Year 12

Geography

GEOGRAPHY

Year 12

GOVERNMENT OF SĀMOA

MINISTRY OF EDUCATION, SPORTS AND CULTURE

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Natural Landscapes	Authors: J. M. Hensman
Population Studies *Population patterns, processes and issues*	Authors: M. S. Harison, J. M. Hensman, J. R. Hensman
Resources and Their Use *Resource use in a farming and mining context*	Authors: M. S. Harison, J. M. Hensman, J. R. Hensman (and Ranger Mining Ltd)

Much of the material in Part One of this book is taken from the following text. It is used with the permission of Dr David Hopley and Dr Steve Ritchie, who were the director and coordinator (respectively) of the UNESCO Project that resulted in the following textbook

Pacific Islands: Origin and Ecology	Authors: D. Hopley and J. O'Brien UNESCO Project: Marine Science Curriculum Materials for South Pacific Schools

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Table Of Contents

Part 1

Physical Environments

The aims of this strand of geography learning.

Students will recognise and understand:

- ❑ Spacial patterns and interacting processes within physical environments.
- ❑ The impact of processes within physical environments on cultural environments and how people can influence physical processes and their impacts.

The achievement objectives of this strand at Year 12 level.

Students will demonstrate knowledge and understanding of:

- ❑ The main climatic, bio-geographic and geologic processes that interact to shape the environments of different islands in tropical Pacific locations.
- ❑ The physical environments of islands and how these have influenced cultural activities and how cultural activities can change and accelerate physical processes.

Key concepts and geographic ideas

The key concepts and important geographic ideas that we will be learning in the topics for this strand are:

Table 1.0.1 Key concepts and geographical ideas

Key Concepts	Geographic Ideas
Process	Processes vary in time and space Processes vary in magnitude and frequency
Interactions	Landscapes are the results of interactions within the environment Interaction takes place at different scales and degrees of intensity and complexity
Systems	The inputs, through-puts and outputs of a system make it dynamic Change in one part of the system will lead to change in another part
Pattern	Spatial patterns (physical or cultural) are the result of processes

Introduction

> **What are Focusing Questions?**
>
> This textbook has been planned and written by geography teachers who have read the curriculum statement carefully in order to write a textbook for students. The writers designed a set of focusing questions that will help both teachers and students to have the right *focus* as they work through the information. Teaching and learning geography at Year 12 is about helping students to develop an in-depth knowledge and understanding answers to these focusing questions.
>
> The focusing questions have been labelled as FQs throughout the units making up Part One of this book, i.e.
>
> **FQ 1**
>
> Whenever you see an FQ you should turn to the back of the book (where all the questions are listed in full) and refer to the appropriate question. They are to help your teacher with his or her efforts to cover the curriculum requirements.

The physical environment has four parts or elements: relief, climate, soil and vegetation. These four elements interact and affect each other to produce distinctive landscapes. A landscape is an area or a region that has common geographical features.

We can understand a physical environment, and the interactions within it, by taking a systems approach to its study. The systems approach uses the systems model.

The Systems Model And The Physical Environment

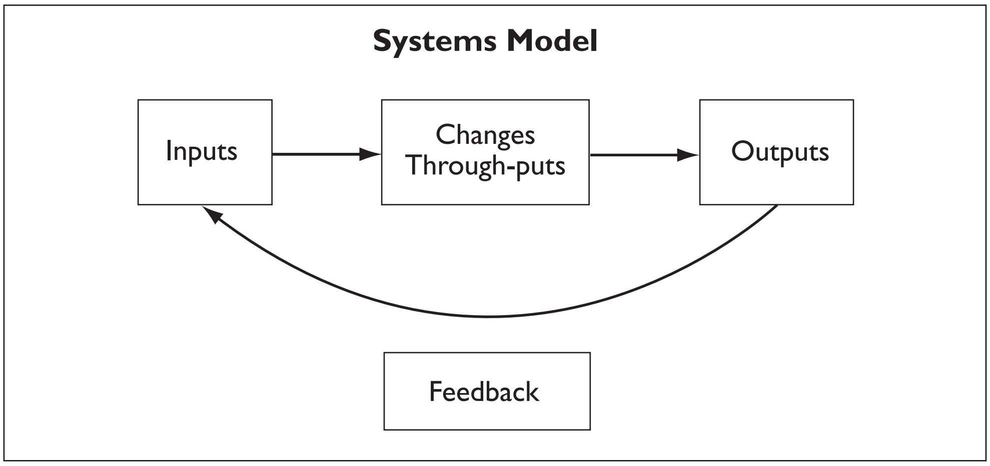


Figure 1.0.1 Systems model

Each of the elements of the physical environment can be seen as an open system. A system has inputs (things going into the system), through-puts (things that go through the system and experience certain changes) and outputs (things that come out of the system). The difference between a closed system and an open system is that, in a closed system, the inputs and outputs do not cross boundaries into or from other systems. In a closed system, the outputs are fed back to become inputs again. In an open system, the inputs often come from elsewhere – from the outputs of other systems.

The elements of the physical environment (climate, relief or geology, soil and vegetation) are systems. The interactions in a physical environment are the relationships between the elements – that is, the outputs of one system being the inputs into another.

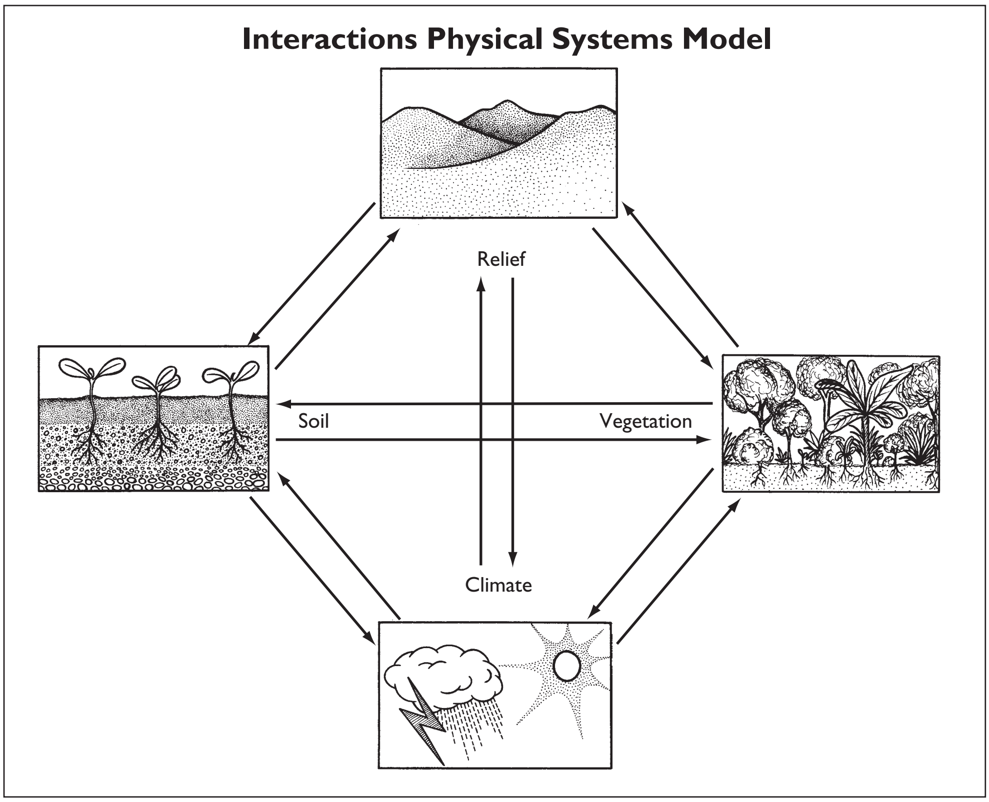


Figure 1.0.2 Interactions physical systems model

Here are some examples of the inter-relationships between the different systems.

