap program.
3. **Identify** how the National Aboriginal and Torres Strait Islander Social Survey might give us more insight into the wellbeing of First Nations Australians.
4. **Explain** some of the causes of disadvantages that exist for First Nations Australian Peoples.
5. **Identify** why the Close the Gap program is necessary.

Apply your understanding

Communicating

6. Did any of the statistics about First Nations Australians surprise you? **Reflect on** your reaction to them, and how they may have either changed or reinforced your own opinions or beliefs.
7. 'Social justice' means fair and equitable access to a community's resources. Do you think First Nations Australians experience social justice in Australia? **Discuss** your answer.
8. **Consider** how the First Nations Australian tourism initiatives such as those run by the Lombadina community can improve the wellbeing of people beyond that community.

Concluding and decision-making

9. a. **Decide** what you consider to be the most significant wellbeing issue facing First Nations Australians today. Use data from this lesson to support your view.
   b. **Propose** a way to address the issue you identified. How could wellbeing in this area be improved?

LESSON
8.8 Investigating topographic maps: Improving wellbeing in Cumborah

LEARNING INTENTION

By the end of this lesson you should be able to outline key wellbeing challenges associated with living in remote and regional areas in New South Wales through the analysis of topographic maps.

8.8.1 Cumborah, New South Wales

Cumborah is located in northern New South Wales, approximately 50 kilometres north-west of Walgett and 50 kilometres south-west of Lightning Ridge. The town is situated in Walgett Shire, on the Country of the Kamilaroi/Gamilaraay people.

At the time of the 2016 Australian Census, there were 249 people living in Cumborah. The town recorded a median age of 55, higher than the New South Wales state and Australian medians of 38. The gender distribution was 58 per cent male and 42 per cent female, a contrast with the New South Wales and Australian distributions of 49.3 per cent male and 50.7 per cent female.

For such a small population, it is interesting to consider whether the measures of wellbeing — such as income, employment, secure housing and access to services such as healthcare — paint an accurate picture of the wellbeing of people in the community.

The median incomes for households are well below state and national medians: Cumborah ($491), New South Wales ($1486) and Australia ($1436); however, 64.8 per cent of residents own their own homes outright, compared with only 32.2 per cent of people across New South Wales and 31 per cent nationwide. Other signs of a strong community and wellbeing are evident in the data comparing Cumborah with the rest of Australia. For example, in the two weeks before the census, 14 per cent of Cumborah residents provided unpaid help to someone with a disability, compared with 11.6 per cent across New South Wales. Similarly, in the 12 months leading up to the census, 28.9 per cent of Cumborah residents did volunteer work through a local group or organisation, compared with only 18.1 per cent of New South Wales residents as a whole.

Explore the ABS census data for Cumborah using the **Cumborah Census Quickstats** weblink in your online Resources.

on Resources

eWorkbook	Investigating topographic maps — Improving wellbeing in Cumborah (ewbk-10375)
Digital document	Topographic map of Cumborah (doc-36375)
Video eLesson	Investigating topographic maps — Improving wellbeing in Cumborah — Key concepts (eles-5333)
Interactivity	Investigating topographic maps — Improving wellbeing in Cumborah (int-8762)
Weblink	Cumborah Census Quickstats
Google Earth	Cumborah (gogl-0146)

FIGURE 1 Topographic map extract of Cumborah, New South Wales

Source: Data based on Spatial Services 2019.

8.8 Exercise

learnon

8.8 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** the location of the following using grid references.
   a. Wyoona
   b. Three opal fields
   c. The highest point shown
2. What is the shortest distance by sealed road between:
   a. Gingie and Wilke
   b. Cumborah and Morella
   c. Morella and Gurley
3. How long is the section of the Big Warrambool River shown in **FIGURE 1**?

Apply your understanding

Interpreting and analysing geographical data and information

4. What features of the landscape might contribute to AR5595 being prone to inundation?
5. What services and facilities are not shown on this map that are generally considered to contribute to wellbeing? **Identify** two and **explain** what impact the absence of these services and facilities might have on residents' wellbeing.
6. **Predict** what the landscape might be like in AR5580. Provide reasons for your answer based on the features shown in **FIGURE 1**.

LESSON
8.9 INQUIRY: Improving wellbeing in a low-HDI ranked country

LEARNING INTENTION

By the end of this lesson you should have a comprehensive understanding of how human wellbeing varies with respect to life expectancy and child mortality and how it has changed over time.

Background

You may have been in the job for only a week, but you already have your first major assignment! Your boss, Australia's representative to the United Nations, has asked for a report on countries with the lowest HDI rankings. As part of the team working on this project, you will choose one country to **investigate** and report on, and make suggestions as to what the Australian government can do to help alleviate the situation there.

Before you begin

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

Inquiry steps

Working in small groups, **discuss** the following:

a. What do you each know about the HDI?
b. How does a lower or higher HDI affect the lives of people in different ways?

Write down your selected **inquiry question** based on the focus of this topic.

Step 1: Questioning and researching using geographical methods

- **Conduct research** into the current issues surrounding the HDI of your chosen country.
- Provide relevant information about your chosen country.
- Provide annotated images and maps to **illustrate** different aspects of the country.

Step 2: Interpreting and analysing geographical data and information

- **Create** a table that **summarises** the effects of your country's HDI score.
- Give details and **explain** three pressing problems for your country.

Step 3: Concluding and decision-making

- **Conclude** your inquiry with potential strategies to help raise the HDI of your country.

Step 4: Communicating

- Prepare a short **summary** of your findings that you could deliver to the class.

Global rank	Country	HDI score	Global rank	Country	HDI score
189	Niger	0.354	170	Côte d'Ivoire	0.492
188	Central African Republic	0.367	168	Haiti	0.498
187	South Sudan	0.388	168	Afghanistan	0.498
186	Chad	0.404	167	Sudan	0.502
185	Burundi	0.417	165	Togo	0.503
184	Sierra Leone	0.419	165	Comoros	0.503
183	Burkina Faso	0.423	164	Senegal	0.505
182	Mali	0.427	163	Benin	0.515
181	Liberia	0.435	162	Uganda	0.516
180	Mozambique	0.437	161	Madagascar	0.519
179	Eritrea	0.440	159	Mauritania	0.520
178	Yemen	0.452	159	Lesotho	0.520
177	Guinea-Bissau	0.455	158	Rwanda	0.524
176	Congo	0.457	157	Nigeria	0.532
175	Guinea	0.459	156	Zimbabwe	0.535
174	Gambia	0.460	155	Syrian Arab Republic	0.536
173	Ethiopia	0.463	154	Tanzania	0.538
172	Djibouti	0.476	153	Papua New Guinea	0.544
171	Malawi	0.477	152	Solomon Islands	0.546

Complete your self-assessment using the **Inquiry rubric** or access the 8.9 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-40160)

LESSON
8.10 Review

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

Review your results

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8.10.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

8.2 How do we measure and improve wellbeing?

- Wellbeing may be defined as a good or satisfactory condition of existence; a state characterised by health, happiness, prosperity and welfare.
- We can use quantitative and qualitative indicators to measure wellbeing.
- Indicators include social, technological, environmental, economic and political measures.
- Old descriptions of different levels of development throughout the world used terms such as 'developed North' and 'undeveloped South' or 'First World' and 'Third World'.
- Today we use terminology such as 'more economically developed country' (MEDC) and 'less economically developed country' (LEDC) to describe levels of development.
- There is a strong interconnection between development and poverty.
- Poverty is most often measured using solely economic indicators, but it may be taken to encompass many other aspects of life.

8.3 How does wealth affect wellbeing?

- A wellbeing approach to development takes into account a variety of quantitative and qualitative indicators.
- The Human Development Index (HDI) is one such index. It measures wellbeing according to life expectancy, income and education.
- Other measures of wellbeing include the Happy Planet Index, Gross National Happiness and the Australian National Development Index (ANDI).

8.4 How are life expectancy and wellbeing connected?

- Life expectancy started to increase in the mid 1700s, due to improvements in agriculture, working conditions, nutrition, medicine and hygiene.
- Improvements in life expectancy have not been uniform because improvements in living conditions are connected to wealth. Therefore, life expectancy is lowest in developing nations.
- Child mortality rates are also linked to wealth. Those counties where life expectancy is low also have higher rates of child mortality than those where life expectancy is higher.
- The world's population increases by around 145 people every minute, but this is not uniform across the Earth. Sub-Saharan Africa has the highest birth rates, with an average fertility rate above 5 children per woman. This region also has a high mortality rate.

8.5 How does wellbeing vary in India?

- India has a rapidly expanding population and is currently the second most populous country in the world. It is predicted that its population will surpass that of China by the year 2025.
- Improvements in health, education and hygiene have significantly improved life expectancy and, although there has been a decrease in the fertility rate, children are an important part of family life.
- Children in India help boost the family budget through working, and later in life they support their ageing parents.

8.6 How does poverty affect wellbeing?

- Despite the strength of Brazil's economy, the benefits of economic growth have not trickled down to the poor, resulting in large differences in wellbeing across the nation.
- Almost a quarter of the Brazilian population lives in poverty.
- There is considerable spatial variation in wellbeing between regions in Brazil.
- Rio's favelas (slums) are home to millions of the city's poor. Living conditions are difficult and affect the wellbeing of the favela residents.
- Various measures have been undertaken in an attempt to improve life in the favelas.
- With the city's hosting of the 2016 Olympic Games, many favela residents were displaced to make way for Olympic-related venues and facilities.
- There is a strong interconnection between poverty, water supply, sanitation and wellbeing.
- Despite progress being made under the MDGs and now the SDGs, many millions still live without access to safe drinking water or adequate sanitation. This presents a significant risk to health and wellbeing.

8.7 How does wellbeing vary in Australia?

- First Nations Australians consistently experience lower levels of health, education, employment and economic independence than those experienced by most other Australians.
- The Close the Gap program set out key target areas for the improvement of First Nations Australians' wellbeing. Only two of these targets are currently on track, with others having seen only some improvement.
- The National Aboriginal and Torres Strait Islander Social Survey reveals some of the key wellbeing issues facing First Nations Australian Peoples, but also highlights the strong cultural and community connections and the importance of these connections in relation to overall sense of life satisfaction and wellbeing.
- There are numerous programs that aim to close the health and wellbeing gap between First Nations Australians and other Australians.

8.8 Investigating topographic maps: Improving wellbeing in Cumborah

- Key features and facilities in the Cumborah area in New South Wales can contribute to and impact the wellbeing of the small number of residents living there.

8.9 INQUIRY: Improving wellbeing in a low-HDI ranked country

- Investigate how human wellbeing varies with respect to life expectancy and child mortality, and how it has changed over time in countries with the lowest HDI rankings.

8.10.2 Key terms

development 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' according to the United Nations

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person for food, water, transport, housing, waste management and other purposes

experienced wellbeing an individual's subjective perception of personal wellbeing

extreme poverty a state of living below the poverty line (US$1.90 per day), and lacking resources to meet basic life necessities (also known as absolute poverty)

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.

female infanticide the killing of female babies, either via abortion or after birth

fertility rate the number of live births per 1000 women of childbearing age (usually 15–44) in a given year

gross domestic product (GDP) the value of all goods and services produced within a country in a given period, usually discussed in terms of GDP per capita (total GDP divided by the population of the country)

Human Development Index (HDI) measures the standard of living and wellbeing by measuring life expectancy, education and income

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.

industrialised having developed a wide range of industries or having highly developed industries

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

maternal mortality the death of a woman while pregnant or within 42 days of termination of pregnancy

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

natural increase the difference between the birth rate (births per thousand) and the death rate (deaths per thousand). This does not include changes due to migration.

non-government organisation (NGO) an organisation that operates independently of government, usually to deliver resources or serve some social or political purpose

qualitative indicators subjective measures that cannot easily be calculated or measured; e.g. indices that measure a particular aspect of quality of life or that describe living conditions, such as freedom or security

quantitative indicators objective indices that are easily measured and can be stated numerically, such as annual income or the number of doctors in a country

replacement rate the number of children each woman would need to have in order to ensure a stable population level — that is, to 'replace' the children's parents. This fertility rate is 2.1 children.

sanitation facilities that safely dispose of human waste (urine, faeces and menstrual waste)

sex ratio the number of females per 1000 males

socioeconomic of, relating to or involving a combination of social and economic factors

spatial variation difference observed (in a particular measure) over an area of the Earth's surface

standard of living a level of material comfort in terms of goods and services available. This is often measured on a continuum; for example, a 'high' or 'excellent' standard of living compared to a 'low' or 'poor' standard of living.

Sustainable Development Goals (SDGs) a set of 17 goals established by the United Nations Development Programme, which aim to end poverty, protect the Earth and promote peace, equality and prosperity

wellbeing a good or satisfactory condition of existence; a state characterised by health, happiness, prosperity and welfare

8.10.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

Everyone wants a good life, but what does that mean for different people? Can wellbeing actually be measured, and how can we improve it if it's not measuring up?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11510)
Reflection (ewbk-12531)
Crossword (ewbk-12532)

Interactivity Measuring and improving wellbeing crossword (int-8243)

8.10 Review exercise

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Multiple choice

1. What is wellbeing?
   - A. A state of existence characterised by good health, happiness, prosperity and welfare
   - B. A state of existence characterised by good health, happiness, extreme wealth and welfare
   - C. A state of existence characterised by extreme wealth, happiness and a large family
   - D. A state of existence characterised by having enough money to live comfortably
2. Which of the following is *not* considered a qualitative indicator of wellbeing?
   - A. Facts and figures about how a country is performing
   - B. Details about how the people in a particular place feel
   - C. An opinion piece news article drawing on personal experiences
   - D. How people in a particular place think
3. What does HDI stand for?
   - A. Health Development Indicator
   - B. Health Developing Index
   - C. Human Development Indicator
   - D. Human Development Index
4. What replaced the Millennium Development Goals?
   - A. World Health Organization
   - B. Sustainable Development Goals
   - C. The United Nations
   - D. UNICEF
5. How did the MDGs change child mortality rates for children under the age of 5?
   - A. They rose from 6 million in 1990 to 6.5 million in 2015.
   - B. They remained the same.
   - C. They declined from 12.7 million in 1990 to 6 million in 2015.
   - D. They declined from 17 000 a day to 7000.
6. What is the name of the index used to measure wellbeing that is specific to Australia?
   - A. Australian Wellbeing Index (AWI)
   - B. Australian National Development Index (ANDI)
   - C. Australian Prosperity Index (API)
   - D. Australian Wellbeing Indicator (AWI)
7. Which statement accurately describes the life expectancy (at birth) for an average Australian?
   - A. More than someone born in Somalia, but less than someone born in India
   - B. The same as someone in Canada, but more than someone in the USA
   - C. The same as someone born in Japan, but more than someone born in Indonesia.
   - D. None of the above
8. What is meant by the term *favela*?
   - A. An area of informal housing usually located on the edge of many Brazilian cities
   - B. An area of formal housing usually located in the centre of large cities
   - C. The measure of human demand on the Earth's natural systems
   - D. Another term meaning 'poverty'

9. What is an NGO?
   - **A.** A government organisation
   - **B.** An organisation that measures the standard of living and wellbeing by measuring life expectancy
   - **C.** An organisation that operates independently of government, usually to deliver resources or serve some social or political purpose
   - **D.** The value of all goods and services produced within a country in a given period
10. What is maternal mortality?
   - **A.** The death of a woman while pregnant or within 42 days of termination of pregnancy
   - **B.** The death of a woman who has children
   - **C.** The killing of female babies, either via abortion or after birth
   - **D.** Murder of a woman

Short answer

Communicating

11. How have improvements in technology led to an increase in life expectancy?
12. What factors might cause some places to experience a decrease in life expectancy?

Concluding and decision-making

13. **Suggest** how the issue of gender imbalance in India could be solved.
14. How might levels of maternal mortality change in future as an increasing percentage of the world's population lives in cities?
15. 'Australia's population distribution is likely to remain concentrated in the south-east.' To what extent do you agree with this statement?

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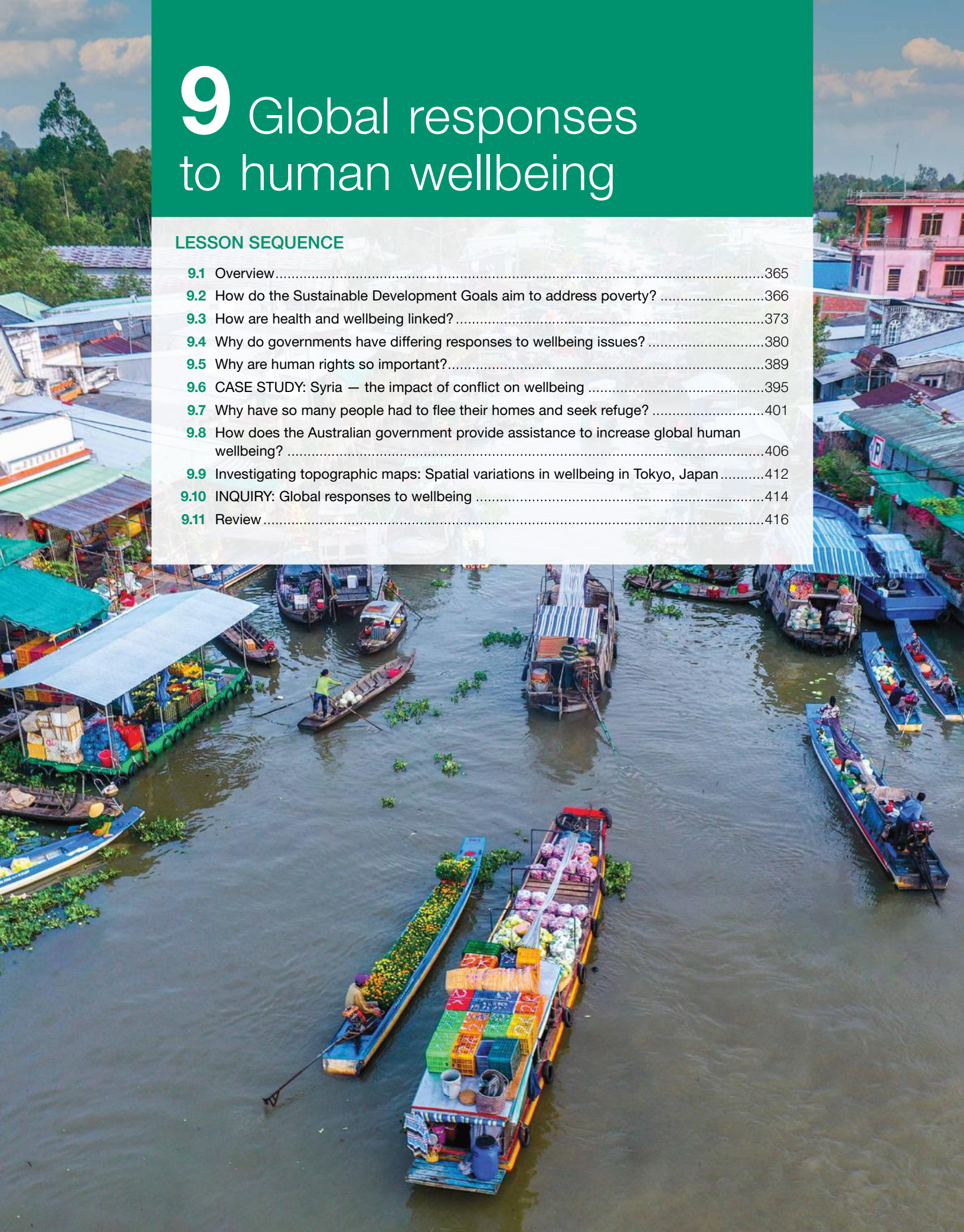
9 Global responses to human wellbeing



LESSON SEQUENCE

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LESSON
9.1 Overview

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The world's population is constantly increasing. Can we fit so many people in the space we have without affecting our quality of life?

9.1.1 Introduction

As the world's living standards have improved, our population has also grown. In November 2022 the world's population reached 8 billion. It is expected that the number of people on the planet will continue to grow, with experts estimating a population of 9.8 billion in 2050 and 11.2 billion by 2100. 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 (our ecological footprint) that affects our wellbeing. Our wellbeing is clearly interconnected with our population characteristics and our geographic location on the planet.

FIGURE 1 As the world's population grows, it is crucial to prioritise the quality of life and wellbeing of individuals.

on Resources

eWorkbook Customisable worksheets for this topic (ewbk-11512)

Video eLesson A long life (eles-1714)

LESSON
9.2 How do the Sustainable Development Goals aim to address poverty?

LEARNING INTENTION

By the end of this lesson you should be able to identify the imbalance in wellbeing that exists throughout the world, and describe how the Sustainable Development Goals seek to address this.

TUNE IN

Levels of wellbeing vary greatly across the planet. To address this variation, which is often expressed in terms of levels of poverty, the United Nations has developed a way forward to improve human wellbeing: the Sustainable Development Goals (SDGs).

Refer to **FIGURE 1.**

1. The image shows the world covered with people, but as you know there is a whole biophysical world out there. What other images would help us gain an understanding of the variations in levels of poverty around the planet?
2. In Australia there are levels of poverty but, by and large, Australia is a wealthy, highly developed country. What elements of your lifestyle contribute to your level of wellbeing?

FIGURE 1 The world's population affects our global wellbeing.

9.2.1 Defining poverty

Poverty is a living condition that is hard to measure and difficult to define. For example, people living in poverty in sub-Saharan Africa may struggle to find a daily meal or access to safe drinking water. This standard of living is known as **absolute poverty** and approximately 1.3 billion people experience this daily. In more developed countries, we may refer to **relative poverty**. In Australia, for example, we compare living standards to a benchmark called the **poverty line**. The majority of the population lives above the poverty line, but those who fall below it struggle to meet their day-to-day needs of adequate shelter, food and education.

Sub-Saharan Africa — the poorest region in the world

Sub-Saharan Africa (see **FIGURE 2**) is affected by many different forms of poverty. Human Development Index (HDI) scores in most countries of sub-Saharan Africa have worsened since 1990, making this region the poorest in the world. Poverty is more common in young families, who often have fewer assets and higher dependency ratios (people who are too young or too old to work). For others, the poverty is chronic rather than temporary. This means poverty is experienced for most of one's life and is often passed on to one's children, creating a generational cycle that is hard to break. The chronically poor experience hunger, undernutrition, illiteracy, lack of access to safe drinking water and basic health services, social discrimination, physical insecurity and political exclusion. Many will die prematurely of easily preventable deaths. With appropriate support and resources, people living in chronic poverty have the ability to overcome the obstacles that trap them in poverty, and

absolute poverty where income levels are inadequate to enjoy a minimum standard of living (also known as extreme poverty)

relative poverty where income levels are relatively too low to enjoy a reasonable standard of living in that society

poverty line an official measure used by governments to define those living below this income level as living in poverty

can create a better future for themselves and their children. There are numerous organisations and agencies that work with such communities to help them break the poverty cycle.

World hunger

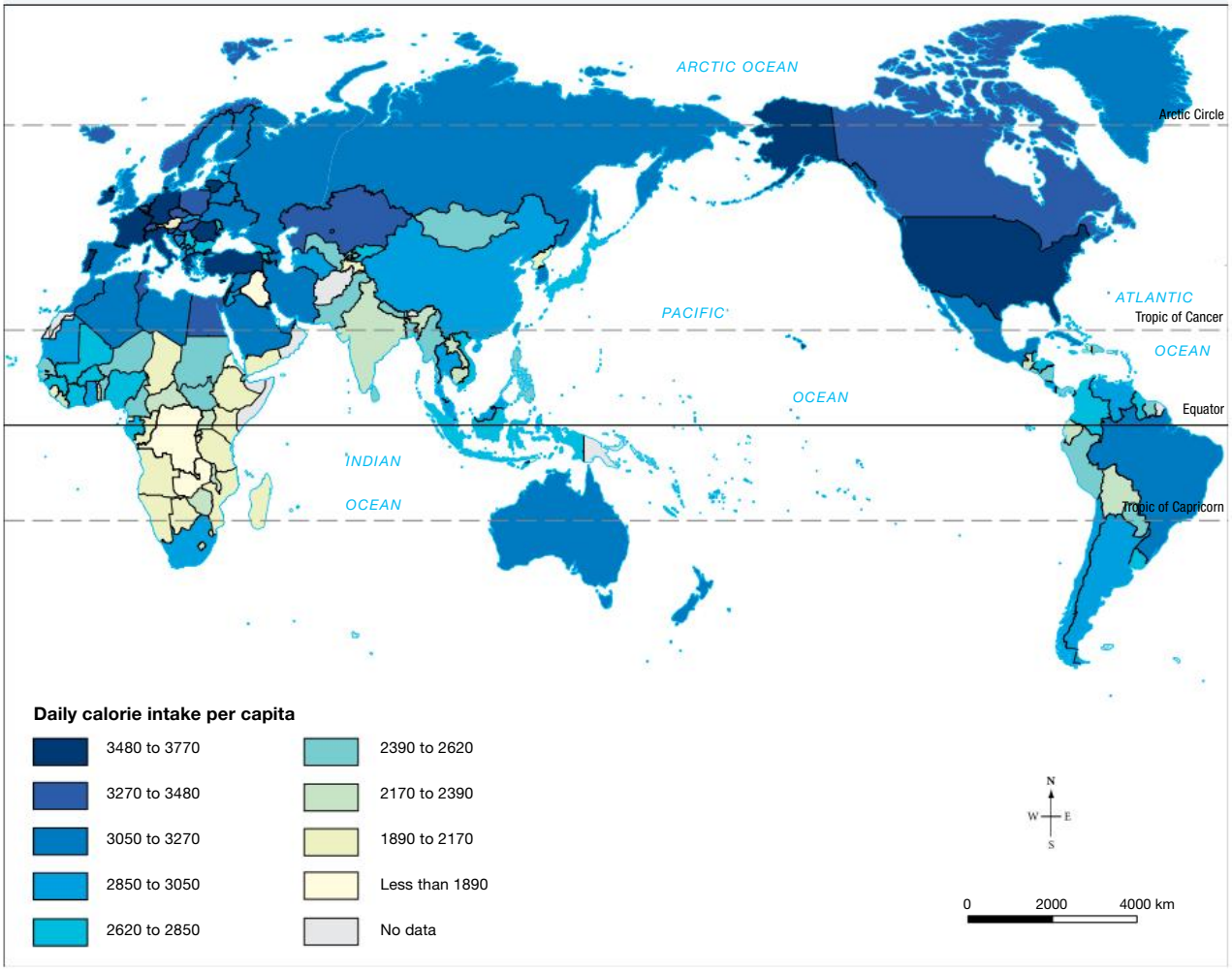
One of the most pressing issues of poverty is hunger, a situation where people experience scarcity of food. Malnutrition is a general term that indicates a lack of some or all nutritional elements necessary for human health. There are two basic types of malnutrition. When we refer to world hunger, we are talking about a lack of food that provides energy (measured in calories), obtained from all the basic food groups, and a lack of protein (from meat and other sources) (see **FIGURE 3**). Another type of malnutrition is micronutrient (vitamin and mineral) deficiency, which may or may not occur with hunger. Recently there has also been a move to include obesity as a third form of malnutrition, expanding on the idea of poor nutrition.

FIGURE 2 The countries of sub-Saharan Africa are affected by many forms of poverty.

Source: Worldmap.org.

int-7974

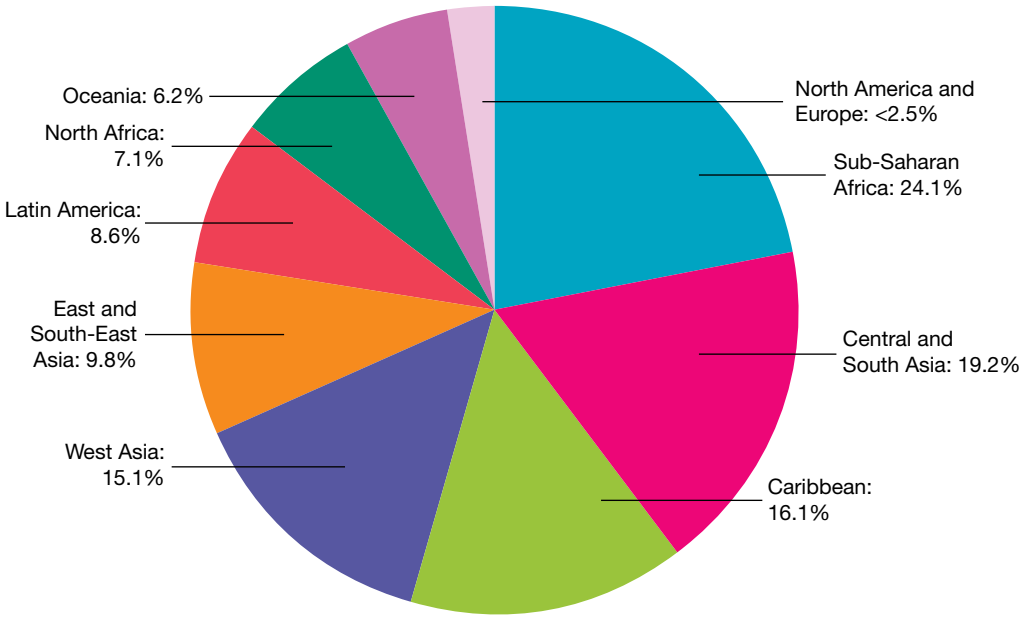
FIGURE 3 Daily calorie intake, per person



Note: Most recent data available

Source: FAO 2013. Made with Natural Earth. Map by Spatial Vision.

FIGURE 4 Prevalence of undernourishment in the world, 2021, by region



Source: Data from *The State of Food Security and Nutrition in the World 2021*, report jointly prepared by FAO, IFAD, UNICEF, WFP and WHO.

9.2.2 Sustainable Development Goals

The Sustainable Development Goals (SDGs) came into being on 25 September 2015 to replace the expired Millennium Development Goals (MDGs). The three overarching themes are to end poverty, protect the planet and ensure prosperity for everyone during the 15 years to 2030. Each of the 17 goals has a number of targets to be met. Indicators are used to assess each target. These SDGs apply to all countries. The United Nations provides an update on the progress towards 2030 in an annual report.

Former New Zealand prime minister and United Nations Development Programme Administrator Helen Clark commented, 'This agreement marks an important milestone in putting our world on an inclusive and sustainable course. If we all work together, we have a chance of meeting citizens' aspirations for peace, prosperity, and wellbeing and to preserve our planet'.

FIGURE 5 While obesity levels are increasing every year in populations of countries such as Australia, billions of people across the world still suffer from starvation.

Source: Global Food Consumption — Richard & Slavomir Svitalsky/Cartoon Movement.

tlvd-10788

TABLE 1 A brief outline of the Sustainable Development Goals

Sustainable development goal		Targets
	Goal 1: End poverty in all its forms everywhere	**Major target:** • By 2030 no-one should live on less than $1.25 per day.
	Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	**Significant targets include:** • By 2030 ensure access by all people to safe, nutritious and sufficient food all year round. • By 2030 end all forms of malnutrition.
	Goal 3: Ensure healthy lives and promote wellbeing for all at all ages	**Targets for 2030 include:** • Reduce the global maternity mortality ratio to less than 70 per 100 000 live births. • Attain an under-five mortality of, at most, 25 per 1000 live births. • End the epidemics of AIDS, tuberculosis and malaria.
	Goal 4: Ensure inclusive and quality education for all and promote lifelong learning	**Targets to achieve include:** • By 2030 all boys and girls can complete free, equitable and quality primary and secondary schooling with effective outcomes. • All women and men have equal access to affordable and quality ongoing educational opportunities.
	Goal 5: Achieve gender equality and empower all women and girls	**Targets include:** • End discrimination against all women and girls everywhere and eliminate violence towards them too.
	Goal 6: Ensure access to water and sanitation for all	**Targets by 2030 include:** • Achieve universal and equitable access to safe and affordable drinking water for all. • Achieve access to adequate and equitable sanitation and hygiene for all.
	Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	**Targets for 2030 include:** • Provide access to affordable, reliable and modern energy services, especially renewable energies.
	Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all	**Major targets:** • Sustain economic growth and productivity aiming to achieve by 2030 full and productive employment and decent work for all. • By 2025 eliminate child labour in all its forms, including forced labour, modern slavery, human trafficking and child soldiers.
	Goal 9: Build resilient infrastructure, promote sustainable industrialisation and foster innovation	**General targets include:** • Develop quality, reliable, sustainable and resilient infrastructure to support economic development and human wellbeing. • Promote inclusive and sustainable industries that raise industries' share of employment and GDP. • Provide universal and affordable internet access to least developed countries by 2020.
	Goal 10: Reduce inequality within and among countries	**Key target:** • By 2030 achieve and sustain income growth of the bottom 40 per cent of the population.

(continued)

Sustainable development goal		Targets
	Goal 11: Make cities inclusive, safe, resilient and sustainable	**Targets include:** • By 2030 ensure adequate, safe, affordable and sustainable housing and transport for all. • Protect and safeguard the world's cultural and natural heritage.
	Goal 12: Ensure sustainable consumption and production patterns	**2030 targets include:** • Achieve the sustainable management and efficient use of natural resources. • Halve per capita global food waste by consumers and during production. • Ensure all people have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.
	Goal 13: Take urgent action to combat climate change and its impacts	**Targets include:** • Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. • Integrate climate change measures into national policies, strategies and planning.
	Goal 14: Conserve and sustainably use oceans, seas and marine resources	**Significant targets:** • By 2025 prevent and reduce marine pollution of all kinds. • By 2020 sustainably manage and protect marine and coastal ecosystems. • By 2020 regulate and end overfishing.
	Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss	**Targets:** • By 2020 protect inland freshwater ecosystems and all types of forests. • By 2020 prevent the introduction of invasive alien species and prevent the extinction of threatened species. • By 2030 combat desertification and protect mountain ecosystems.
	Goal 16: Promote just, peaceful and inclusive societies	**Targets:** • End abuse, exploitation, trafficking and all forms of violence against children. • Reduce bribery and corruption in all forms. • By 2030 provide legal identity for all, including birth registration.
	Goal 17: Strengthen the means of implementation and revitalise the global partnership for sustainable development	**Targets:** • Address finance, technology, capacity building, trade and systemic issues to support sustainable development goals.

9.2.3 What can we do?

The fact that over a billion people experience severe hardship every day can appear extremely daunting. Compassion is the first step, but action is what is required. It is important to remember that those experiencing hardship do not live exclusively in less developed countries. Some of them live in more developed countries, like Australia. Many of them live in places where wellbeing for some is improving dramatically, but there are many who are being left behind.

International aid provides just one avenue for change. It is **grassroots movements** that will provide the greatest and most effective change for those who are most disadvantaged or without a voice. Education can provide a means for people to change their own destiny. Lowering population growth will reduce population pressures on a country's resources and government, and good governance can build a strong economy and provide opportunities for residents.

grassroots movements action by ordinary citizens, as compared with the government, aid or a social organisation

SkillBuilders to support skill development

- 1.11 SkillBuilder: Using multiple data formats

9.2 SKILL ACTIVITY: Questioning and researching using geographical methods, Interpreting and analysing geographical data and information

1. Divide your class into groups.
2. Each group is to be assigned an SDG.
3. Using the internet:
   a. **research** the targets of each goal
   b. provide a tick or a cross depending on whether you think the world will meet each target as set out. (A number of targets were to have been met by 2020 — have these been achieved?)
4. Be prepared to **justify** your point of view in a class debate.
5. **Decide:** Are there too many goals and targets to be met by all countries in the world?

9.2 Exercise

learnon

9.2 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** what is meant by the 'poverty line'.
   A. The minimum level of income required to provide an adequate living standard in a country
   B. The minimum level of education required to provide an adequate living standard in a country
   C. The minimum level of income required to receive an education
   D. The minimum level of income required to purchase a house
2. **Judge** what is the difference between 'absolute poverty' and 'relative poverty' and complete the sentences below.
   _____ poverty is when people find it difficult to get a daily meal and access safe drinking water (the minimum standard of living).
   _____ poverty is when the level of living standard is low compared to the benchmark poverty line for a country.
3. Which of the following SDGs **applies** only to women and girls?
   A. Goal 2
   B. Goal 3
   C. Goal 5
   D. Goal 6
4. **Determine** whether the following statements are true or false.
   a. The target date for the SDGs to be achieved is 2100.
   b. Approximately 1.3 billion people experience absolute poverty daily.

5. Refer to **FIGURE 3**.
   a. The two regions combined that make up nearly 40 per cent of the world's undernourished are:
      A. West Asia and North Africa.
      B. Oceania and North Africa.
      C. Sub-Saharan Africa and the Caribbean.
      D. West Africa and the Caribbean.
   b. Which two regions have the lowest prevalence of undernourishment?

Apply your understanding

Communicating

6. Using the three overarching themes of the SDGs, create a table to **state** how each of the 17 goals is aligned.

Interpreting and analysing geographical data and information

7. Refer to **FIGURE 3**. Identify the region of sub-Saharan Africa. If we **compare** the general results for this region with other regions across the world, how does it rate in terms of calorie intake? Give examples of specific places where appropriate.
8. Given sub-Saharan Africa's slow progress in improving the wellbeing of its people, choose three SDGs that are most likely to have an impact on improving the region. **Reflect on** and explain your answer.
9. **Analyse** the **FIGURE 5** cartoon from the perspective of each person.

Concluding and decision-making

10. How ambitious is Helen Clark's quote (in section 9.2.2)? Do you think this is achievable by 2030? Which aspects do you think may be more achievable than others? **Discuss**, providing reasons for your opinion.

LESSON
9.3 How are health and wellbeing linked?

LEARNING INTENTION

By the end of this lesson you should be able to explain how health is intrinsically linked to wellbeing, and identify why malaria and HIV/AIDS significantly affect wellbeing, particularly in developing countries.

TUNE IN

Good health is something we all hope to achieve; however, there are many diseases that are 'brewing' in the environment. The recent COVID-19 pandemic is just one example of how vulnerable human society is to disease.

FIGURE 1 Malaria-carrying mosquito

Consider **FIGURE 1** and answer the questions below.

1. How might we protect ourselves against mosquito-borne diseases?
2. How did COVID-19 impact on your family?

9.3.1 SDG targets for health and wellbeing

Health is a key indicator of wellbeing. Goal 3 of the SDGs is to 'ensure healthy lives and promote wellbeing for all at all ages'. Key among the 2030 targets for this goal is the eradication of tuberculosis, AIDS and malaria epidemics. Developing nations, where the standard of living and health care services are generally low, are more likely to be affected by such epidemics because they lack the resources to deal with these health issues. In this lesson, we explore the threats to wellbeing associated with malaria and HIV/AIDS and what is being done to combat them globally.

9.3.2 What is malaria?

Have you ever been kept awake on a warm summer's night by an annoying mosquito buzzing around your head? For us, such an occurrence is merely a nuisance. However, for many people, particularly children under five years of age in Africa, a bite from a malaria-carrying mosquito can be life threatening. Malaria therefore has a major impact on their wellbeing. Fortunately, we do not have that potentially deadly mosquito in Australia.

Malaria is a preventable and curable disease caused by plasmodium parasites transmitted by the female *Anopheles* mosquito. These parasites destroy red blood cells and initially cause headaches and fever but may also cause death if sufficient organs are affected. There are four species of these parasites, which are found in tropical and subtropical places of the world, with the species commonly found in Africa being particularly severe in its impact. There is therefore a significant interconnection between such tropical conditions and incidence of this disease.

9.3.3 Why should we worry about malaria?

According to the World Health Organization (WHO), in 2020 about 3.75 billion people (half the world's population) located in 87 countries were at risk of malaria (see **FIGURE 3**). There were around 241 million cases of malaria in these 87 countries; however, just over half of malaria cases occurred in just five countries, and four of these are located in sub-Saharan Africa — 95 per cent of recorded cases and 96 per cent of all deaths from malaria were in Africa. Approximately 627 000 people died as a result of contracting the disease.

The most at-risk group is children under the age of five; in 2021, for example, 80 per cent of malaria deaths in Africa were children in this age group. This is the equivalent of one child dying every two minutes. Pregnant women are also particularly vulnerable to malaria and the disease can cause complications such as still and premature births, and low birth weights. Twenty-five million pregnant women are at risk of malaria each year.

Malaria costs Africa approximately $12 billion per year. People affected are not able to work, so this affects both an individual's and a country's income. In addition, malaria accounts for 40 per cent of public health expenditure and between one-third and one-half of hospital admissions.

9.3.4 Malaria control and elimination

To address the aims of malaria control and elimination, the WHO developed the Global Technical Strategy for Malaria 2016–2030, setting a target of reducing global malaria cases and mortality rates by at least 40 per cent by 2020 and 90 per cent by 2030. Before this, under the Millennium Development Goals action, both the number of cases of malaria and the number of deaths due to this disease declined as a result of increased prevention and control measures. Between 2000 and 2015, there was a 37 per cent reduction in global malaria incidence and a fall of 60 per cent in malaria mortality. Progress has not been uniform, however, and has stalled to some extent since 2015. Although 21 countries are set to be declared malaria-free, of the 11 countries that record the most cases of malaria, only India has recorded any significant progress, with a 24 per cent reduction in cases since 2016. Some countries in sub-Saharan Africa have actually recorded an increase in the number of cases of malaria.

FIGURE 2 Malaria testing

Many government and non-government organisations have been involved in combating malaria — for example, the WHO Global Malaria Programme, Roll Back Malaria, the President's Malaria Initiative, Malaria No More and the Bill and Melinda Gates Foundation. Such organisations have focused on one or more of the following strategies:

- provision of insecticide-treated nets to protect people at night, when mosquitoes most like to bite. More than half the households in sub-Saharan Africa now have at least one bed net (see **FIGURE 5**)
- use of insecticide sprays, both to treat inside houses and in mosquito habitat areas
- improved access to diagnostic testing and treatment.

In 2019, the world's first malaria vaccine pilot program began in Ghana, Kenya and Malawi. After four years, nearly 1.5 million children had received their first vaccine dose.

The success of the pilot led to the WHO recommending the vaccine to prevent malaria to children at risk. The four-dose vaccine represents a breakthrough in combating malaria. Several other malaria vaccines are under development.

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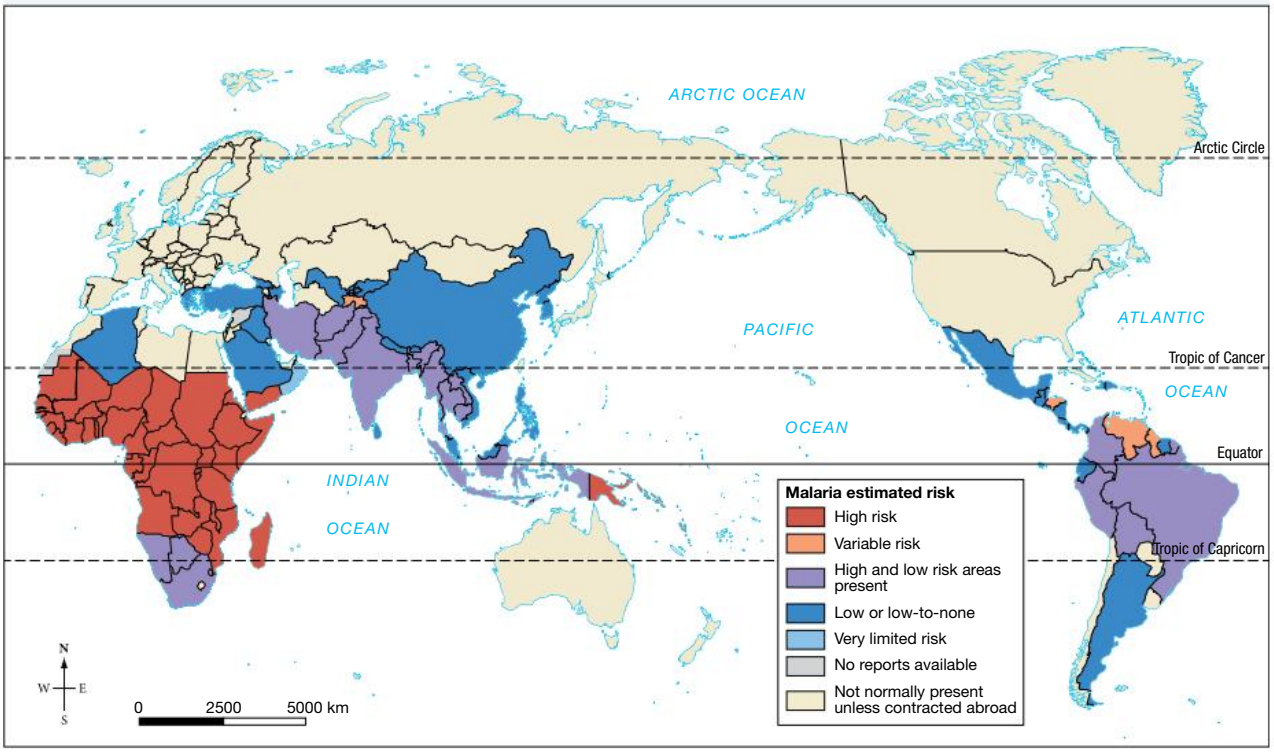
FIGURE 3 Distribution of malaria



Source: CDC, www.cdc.gov/malaria/travelers/country_table/a.html.