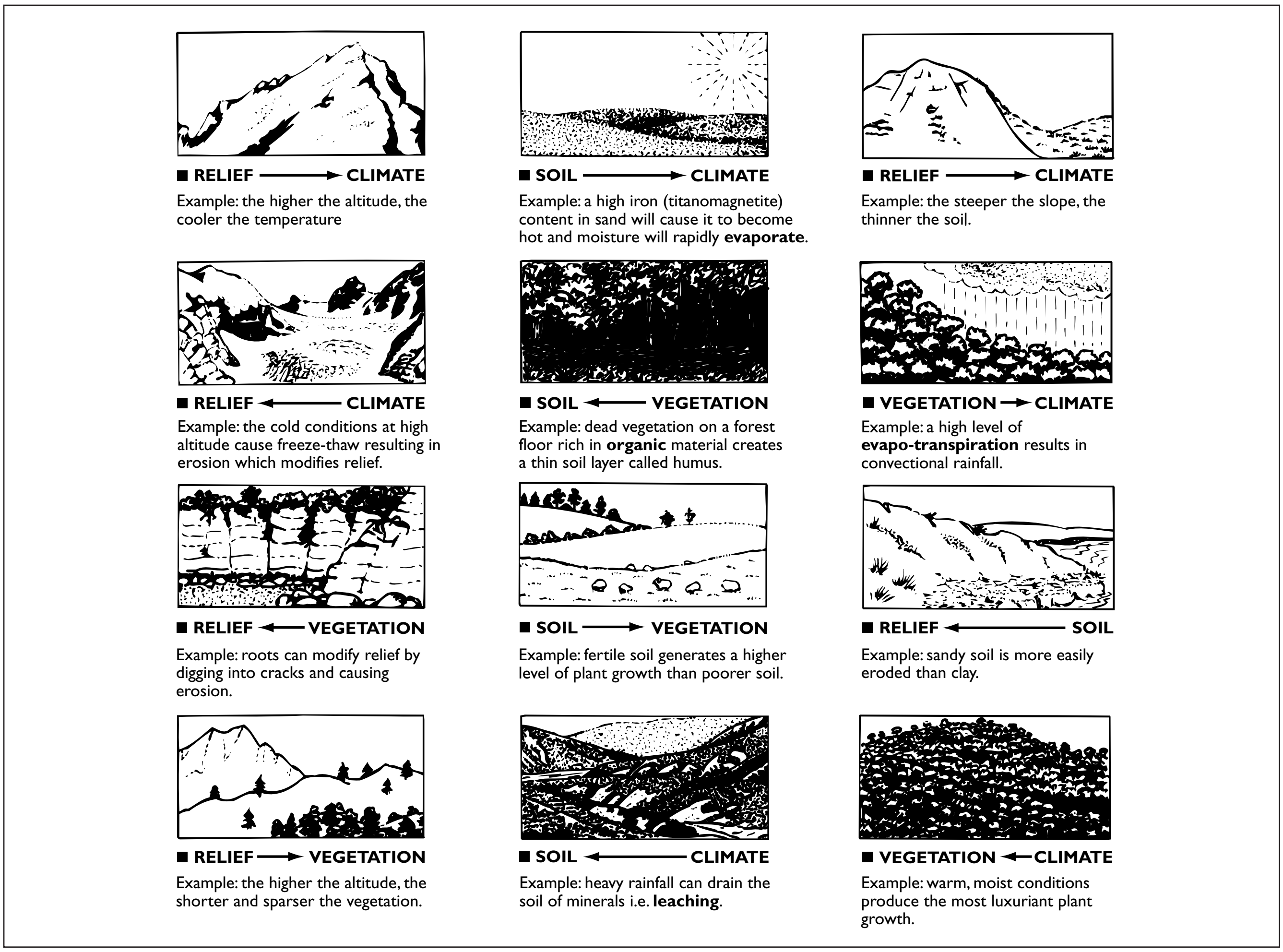


Figure 1.0.3 Natural landscapes

The Pacific Ocean is our planet's greatest geographic entity. It covers 1/3 of the Earth's surface. There are 22 island nations and territories with a combined total of 7500 islands. These islands are spread over 30 million square kilometres. The islands vary greatly in terms of their physical geographic characteristics. However, only about 500 islands have people living on them.

There are different types of islands. This means that the physical environments of these different types will not be the same. If we can identify and understand the interactions between the physical systems of the islands that we and our Pacific neighbours live on, we will be able to develop a better understanding of our physical environments. This can help us to examine the ways that we as Pacific people live on our islands – and find out if the ways we are living within our island environments are sustainable.

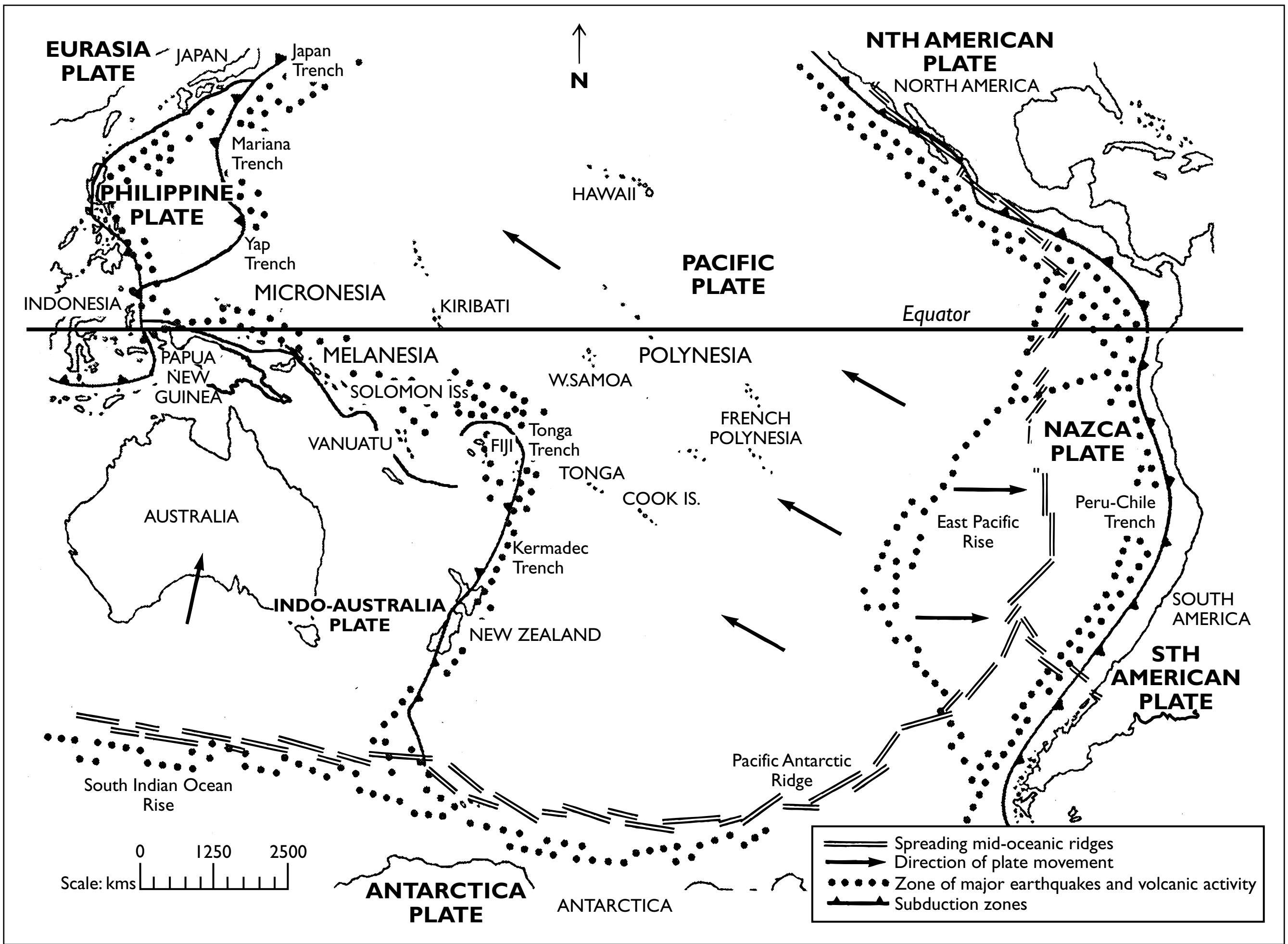


Figure 1.0.4 The area of Melanesia, Micronesia and Polynesia showing the island nations of the South Pacific and the tectonic plates of the region

Unit

High And Low Islands Of The Pacific Ocean

1

Learning Outcomes

By the end of this unit you should be able to:

- ❑ Recall some stories about the first people to arrive on your island.
- ❑ Define: open vegetation, high island and low island.
- ❑ Describe the physical characteristics of a low island and a high island.
- ❑ Classify the island on which you live as either a high island or a low island.

Some of the oldest human remains have been found in eastern Asia and the islands of Indonesia. These remains are hundreds of thousands of years old. Humans first reached the larger islands that rim the Western Pacific about 20 000 years ago.

About 5000 years ago, people sailed out into the great unknown area that is now called the Pacific Ocean. They went to **Melanesia** and later to **Micronesia**. See Figure 1.0.4 on page 8.

About 2500 years ago, Polynesian navigators sailed into the central and eastern Pacific. They landed on some of the most remote islands in the world.

Figure 1.1.1 Like generations before them Papuan navigators set sail for outlying islands (Nimoa island, Louisiade group)

European sailors came later. They sailed into the Pacific only 500 years ago. Such explorers as Magellan (Spanish), Tasman (Dutch), Cook (British) and de Bougainville (French) rediscovered islands that had been settled for at least a thousand years. Within about 200 years, they had landed on the shores of nearly all the major Pacific islands.

All these voyages showed great courage. Navigation is a very dangerous activity. We do not know how many sailing canoes or sailing ships disappeared at sea. The islands were a refuge for some navigators and a new home for others. The islands provided a place for rest and food. Some navigators took the natural resources of the islands back to their own countries.

FQ I

They could not find food and water on all of the islands. The navigators very quickly learnt to recognize the difference between the **high islands** and the **low islands**. The high islands (Figure 1.1.2 below), often rising steeply from the sea, are made up of dark rocks, called **basalts**. Basalts produce rich, red, volcanic soils.

Figure 1.1.2 Panarora Island in Papua New Guinea is a good example of a high island. Note how the more resistant igneous rock is less weathered.

Figure 1.1.3 A low island in Eastern Papua New Guinea. It is no more than a metre or two above sea level and composed of coral fragments. The highest coconut trees on the island are not visible from a few kilometres out to sea.

Usually, the high islands have high rainfall and are covered in forest vegetation. Sometimes these islands rise thousands of metres into the air. Clouds cover their highest peaks most of the time.

In contrast, the low islands (Figure 1.1.3 above) never rise more than a few metres above the sea. They are visible from the top of a boat's mast, only when the boat is close to the shore. These low islands are made of broken fragments from the coral reefs that surrounded them.

Most low islands are small, some have forests, but many have an open vegetation. Some have no vegetation at all. They are a poor source of food and water. Some of these low islands are found around the edges of large reefs that rise steeply from the deep ocean floor. Other low islands formed on top of reefs that are offshore from the high islands.

The low islands of the coral reefs are the main focus of these sections of this chapter. The soils, plants and animals of these isolated islands form unique **ecosystems**. Already, many of these island ecosystems have been changed permanently by human occupation.

High and low islands are very different, but they began in the same way. The next chapter explains **plate tectonics** and **sea-floor spreading**, which help to explain the origin of high and low islands. There are big differences between islands within the categories high island and low island. Understanding plate tectonics and sea-floor spreading helps to explain the variety within these classifications.

Discussion Questions

- ❑ Do you know any stories about the first people to arrive on your island?
- ❑ Is the island on which you live a low island or a high island?
- ❑ List all the reasons that led to your decision.

Review Questions

1. List four major differences between low islands and high islands.
2. If your island is a high island, how many years is it since there were active volcanoes on the island?
3. If your island is a low island name any coral reefs that surround it.

Unit 2

The Moving Earth And The Origin Of Oceanic Islands

Learning Outcomes

By the end of this unit you should be able to:

- ❑ Calculate the rate at which various continents have drifted over time.
- ❑ Discuss the movement of India over the last 170 million years.
- ❑ Predict where drifting continents will be located in the future.
- ❑ Describe: oceanic crust, continental crust, mantle, mid-ocean ridge, magma, sea-floor spreading, oceanic plate, subduction zone, oceanic trench, hot-spot, coral reef, guyot, Pacific plate, Eurasian plate, lithosphere, asthenosphere, mesosphere, mantle and core.
- ❑ Identify on a diagram the terms listed in the outcome above.
- ❑ Explain why molten material deep underground can move towards the surface.
- ❑ Explain how convection currents may cause continental plates to drift.
- ❑ Explain why volcanoes and earthquakes are common at the boundaries of the Pacific Ocean.
- ❑ Suggest how the island on which you live has been affected by plate tectonic forces.
- ❑ Describe the landforms that are characteristic of plate tectonic boundaries.
- ❑ Estimate distances from a map.
- ❑ Use data to calculate an approximate rate of movement of the Hawai‘ian island chain.
- ❑ Draw a line of best fit on a graph.
- ❑ Explain island subsidence and suggest where it is likely to occur.
- ❑ Explain how volcanic islands can form: at mid-ocean ridges, as island arcs, on continental crust, from oceanic hot-spots.
- ❑ Discuss the factors that affect coral growth.
- ❑ Discuss the relationships that exist between coral reefs and volcanic islands.

The Earth's Interior And Continental Drift

Some people think the southern continents have moved in the last 170 million years. Figure 1.2.1 shows the idea some people have about how these continents have moved. Can you identify Antarctica, Africa, New Guinea, Madagascar, South America, New Zealand, India and Australia?