One problem for the continued fight against malaria is insufficient funding. Although US$3.5 billion was available in 2022, an estimated US$7.3 billion is needed annually to achieve global malaria targets by 2030. Another concern is drug resistance, particularly along the Cambodia–Thailand border. The WHO launched a global plan to address this issue in 2010. In 2022 a new program 'Strategy to respond to antimalarial drug resistance in Africa' was launched. This is approach targets those African countries where malaria rates are increasing.

During the COVID-19 pandemic, restrictions caused major disruptions in essential malaria services. Early messaging aimed at reducing COVID transmission told the public to stay at home

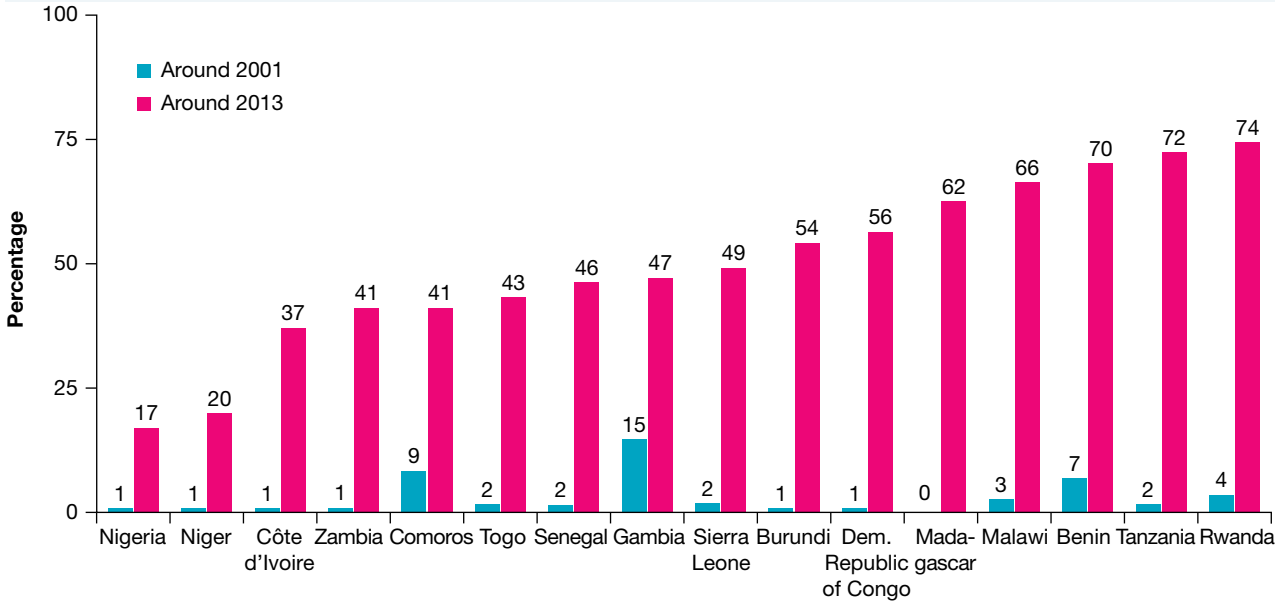
FIGURE 4 Insecticide-treated nets, Kenya

if they had a fever, potentially disrupting treatment for malaria. At the same time, many countries with a high malaria burden had plans to implement large prevention campaigns before the peak malaria transmission season (which was likely to coincide with peak COVID-19 cases). These plans needed to be adapted to conform with COVID-19 restrictions. In March 2020, as the COVID-19 pandemic spread rapidly around the globe, the WHO organised a cross-partner effort to help combat the negative impact of COVID-19 in malaria-affected countries and contribute to the COVID-19 response.

9.3.5 HIV and AIDS

When HIV (Human Immunodeficiency Virus) was first identified in the early 1980s, it was seen as a death sentence. Those infected succumbed to Acquired Immune Deficiency Syndrome (AIDS) and there was little to be done but wait. However, advances in treatments and extensive use of drug combinations mean that today, depending on the infected person's location, having HIV no longer means AIDS is inevitable. Despite this, the disease has a major impact on wellbeing, not only on a local scale but also at a national and regional level.

FIGURE 5 Proportion of children under age five sleeping under insecticide-treated nets in sub-Saharan African countries, 2001 and 2013



Note: 'Around 2001' refers to a survey conducted during 1999–2003. 'Around 2013' refers to a survey conducted during 2012–2014. Most recent data available.

Source: © UNDP.

AIDS is caused by HIV. The virus reduces the body's ability to fight infections. According to the WHO, since 1981, more than 79 million people have been infected and approximately 36 million people have been killed by this pandemic. UNAIDS reported that at the end of 2021, 38.4 million people were living with HIV, of whom 1.7 million were children aged from 0 to 14 years. UNAIDS estimates that in 2021 there were 1.5 million new infections; of these, women and girls made up 50 per cent. It is estimated that in 2021, 650 000 people died of AIDS-related illnesses.

The virus is spread via infected bodily fluids entering a person's bloodstream. This may occur via unprotected sex, intravenous drug use, or from mother to child in the womb or through breastfeeding. Women and young people (aged 15–24 years) are disproportionately affected.

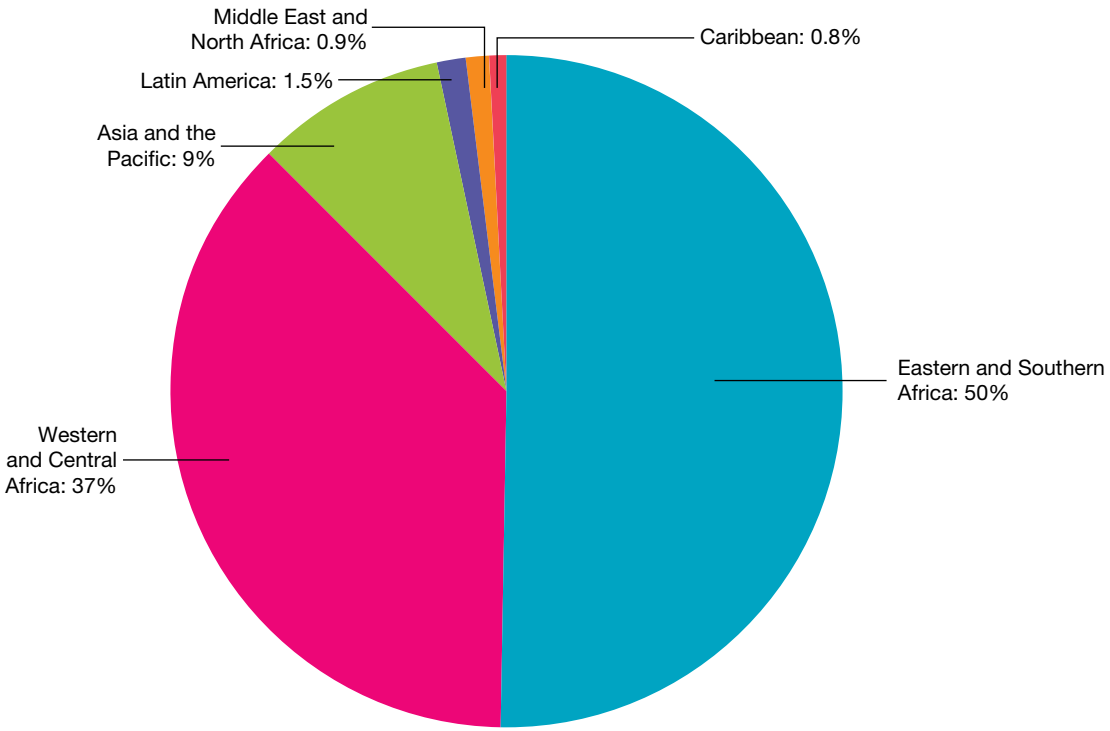
As **FIGURE 6** shows, the prevalence of HIV infections in children aged 0–14 years is concentrated in places that lie within sub-Saharan Africa, which, as a region, is home to nearly two-thirds of all people living with HIV. The countries most affected are Swaziland, Botswana and South Africa. New infections fell by 10 per cent in western and central Africa and 43 per cent in eastern and southern Africa between 2010 and 2020. Globally,

the incidence rate of new infections has fallen by 31 per cent and by 53 per cent for children since 2010. In 2021, 81 per cent of pregnant women had access to medications to prevent the transmission of HIV to their unborn babies. This is an increase over 2010 levels, where only 40 per cent of pregnant women had access to such medication. However, while 62 per cent of women take antiviral medication while pregnant, only 49 per cent continue to take this medication while breastfeeding. Globally, AIDS-related deaths have reduced by 64 per cent since the peak in 2004 and by 47 per cent since 2010.

HIV has major impacts across the communities affected, and is reversing decades of improvements in living conditions. The pressures of illness and caring for sick family members can result in loss of income, and children may be taken out of school. Those in poverty may feel they have no choice but to engage in high-risk behaviours to earn income, such as women taking up sex work. In addition, loss of adults to AIDS has had devastating effects on children: globally, an estimated 5.4 million children in 2020 had lost at least one parent to the disease (80 per cent of these live in sub-Saharan Africa), compounding the likelihood they will not attend school and maintaining the **poverty cycle**.

poverty cycle circumstances whereby poor families become trapped in poverty from one generation to the next

FIGURE 6 Distribution of children under 15 who are living with HIV, 2021



Note: Due to rounding, figures do not add to 100%.
Source: UNAIDS 2021 epidemiological estimates.

9.3.6 HIV and AIDS successes

There is currently no cure for HIV or AIDS or a vaccination to prevent people contracting the virus. However, since the mid 1990s, antiretroviral treatment (ART) has been available to persons with HIV. These drugs reduce the level of the virus in the infected person, not only extending their life but also reducing the risk of them transmitting the disease to an uninfected partner. In June 2021, around 28.2 million (73 per cent of people living with AIDS) had access to this treatment. The number of AIDS-related deaths is now declining, as is the rate of new infections. Approximately US$22–24 billion is needed annually to meet the UNAIDS vision; at the end of 2021 around US$21 billion in funding was available to fund the fight against AIDS in low-income

and middle-income countries. An estimated US$29.3 billion will be needed annually by 2030. **FIGURE 7** shows how some countries in southern Africa experienced a major decline in **life expectancy** with the onset of AIDS; however, with improvements in treatment, life expectancy is increasing again.

AusAID work in Papua New Guinea

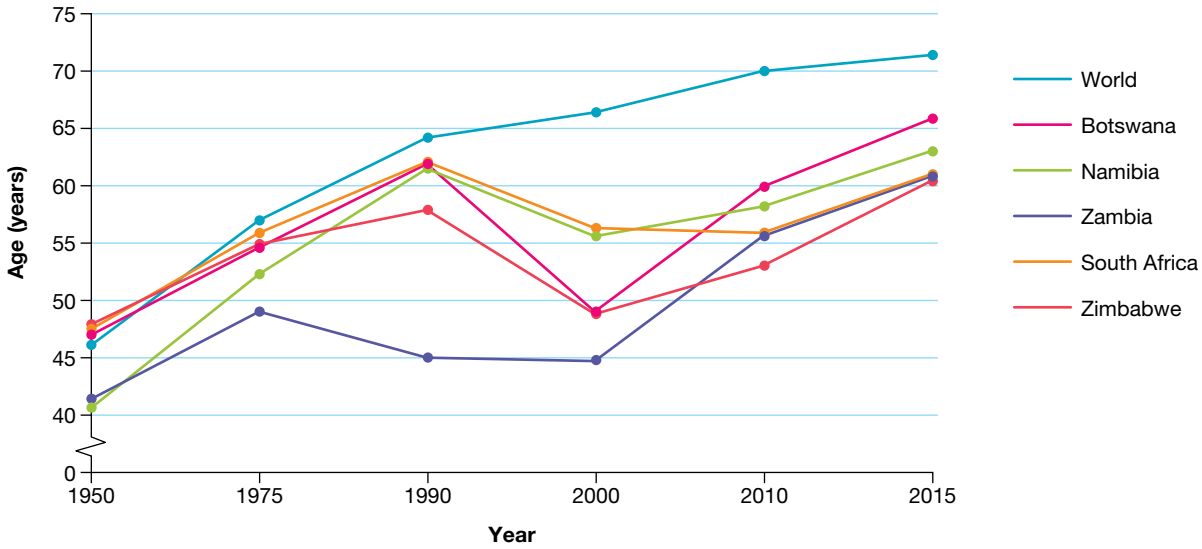
The Australian government, via the Department of Foreign Affairs and Trade, committed $588 million in the 2021–22 development aid budget to support Papua New Guinea. This includes money directly allocated to fund services linked to sexual and reproductive services. Papua New Guinea faces particular issues in dealing with HIV and AIDS because of its predominantly rural population and because access to many locations is difficult due to rugged topography. The main response activities include education, condom promotion and distribution, **STI** and HIV testing, and treatment delivered mostly through a variety of organisations such as the National Catholic AIDS Office, Save the Children Fund and UNICEF. As a result of this work, more than 2700 people with sexually transmitted diseases, such as AIDS, accessed antiretroviral medication.

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

STI sexually transmitted infection

int-7980

FIGURE 7 Impact of AIDS on life expectancy, 1950 to 2015



Note: Data shows change in life expectancy at birth in selected countries in southern Africa

Source: Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2016 Results. Seattle, United States: Institute for Health Metrics and Evaluation IHME, 2017

As with malaria, COVID-19 is threatening gains against the HIV epidemic, delaying the HIV epidemic goals. The combination of these two global pandemics will continue to need both study and interventions to lessen the effects of COVID-19 on HIV efforts worldwide.

9.3 SKILL ACTIVITY: Interpreting and analysing geographical data and information

Complete the **Malaria and HIV** worksheet to learn more about these diseases and efforts to combat them.

9.3 Exercise

learnon

9.3 Exercise

Learning pathways

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

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Check your understanding

1. **Discuss** the following statement, including an explanation of why. 'Tropical and sub-tropical locations are particularly vulnerable to malaria'.
2. HIV is *not* transmitted by:
   - A. having unprotected sex.
   - B. being in the same room as an infected person.
   - C. infected bodily fluids entering a person's bloodstream.
   - D. intravenous drug use.
3. Which area has the highest rate of HIV/AIDS?
   - A. Asia
   - B. Sub-Saharan Africa
   - C. Northern Africa
   - D. South America
4. **Identify** why children would be more likely to develop malaria than adults.
5. From **FIGURE 7**, **determine** during what period HIV/AIDS appears to have had the greatest impact on life expectancy.

Apply your understanding

Concluding and decision-making

6. **Explain** how the global distribution of malaria may change with an increase in temperatures due to global warming.
7. **Consider** how the distribution of malaria may change if the problem of drug resistance is not overcome.
8. **Discuss** in what way malaria is both a disease of poverty and a cause of poverty.

Communicating

9. **Consider** that there are only limited supplies of the malaria vaccine. Which countries and which groups of people would you target to receive this vaccination? **Justify** your answer.
10. **Discuss** how changing global economic conditions affect the response to HIV/AIDS by aid organisations or donor companies.
11. **Discuss** what could be done to help poor families affected by HIV/AIDS break the poverty cycle.

LESSON
9.4 Why do governments have differing responses to wellbeing issues?

LEARNING INTENTION

By the end of this lesson you should be able to explain why different factors in population statistics lead to different wellbeing issues for different nations.

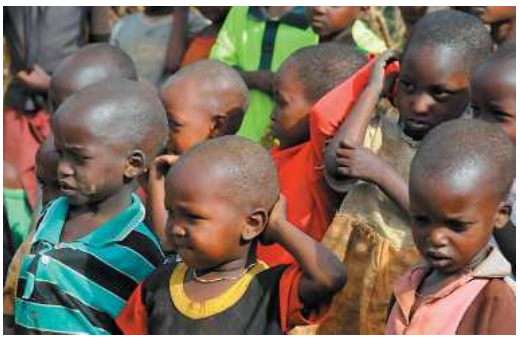
TUNE IN

Governments are elected by the people to provided services such as health and education, funded by taxpayer funds. Different countries around the world have very different issues in terms of enhancing wellbeing for their people.

Examine **FIGURE 1** and answer the questions below.

1. What could be the wellbeing issues the children in the image may be experiencing?
2. As an Australian child, what wellbeing issues do you have, if any?

FIGURE 1 The Kenyan population has a high proportion of young people.



In most societies, major wellbeing concerns relate to social, economic and political factors. Human rights and sustainability issues are other matters of concern when trying to balance growing populations with increasing competition for limited resources.

The wellbeing of nations can be best understood by analysing demographic factors such as health, education and employment, and it is the responsibility of governments and NGOs to monitor these factors and provide programs to overcome identified issues. Three studies are detailed in this lesson on Kenya, Japan and Australia, looking at their current and future populations and wellbeing issues.

TABLE 1 Selected demographic characteristics for Japan and Kenya

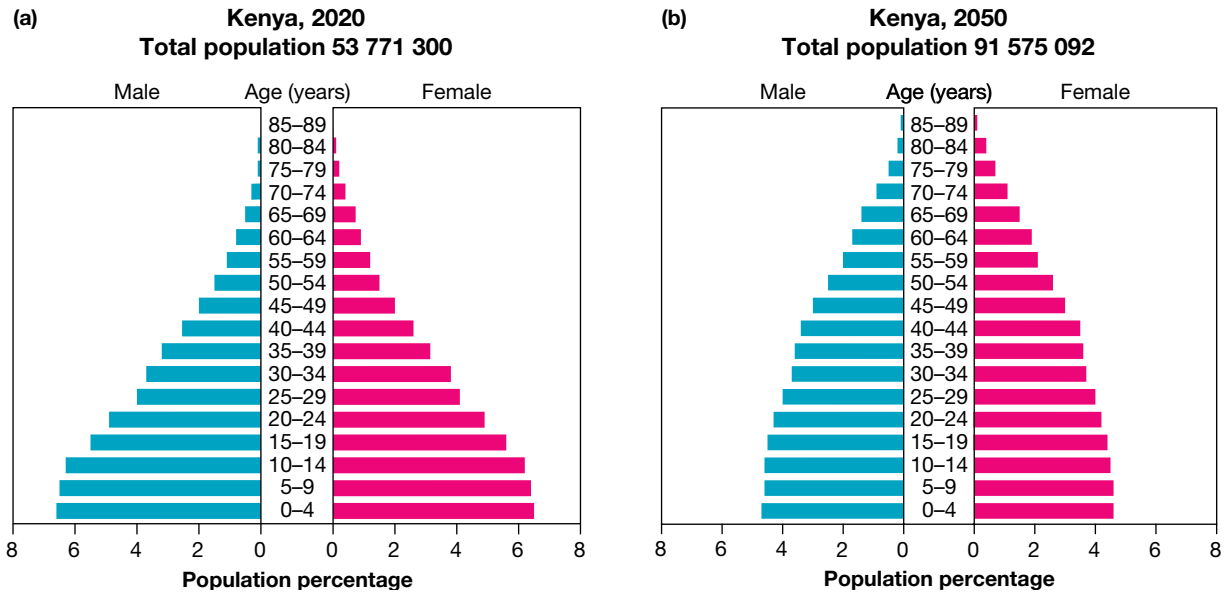
Demographic characteristic	Kenya	Japan
Population, 2020	53.8 million	126.5 million
Life expectancy at birth	67 years	84 years
Fertility rate	3.34	1.4
Natural increase	2.3%	–0.3%
Infant mortality	36 per 1000	2 per 1000
Projected population, 2050	91.6 million	105.8 million
Population under 15 years	38.5%	12%
Population 60+ years	4%	34.4%
Percentage urban	32%	92%
Gross national income per capita (US$)	1878	40 193

Source: World Bank.

9.4.1 Kenya: response to a youthful population

Although Kenya's **fertility rate** has fallen substantially (from a high of 8.1 children per woman in 1967, down to 3.3 children per woman in 2021), 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 2**), so by 2030 it is estimated that there will be over 65 million people, with further growth up to 91.6 million by 2050. 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 land per person available for crop-growing is falling.

FIGURE 2 Population pyramid for Kenya (a) 2020 and (b) 2050



Kenya's Vision 2030 is a national framework for development. Within this framework, population management is an essential component of achieving their 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. The UNFPA has provided financial aid to facilitate a range of services to promote wellbeing. These include family planning with free contraceptives provided, increased availability of maternal and newborn health services, services to prevent the contraction of HIV and STIs, advocacy 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.

9.4.2 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 around one-third of Japan's population in the 60-plus age group (see **TABLE 1** and **FIGURE 4**). Fertility in Japan has been consistently below replacement level since the 1970s (1.3 in 2021). 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 126.5 million in 2020 to 120 million in 2030, 105.8 million in 2050 and 83 million by 2100.

The workforce is expected to fall 15 per cent over the next 20 years and halve in the next 50 years. This means that in 2025, three working people will have to support two retirees. The Japanese government also faces rising pension and

fertility rate the number of live births per 1000 women of childbearing age (usually 15–44) in a given year

population structure the number or percentage of males and females in a particular age group

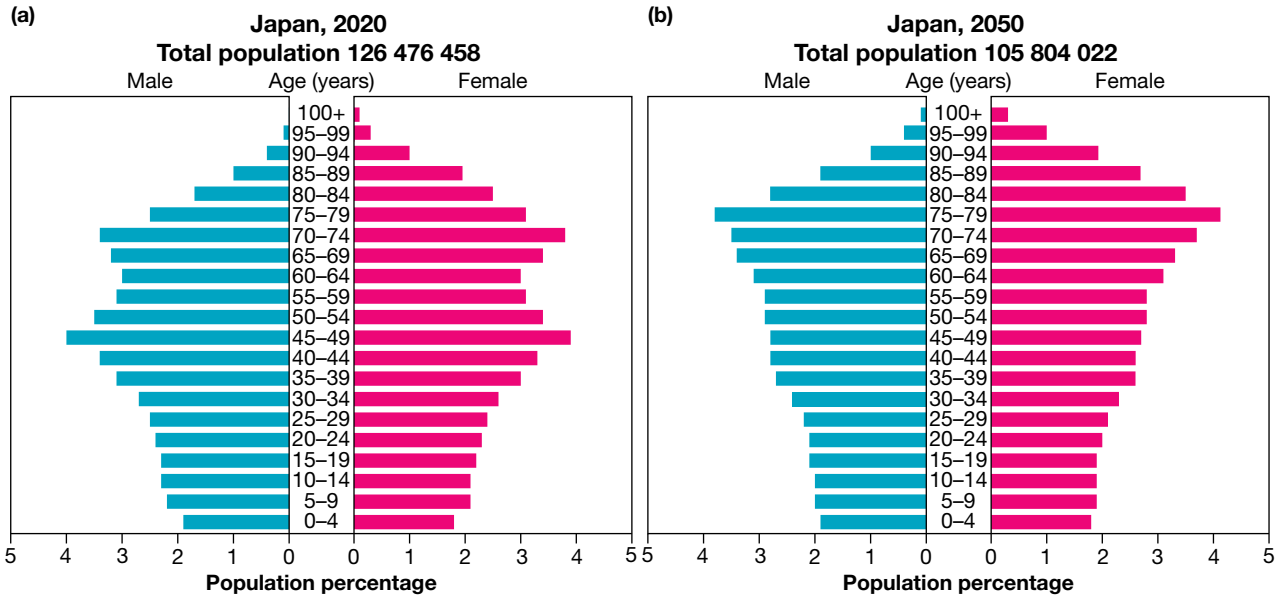
ageing population an increase in the number and percentage of people in the older age groups (usually 60 years and over)

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). In 2009, the government introduced the 'plus one' policy, offering further incentives for families by offering free education, more childcare places and providing fathers with up to 12 months subsidised paternity leave. These policies have been largely ineffective: although the fertility rate rose slightly initially, it has remained well below replacement level.

FIGURE 3 High life expectancy and a low fertility rate have led to an ageing Japanese population.

The Japanese government has historically been reluctant to use immigration to fill labour shortages, and although this may change slowly, improving female workforce participation rates, particularly after marriage, may be a more viable option. In 2018 Japan recorded its highest level of natural decline, with the population falling by 449 000 (the difference between the 921 000 recorded births and 1.37 million deaths). Japan's population went down 640 000 in 2021, which is the biggest drop on record.

FIGURE 4 Population pyramid for Japan (a) 2020 and (b) 2050



9.4.3 Improving wellbeing for First Nations Australians living in remote areas

Remote communities

Eighty per cent of First Nations Australians live in urban or regional centres and the remaining 20 per cent live in remote communities. While there are wellbeing issues for urban and regional First Nations Australians, remote communities have to contend with the highest levels of disadvantage (see **FIGURE 5**).

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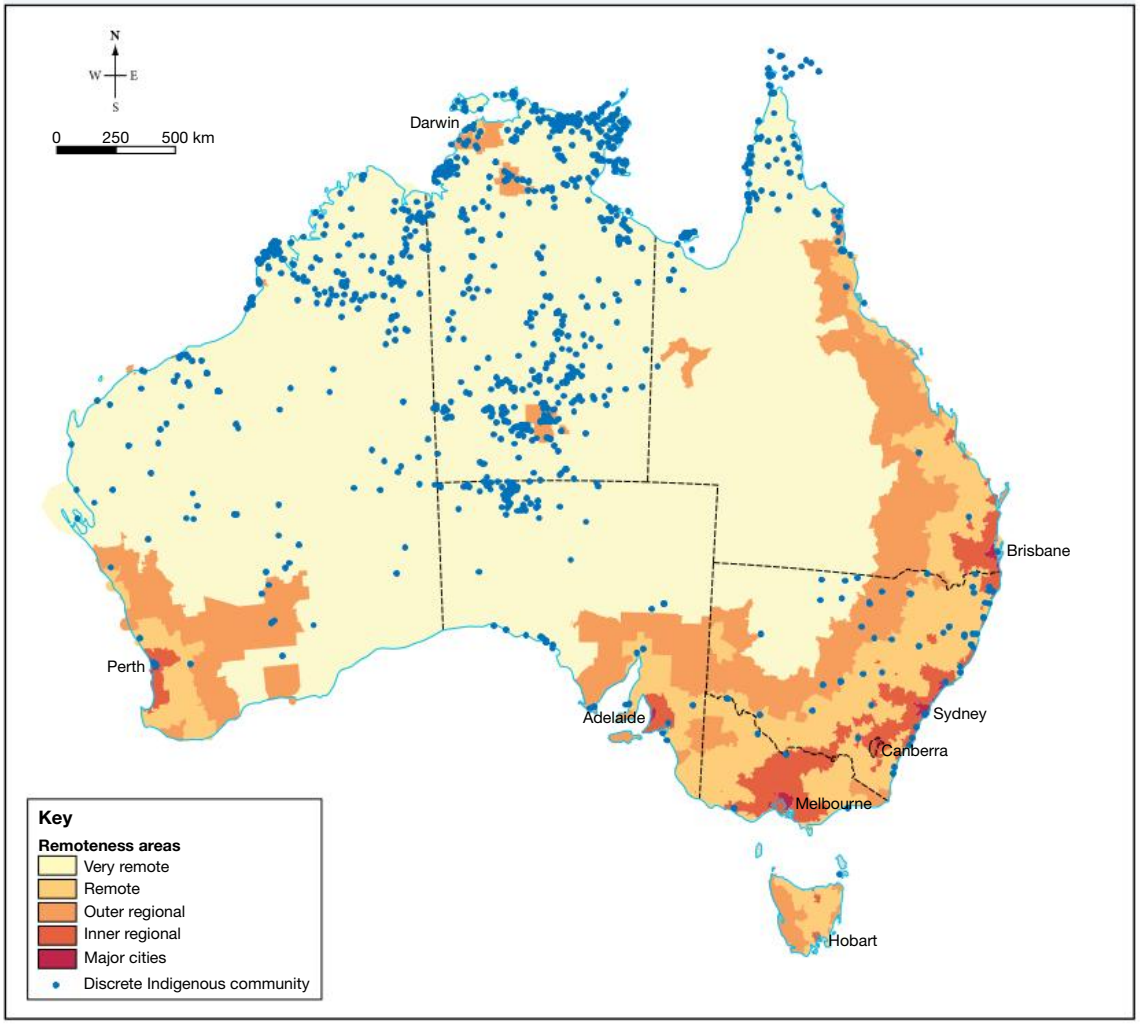
FIGURE 5 Distribution of remote First Nations communities



Source: Australian Bureau of Statistics

The inequalities experienced by First Nations Australians can be linked to three main causes:

- the dispossession of land
- the displacement of people
- discrimination.

Throughout history, First Nations Australians have been denied or have been unable to access the same services and opportunities as other Australians, creating ongoing negative consequences — social, economic and health-related.

Remote communities, in particular, struggle to achieve wellbeing due to a host of issues but most relate to health education and employment. In general, they are not exposed to the same social and economic opportunities as other Australians. As well as the high cost of living, limited educational outcomes, insufficient social services and work opportunities, economic insecurity prevails. The economic insecurity includes a lack of access to infrastructure to support the development of business ventures that can provide financial and employment opportunities, without which welfare dependency often results.

What issues do demographic profiles show?

The following population pyramid shows us that there are many younger First Nations Australians, with the upper and middle age groups smaller. Hence, we can conclude that there is a considerably lower life expectancy for First Nations Australians in the middle and upper age groups compared with non-First Nations Australians (see **FIGURE 6)**. The reasons for this difference can be found in the next set of demographic statistics.

FIGURE 6 Population pyramid for First Nations and non-First Nations Australians

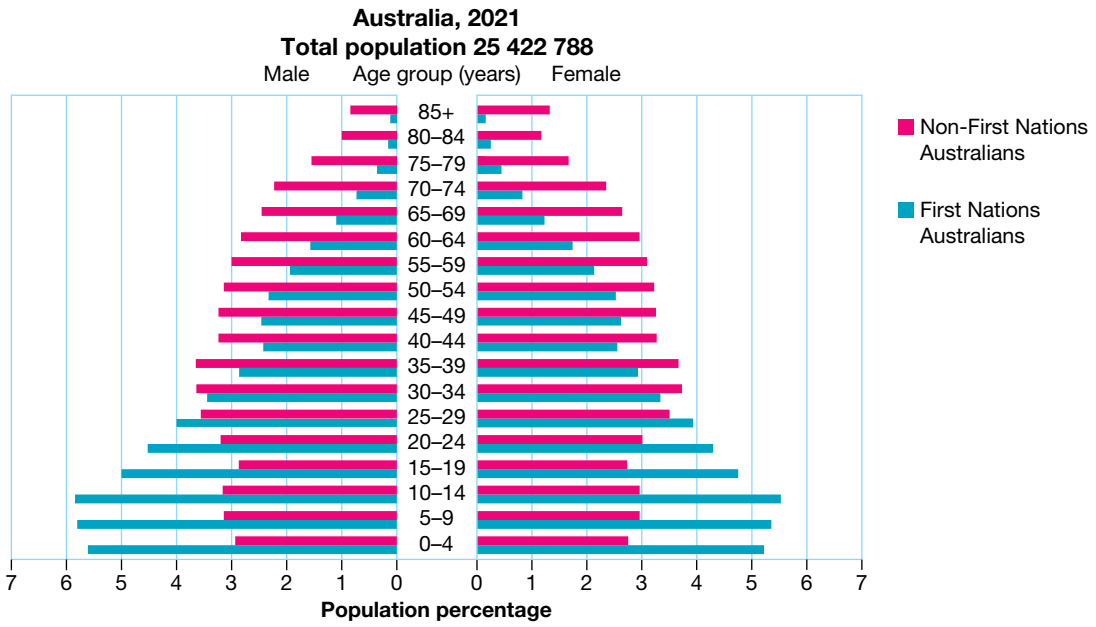


FIGURE 7 Indicators of First Nations Australians' wellbeing

Across all socioeconomic factors, First Nations Australians show lower levels for life expectancy related to health considerations, participation in the workforce related to unemployment, and achievement in education related to levels of education. This gives a formula for disadvantage and hence lower levels of wellbeing for people and their communities (see **FIGURE 7**).

Government programs

In an effort to address the issues impacting on First Nations Australians governments at federal and state levels have set up programs to improve wellbeing. Some of these programs are:

1. **National Agreement on Closing the Gap** (replacing the original Closing the Gap strategy)
   The current plan for this strategy identifies a range of socioeconomic outcomes that need to be met to improve wellbeing. Crucial to these goals is a partnership between First Nations Australians and governments to work together to overcome inequality. The views of Elders, communities and organisations are important and

ongoing. The Agreement established four priority reforms and 17 targets. These include improvements in education, employment, health and wellbeing, justice, safety, housing, land and waters, and languages.

2. **Remote Area Health Corps** — funds health professionals to work in remote communities for periods of 3 to 12 weeks
3. **2022 Indigenous Skills and Employment Program (ISEP)**
4. **2020 The Community Development Program (CDP)** — supports remote employment and community development service
5. **2022 Remote Jobs Program** (which will replace the CDP) — aims to foster self-employment and develop small businesses
6. **2018–2022 Indigenous Business Sector Strategy (IBSS)** — helps build sustainable businesses that will support families and their communities

9.4.4 CASE STUDY 1: Improving food security

Historically, First Nations Australians managed their food and water resources carefully to ensure wellbeing and sustainable living on their lands. However, after European occupation they were removed from and denied access to their lands and natural resources. Being denied access to food and water sources played a role in limiting access to nutritious and fresh sources of food, leading to food insecurity.

FIGURE 8 Outback Store, Papunya Community, situated 240 km northwest of Alice Springs in the Luritja Pintubi Ward of the MacDonnell Regional Council

The 2013–2021 National Food Plan addressed food security and the affordability and quality of food available to remote First Nations Australian communities. Some measures that were funded by governments include:

- improving the food supply chain to remote areas
- establishing community stores in remote areas, such as the Outback Stores program
- education campaigns about nutrition guidelines and healthy food choices
- promoting 'healthy choices' on the basis of food or brand content, based on the Health Star Rating system

- small grants to support the establishment or improvement of community food initiatives, such as farmers' markets, food cooperatives, food hubs, community gardens and city farms
- food subsidy funds for the fruit and vegetable program to improve health and nutrition for First Nations Australian children
- funding for the Stephanie Alexander Kitchen Garden National Program to develop gardens in schools.

These initiatives help improve the skills of First Nations Australians to enable them to have a greater influence on food security and to address health promotion and nutrition at the local level.

9.4.5 CASE STUDY 2: Engagement with Country — The Fish River Station

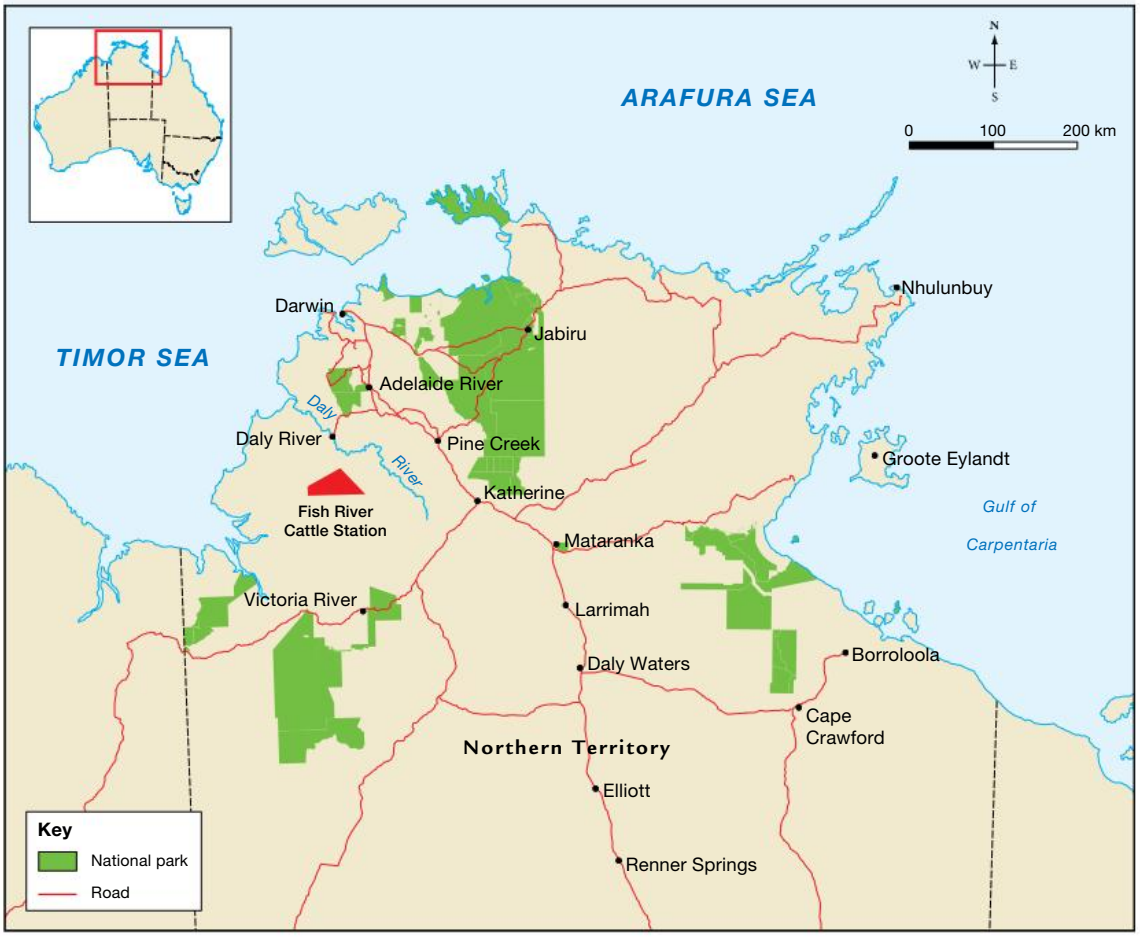
The Fish River Station (1800000 hectares) in the Daly River region of the Northern Territory is an example of Park and Ranch management by First Nations Australians. It is owned and managed using traditional ecological knowledge applied to large-scale conservation and the protection of biodiversity. It is home to fresh and saltwater crocodiles, barramundi and freshwater turtles. The landscape is one of wetlands, with the river and its billabongs, rainforests and savanna woodland.

The tropical savanna environment was formerly run as a cattle property, but its original inhabitants were the Ngan'giwumirri (Labarganyin), Wagiman, Malak and Kamu Peoples. The land was purchased in 2011 with funding from the Indigenous Land Corporation, Caring for our Country, The Nature Conservancy and Pew Environment Group and is part of Australia's National Reserve System.

The 2019 Management Plan is 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 to encourage biodiversity and will find ways to pass this knowledge to future generations.

FIGURE 9 Daly River in the wet season

FIGURE 10 Daly River location map



Source: Spatial Vision

Its development as a conservation project has connections to the National Workforce Strategy Action Plan, the Community Development Program, the Remote Engagement Program and the Indigenous Business Sector Strategy to help build sustainable businesses that will support families and their communities and improve their wellbeing.

FIGURE 11 Fish River Station rangers Desmond Daly and Jeff Long patrol 178 000 hectares of land

9.4 SKILL ACTIVITY: Interpreting and analysing geographical data and information

1. **Research** the Japanese government's three plans (listed below) designed to help increase the country's falling birth rate.
   a. Angel Plan
   b. New Angel Plan
   c. Plus One Policy

   Things to find out include:
   - What is the plan?
   - When did it start?
   - What was its aim?
   - Who were its targets?
   - Did it achieve its goal?
2. **Identify** what aspects of the government's beliefs and values led to the development of these plans.
3. **Describe** what aspects of Japanese culture, values and beliefs have prevented the plans from achieving success.

9.4 Exercise

learnon

9.4 Exercise

Learning pathways

LEVEL 1	LEVEL 2	LEVEL 3
1, 3, 5, 6	2, 7, 8, 11	4, 9, 10, 12

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Check your understanding

1. Complete the following sentence to explain how an improvement in living conditions can lead to a change in population structure.
   An improvement in living conditions has led to a _____ percentage of people in the under 15 years age group (_____ children being born) and _____ in the 60-plus age group (_____ life expectancy).
2. Kenya's population is expected to grow between 2030 and 2050 by:
   A. 26.6 million.
   B. 35.5 million.
   C. 95.5 million.
   D. 65 million.
3. The most important factors that have contributed to low fertility rates in Japan since the 1970s are:
   A. a low standard of living.
   B. increased participation of women in the workforce.
   C. low costs of raising children.
   D. lack of supporting childcare facilities.
4. **Determine** reasons for the variation in shape of the population pyramids for Japan and Kenya in 2020 and 2050.
5. Identify the difference in life expectancy between Kenya and Japan.

Apply your understanding

Interpreting and analysing geographical data and information

6. **Describe** the changing percentage of aged population between 2020 and 2050 in Kenya and Japan.
7. **Analyse** what problems the Kenyan government faces with a large proportion of the population being young.
8. **Consider** what problems Japan faces with a large proportion of the population being aged.
9. **Investigate** how population structure issues affect the wellbeing of people in those countries.
10. Of the problems you **identified** in questions 7 and 8, which do you **determine** is more serious?
11. **Explain** what is meant by a lack of infrastructure in remote communities.
12. **Discuss** why food security is a key element of a remote community's wellbeing.

LESSON
9.5 Why are human rights so important?

LEARNING INTENTION

By the end of this lesson you should be able to describe the basis of human rights, identify how these can vary between countries and be able to explain why children have special human rights because of their vulnerability to exploitation and abuse.

TUNE IN

The United Nations developed a Rights of the Child Charter in 1989 to which Australia is a signatory. The image of the child shown in **FIGURE 1** is taken from New Delhi, India. The child collecting rubbish to make money for his family is very different from what we would see in Australia.

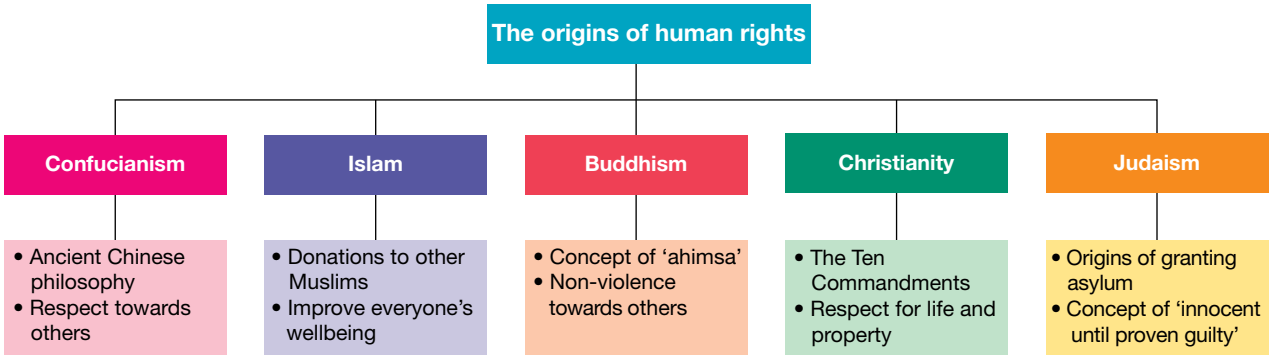
1. What could be the wellbeing issues for this child?
2. Can you detail any human rights that you think might be abused by this form of labour?