FQ 2

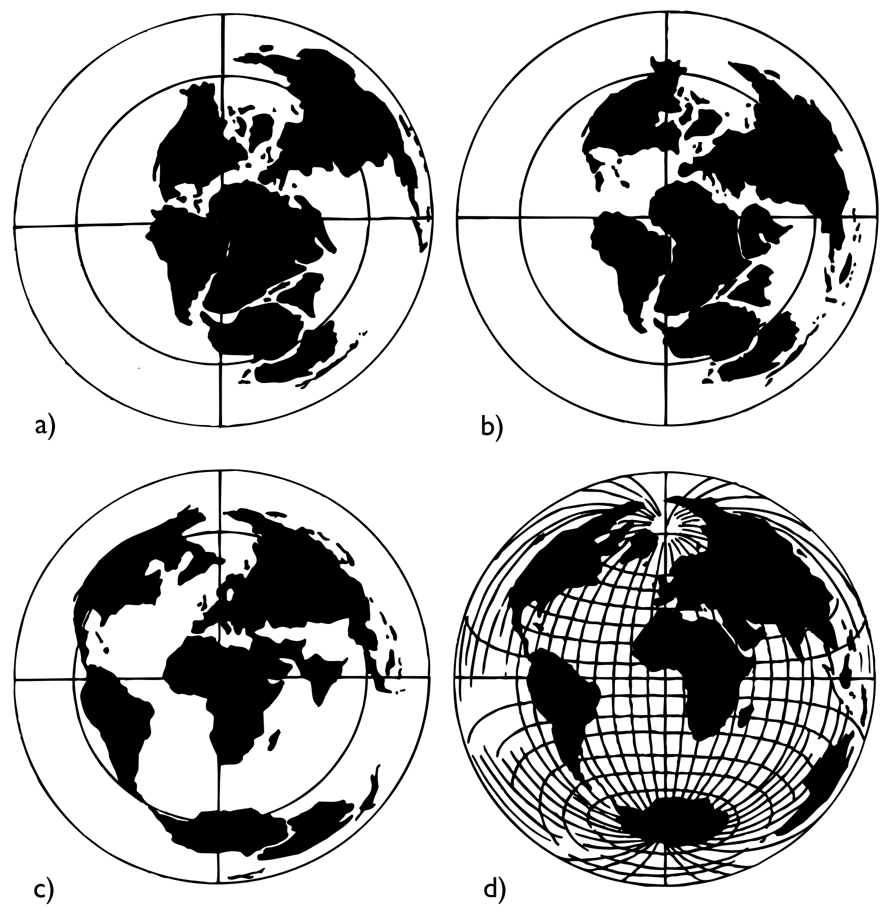


Figure 1.2.1 This is an artist's impression of how the major continents of the world have shifted over the last 170 million years. To gain some idea of distance note that the earth's polar circumference is 40 009 kilometres and the earth's equatorial circumference is 40 077 kilometres.

Geologists believe the countries have moved to their present positions by a process called **continental drift**. For example, look at India in Figure 1.2.1. It has moved from near the South Pole to collide with the great Asian land mass. But how can this happen? The question is where on Earth do you get forces big enough to move continents? How do the islands of the Pacific fit into this picture? To answer this you need to know that the Earth is made up of a series of layers. If you could drill a hole down through the middle of a continent to the centre of the earth, what would you find along the way? Figure 1.2.2 on page 14 shows the answer to this question.

Discussion Questions

- ❑ At what rate has India drifted? Make an approximate calculation using the information provided in Figure 1.2.1 above. Note: rate = distance divided by time.
- ❑ Why isn't India still drifting at this rate? Record your ideas.

The Layers Of The Earth

1 Light, continental rocks make up the top layer. It is about 40 km thick.

2 There are denser rocks below the continental rocks and also below the ocean basins. They are found at a depth of between 40 km and 70 km. The first two layers are known as **lithosphere** or **crust**. The less dense **continental lithosphere** or crust seems to float on the denser **oceanic lithosphere** or crust. The bulk of the continental crust is below the surface. It is a little like icebergs floating in water.

3 If you drilled down through the lithosphere you would reach the **asthenosphere**. You would be deep inside the Earth. This part of the asthenosphere is also known as the upper mantle. Pressure increases as you go down into the Earth. The more material you have above you, the greater the pressure. Temperature increases due to radiation from the **nuclear decay** of minerals. As a result of these temperatures and pressures, the rock materials become soft and plastic. This provides a lubricated zone at the bottom of the lithosphere. Over long periods of time, this lubrication allows some lithosphere crust to move. You can see the approximate location of the lubricated zone in Figure 1.2.2 below.

4 Deeper still is the **mesosphere,** which contains large amounts of **magma**. This region is also referred to as the lower mantle. The molten rock, **magma**, can rise through weaker points to the Earth's surface, forming volcanoes. The mesosphere goes down to a depth of about 3000 kilometres.

5 The bottom 3500 kilometres is known as the **core** of the Earth. The core is thought to be very dense. It is made up of an **outer core** that is fluid and a solid inner core. But we know very little about the core.

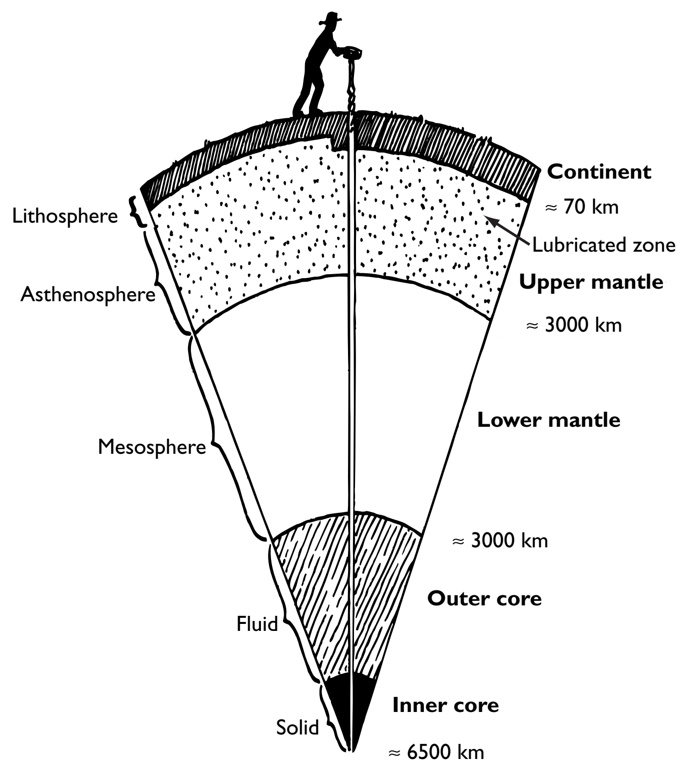


Figure 1.2.2 If we could drill a hole to the centre of the earth we would pass through a number of layers. Scientists believe that the centre of the earth is very hot. Note the lubricated zone allows the crustal plate above it to move

Moving Seabeds

The following information refers to Figure 1.2.3 below.

Geologists think that huge amounts of heat move from inside the Earth towards the surface by **convection currents** (see A in Figure 1.2.3). These convection currents rise within the asthenosphere and spread beneath the solid lithospheric crust. At certain points (see B in Figure 1.2.3), these convection currents can force magma through cracks in the lithosphere to the surface. This causes volcanic activity. This type of volcanic activity occurs mainly below the oceans. Huge ridges of material, called **mid-ocean ridges**, are forced upwards and sideways. These mid-ocean ridges are the youngest parts of the Earth's lithosphere and form areas of sea-floor spreading. In this way, the lithosphere is broken up into large sections known as **tectonic plates**.

FQ 2

You can see from Figure 1.0.4 on page 8, the six major plates and a large number of smaller fragments that make up the Earth's surface. Note the long line of mid-ocean ridges, called the East Pacific Rise, which push the Pacific Plate towards the west. Further south this becomes the Pacific Antarctic Ridge, which passes west, south of Australia, where it becomes the South Indian Ocean Ridge. The Earth's tectonic plates move away from these ridges. For example, the Pacific Plate, which underlies most of the Pacific Ocean, is moving to the northwest at about 9 centimetres (cm) per year. The Indo-Australian Plate is moving towards the north at about 7 cm per year. When new crustal material surfaces at the South Indian Ocean Ridge, it causes the Indo-Australian Plate to move. When plates collide with one another, one plate slides below the other to form a **subduction zone** (see C in Figure 1.2.3). In these areas, the ocean floor is dragged down and forms deep **ocean trenches** (see D in Figure 1.2.3). This keeps the Earth the same size. These trenches are the deepest parts of the ocean floor. Ocean trenches are found at the edges of plates that are disappearing back into the asthenosphere. Great forces are involved in the collision of plates, causing volcanoes and earthquakes.