FIGURE 1 What is this child at risk of while collecting rubbish?

9.5.1 The basis of human rights

Global wellbeing is about more than just having enough to eat and being healthy; it extends to also having freedom to exercise your human rights. Human rights are so much a part of our daily lives here in Australia that we tend to take them for granted. Many principles that have been adopted in international human rights practices have their roots in traditions and religions that are thousands of years old. Different countries, societies and cultures have come up with their own definitions over time to suit their particular environment or context.

FIGURE 2 Origins of human rights



In some societies, human rights may be enshrined in law and legislation, whereas in others they may simply exist as guidelines that reflect the values of that particular community. In short, the concept of human rights stems from the belief that there is an instinctive human ability to distinguish right from wrong.

Human rights can be defined in different ways. The Australian Human Rights Commission notes that definitions may include:

- the recognition and respect of people's dignity
- a set of moral and legal guidelines that promote and protect a recognition of our values
- our identity and ability to ensure an adequate standard of living
- the basic standards by which we can identify and measure inequality and fairness
- those rights associated with the Universal Declaration of Human Rights.

9.5.2 The role of the United Nations

The UN was formed in the aftermath of World War II on 24 October 1945 by countries committed to preserving peace through international cooperation and security. Today, nearly every nation (currently 193 countries) in the world belongs to the UN. One of the main aims of the UN Charter is to promote respect for human rights. The **Universal Declaration of Human Rights**, proclaimed by the UN General Assembly in 1948, sets out basic rights and freedoms to which all women and men are entitled, including:

- the right to life, liberty and nationality
- the right to freedom of thought, conscience and religion
- the right to work and to be educated
- the right to food and housing
- the right to take part in government.

These rights are legally binding by virtue of two **International Covenants**, to which most states are parties. One covenant deals with economic, social and cultural rights, and the other deals with civil and political rights. Together with the Declaration, they constitute the **International Bill of Human Rights**. **FIGURE 3** shows where political rights exist or are lacking throughout the world.

Universal Declaration of Human Rights the first specific global expression of rights to which all human beings are inherently entitled

International Covenants a multilateral treaty adopted by the United Nations General Assembly, in force from 1976; it commits those who have signed the Covenant to respect the civil and political rights of individuals and their economic, social and cultural rights

International Bill of Human Rights the informal name given to the Universal Declaration of Human Rights and the two International Covenants

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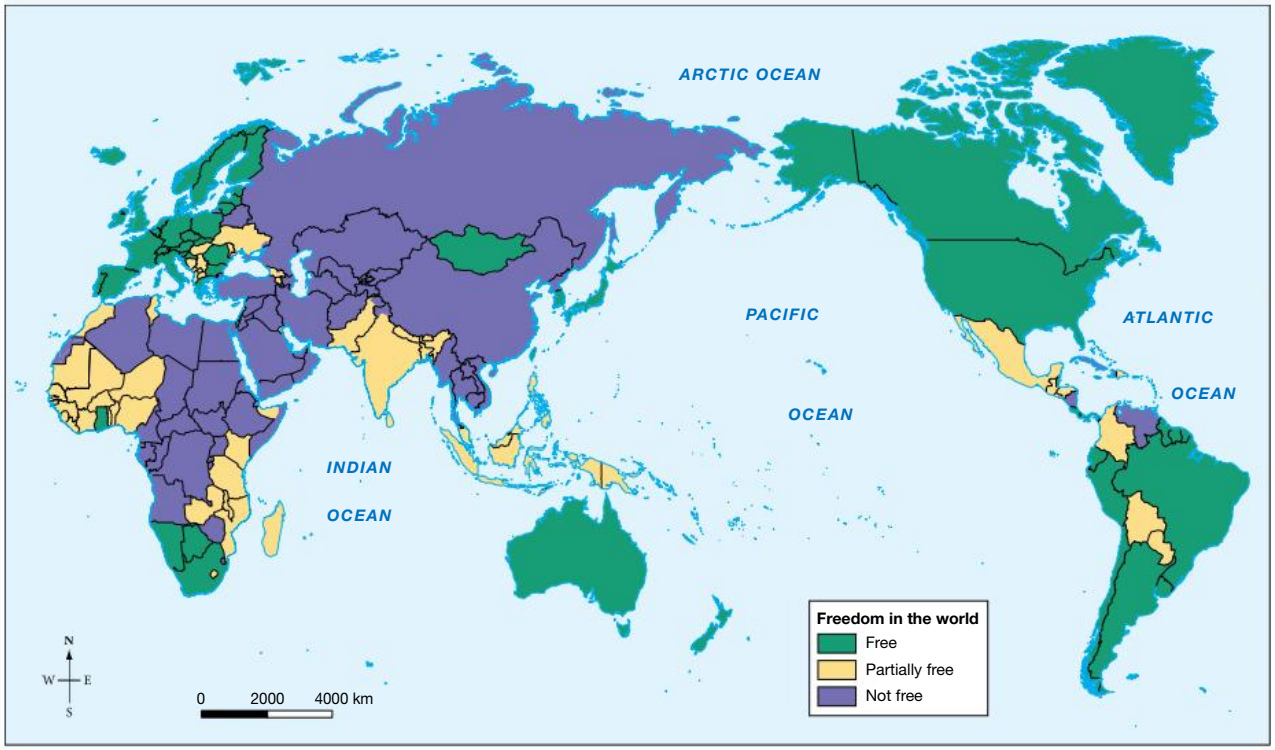
FIGURE 3 Political rights around the world, 2022. A free country is one where political rights are available and protected. A country that is not free is one where basic political rights are absent, and basic civil liberties are widely and systematically denied.



Source: Map redrawn by Spatial Vision based on information from The Global Expansion of Authoritarian Rule, 2022. Freedom House. Freedom in the World 2022 www.freedomhouse.org.

9.5.3 Who protects our human rights?

Although Australia has agreed to be bound by these major international human rights treaties, they do not form part of Australia's domestic law unless they have been specifically written into Australian law through legislation. The Australian Human Rights Commission is the national organisation that advocates for promotion and protection of human rights. In addition to monitoring economic, social, cultural, civil and political rights, other areas of human rights include peacekeeping, eradication of poverty and the humanitarian tribunals (for example, the International Criminal Court that deals with mass human rights violations, such as genocide). Amnesty International is a global organisation that works to uphold human rights. One area on which it focuses its human rights advocacy is the death penalty (capital punishment), a contentious issue on the global political stage (see **TABLE 1**).

TABLE 1 The death penalty, a violation of the right to life as proclaimed in the Universal Declaration of Human Rights

Countries with the most confirmed executions 2019		Countries with the most death sentences 2019	
China	1000s*	China	1000s*
Iran	251+	Pakistan	632+
Saudi Arabia	184	Egypt	435+
Iraq	100+	Bangladesh	220+
Egypt	32+	India	102+
United States	22	Zambia	101
Pakistan	14+		
Somalia	12+		

* Exact figures for China are unknown, but Amnesty International estimates executions to have been in the thousands.
Amnesty International reported that at least 26 604 people were known to be on death rows around the world at the end of 2019.
According to Amnesty International, of 142 countries worldwide, more than 70 per cent of all the world's countries are against capital punishment in law or practice.
Execution totals not known for Vietnam, North Korea and Syria.
Death sentencing totals unknown for Iran, Malaysia, Nigeria, North Korea, Sri Lanka and Syria.

Source: Data from Amnesty International.

DISCUSS

How are your rights protected? And what are some of the big issues for children's rights in Australia today? How might your perception of what is just and fair treatment be different to children living in other parts of the world?

9.5.4 Protecting the vulnerable

International human rights organisations recognise that children have special human rights because of their vulnerability to exploitation and abuse. The United Nations General Assembly adopted the Convention on the Rights of the Child (the CRC) in November 1989. How are your rights protected? And what are some of the big issues for children's rights today?

Some of the rights and protections that a **child** is entitled to according to the CRC include:

- the right to life
- the right to a name and a nationality
- the right to live with their parents

child any person below 18 years of age

- the right to freedom of thought, conscience and religion
- the right to privacy
- protection from abuse and neglect
- the right to education
- the right to participate in leisure, recreation and cultural activities
- protection from economic exploitation
- protection from or prevention of abduction, sale or trafficking.

Two key areas that are currently a focus for rights are the use of children in conflict and the use of children for labour.

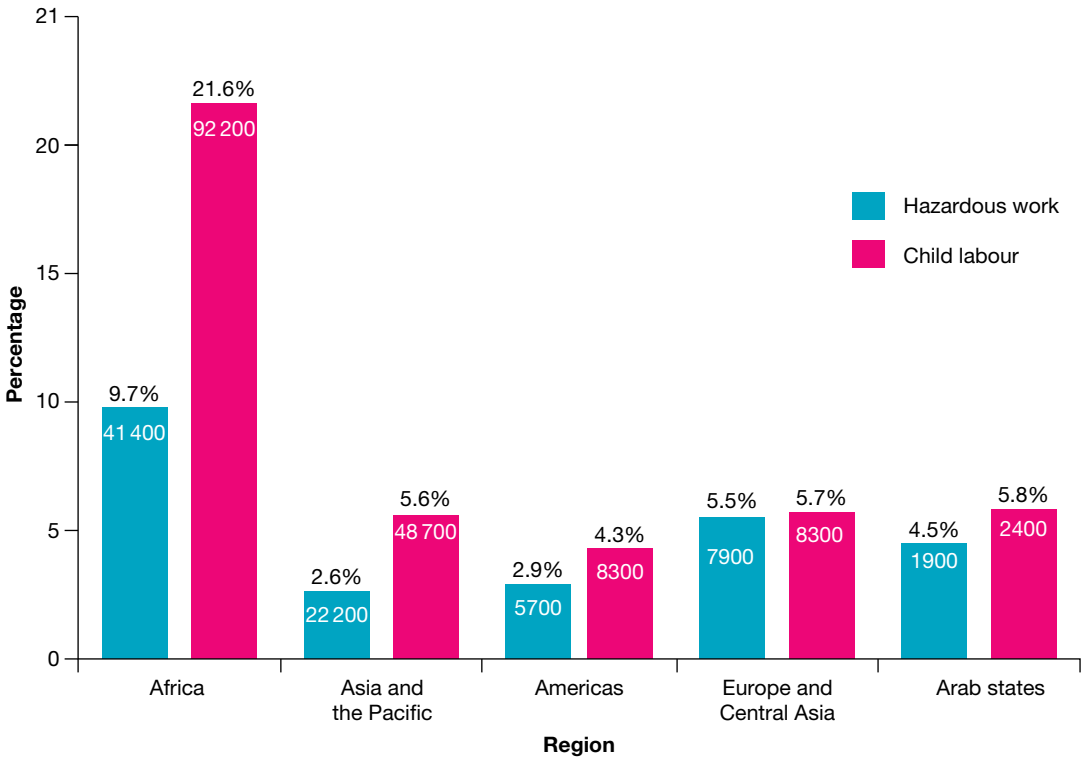
Child soldiers and child labour

The issue of children in armed conflict has become a pressing one over the past few decades because of the serious risks of involving children in war or conflict situations. Approximately 300 000 children are believed to be combatants in conflicts worldwide. **Child soldiers** have gone to battle in a range of countries, including Afghanistan, the Central African Republic, the Democratic Republic of the Congo, Myanmar, Somalia, South Sudan, Sudan, Syria and Yemen.

Sustainable Development Goal 8 has a target specifically relating to child labour. From 2012 to 2016 child labour declined, but the rate of decline is slowing. Sub-Saharan Africa has seen an increase in child labour. Places in conflict, experiencing disasters and of low income have a heightened risk of child labour.

child soldier a child who is, or who has been, recruited or used by an armed force or armed group in any capacity, including but not limited to children, boys and girls, used as fighters, cooks, porters, messengers, spies or for sexual purposes. This term does not refer only to a child who is taking or has taken a direct part in hostilities.

FIGURE 4 Children's involvement in child labour and hazardous work, by region, 2020



The latest global estimates indicate that:

- 160 million children (63 million girls and 97 million boys) were in child labour globally at the beginning of 2020, accounting for almost 1 in 10 of all children worldwide
- 79 million children — nearly half of all those in child labour — were in hazardous work
- the highest number of child labourers are in Africa; almost half the children in labour globally are found there (76 million, or one in five children)
- sub-Saharan Africa stands out as the region with the highest prevalence and largest number of children in child labour (23.9 per cent or 86.6 million)
- new analysis suggests a further 8.9 million children will be in child labour by the end of 2022 as a result of rising poverty driven by the pandemic.

In many countries, poor girls are put to work as domestic servants for richer families. In many places, children (especially girls) perform unpaid work for their families. In all cases, children are exploited, and in many cases, they are excluded from attending school (denying them their right to education).

DISCUSS

How might the values and beliefs differ between countries with a higher incidence of child labour and hazardous work compared to those countries with a lower incidence of these issues?

9.5 SKILL ACTIVITY: Questioning and researching using geographical methods, Interpreting and analysing geographical data and information

1. Refer to **FIGURE 3**.
2. **Identify** one of the countries that is not free.
3. Conduct additional research. Organise your research into a table and find out:
   - where the country is located
   - population profile
   - type of government
   - main religion.
4. **Identify** what violations of this area of human rights have contributed to this rating.
5. You may wish to use the **Human Rights Watch** weblink in your online Resources as one source of information.

on Resources

Weblink Human Rights Watch

9.5 Exercise

learnon

9.5 Exercise

Learning pathways

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

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Check your understanding

1. **Determine** whether the following statements are true or false.
   a. The Universal Declaration of Human Rights sets out basic rights and freedoms to which all women and men are entitled.
   b. The International Bill of Human Rights consists of the Universal Declaration of Human Rights and the two International Covenants.
2. **Identify** the definition of 'human rights' from the options below.
   A. The voluntary transfer of resources from one country to another, given at least partly with the aim of benefiting the receiving country
   B. The basic principles that guide human behaviour and the attitudes and beliefs of communities
   C. Concern for the welfare of other human beings
3. **Determine** whether the following statements are true or false.
   a. The Convention on the Rights of the Child is the name of the document that sets out the rights of children.
   b. A 'child' is defined as any person below 18 years of age.
4. **Identify** who the Universal Declaration of Human Rights applies to.
5. **Elaborate** on why children need a separate declaration outlining their rights.

Apply your understanding

Interpreting and analysing geographical data and information

6. Study **FIGURE 2**. **Name** the philosophies that have influenced your understanding of human rights.
7. **Consider FIGURE 3**.
   a. What does this map illustrate?
   b. Which places around the world are 'free', and which are 'not free'?

Concluding and decision-making

8. Only a small selection of the rights outlined by the Convention on the Rights of the Child (CRC) is provided in this lesson.
   a. How would you rank the 10 rights listed in this section in order of importance (1 being the most important)? **Justify** your choices.
   b. Do you think someone in sub-Saharan Africa would agree with your choices? **Explain.**
9. If you had to stay home and babysit your younger siblings during the day, then your right to an education may be compromised. **Evaluate** how simple daily events might prevent you from achieving your rights or protections, as outlined by the CRC.

LESSON
9.6 CASE STUDY: Syria — the impact of conflict on wellbeing

LEARNING INTENTION

By the end of this lesson you should be able to evaluate how civil war in Syria has affected the wellbeing of the Syrian people since 2011.

TUNE IN

Warfare can have significant impacts on the wellbeing of a society. Think of the damage to property and the loss of lives. The current Civil War in Myanmar and the invasion of the Ukraine by Russia are just two examples of warfare and civil unrest in the world today.

FIGURE 1 A Syrian refugee makes a cooking fire.

FIGURE 2 The destruction of their homes is just one of the many significant effects the war has had on the children of Syria.

Examine **FIGURES 1** and **2** and answer the following questions.

1. What would life be like for the people in the images across all the elements of wellbeing with which you are familiar?
2. What places in the world do you know of that are in a state of warfare?

9.6.1 The impact on the Syrian people

The civil war in the Syrian Arab Republic has become a long-term event. It began in 2011 as part of the uprising of its people against the government in the Arab Awakening (also known as the Arab Spring). Civil war does not mean that everyone living in the country is involved in the war, but everyone living in the country is affected by the war. Life and wellbeing are changed.

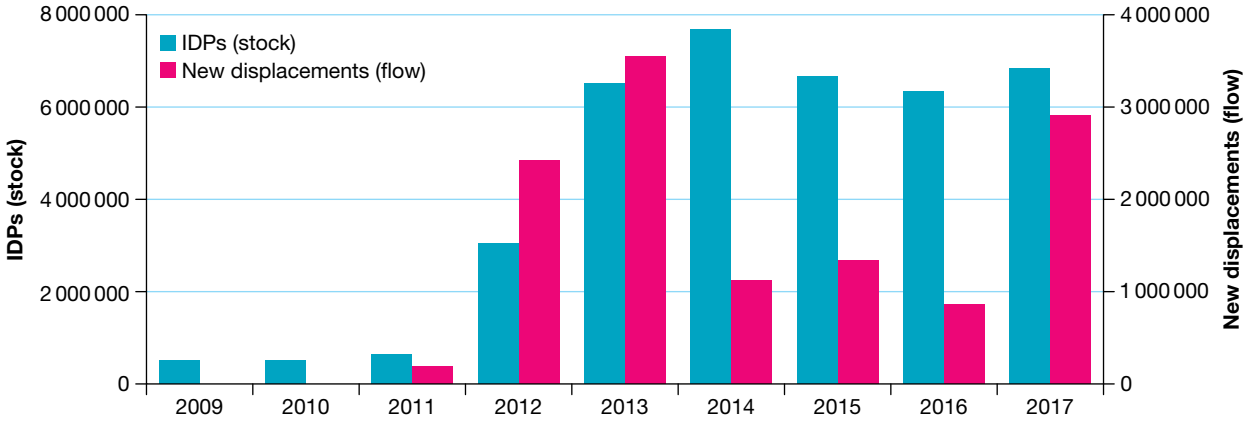
The Syrian people had four choices when government forces commenced hostilities against their protests in the Arab Awakening: join the Syrian Arab Republic's army, join the rebels, leave the fighting zones or stay in their homes.

By 2018, 7.8 million Syrian people — especially women, children and young men — had fled areas of conflict to somewhere else within the Syrian Arab Republic, becoming internally displaced persons (IDPs) in their own country (see **FIGURE 3**). These people make up one in five of all IDPs globally — this is the largest displaced population worldwide.

In 2013, the Assad-led government declared 'surrender or starve' to its people and began sieges on key cities, particularly the capital city, Damascus, and large populations to the north of the country. Sieges 'lock' people

within a city's boundaries, preventing easy movement out and denying entry to the city. In early 2016 it was estimated that between 390 000 and 1.9 million people were trapped in cities.

FIGURE 3 The number of IDPs in Syria 2011–17



Note: 'Stock' refers to people living in a region during a period of time; 'flow' refers to people entering or leaving a region during a period of time.

Source: © Internal Displacement Monitoring Centre.

Multiple opposition groups formed in a wider context throughout the region and began to have a presence in the Syrian Arab Republic. Some of these groups have a religious base and others are terrorist cells. Since then the pressures of conflict in different areas have seen many IDPs flee again, often at night to avoid detection. Some of these people have crossed the border into surrounding countries to become refugees, massing in 'tent cities' on the border with Turkey, with many ultimately moving on either to other neighbouring countries or even further, into Europe (see **FIGURE 4**). The level of liveability for the Syrian people has declined. (For help understanding **FIGURES 4** and **5** see 1.12 SkillBuilder: Constructing and describing complex choropleth maps in topic 1.)

9.6.2 The impact on housing

FIGURE 5 shows a significant change in liveability for Damascus from 2008 to 2018. Living conditions have changed: safety in homes is at risk, there is food insecurity and children are traumatised. Global relief organisations estimate that more than 13 million people in Syria need humanitarian aid.

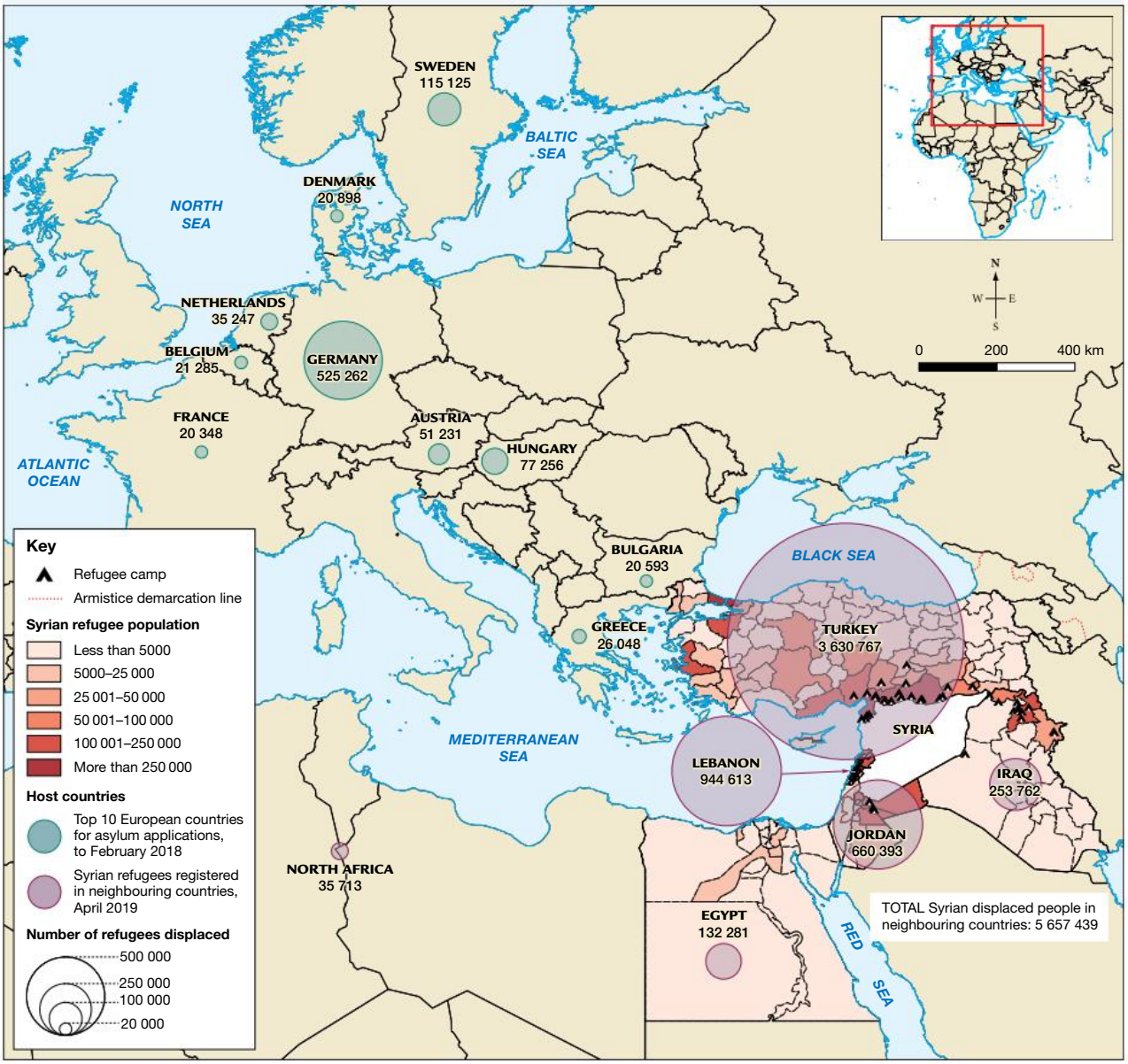
The street-to-street fighting that is a key element of civil war has destroyed buildings, including houses, in major cities such as Aleppo and Homs. Public services such as electricity, running water and gas supplies no longer operate. There is no transport system. Without oil, people rely on wood fires for heating and cooking, but this has brought about local deforestation. War continues to injure and kill local people who have remained in their homes. In late 2014 the United States, the United Kingdom and France began airborne bombing of cities to reduce the threat of rebel groups; Russia began air strikes in late 2015. Ongoing bombing strikes by the Syrian regime have further destroyed buildings.

9.6.3 Feeding the Syrian people

Food insecurity is a daily issue for the war-torn areas of the Syrian Arab Republic. It is not safe to be outside for too long tending plants. Food transport cannot reach the besieged cities. Reports of malnourishment surfaced in 2016 at besieged Madaya (where 40 000 people were trapped) when social media reported that families were stripping the trees of leaves and boiling them to provide one meal a day. Aid organisations negotiated with the Assad government to be allowed to enter the city (free from attack) with a convoy of trucks bringing food, but this was only a short-term solution. As the conflict continues, food remains a major issue for the people trapped in the conflict zones of Syria.

int-7988

FIGURE 4 The distribution of Syrian refugees



Source: Based on data from UNHCR, Government of Turkey.

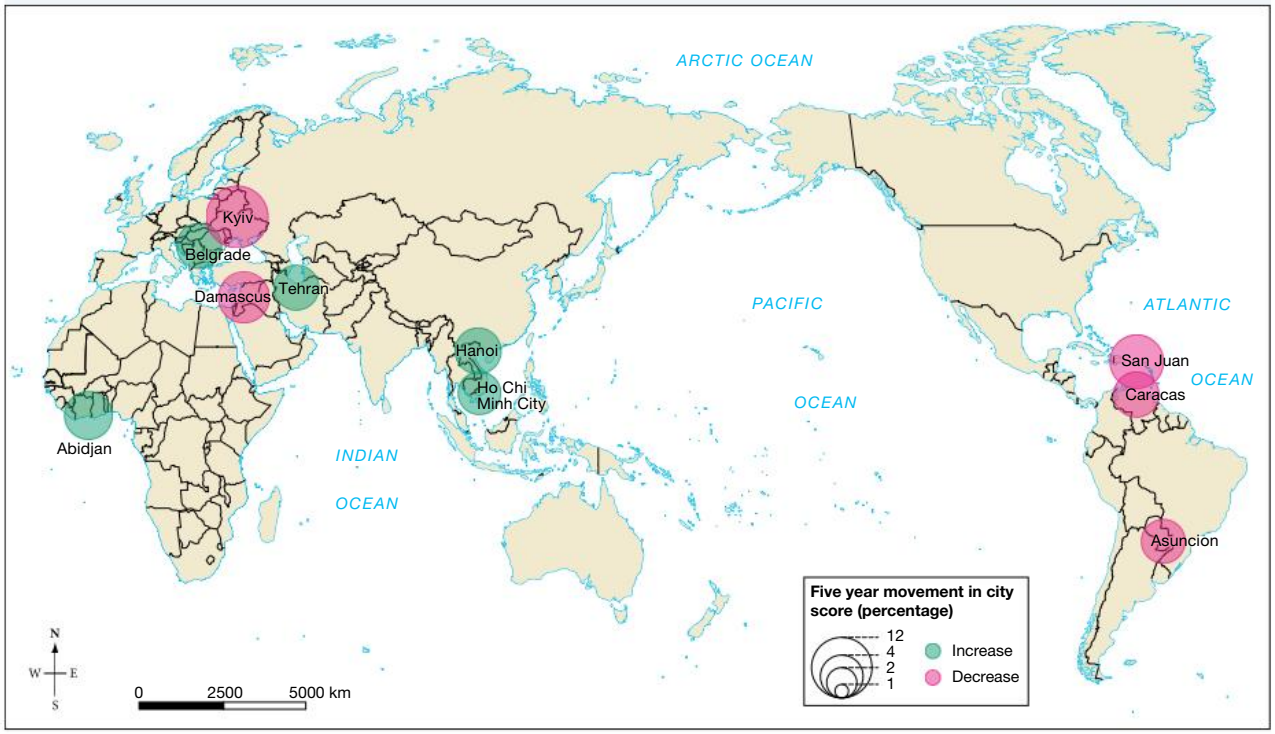
9.6.4 The impact on children

Children in any war-torn area have their lives dramatically changed. The streets are no longer playgrounds. Education is disrupted or abandoned for months or years. Fear enters their lives — the sounds of aircraft, bombing and shooting punctuate their days and nights. Deafness in children becomes a problem. Families are torn apart, with some people fleeing and others staying. Children miss their friends. Young men are recruited for the fight by both sides of the conflict with blackmail, threats, fear and propaganda. Life is insecure, confusing and scary; children grow old before their time.

9.6.5 Adapting to life in the besieged cities

The resilience of people is evident in the besieged cities as people become accustomed to a basic lifestyle. Innovation is required: static bicycles are pedalled to generate power for mobile phones, medicines are produced from home remedies, plastic is burned to extract oil derivatives and rooftop gardens produce small amounts of vegetables.

FIGURE 5 Change in liveability score 2008–18, showing the change in Syria in comparison to other areas of significant change



Source: Economist Intelligence Unit

9.6.6 What are the costs to the Syrian Arab Republic?

International peace talks have brought ceasefires in the fighting, but will peace ever be achieved? In 2018–19, the Syrian armed forces continued to retake cities and push terrorist cells out of the country. The costs to the Syrian Arab Republic are immense. So many of its people have fled — more than 5.6 million are refugees and 7 million are IDPs, of whom nearly 3 million are in besieged cities or hard-to-reach locations. Some of those who fled will return to the Syrian Arab Republic, but they too have changed as a result of the experiences they have been through. And how will those who remained perceive the returnees and those who stay away? Families have been changed forever. The cities will take years to rebuild; more than a quarter of all housing has been destroyed. Services and food supplies will need to be re-established. Children will have years of schooling to catch up on.

FIGURE 6 Residents of Homs go about daily life among the destruction.

9.6 SKILL ACTIVITY: Questioning and researching using geographical methods, Interpreting and analysing geographical data and information

1. **Conduct** an internet search to locate the latest Human Development Report.
2. Copy the following table and complete it using data from the report.
3. **Using** the indicators in the completed table, **describe** life in Syria.

4. From the table, **identify** if is there an indication of why refugees opt to go to Turkey and Lebanon in preference to other cross-border countries.
5. Support your answer using statistics.

Country indicator	Syrian Arab Republic	Turkey	Jordan	Lebanon	Iraq	Egypt
HDI ranking						
GNI per capita						
Public expenditure on education (% of GDP)						
Local labour market (% answering 'good')						
Public health expenditure (% GDP)						
Internet users (% of population)						

9.6 Exercise

learnon

9.6 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** the sides in the civil war in the Syrian Arab Republic.
   - A. The Syrian Arab Republic's Army
   - B. Syrian citizens
   - C. Government of Turkey
   - D. The rebels
2. Food security is one of the most significant issues for Syrian people who have remained in their homes. True or false?
3. Make a list of the things that Syrian refugees are seeking in order to improve their wellbeing by journeying so far into Europe.
4. What was the government policy that forced great hardship on the Syrians? **Explain** its implications.
5. **FIGURE 4** shows the cross-border movement of Syrian refugees.
   a. Rank the neighbouring countries from highest to lowest in relation to the number of Syrian refugees registered in each country in April 2019.

Country	Rank
Iraq	
Turkey	
Egypt	
Lebanon	
Jordan	

b. Is the distribution of Syrian refugees even across the neighbouring countries? In particular, refer to the situation in Turkey.
c. **Summarise** why the refugee camps are found along the borders.

Apply your understanding

Concluding and decision-making

6. Using **FIGURE 5**, **describe** how Syria's capital, Damascus, has faired in terms of liveability as a city.
7. Is the wellbeing of the Syrian refugees likely to improve in a cross-border country? **Justify** your answer.

Interpreting and analysing geographical data and information

8. **Interpret** the distribution of Syrian refugees across Europe in 2018.

Communicating

9. **Explain** what you might do to make your life as 'normal' as possible and ensure your wellbeing if you found your neighbourhood in a situation similar to the embattled regions of Syria.

LESSON
9.7 Why have so many people had to flee their homes and seek refuge?

LEARNING INTENTION

By the end of this lesson you should be able to describe why people fleeing from countries involved in conflict in northern Africa and Western Asia have crossed the Mediterranean Sea to find new homes in Europe, and explain the different responses of European countries to this movement of people.

TUNE IN

Around the world there are people fleeing war zones in an effort to protect their wellbeing and hopefully find refuge in a new land. Some countries welcome refugees but others try to prevent these people crossing their borders. In the first 50 days of the Russian invasion of Ukraine, nearly 5 million Ukrainian refugees fled their homes in what may be the largest movement of people in Europe since World War II.

FIGURE 1 Refugees board a dinghy with all their possessions to make the short crossing from Turkey to Greece.

FIGURE 2 Tents of migrants and refugees in the port of Piraeus, Athens, Greece

Examine **FIGURES 1** and **2** and answer the following questions.

1. What do these images show about the struggle for life of these refugees?
2. Have you met a refugee? If so, what did they tell you about their struggle to survive?

9.7.1 Refugees and asylum seekers

As shown in the case study on Syria, refugees flee conflict and cross a border into another country to seek relief from the trauma of war and make a home elsewhere. All refugees (those who cannot return home due to a fear of persecution because of race, religion, nationality or membership of a social group) have been **asylum seekers**, but not all asylum seekers are found to be refugees. Asylum seekers who are not found to be refugees have either not satisfied the UNHCR criteria to be deemed a refugee or have gone outside of the formal process to seek a place to live.

asylum seekers people entering another country asking to be assessed and classified as refugees

9.7.2 The movement of people to Europe

Most of those arriving in Europe are fleeing the civil war in the Syrian Arab Republic, with other significant numbers arriving from the ongoing conflict in northern Africa

since the Arab Awakening. Syrians have fled through Turkey to reach the shores of the Aegean Sea, from which on a clear day the Greek islands of Lesbos and Kos can be seen a mere four kilometres away (**FIGURE 1**). People from northern Africa come across the Mediterranean Sea, particularly from Libya. However, movement across these waters is treacherous in small boats and dinghies, and the rate of loss of life by drowning is high (see **FIGURE 3**).

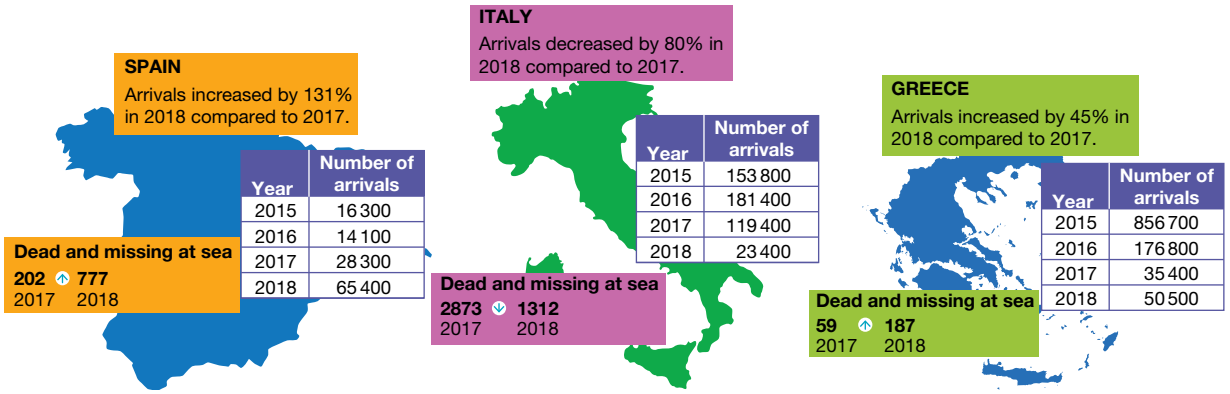
On the eastern route, Greece's islands are the first point of arrival, where the refugees are fingerprinted, photographed and given a document allowing legal residency for 30 days in Greece. Greece does not accommodate the mass of people arriving on its shores. It is costly for the already poor country to rescue people from the seas and process their movement.

People crossing from Africa reach Italy or Spain as the closest landfall places, or are picked up by the rescue ships in the middle of the Mediterranean Sea and taken either back to Africa or to a European country that will accept them.

9.7.3 Arranging the journey

It is estimated that 90 per cent of refugees have their journeys organised by criminal gangs, including individual people smugglers and migrant-smuggling networks across Europe. Thousands of dollars are extorted for the risky sea crossings and for travel on trains within Europe. High prices are paid for accommodation and fake documents such as passports that allow refugees to apply for asylum elsewhere in Europe, especially in Germany and Sweden. People smugglers often instruct refugees that when a coastguard ship is in sight, the boat or dinghy should be destroyed to ensure the refugees' rescue, a meal and health checks before arriving on European soil. **FIGURE 3** shows the number of asylum seekers moving to Europe over a four-year period.

FIGURE 3 Crossings of the Mediterranean Sea, 2015–18



Source: Data from UNHCR, www.unhcr.org/desperatejourneys.

9.7.4 Syrian refugees across Europe

FIGURE 4 in lesson 9.6 shows the distribution of Syrian refugees throughout Syria's neighbouring countries and beyond, across Europe. After the sea crossing from Turkey, Syrians seeking asylum in Europe entered the region predominantly through Greece, although some entered via Bulgaria and then spread through neighbouring countries.

9.7.5 The European response that affects human wellbeing

In 2015, four times as many refugees arrived in Europe as in 2014. This was to be the peak in arrivals from the eastern Mediterranean route (see **FIGURE 3**). Germany, with its developed economy, high living standards and political compassion was targeted as a place to go. The German community initially showed open-minded goodwill and generosity (see **FIGURE 4a**), but in 2016 attitudes began to change; the numbers of migrants became overwhelming. By mid 2018, 1.4 million people had sought asylum in Germany. In 2018 the surge of

asylum seekers from the western Mediterranean route through Spain and onward to Germany raised further concerns about the impact on the German way of life, with issues raised such as housing availability and infrastructure pressure, as well as how people with different languages and cultures would live together.

Sweden had a very open approach to asylum seekers, providing safety for people in need of protection (see **FIGURE 4b**). Permanent residency permits were offered to those with appropriate documents. Accommodation, a small daily allowance, health care and schooling were provided. Early in 2016, Sweden announced tougher rules as it felt that it had reached its limit regarding the numbers of asylum seekers that it could take. Some scenes of violence and criminal activity had changed Swedish attitudes and expulsion of asylum seekers began.

Hungary saw itself as a stepping stone for those moving north, but the sheer number of people moving through the country along disused railway lines, on roads and across paddocks struck fear within the government. In late 2015, a 4-metre-high wire fence was erected along the border with Serbia and patrolled by police with tear gas and water cannons (see **FIGURE 4c**), but refugees found gaps and cut holes to continue their movement north-west, or changed their path to go through Croatia.

FIGURE 4 (a) Welcome to Germany (b) Volunteers providing supplies in Sweden (c) The Hungarian fence (d) Sleeping at an Italian shelter (e) The Calais tent city before it was dismantled in 2016

Italy, with its influx of refugees from northern Africa, has given the task of caring for the refugees to charities, companies, cooperatives and individuals. Shelters are often substandard and overcrowded (see **FIGURE 4d**). Italy hopes that the people will move on from the southern regions, through Milan and on to other European countries. In 2018 Italy banned the rescue ships operating in the Mediterranean Sea from disembarking asylum seekers at its ports.

France has settled many of the northern African refugees within its cities. Most of these refugees speak French because of France's colonial occupation of areas in northern Africa in the nineteenth century. Some refugees aimed to reach Britain by stowing away on ferries or on trucks travelling through the tunnel under the English Channel. Refugees established a tent camp city near Calais (see **FIGURE 4e**) while they waited to attempt a crossing. Authorities did not approve and in October 2016, amid protests and clashes, the camp was closed and dismantled. A program introduced in France in 2019 aims to assimilate the migrants via a volunteering scheme that will see people contribute to the public good, learn work skills, gain additional language lessons and receive a monthly payment.

DISCUSS

Using the criteria of fairness and two other criteria of your choice, evaluate the effectiveness of the responses of two European countries to the Syrian refugee crisis. When you have completed your evaluation, in small groups or as a class discuss the criteria you chose, and why you chose them. What are some of the difficulties involved in providing responses to the refugee crisis? Consider social, economic, political and environmental perspectives in your discussion.

9.7.6 A regional perspective on asylum seekers

The European countries tried to find a regional solution to the flood of migrants and found themselves bickering with each other over decisions made within one country that affected a neighbouring country — a domino effect. Greece, Italy and Spain, as major entry points, felt the pressure as other countries closed their borders and restricted the on-flow of migrants. Some countries felt they had taken their 'fair share' of the numbers of asylum seekers and began turning away those that couldn't prove their status.

By 2019 the European Union (EU) had taken some control of the situation. It claims there is no longer a crisis situation — arrivals in 2018 were at the lowest for five years. The EU works with countries of origin of asylum seekers, in particular Turkey, Syria and Libya, to provide financial assistance and assistance with processing arrivals at the EU borders. It also provides financial, operational and material support to its member states most affected by the arrivals — Greece, Italy and Spain. Since 2015 two EU programs have assisted in the resettlement of 50 000 people across Europe.

9.7 SKILL ACTIVITY: Concluding and decision-making

1. **Research** the members of the European Union and the Schengen Area.
   - **Identify** who the members are.
   - **Describe** the features of each group.
   - **Describe** how they operate.
2. **Explain** in what ways they may have contributed to the mass movement of people.

9.7 Exercise

learnon

9.7 Exercise

Learning pathways

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

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Check your understanding

1. **Identify** the difference between a refugee and an asylum seeker.
   - A. They are the same.
   - B. A refugee is a person who flees their home through fear of persecution and crosses their country's borders. An asylum seeker is a person awaiting confirmation of their refugee status.
   - C. An asylum seeker is a person who flees their home through fear of persecution and crosses their country's borders. A refugee is a person awaiting confirmation of their asylum seeker status.
2. People smugglers encourage refugees to sink their boats. True or false?
3. Complete the following sentence to **explain** the role Greece plays in the movement of Syrian refugees.
   Greece is so close to _____ across the Aegean Sea. The Greek islands of Lesbos and Kos are _____ kilometres and in sight of the Turkish mainland. _____ see this as a means of escape and the beginning of getting papers to allow them to continue on their journey.
4. **Define** the role of people smugglers in the mass movement of people across Europe.
5. **Describe** the changing role of rescue ships in the Mediterranean Sea between Africa and Spain/Italy in the movement of refugees over time.

Apply your understanding

Interpreting and analysing geographical data and information

6. Use **FIGURE 3** to answer the following questions.
   - a. **Identify** in which year the greatest number of people arriving in Europe were asylum seekers.
   - b. How have the numbers of people arriving changed for each of Spain, Italy and Greece?
   - c. **Describe** the trend seen in the pattern of arrivals between 2015 and 2018.

Communicating

7. Western European countries have the greatest number of Syrians applying for asylum. What factors influence the Syrians' push to reach these countries?
8. **Discuss** how Europe, as a region, has dealt with the intake of refugees.

LESSON
9.8 How does the Australian government provide assistance to increase global human wellbeing?

LEARNING INTENTION

By the end of this lesson you should be able to describe how the Australian government works to promote peace, stability and wellbeing throughout our region and beyond, and identify some of the non-government organisations who work to promote human wellbeing throughout the world.

TUNE IN

The Australian government provides over $4 billion every year to nations that require help in their development and to improve wellbeing elements identified by the Sustainable Development Goals of the United Nations.