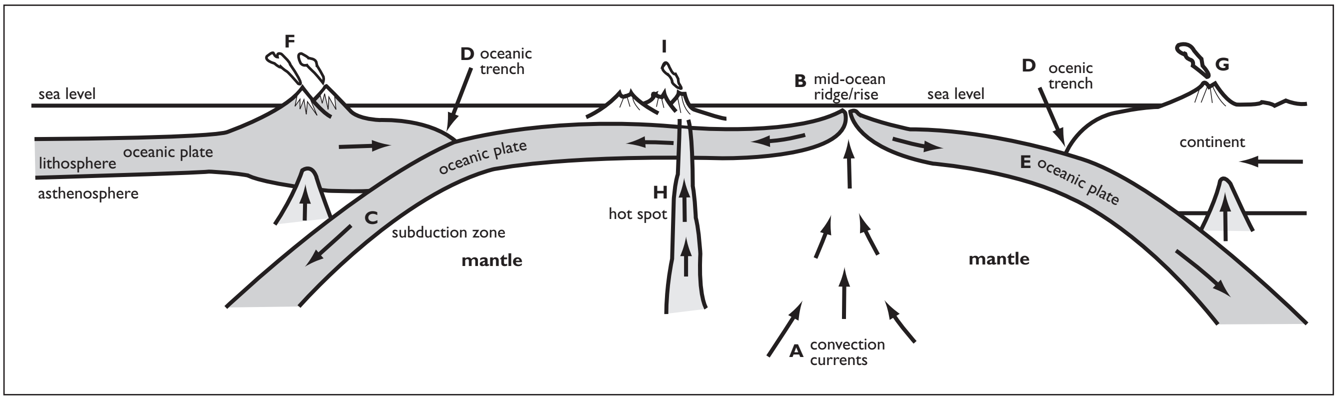


Figure 1.2.3 A cross-section through tectonic plates showing major features that can be found in the Western Pacific.

Discussion Questions

- ❑ What would the pressures and temperatures be like 100 km below the surface?
- ❑ Discuss this with your classmates and record your ideas.

The less dense continents float on more dense **oceanic plates**. So the continents are moved around at the same speed as the oceanic plate that is carrying them. These speeds can be up to 9 cm per year. This explains how continental drift occurs. When an oceanic plate collides with a continent (see E in Figure 1.2.3 on page 15), it is always the more dense oceanic plate that moves down below the less dense continental plate. For example, this is happening where the Pacific Plate meets the Eurasian Plate. You can see this in Figure 1.0.4 on page 8.

When two plates carrying continental crust collide, they can build spectacular mountains. Such collisions produce **fold mountains**. The most spectacular example of this is the Himalayan mountain chain.

Discussion Questions

- ❑ If new material is coming to the surface at the mid-ocean ridges, why isn't the earth getting bigger? Discuss this with your classmates and record your answers. (Refer to Figures 1.0.4 on page 8 and 1.2.1 on page 13)
- ❑ What plates collided to form the Himalayan fold mountains?
- ❑ Explain how you think these mountains would have formed.

Volcanic Islands Rise Above The Sea

How have the Pacific islands formed? You must remember the Pacific Plate is made up of mainly oceanic crust moving northwest at 9 cm per year. You can conclude from Figure 1.0.4 on page 8 that the Pacific Plate goes beneath the Indo-Australian and Eurasian Plates. Unlike the Pacific Plate, these two plates have large masses of continental rocks close to their boundaries. So where do the Pacific islands form? For our discussion of that question we will group the Pacific islands in four categories: **mid-ocean ridge** islands, **island arcs, continental islands** and islands from **oceanic hot-spots.**

FQ I

Mid-ocean ridge islands

Areas where the ocean floor spreads are locations for volcanic activity. But only a few isolated volcanoes along the mid-oceanic ridges actually break the surface of the sea to form islands.

In Figure 1.0.4 on page 8, can you identify any volcanic islands along the ridges from which the Pacific Plate is spreading? There are not so many. Also examine the mid-Atlantic ridge where sea floor spreading is taking place. This ridge extends along the entire length of the Atlantic Ocean. It has a number of volcanic islands. Do any of these islands have **active volcanoes** at the present time?

Island arcs

In what other places does volcanic activity occur?

The crust is dragged down at the edges of the tectonic plates. This is close to the subduction zones and ocean trenches. It is where a lot of volcanic activity occurs (see F in Figure 1.2.3 on page 15). The volcanoes are found in lines or arcs along the edges of the tectonic plates. They also follow the deep ocean trenches. If there is sufficient uplift on the uppermost plate, some volcanoes break the ocean surface.

These types of volcanoes include some of the most active and famous volcanoes in the world. Krakatoa, one of the most spectacular examples, is found along the Java Trench. The nearby island arc forms the islands of Indonesia (see Figure 1.2.4 on page 17). When Krakatoa erupted in 1883, the sound of the blast could be heard 2500 kilometres away in Australia.

Figure 1.2.4 The very active volcano of Gunung Merapi in central Java, Indonesia is 2912 metres high. It is a typically explosive volcano which forms along island arcs.

Continental islands

The continental crust, because it is less dense, is not forced down at the subduction zone. Instead, these large pieces of continental crust may be uplifted by violent earth movements. Also, because these are points of weakness in the Earth's crust, new volcanic material can be added to them (see G in Figure 1.2.3 on page 15). Papua New Guinea is an excellent example of this. It is the northern edge of the Indo-Australian Plate, and its continental rocks have been uplifted to form the Owen Stanley Ranges (see Figure 1.2.5 below). These rise to a height of more than 4000 metres. Volcanoes on the main part of Papua New Guinea include Goropu, Lamington and Yelia. Other volcanoes form islands off the coast such as Bam, Uluman (Krakar Island) and Dobu.

Other island groups showing this mixture of continental and volcanic rocks include the Solomon Islands, Vanuatu, New Caledonia, Fiji and New Zealand.

Figure 1.2.5 The Owen Stanley Ranges of Papua New Guinea. These ranges are on the edge of the Indo-Australian plate. How would these ranges be affected by their location?

Islands from oceanic hot-spots

There are other areas of crustal weakness in the middle of oceanic plates that can produce spectacular volcanism. These are called oceanic hot-spots (see H in Figure 1.2.3 on page 15). These hot-spots appear to remain stationary over millions of years. This results in a line of volcanoes forming as the crustal plates move over the stationary hot-spot (see I in Figure 1.2.3). The youngest volcano will be at one end of the line, and the oldest volcano will be at the other.

Learning Activities

1. Look at Figure 1.0.4 on page 8 and, if possible, identify the nearest oceanic trench to your country
2. What is the name of the tectonic plate on which your country is located?
3. Does any part of your country ever experience volcanic or earthquake activity? Can this be explained by your country's position on its tectonic plate?

FQ 2

The best studied example is in the Pacific and forms the Hawai'ian Island Chain. See Figure 1.2.7 below. The active hot-spot is at the southern end of the big island of Hawai'i, forming the volcanoes of Kilauea and Manua Loa. See Figure 1.2.6 below. The ages of the volcanic rocks of the older islands have been determined and are shown in Table 1.2.1 on page 21. At the end of the Hawai'ian chain are Pearl and Hermes Reef, and Midway and Kure Islands. All of these structures are on volcanic foundations. These volcanic foundations are now approximately 1000 metres below the surface of the water. The coral growth upwards has kept pace with the **subsidence** rate downwards of the volcanic rocks.

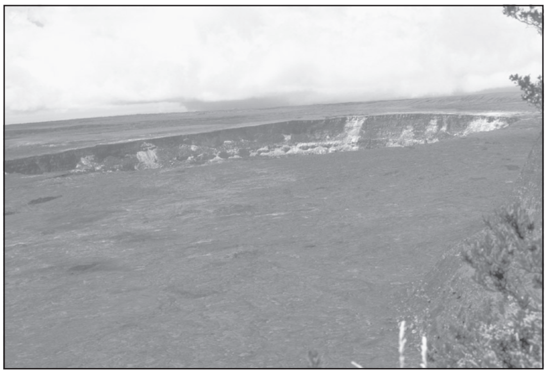


Figure 1.2.6 The Active crater of the Kilauea volcano is located above the active hot-spot. This volcano is at the southern end of Hawai'i.