Examine **FIGURE 1** and answer the questions below.

1. Why is it in Australia's interests to provide peacekeeping forces around the world?
2. Have you heard of the non-government organisation (NGO) Médecins Sans Frontières? How does this aid organisation provide assistance in human wellbeing around the world?

FIGURE 1 It is in Australia's interests to promote peace and stability throughout the Indo-Pacific region. Australia has provided military personnel for numerous peacekeeping missions; our role in East Timor was of particular importance.

9.8.1 The Global Peace Index

The Global Peace Index (see **FIGURE 2**) uses 23 indicators and 30 other factors of wellbeing to assess a country's 'peacefulness'. Among the criteria used are elements of peace at home (government stability, democratic processes, community relations, security and trust between people) and peace in foreign relations (military spending levels, commitment to the United Nations and avoidance of war). Where countries experience low and very low states of peace, they are often greatly in need of assistance from other countries throughout the world in order to maintain their people's wellbeing.

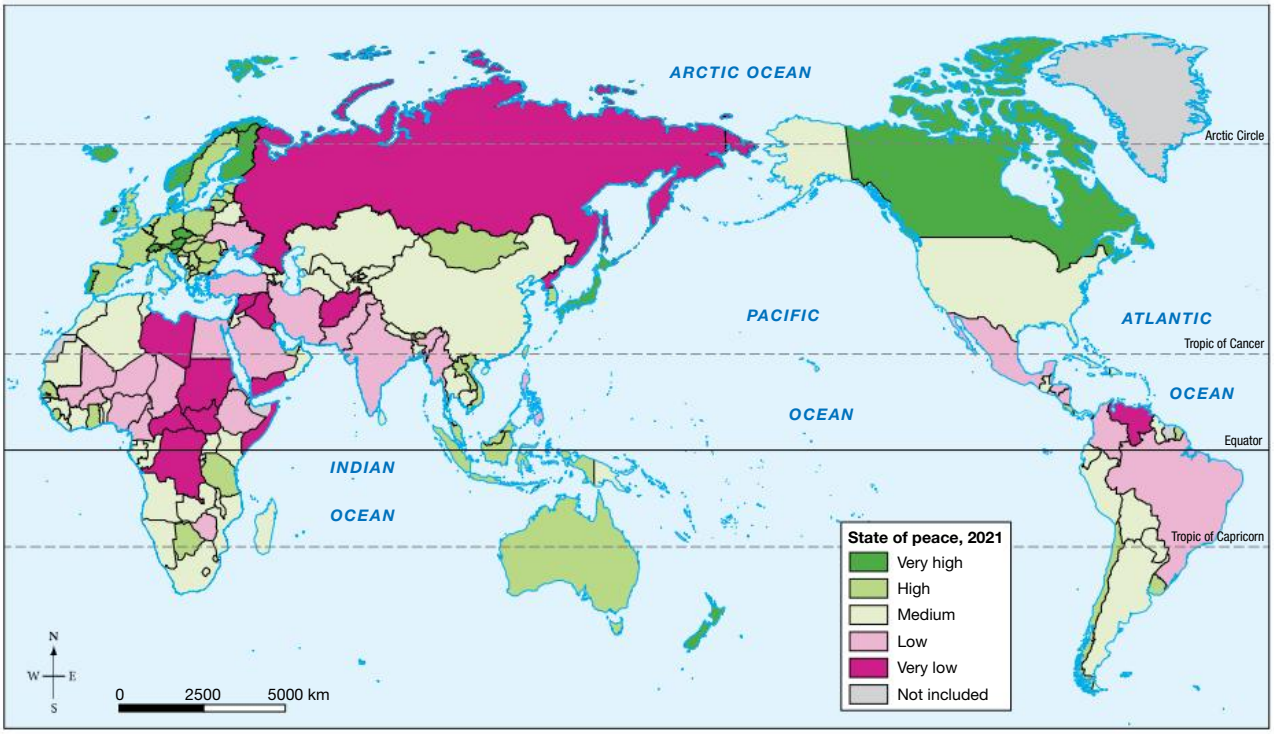
9.8.2 Caring for human wellbeing

Developed countries across the world provide financial and personnel assistance to those who have their wellbeing pressured by environmental, social, political or economic factors. This includes in countries where conflict disrupts lives and makes human wellbeing a struggle, such as Syria.

During the twentieth century, Australia accepted many people hoping to improve their wellbeing after conflict. Many thousands of migrants from Europe, in particular Italians and Greeks, arrived after World War II; the Vietnamese came as a result of the Vietnam War; and eastern Europeans came after the break-up of Yugoslavia. In the twenty-first century, conflict in the Middle East, western Asia and Africa has seen people of these cultures seek refuge in an ever-changing multicultural Australia.

int-7989

FIGURE 2 Global Peace Index, 2021



Source: Map drawn by Spatial Vision based on information from Institute for Economics & Peace. Global Peace Index 2021: Measuring Peace in a Complex World, Sydney, June 2021. Available from: http://visionofhumanity.org/reports

9.8.3 Giving aid to bridge the gap

Aid (also known as international aid, overseas aid or foreign aid) is the voluntary transfer of resources from one country to another, given at least partly with the aim of benefiting the receiving country.

Aid may be given by government, private organisations or individuals. **Humanitarianism** is still the most significant motivation for the giving of aid, but it may be motivated by other functions including:

- 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.

9.8.4 What types of aid exist?

Bilateral aid is aid given by governments to donor countries. Multilateral aid is provided through international institutions such as UNICEF. **Non-government organisation** (NGO) 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 (to name just a few). Large-scale aid (top-down aid) is usually given to the government of a developing country so that it can spend it on the projects that it needs. Small-scale aid projects (bottom-up aid) target the people most in need of the aid and help them directly, without any government interference. Aid from NGOs tends to be bottom-up aid.

aid (foreign or international) the voluntary transfer of resources from one country to another, given at least partly with the aim of benefiting the receiving country

humanitarianism concern for the welfare of other human beings

non-government organisation (NGO) an organisation that operates independently of government, usually to deliver resources or serve some social or political purpose

There are positive and negative impacts of aid (see **TABLE 1**). Aid can increase the dependency of recipient countries on donor countries. Sometimes aid is not a gift but a loan, and poor countries may struggle to repay the money. Aid may also be used to put political or economic pressure on a country, which may leave its people feeling like they owe their donors a favour. There is also the threat that corruption among 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 improve.

FIGURE 3 The Friendship Bridge across the Mekong River, which connects Thailand with Laos, was built with Australian aid.

TABLE 1 Advantages and disadvantages of different types of aid

	Advantages	Disadvantages
Bilateral aid	• Helps expand infrastructure: roads, railways, ports, power generation. • Aid that directly supports economic, social or environmental policies can result in successful programs.	• 'Tied aid' obliges the country receiving aid to spend it on goods and services from the donor country (may be expensive). • Inappropriate technology may be given (e.g. tractors are of little use if there are no spare parts or fuel).
Multilateral aid	• The organisations have clear aims about what they are trying to achieve (e.g. WHO combats disease and promotes health). • Leading experts in their field work to achieve multilateral aid program objectives.	• Sometimes directed only towards specific areas or organisations, leaving many without benefit. • Many come with conditions to make big changes to structures, which can be difficult to manage once aid has 'finished'.
NGO/charity aid	• Usually targeted at long-term development within a country. • Raises awareness of specific situations in a country or region.	• The greatest source of need may not be prioritised (e.g. the 2006 tsunami devastation received many donations, but areas in sub-Saharan Africa were just as much in need daily). • Up to 30 per cent of donations may be 'eaten up' by administration costs.

9.8.5 The role of the Australian government today

The Australian government's official development assistance (ODA) is designed to promote prosperity, reduce poverty and enhance stability in developing countries. Special targets in recent years include $281 million for COVID-19 recovery programs in the Pacific and Timor-Leste; $98.3 million for vaccines in the Pacific and Southeast Asia; $61.5 million to support economic recovery in Southeast Asia; $13.6 million for Pacific Labour Mobility; and $5.7 million for ASEAN Comprehensive Strategic Partnership. In 2023–24, Australia provided $4.8 billion of ODA, 90 per cent of which was allocated to the Indo-Pacific region. Australia's ODA focuses on strengthening private sector development and enabling human development. In 2023–24 the ODA contributed to investment in trade, infrastructure, agriculture, humanitarian, water, health, education, and effective governance (see **FIGURE 4**).

Australian officials also sit on many international organisations providing a global perspective on issues, including events in conflict zones. For over 70 years, Australia has been a member of the many United Nations

peacekeeping and security groups providing support in conflict zones. In numerous other organisations, Australia is seen as a key driver of a change in attitude to ensuring civilians caught up in conflict are treated in a humane manner.

FIGURE 4 Distribution of Australia's ODA budget by investment priority, 2023–24

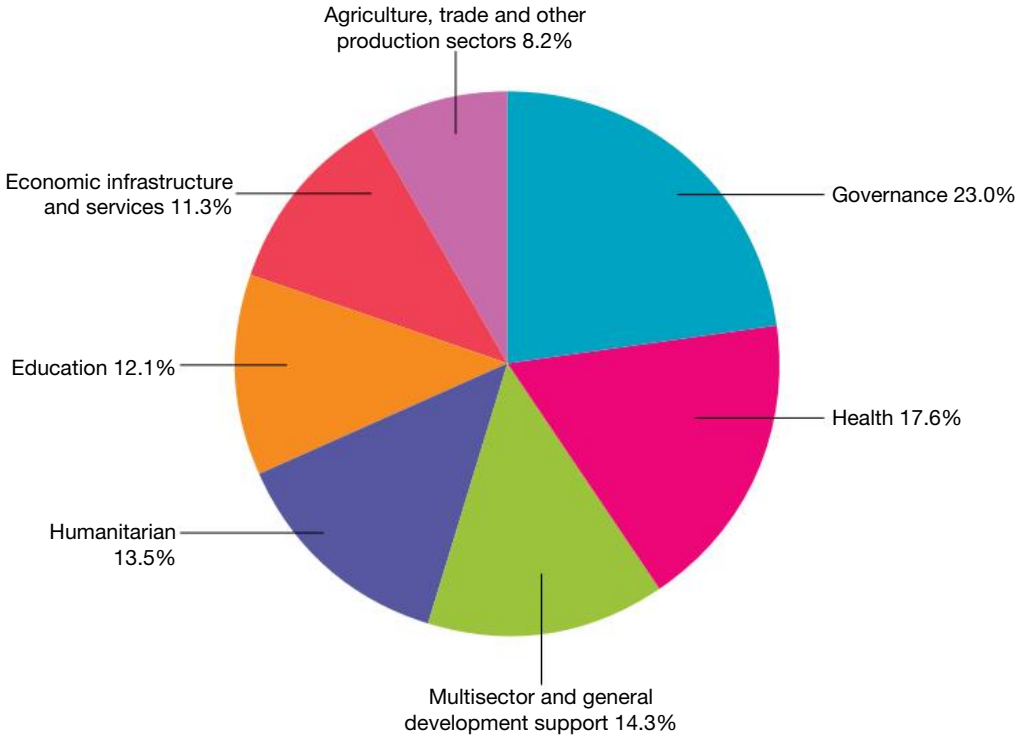
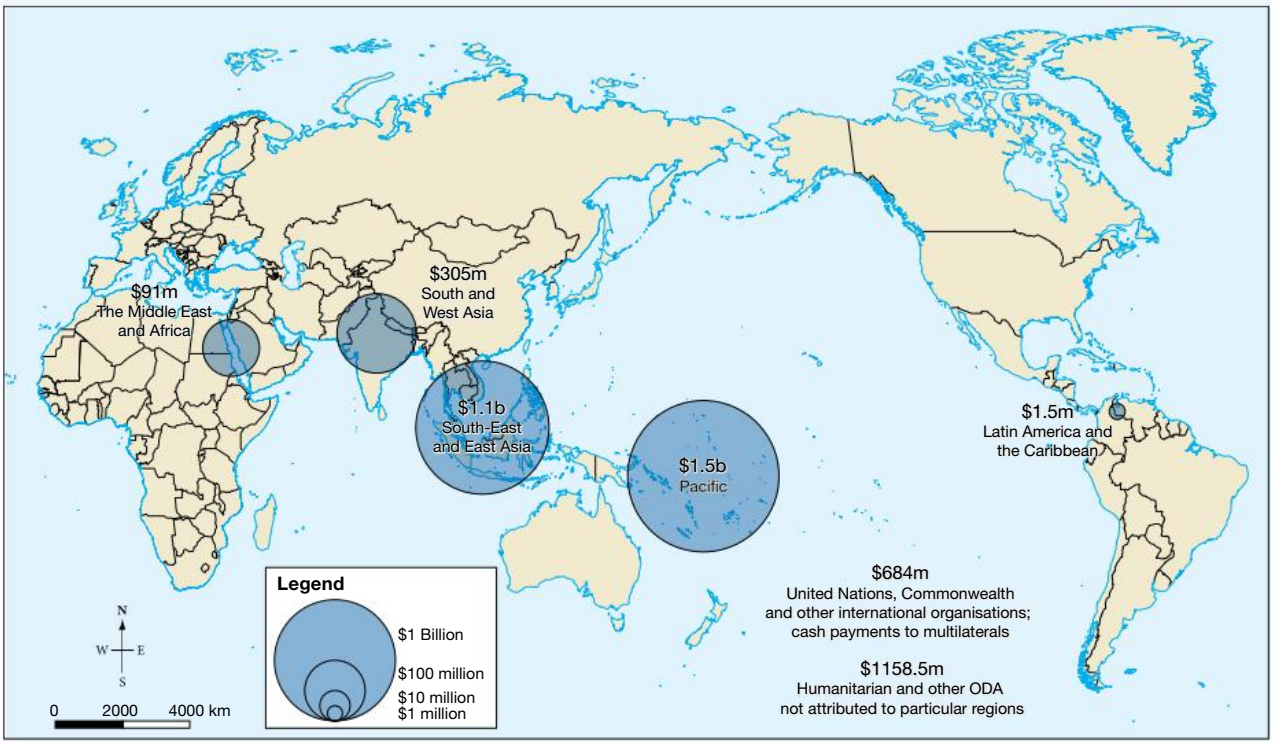


FIGURE 5 Australian ODA by region, 2022–23



Source: Map drawn by Spatial Vision based on the information taken from Australian Aid Budget Summary 2022-23 Department of Foreign Affairs and Trade website – www.dfat.gov.au.

In 2017 Australia was elected by the United Nations General Assembly to serve on the UN Human Rights Council from 2018 to 2020. This is the first time Australia had been chosen to serve on this council, and it is seen as a reflection of our commitment to the protection of human rights. In addition to this role, Australia is actively engaged with other entities that promote human rights, such as the Asia Pacific Forum of National Human Rights Institutions, of which the Australian Human Rights Commission was a founding member in 1996.

Among Australia's immigration statistics there is also a specified annual intake of humanitarian refugees. This was increased in 2015 to accept an additional 12 000 refugees from the Syrian crisis for the following five years. For the 2022–23 period, it was expected that Australia's humanitarian refugee intake would be just under 18 000 people.

9.8.6 International NGOs working for human wellbeing

International NGOs assist the wellbeing of civilians caught up in conflicts. Three significant organisations are Médecins Sans Frontières (also known as Doctors Without Borders), the International Red Cross and Red Crescent Movement, and the World Food Programme.

- Médecins Sans Frontières provides emergency medical care (see **FIGURE 6**). During conflict, local health systems often fail and hospitals close. In refugee camps, waterways may become contaminated, waste abounds and there is a lack of sanitation, all of which can lead to an outbreak of disease.
- The International Red Cross and Red Crescent Movement is the largest global humanitarian network. It aims to alleviate human suffering, protect life and health, and uphold human dignity.
- The World Food Programme (WFP) steps in when the distribution of food and other resources for the population is disrupted. The WFP saves lives and protects livelihoods, reduces chronic hunger, and restores and rebuilds lives, especially for women and children.

FIGURE 6 Médecins Sans Frontières personnel help children in South Sudan

DISCUSS

1. Hold a class debate on the contention 'Australia should do more to support global human wellbeing'. For help, see 1.21 SkillBuilder: Debating like a geographer in topic 1.
2. Is aid ever inappropriate? Discuss this in a small group.

9.8 SKILL ACTIVITY: Questioning and researching using geographical methods, Concluding and decision-making

1. Using the internet, **research** an international NGO. Consider the following:
   - **Identify** if they focus on a particular type of problem.
   - **Identify** if they operate globally or in certain areas.
   - **Describe** what type of work they do.

   This information could be placed in a table to help you organise it.
2. **Explain** how your chosen organisation is working towards peace in areas of very low peacefulness.
3. Focus on a country not studied in this topic.

Resources

Weblink Peacekeeping

Interactivity Helping others (int-3305)

9.8 Exercise

learnon

9.8 Exercise

Learning pathways

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

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Check your understanding

1. There are three types of aid. **Identify** the correct definition of each type of aid below.
   _____ aid is aid given by governments to donor countries.
   _____ aid is provided through international institutions such as UNICEF.
   _____ aid is voluntary, private, individual donations collected by organisations such as the Red Cross.
2. NGOs play important roles in restoring wellbeing to countries. These roles include:
   A. alleviating human suffering, protecting life and health, upholding human dignity.
   B. emergency medical care.
   C. reducing chronic hunger, restoring and rebuilding lives, saving lives.
   D. All of the above.
3. **Determine** whether the following statements are true or false.
   a. The UN provides assistance for a country to move towards peace by working to prevent conflict, helping parties in conflict make peace, deploying peacekeepers, and creating the conditions to allow peace to hold and flourish.
   b. The UN is an example of an international NGO.
4. The Global Peace Index 2021 is mapped in **FIGURE 2**. **Identify** the places with a very low level of peacefulness and those with a high level of peacefulness.
5. **Consider** why criteria for assessing peace levels of a country use indicators at home and in foreign relations.
6. **Discuss** how Australia has become a multicultural country.

Apply your understanding

Interpreting and analysing geographical data and information

7. The amount and distribution of Australian development assistance is shown in **FIGURES 4** and **5**.
   a. **Identify** to which regions of the world Australia provides assistance.
   b. **Explain** why Australia provides assistance to these regions.
   c. More than half of the assistance is provided to improve governance, infrastructure, trade and education. **Explain** why each of these aspects is important to human wellbeing in the regions receiving assistance.
   d. **Suggest** any aspects in which you would like to see Australia's priority in assistance expanded. Justify your response.
8. From the conflicts discussed in this topic, **identify** which countries you would expect to be rated differently on the Global Peace Index in 2025.

Communicating

9. Australia took on a role in the UN Human Rights Council for 2018–20. **Consider** what you think this should have meant in terms of our understanding of the wellbeing of refugees. **Explain**.
10. Do you think Australia takes enough refugees? **Justify** your answer.
11. Do the positive impacts of resettling refugees outweigh the negatives for a country like Australia? **Justify** your view, citing at least one social and one economic reason.

LESSON

9.9 Investigating topographic maps: Spatial variations in wellbeing in Tokyo, Japan

LEARNING INTENTION

By the end of this lesson you should be able to discuss ways that densely populated urban areas might influence wellbeing levels.

9.9.1 Japan

Japan, as a developed nation with an ageing population, faces a very specific set of issues pertaining to development and wellbeing in both rural and urban areas. The greater Tokyo–Yokohama conurbation is the largest urban area in the world with a population of just under 38.2 million people in 2020.

FIGURE 1 Images of Tokyo (a) Aerial view of the famous Shibuya Crossing, one of the busiest crossings in the world (b) Shinjuku's Kabuki-cho district, known as Tokyo's 'nightlife' area (c) Meiji-Jingu Shinto Shrine and surrounding parkland in central Tokyo near Shinjuku business district (d) Residential streets, Daizawa, Setagaya-ku, Tokyo (e) Shimokitazawa district, Tokyo, known for its independent fashion and design stores, and cafés (f) Shinagawa station, Tokyo, during morning rush hour; just under 400 000 people pass through the station on an average working day.

FIGURE 2 Topographic map extract of Tokyo, 2021

Source: Map data © OpenStreetMap contributors, https://openstreetmap.org. Data is available under the Open Database Licence, https://opendatacommons.org/licenses/odbl/; urban area data sourced from Atlas of Human Expansion (2016); elevation data sourced from USGS.

Resources

eWorkbook	Investigating topographic maps — Spatial variations in wellbeing in Tokyo, Japan (ewbk-10333)
Digital document	Topographic map of Tokyo, Japan (doc-36373)
Video eLesson	Investigating topographic maps — Spatial variations in wellbeing in Tokyo, Japan — Key concepts (eles-5317)
Interactivity	Investigating topographic maps — Spatial variations in wellbeing in Tokyo, Japan (int-8747)
Google Earth	Tokyo, Japan (gogl-0063)

9.9 Exercise

learnon

9.9 Exercise

Learning pathways

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

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- Receive immediate feedback
- Access sample responses
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Check your understanding

1. On the map, **identify** the area references for these parts of Tokyo mentioned in **FIGURE 1**.
   a. Shibuya City
   b. Shinjuku City
   c. Setagaya City
   d. Shinagawa City
2. What is the bearing of Haneda Airport from Noda?
3. **Describe** the topography of the greater Tokyo area, providing specific examples from **FIGURE 2**.

Apply your understanding

Interpreting and analysing geographical data and information

4. **Select** one natural and one human feature shown in **FIGURES 1** and/or **2**. **Explain** how each of these features might impact on the wellbeing of people living in the surrounding areas.
5. What factors do you consider to be important for wellbeing? **Identify** whether there is evidence of these factors existing in Tokyo, based on the information provided in **FIGURES 1** and **2**.
6. **Identify** from **FIGURE 2** which areas of the city might be reclaimed land. **Explain** the reasons why you think that specific area is reclaimed based on evidence from **FIGURE 2**.

LESSON
9.10 INQUIRY: Global responses to wellbeing

LEARNING INTENTION

By the end of this lesson you should have a comprehensive understanding of how human wellbeing varies with respect to life expectancy and child mortality.