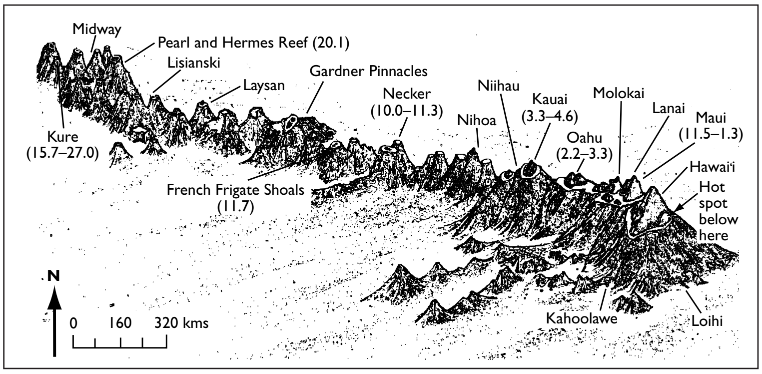


Figure 1.2.7 These are the islands of the Hawai'i island chain as they would appear without the ocean around them. The active volcanoes are on the island of Hawai'i. Numbers indicate the ages of the basaltic lavas in millions of years. Where appropriate the average age of the basalt has been listed in Table 1.2.1 on page 21.

Kure Atoll is the most northern atoll in the world. Coral reef growth is at a minimum because it is outside the tropics and its waters are cooler. As Kure will move further north in the future, coral growth is likely to cease and the atoll will slowly sink beneath the ocean. See Figure 1.2.8 on page 19. This has already taken place on former volcanoes. It is seen today in the line of **sea mounts** known as **guyots** that form the Emperor Sea Mount chain. Guyots are flat topped and were previously coral reefs that could not keep up with the subsidence of their foundations.

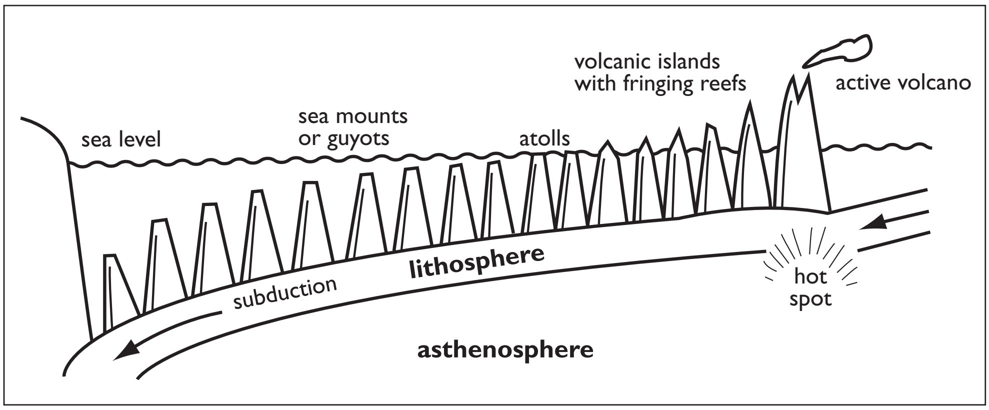


Figure 1.2.8 The sea floor sinks lower, the further it travels from the original oceanic hot-spot. As the volcanic islands sink, coral reefs can start to grow on their edges. Over time these reefs can grow upwards. In fact the volcanic rocks can disappear completely beneath the sea and be covered over by coral reefs.

Discussion Questions

- ❑ What other major volcanoes can be found along the Indonesian island arc?
- ❑ Which of these volcanoes are still active?
- ❑ What other island arcs, close to oceanic trenches, can be identified in the western Pacific? Record your answers.

Learning Activities

1. Refer to Figure 1.0.4 on page 8 and note the general locations of volcanoes and earthquakes in the South Pacific region.
2. Why do volcanoes and earthquakes tend to occur in certain areas but not others?
3. Why is the Pacific region known as the **Ring of Fire**?
4. Suggest two ways in which scientists may determine the speed at which a whole continent is moving.

Where Do Coral Reefs Fit In?

FQ 2

Corals have a very limited distribution. They can only live in warmer waters near the tropics. The maximum ocean depth at which they can grow is approximately 100 metres. Light does not penetrate much beyond this depth. Most of the ocean is well below this depth. Where coral reefs currently exist the explanation is either:

a Volcanic action built underwater mountains close to the surface, or

b Uplift near a subduction zone raised the floor of the ocean, or

c Shallower shelf areas existed around large continental islands.

As a result, many coral reefs in the tropics are found in close connection with volcanic islands or volcanic foundations.

The relationships of coral reefs and volcanic islands are illustrated in Figure 1.2.8 above. Volcanic islands, formed over oceanic hot-spots, acquire fringing reefs. These in turn may develop into **barrier reefs** and **atolls** as the volcanic core subsides and is eroded. Even the large Pacific atolls with their rim of islands have volcanic foundations. Millions of years of erosion and subsidence have covered the evidence. See Figure 1.2.9 on page 20.

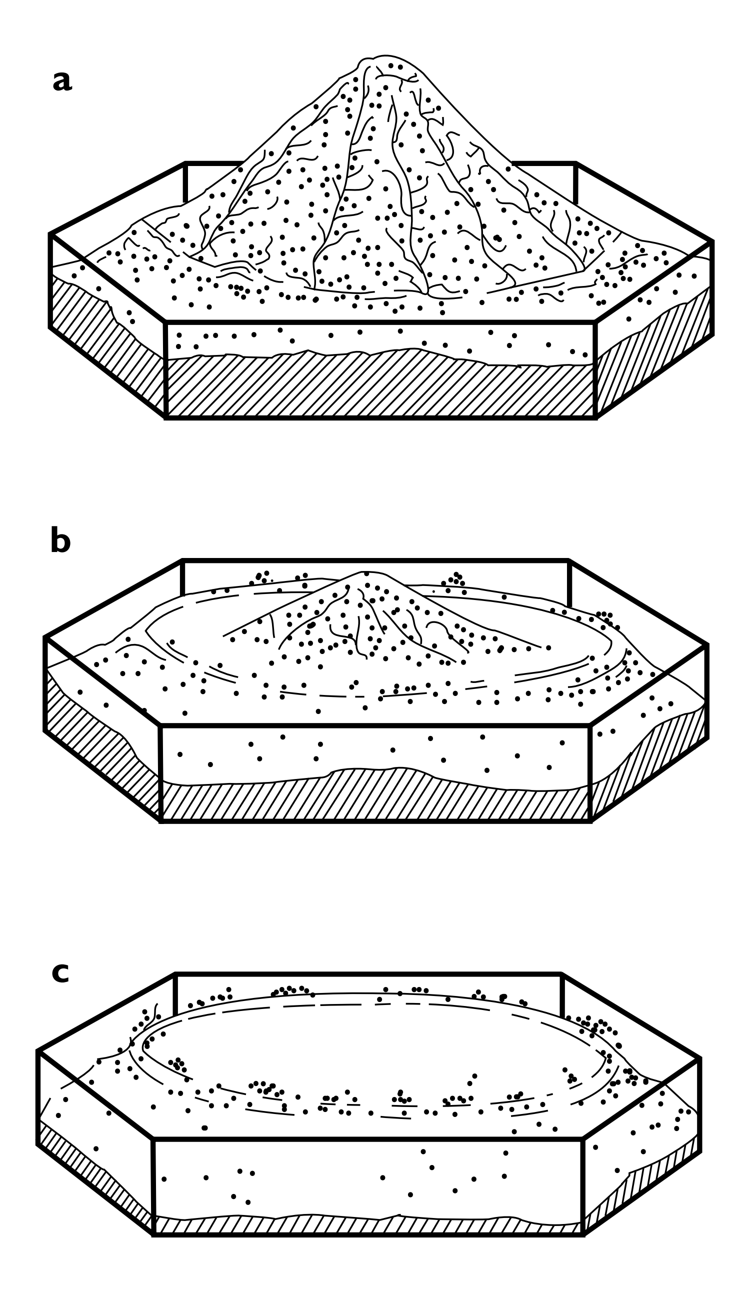


Figure 1.2.9 Typical island reef relationships along an island chain: a) a slightly eroded volcano with fringing reefs; b) a more severely eroded volcano with barrier reef; c) an eroded volcano which is subsiding beneath the sea. It has been covered with coral reef to form an atoll.

Figure 1.2.9a The island of Tahiti in French Polynesia. Can you see the original volcanic landform and fringing reef?

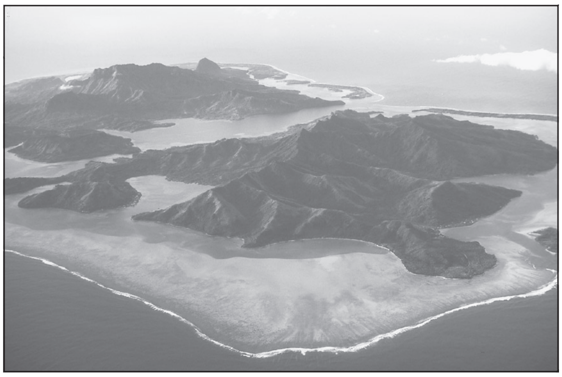


Figure 1.2.9b The island of Huahine in French Polynesia. A pair of volcanoes which have been severely eroded. Note the extensive barrier reef.

Figure 1.2.9c The island of Tupai in French Polynesia. A coral reef and islands formed over an eroded and subsiding volcanic base.

So the pattern of island development depends on both erosion and subsidence. The volcanic foundation subsides or sinks as it moves on its oceanic plate. Over time, some of these islands can move outside the warmer areas of coral growth and become guyots. Others may be carried into ocean trenches and subduction zones, and become buried in the asthenosphere. Some volcanic foundations may be uplifted hundreds of metres by violent earth movements at subduction zones.

FQ 2

When coral reefs are lifted out of the water, they become **limestone**. Limestone can tell us a great deal about the islands to which these coral reefs were attached. Therefore, relationships between reef and island can tell us a lot. You should be able to use the classifications in the following unit to understand how your island fits into the overall pattern.

Learning Activities

Table 1.2.1 Landform statistics

Name of Landform	**Approx. age of base basalt (millions of years)**	**Approx. height above ocean floor (metres)**	**Distance from nearest hot-spot (kilometres)**
Hawaiʻi: Kilauea	Active volcano	5800	0
Hawaiʻi: Mauna Loa	Active volcano	8700	?
Hawaiʻi: Hualalai	0.1	7050	?
Hawaiʻi: Mauna Kea	0.2	8700	?
Hawaiʻi: Kohala	0.4	6200	?
Maui	0.8	6000	?
Oahu	3.0	*5500*	320
Nihoa	7.0	*5000*	?
Necker	10.0	*4500*	?
La Perouse Pinnacle	11.7	*4500*	?
Pearl + Hermes Atoll	20.1	*4000*	?
Midway Atoll	21.4	*3500*	?
Kure Atoll	21.5	*3500*	2200

Italics indicates estimated heights

1 Find Hawaiʻi on Figure 1.0.4 on page 8 and name the oceanic plate on which Hawaiʻi is located.

2 How far is Hawaiʻi from (i) the nearest mid-ocean ridge and (ii) the nearest subduction zone? See Figure 1.0.4.

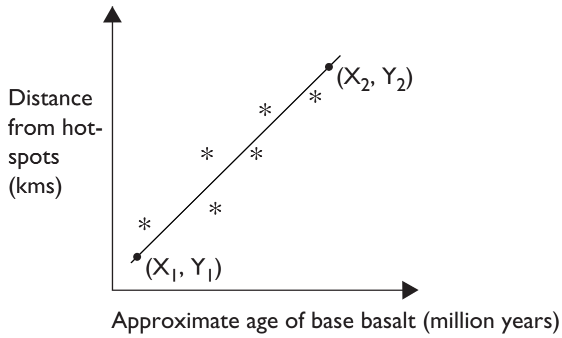
3 Why are active volcanoes only found on the island of Hawaiʻi?

4 In which direction is Hawaiʻi's supporting oceanic plate moving? Explain how you worked out your answer. See Figure 1.2.7 on page 18.

5 Estimate the minimum age of Hawaiʻi's hot-spot. Use the available evidence from Table 1.2.1 above and Figure 1.2.7 on page 18.

6 In Table 1.2.1, some places have no entry in column 3, which indicates their distance from the nearest hot-spot. Use Figure 1.2.7 on page 18 to help you calculate the missing distances. Draw your own table in your book and enter your calculations.

7 On a graph (as illustrated below), plot the approximate age of each of the listed landforms against their distance from the hot-spot.



8 Use the **line of best fit** from the graph to estimate the speed at which the plate is moving. Please note speed = gradient of the line = (Y2-Y1) / (X2-X1)

9 Suggest as many reasons as possible why the speed you have calculated in Activity 8 can be at best only an estimate.

Review Questions

1 Why does continental crust float on oceanic crust?

2 Draw a diagram to show how convection currents are understood to cause continents to move.

3 Describe the physical characteristics of a mid-ocean ridge.

4 Assuming constant rate of movement, calculate the approximate rate at which Papua New Guinea has drifted over the last 170 million years.

Locate your country on Figure 1.0.4 on page 8 to answer a number of the following questions:

5 List the major ways in which plate tectonics has affected the island on which you live.

6 Predict where your country will be located in 10 million years time.

7 List the major differences between continental crust and oceanic crust.

8 Predict what will happen to the Himalayan mountain chain over the next 10 million years.

9 What three major features in a chain of islands would indicate hot-spot volcanism?

10 Which of the following statements about the line of best fit is true?

The line of best fit on a graph:

a usually passes through the origin

b must pass through all plotted points

c must have the same number of points above the line as below the line

d does not take into account those plotted points which are very different to the majority of points.

11 Select the response that correctly completes the following statement.

The location of hot-spots could be determined by looking for volcanoes that are:

a growing above mid-ocean ridges

b on the coastal plains of large continents

c found in the central highlands of continental crust

d found on oceanic crust some distance from mid-ocean ridges.

12 Describe how a guyot forms.

Unit 3

The Formation Of Low Islands: Cays And Motus

Learning Outcomes

By the end of this unit you should be able to:

- ❑ Appreciate the energy of ocean waves.
- ❑ Understand how waves move in shallow water.
- ❑ Explain how coral cays form.
- ❑ Illustrate how motus form.
- ❑ Explain why calcium carbonate is such an important material in cay and motu formation.
- ❑ Describe how coral cays and motus may be stabilised by:
  - **a** the size of the coral cay or motu, and
  - **b** the vegetation on the cay or motu, and
  - **c** the presence of freshwater, and
  - **d** cementation processes, and
  - **e** the presence of guano.
- ❑ Illustrate how the freshwater – seawater boundary changes after an island receives a lot of rain.
- ❑ Determine the depth of the freshwater lens on your island (if you obtain water from wells).

How Do Islands Grow From Underwater Reefs?