Background

The United Nations has asked you to report on changes and variations on human wellbeing found across one developed and one developing country. Life expectancy, child mortality and the prevalence of disease will all come under your microscope as you investigate and prepare your report.

Before you begin

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

Inquiry

Research and create a report focusing on how human wellbeing varies with respect to life expectancy and child mortality and how it has changed over time. You should look at one **developed** nation and one **developing** nation.

a. What do you know about human wellbeing?
b. How have life expectancy and child mortality, as indicators of wellbeing, changed over time?

Write your selected **inquiry question** down based on the focus of this topic.

Use the following inquiry questions as a guide to develop your own inquiry question:

- Why is human wellbeing so important to us?
- What changes in social and economic factors can cause an improvement in human wellbeing, particularly with respect to life expectancy and child mortality?

Step 1: Questioning and researching using geographical methods

- Conduct **research** into the current issues surrounding your inquiry question concerning human wellbeing.
- Provide relevant data in table or graph form associated with life expectancy and child mortality.
- Provide annotated images and maps to illustrate different aspects of human wellbeing.

Step 2: Interpreting and analysing geographical data and information

- **Identify** any issues related to the increase or decrease of human wellbeing.

Step 3: Concluding and decision-making

- **Conclude** your study with potential strategies to help raise human wellbeing in certain countries.

Step 4: Communicating

- Make sure you understand the report format and structure your inquiry appropriately.

Complete your self-assessment using the **Inquiry rubric** or access the 9.10 exercise set to complete it online.

on Resources

Digital document Inquiry rubric (doc-39964)

LESSON
9.11 Review

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

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

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9.11.1 Key knowledge summary

Use this dot point summary to review the content covered in this topic.

9.2 How do the Sustainable Development Goals aim to address poverty?

- Absolute poverty is experienced when income levels are inadequate to sustain a minimum standard of living.
- The poverty line is an official measure used by governments to define those living below this income level as living in poverty.
- Relative poverty is a situation in which a person's income levels are too low to enjoy a reasonable standard of living within their society.
- Sub-Saharan Africa is the poorest region of the world.
- One of the most pressing issues of poverty is hunger, which affects over a billion people.
- The Sustainable Development Goals (SDGs) came into effect in September 2015, replacing the Millennium Development Goals.
- There are 17 goals, aimed at improving the wellbeing of the world's people and environment.

9.3 How are health and wellbeing linked?

- Health is a key factor in wellbeing. Sustainable Development Goal 3 aims to ensure healthy lives for all. It targets the eradication of tuberculosis, AIDS and malaria by 2030.
- Major health issues such as HIV/AIDS and malaria lead to a high mortality rate in developing nations, especially those in sub-Saharan Africa.
- The group within the population most at risk from health-related issues is children under the age of five.
- Although the incidence of both malaria and AIDS are decreasing at the global level, people living in sub-Saharan Africa are most at risk of contracting these diseases.

9.4 Why do governments have differing responses to wellbeing issues?

- Governments have had to respond to wellbeing issues related to the characteristics of their population.
- Kenya has a youthful population; the government, in conjunction with the United Nations has worked to bring down the country's unsustainably high birth rate, as well as improve health and education services.
- Japan has an ageing population and its population is predicted to fall through the remainder of this century due to a very low fertility rate of 1.4. Government incentives have been unsuccessful in reversing this trend.
- Australia has set up strategies to improve wellbeing for remote First Nations Australian communities.

9.5 Why are human rights so important?

- In some societies, human rights may be enshrined in law and legislation, whereas in others they may simply exist as guidelines that reflect the values of that particular community.
- Human rights can be defined in different ways, but definitions generally involve principles of respect, dignity and fairness.
- One of the main aims of the United Nations Charter is to promote respect for human rights. The Universal Declaration of Human Rights sets out basic rights and freedoms to which all people are entitled.

- The Australian Human Rights Commission is the national organisation that advocates for promotion and protection of human rights.
- The United Nations General Assembly adopted the Convention on the Rights of the Child (the CRC) in November 1989.
- Child labour is an ongoing issue, particularly prevalent in regions experiencing conflict and with low income.

9.6 CASE STUDY: Syria — the impact of conflict on wellbeing

- The wellbeing of people in Syria has been affected by the need to flee conflict.
- Many Syrians have been internally displaced; many others have fled to neighbouring countries or across the seas to new lands.
- Some Syrians remain in the towns experiencing conflict and are very resilient in an endeavour to maintain their wellbeing.

9.7 Why have so many people had to flee their homes and seek refuge?

- In 2015 the mass exodus of people from western Asia used the freedom of movement between European countries to reach countries with a high HDI ranking, especially Germany.
- By 2019 this exodus continued but in addition large numbers of people were crossing to Europe from Africa.
- European countries had various responses to this situation.

9.8 How does the Australian government provide assistance to increase global human wellbeing?

- Aid may be given by governments, private organisations or individuals.
- There are various reasons for giving aid assistance; humanitarianism is just one of these.
- Bilateral and multilateral aid may take many forms, such as money, food, medicine, equipment, expertise, scholarships, training, clothing or military assistance.
- There are positive and negative impacts of aid.
- The Australian government's official development assistance (ODA) is designed to promote prosperity, reduce poverty and enhance stability in developing countries, particularly those in the Indo-Pacific region.
- Non-government and charitable organisations work in conflict zones addressing the daily wellbeing of people caught up in conflict.

9.9 Investigating topographic maps: Spatial variations in wellbeing in Tokyo, Japan

- Topographic maps can help us discuss ways that densely populated urban areas might influence wellbeing levels.

9.10 INQUIRY: Global responses to wellbeing

- Human wellbeing varies with respect to life expectancy and child mortality.
- Changes in social and economic factors can cause an improvement in human wellbeing.

9.11.2 Key terms

absolute poverty where income levels are inadequate to enjoy a minimum standard of living (also known as extreme poverty)
ageing population an increase in the number and percentage of people in the older age groups (usually 60 years and over)
aid (foreign or international) the voluntary transfer of resources from one country to another, given at least partly with the aim of benefiting the receiving country
asylum seekers people entering another country asking to be assessed and classified as refugees
child any person below 18 years of age
child soldier a child who is, or who has been, recruited or used by an armed force or armed group in any capacity, including but not limited to children, boys and girls, used as fighters, cooks, porters, messengers, spies or for sexual purposes. This term does not refer only to a child who is taking or has taken a direct part in hostilities.
fertility rate the number of live births per 1000 women of childbearing age (usually 15–44) in a given year
grassroots movements action by ordinary citizens, as compared with the government, aid or a social organisation
humanitarianism concern for the welfare of other human beings

International Bill of Human Rights the informal name given to the Universal Declaration of Human Rights and the two International Covenants

International Covenants a multilateral treaty adopted by the United Nations General Assembly, in force from 1976; it commits those who have signed the Covenant to respect the civil and political rights of individuals and their economic, social and cultural rights

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

non-government organisation (NGO) an organisation that operates independently of government, usually to deliver resources or serve some social or political purpose

population structure the number or percentage of males and females in a particular age group

poverty cycle circumstances whereby poor families become trapped in poverty from one generation to the next

poverty line an official measure used by governments to define those living below this income level as living in poverty

relative poverty where income levels are relatively too low to enjoy a reasonable standard of living in that society

STI sexually transmitted infection

Universal Declaration of Human Rights the first specific global expression of rights to which all human beings are inherently entitled

9.11.3 Reflection

Complete the following to reflect on your learning.

Revisit the inquiry question posed in the Overview:

The world's population is constantly increasing. Can we fit so many people in the space we have without affecting our quality of life?

1. Now that you have completed this topic, what is your view on the question? Discuss with a partner. Has your learning in this topic changed your view? If so, how?
2. Write a paragraph in response to the inquiry question, outlining your views.

on Resources

eWorkbooks Customisable worksheets for this topic (ewbk-11512)
Reflection (ewbk-11836)
Crossword (ewbk-11837)

Interactivity Global responses to human wellbeing crossword (int-8244)

9.11 Review exercise

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Multiple choice

1. Which of the following factors might *not* cause an area to experience a decrease in life expectancy?
   - A. Ageing population
   - B. Disease epidemic
   - C. Natural disaster
   - D. Ongoing conflict
2. Which commonly used method can be put in place to ensure people who contract HIV continue to live healthy productive lives?
   - A. Use of antibacterial drugs
   - B. Use of antiretroviral drugs
   - C. Immunotherapy
   - D. Use of needles
3. Which of the following is *not* one of the three overarching or core themes of the Sustainable Development Goals?
   - A. Ending poverty
   - B. Protecting the planet
   - C. Ensuring prosperity
   - D. Promoting multinational business development
4. What is the best definition of a grassroots movement?
   - A. Action by ordinary citizens to promote and create change
   - B. Action taken on environmental issues
   - C. Politicians making decisions based on their own local electorate's interests
   - D. Environmental damage that forces a wide-scale population shift
5. Which of the following are rights and protections afforded to children under the CRC?
   - A. The right to live with their parents
   - B. The right to privacy
   - C. Protection from abuse and neglect
   - D. All of the above
6. Approximately how many children between the ages of 5 and 17 are estimated to be working in hazardous conditions?
   - A. 7 million
   - B. 17 million
   - C. 57 million
   - D. 79 million
7. Which European country received the highest number of applications for asylum in 2018?
   - A. Sweden
   - B. Germany
   - C. Turkey
   - D. Lebanon

8. What does ‘IDP’ refer to in terms of refugee data?
   - **A.** Internally displaced persons
   - **B.** Internationally disputed population
   - **C.** Insecure demographic percentage
   - **D.** Identified data provider
9. Which European country had the largest increase of people arriving to seek asylum from 2017 to 2018?
   - **A.** Greece
   - **B.** Italy
   - **C.** France
   - **D.** Spain
10. Which of the following countries rated ‘very high' on the Global Peace Index in 2021? Select all options that apply.
   - **A.** Russia
   - **B.** South Africa
   - **C.** Canada
   - **D.** United States

Short answer

Communicating

11. What are the long-term impacts of a low rate of natural increase in population?
12. Why is HIV/AIDS considered to be a pandemic?

Interpreting and analysing geographical data and information

13. Do you think Kenya or Japan has a more difficult fertility problem to deal with? Give reasons and examples to support your answer.
14. **Identify** the common wellbeing challenges experienced by First Nations Australians.
15. **Predict** whether human wellbeing, in general globally, will increase or decrease overall during your lifetime. Give reasons for your view that include references to three of the Sustainable Development Goals and whether or not you think these will be achieved in the next 70 years.

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GLOSSARY

absolute poverty where income levels are inadequate to enjoy a minimum standard of living (also known as extreme poverty)

ageing population an increase in the number and percentage of people in the older age groups (usually 60 years and over)

aid (foreign or international) the voluntary transfer of resources from one country to another, given at least partly with the aim of benefiting the receiving country

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

anthropocentric the belief that humans are the central and most important component of the universe

anthropogenic caused by humans or their activity

aquifers layers of porous rock that can hold large quantities of water in the pore spaces

asylum seekers people entering another country asking to be assessed and classified as refugees

atoll a coral island that encircles a lagoon

base flow water entering a stream from groundwater seepage, usually through the banks and bed of the stream

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

biodiversity the variety of plant and animal life within an area

biodiversity hotspot a biodiversity region with significant levels of biodiversity that is threatened by human habitation

biophysical environment all elements or features of the natural or physical and the human or urban environment, including the interaction of these elements

brackish water that contains more salt than fresh water but not as much as sea water

carbon credit a tradeable certificate representing the right of a company to emit one metric tonne of carbon dioxide into the atmosphere

carrying capacity the ability of the land to support livestock

catchment (or drainage basin) any area of land where precipitation collects and drains off into a common outlet, such as a river, bay or other body of water

change refers to using time to better understand a place, an environment, a spatial pattern or a geographical problem. The concept of change involves both time and space — change can take place over a period of time, or over an area.

child any person below 18 years of age

child soldier a child who is, or who has been, recruited or used by an armed force or armed group in any capacity, including but not limited to children, boys and girls, used as fighters, cooks, porters, messengers, spies or for sexual purposes. This term does not refer only to a child who is taking or has taken a direct part in hostilities.

chlamydia a sexually transmitted disease infecting koalas

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

conurbation an urban area formed when two or more towns or cities (e.g. Tokyo and Yokohama) spread into and merge with each other

Coriolis force a 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.

cull selective reduction of a species by killing

custodial management a sense of responsibility towards land and the landscape. Includes the concepts of sustainable natural resource management and managing natural resources, both now and in the future.

deltaic plain flat area where a river(s) 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 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' according to the United Nations

drainage area (or basin) an area drained by a river and its tributaries

dryland ecosystems characterised by a lack of water, including cultivated lands, scrublands, shrublands, grasslands, savannas and semi-deserts; the lack of water constrains the production of crops, wood and other ecosystem services

dyke an embankment constructed to prevent flooding by the sea or a river

dynamic equilibrium when the input of a coastal system such as winds and waves moving sediments onshore is equal to the output that moves sediments offshore, the system is said to be in a steady state. It is therefore not unstable and it has a dynamic equilibrium.

ecological corridor wildlife corridor that connects wildlife habitats that have been separated by human activity or structures such as roads, enabling wildlife to move between habitats that have become fragmented

ecological footprint a measure of human demand on the Earth's natural systems in general and ecosystems in particular; the amount of productive land required by each person for food, water, transport, housing, waste management and other purposes

ecological service the benefits to humanity from the resources and processes that are supplied by natural ecosystems

ecological species species that helps maintain or care for the ecology of an area, and creates and maintains habitats for other species

ecology the environment as it relates to living organisms

economic downturn a recession or downturn in economic activity that includes increased unemployment and decreased consumer spending

ecosystems systems formed by the interactions between the living organisms (plants, animals, humans) and the physical elements of an environment

endemic a plant or animal restricted to a certain place

enhanced greenhouse effect increasing concentrations of greenhouse gases in the Earth's atmosphere, contributing to global warming and climate change

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

environmental flows the quantity, quality and timing of water flows 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 stewardship a worldview that maintains we have an ethical responsibility to care for and manage the environment in a responsible manner, and that humans should act as the caretakers of the environment

environmental worldview varying viewpoints, such as Earth-centred as opposed to human-centred, in managing ecological services

ephemeral describes a stream or river that flows only occasionally, usually after heavy rain

eutrophication a process where water bodies receive excess nutrients that stimulate excessive plant growth

exotic species species introduced from a foreign country

experienced wellbeing an individual's subjective perception of personal wellbeing

extreme poverty a state of living below the poverty line (US$1.90 per day), and lacking resources to meet basic life necessities (also known as absolute poverty)

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.

female infanticide the killing of female babies, either via abortion or after birth

fertility rate the number of live births per 1000 women of childbearing age (usually 15–44) in a given year
floating settlements anchored buildings that float on water and are able to move up and down with the tides
flood mitigation managing the effects of floods rather than trying to prevent them altogether
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.
geothermal (power) 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.
global warming the observable rising trend in the Earth's atmospheric temperatures, generally attributed to the enhanced greenhouse effect
grassroots movements action by ordinary citizens, as compared with the government, aid or a social organisation
green energy sustainable or alternative energy (e.g. wind, solar and tidal)
gross domestic product (GDP) the value of all goods and services produced within a country in a given period, usually discussed in terms of GDP per capita (total GDP divided by the population of the country)
groundwater water held underground within water-bearing rocks or aquifers
groundwater salinity presence of salty water that has replaced fresh water in the subsurface layers of soil
hinterland the land behind a coast or shoreline extending a few kilometres inland
historical architecture urban environment that has significant value due to its unique form and history of development
holistic relating to the whole of something or to the total system instead of just to its parts. The environment is made up of many parts, all interconnected.
Human Development Index (HDI) measures the standard of living and wellbeing by measuring life expectancy, education and income
humanitarianism concern for the welfare of other human beings
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
humus decaying organic matter that is rich in nutrients needed for plant growth
hydrothermal vent an opening on the seafloor from which geothermally heated water is released. They are commonly found near volcanically active places.
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 a rock layer that does not allow water to move through it due to a lack of cracks and fissures
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.
Industrial Revolution the period from the mid 1700s into the 1800s that saw major technological changes in agriculture, manufacturing, mining and transportation, with far-reaching social and economic impacts
industrialised having developed a wide range of industries or having highly developed industries
infrastructure the basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society
interconnection the fact that people and things are connected to other people and things in their own and other places around the world
International Bill of Human Rights the informal name given to the Universal Declaration of Human Rights and the two International Covenants
International Covenants a multilateral treaty adopted by the United Nations General Assembly, in force from 1976; it commits those who have signed the Covenant to respect the civil and political rights of individuals and their economic, social and cultural rights
invasive plant species commonly seen as weeds; any species that dominates an area outside its normal region and requires action to control its spread
Kyoto Protocol an internationally agreed set of rules developed by the United Nations aimed at reducing climate change through the stabilisation of greenhouse gas emissions into the atmosphere
lagoon a shallow body of water separated from the sea by a sand barrier or coral reef

life expectancy the number of years a person can expect to live, based on the average living conditions within a country

Marine Protected Areas areas of the oceans set aside to be conserved for biodiversity conservation, species protection or to protect economic resources. There are strict guidelines on what is permitted in these zones.

mass wasting the movement of rock and other debris downslope in bulk, due to a destabilising force such as undermining compounded by the pull of gravity

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 a form of residential development such as detached, semi-attached and multi-unit housing that can range from about 25 to 80 dwellings per hectare

megacity a settlement with 10 million or more inhabitants

micro hydro-dams dams that produce 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.

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

monoculture cultivating a single crop or plant species over a wide area over a prolonged period of time

mulch organic matter such as grass clippings

national park an area set aside for the purpose of conservation

natural increase the difference between the birth rate (births per thousand) and the death rate (deaths per thousand). This does not include changes due to migration.

non-government organisation (NGO) an organisation that operates independently of government, usually to deliver resources or serve some social or political purpose

nutrients essential chemical substances in the soil needed for plants to grow and develop

Paris Agreement United Nations Framework Convention on Climate Change (UNFCCC) agreement outlining steps to reduce greenhouse gas emissions and tackle global warming

pastoral run an area or tract of land for grazing livestock

perennial describes a stream or river that flows permanently

perspective the way in which a person views things based on their current position; reflects current views and is affected by personal circumstances

place an area on the Earth's surface which is identified and has meaning for people

population structure the number or percentage of males and females in a particular age group

poverty cycle circumstances whereby poor families become trapped in poverty from one generation to the next

poverty line an official measure used by governments to define those living below this income level as living in poverty

qualitative indicators subjective measures that cannot easily be calculated or measured; e.g. indices that measure a particular aspect of quality of life or that describe living conditions, such as freedom or security

quantitative indicators objective indices that are easily measured and can be stated numerically, such as annual income or the number of doctors in a country

rafting when small marine creatures attach themselves to floating objects and are moved around by wave and current action

rainwater harvesting the accumulation and storage of rainwater for reuse before it soaks into underground aquifers

Ramsar Convention an international treaty for the conservation and sustainable use of wetlands

ratify to formally consent to and agree to be bound by a treaty, contract or agreement

recharge the process by which groundwater is replenished by the slow movement of water down through soil and rock layers

relative poverty where income levels are relatively too low to enjoy a reasonable standard of living in that society

replacement rate the number of children each woman would need to have in order to ensure a stable population level — that is, to 'replace' the children's parents. This fertility rate is 2.1 children.

reservoir large natural or artificial lake used to store water, created behind a barrier or dam wall

ringbark removing 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

Royal Commission a public judicial inquiry into an important issue, with powers to make recommendations to government

rural–urban fringe the transition zone where rural (country) and urban (city) areas meet

Sahel a semi-arid region in sub-Saharan Africa; 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

salinity an excess of salt in soil or water, making it less useful for agriculture

salt scald the visible presence of salt crystals on the surface of the land, giving it a crust-like appearance

sanitation facilities that safely dispose of human waste (urine, faeces and menstrual waste)

scale the way that geographical phenomena and processes can be examined at different spatial levels. Scale can be applied from personal and local levels to regional, national or global levels.

sea mount under-sea mountains, usually formed from volcanic activity on the seabed. They are known for their rich biodiversity.

sex ratio the number of females per 1000 males

slum rundown area of a city with substandard housing

socioeconomic of, relating to or involving a combination of social and economic factors

space where things are located and distributed on the surface of the Earth

spatial variation difference observed (in a particular measure) over an area of the Earth's surface

standard of living a level of material comfort in terms of goods and services available. This is often measured on a continuum; for example, a 'high' or 'excellent' standard of living compared to a 'low' or 'poor' standard of living.

stewardship the belief that humans have a responsibility to care for the Earth to protect its future

STI sexually transmitted infection

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

sustainability refers to maintaining the capacity of the environment to support our lives and those of other living creatures now and into the future

Sustainable Development Goals (SDGs) a set of 17 goals established by the United Nations Development Programme, which aim to end poverty, protect the Earth and promote peace, equality and prosperity

terminal lake a lake where 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.

thermohaline relating to the combined influence of temperature and salinity

topsoil the top layers of soil that contain the nutrients necessary for healthy plant growth

training walls a pair of rock walls built at a river's mouth to force the water into a deeper and more stable channel. The walls improve navigation and reduce sand blockages.

turbid water that contains sediment and is cloudy rather than clear

UNESCO biosphere reserve The Man and Biosphere Programme is an international scientific program established by the United Nations to create biosphere reserves as 'learning places for sustainable development'.

Universal Declaration of Human Rights the first specific global expression of rights to which all human beings are inherently entitled

urban environment the human-made or built structures and spaces in which people live, work and recreate on a day-to-day basis

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

urban sprawl the spreading of urban developments into areas on the city boundary

water rights refers to the right to use water from a water source such as a river, stream, pond or groundwater source

water security the reliable availability of acceptable quality water to sustain a population

watertable upper level of groundwater; the level below which the earth is saturated with water

weed 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

wetland an area covered by water permanently, seasonally or ephemerally. They include 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.

worldview reflects your fundamental beliefs and values based on your idea of what is fair and right; may be aligned with the values of the wider community or time in which you live

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