It may be easy to understand how some volcanic islands rise above sea level as they form. But how do the low islands of the Pacific coral reefs form? It is the action of waves: a) the reefs themselves produce all the materials and b) when the waves break over the reef they push these materials above sea level. If these materials are mostly sand, a **coral cay** will form. If the material is coarse rubble, a **motu** will form. A motu is a long, narrow island that forms close to the edge of a reef.

Waves On Coral Reefs

Waves are created by winds blowing over the water surface. The size of these waves depends on three things. These are:

a the constancy of the wind direction

b the strength of the wind and

c the distance of open ocean over which the wind is blowing.

FQ 2

In the South West Pacific, the Southeast Trade Winds cause wind waves to be mainly from the southeast. In the open ocean, waves can be several metres high.

When waves move into shallow water, a number of changes take place.

1. The circular movement of water beneath the wave is changed by the shape of the sea floor. The wave slows down as it drags along the bottom. Wave crests become shorter and closer together. The end result is that the waves are bent by the sea floor. This bending is called **wave refraction**.
2. The wave also becomes higher as it approaches a shallow shore. The circular motion beneath the wave becomes distorted. There is a short, sharp shoreward movement and a much longer movement seawards. Eventually, these changes cause the wave crest to collapse and it breaks as **surf** on the shore or reef.

The next time you are at the beach, have a look at the patterns of the waves. At low tide, you might be able to see the shape of the sea floor.

The Origin Of Coral Cays

How are waves related to the formation of coral cays? How did the sand, broken coral and boulders get on to your island?

Figure 1.3.1 Aitutaki, Cook Islands

Reefs rise steeply from the ocean floor. Therefore, wave refraction and other changes take place only very close to the reef. The waves tend to bend around the reef. Waves that are about a metre high have enough energy to pick up sand-sized particles. Large waves can pick up gravel-sized material, perhaps 10 cm in diameter. During tropical cyclones, wave heights up to 10 metres can be produced. When these waves crash on to a reef, they can cause massive damage. They can remove blocks of reef that are many metres in diameter.

A wave that has broken on the reef edge may reform. It can then continue to travel across the shallow water of the **reef flat** and lagoon. It has the ability to carry sediment along its path. This sweeping action of the waves may form a coral cay.

Finer sediment of the reef flat can be swept towards a focal point on the reef. This depends upon three things:

a the direction of the wave approach, and

b the shape of the reef, and

c the size of the reef.

Where the reef is oval in shape, wave refraction around its margins (edges) may be complete. Waves will sweep sediment from around the entire reef margin. As waves from the windward have greater energy, the sediment will probably be moved towards the **leeward side** of the reef.

In contrast, a long, linear reef may cause the wave to approach in a different pattern. In this instance, the wave refraction produces waves from opposite directions. These waves meet along the entire length of the reef. Sediment is moved to where the waves meet. The resulting sediment pile will eventually form a cay which is long and linear.

Learning Activity

Use brief notes and diagrams to describe how a coral cay forms.

The Origin Of Motus

Another type of low island is a motu. These islands are mainly caused by tropical cyclones.

Very large waves are needed to carry coarse sediment. Even waves from tropical cyclones may not be strong enough to carry coarse sediment after they cross the outer edge of the reef flat. Therefore, sediment transport is mainly limited to the windward margins of coral reefs, especially the very exposed open ocean atolls.

Water has to drain off the reef flat or from the lagoon. This water may eventually form gaps through the motu ridge. These gaps produce the typically shallow passes that are found between motu islands. In **Polynesia,** such a pass is referred to as a **hoa**.

Tropical cyclones can produce enormous amounts of damage. But they can also help build motus. An example of the construction of a new motu happened on Funafuti Atoll in Tuvalu on 21 October 1972. When Hurricane Bebe struck the atoll, major waves came from the southeast. As a result of Hurricane Bebe, a storm beach 19 km long, 4 metres high and 37 metres wide was added to the islands of the atoll rim. 2.8 million tonnes of broken coral were washed on to the reef flat from depths down to 20 metres on the **reef front**. On more sheltered areas, separate low rubble ridges formed. Since 1972, under less extreme weather conditions, the Funafuti ridge has altered its original **convex** profile to a **concave** one. Also the ridge migrated 10 to 20 metres shoreward and significantly reduced in height. Only the largest coral boulders remain in the original position of the ridge.

How Do Cays And Motus Become More Permanent?

Sand cays without vegetation are very unstable. There are many examples in the Pacific of unvegetated cays disappearing completely after major storms. Even in normal weather conditions, small sand cays can move tens of metres in a 24-hour period. They can move up to 100 metres in less than a month.

Eventually, if sediment is constantly supplied to the same area of reef flat, the unvegetated cay becomes more stable. It may change into a vegetated, mature coral reef island. The following things help to stabilise cays and motus.

Increase in the size of the coral Cay or Motu

The larger the forming coral cay, the more stable it is on the reef flat. Even major storms can no longer move the entire sediment body. Seasonal weather changes produce only minor changes around the edges of the unvegetated reef island. The area of the island may get bigger and the height may also increase. This happens during periods when tides are higher than normal or when storm waves are particularly high. At these times, sediment may be deposited above the normal water level. At low tide, the sun dries the sand around the edges of the cay. A strong wind may pick up this sand and add a further **dune cap** to the cay or motu.

Vegetation

Over time, vegetation develops from **drift seeds** or seeds brought in by birds. If there is a part of the cay that does not change over a number of years, more permanent vegetation can grow. Even then, a large storm or prolonged erosion can destroy the vegetation.

Figure 1.3.1 A tropical shoreline

The vegetation process is a slow but important one. The roots of the vegetation bind the loose sediment together. This helps to stop erosion. Decaying vegetation also adds organic material to the limestone base of sands and gravels that originally made up the island. Over time, you get denser vegetation and greater stabilisation of the sand cay.

FQ 2

Freshwater

When rain falls on a young sand cay, it runs through the sand and rubble and mixes with the seawater. To survive, a plant has to get moisture from rain or be able to grow in salty places. These plants are referred to as **salt tolerant**. Eventually, when the cay is big enough, a permanent **freshwater lens** or a slightly salty lens can form under the island. Whether or not this lens forms depends on the local climate. For example, you need good rainfall. It has been suggested that, in wet climates, a minimum island diameter of about 100 metres, or an area of approximately 9000 m^2, is needed for a lens to develop.

After heavy rain, the water soaks down through the soil or sand. The freshwater will collect above the seawater because freshwater is less dense than seawater. Therefore, a lens of fresh or **brackish** water gradually forms beneath the reef island. The term **Ghyben-Herzberg** lens is given to this fresh or brackish lens of water. The top of the lens may be slightly curved and rise above the adjacent sea level. Generally, it will rise and fall with changes in tides or waves.

The Ghyben-Herzberg lens is very important as a source of freshwater for vegetation and human use. It allows a greater range of vegetation to grow on the island. Also, it probably helps the **cementation** processes described below.

Cementation

Sand particles can join together to form bedrock. Coral rubble joins together to form **coral conglomerate**. These processes are called cementation. **Beachrock** forms inside the cay. So if you see exposed beachrock you know there has been a lot of erosion. Once big layers of beachrock are exposed, they provide protection from further erosion. Similarly, the coral conglomerate of the motus has usually formed under large **storm ridges**. Eventually, these ridges grow towards the lagoon.

Both beachrock and coral conglomerate are very hard, like concrete. Although they help to stop erosion, sometimes major storms wash the sand and rubble away. All that remains is the beachrock and coral conglomerate sitting on the reef top.

The effect of guano

A different type of cementation process may stabilise the interior parts of coral reef islands. Once the island has established vegetation, it attracts seabirds for nesting and roosting. Even small islands may have tens of thousands of birds nesting each night. The droppings from these birds **leach** down into the soil. They can leach down as far as the upper part of the water table. Here the droppings combine with the sands or shingle of the island to form **cay sandstone**. Such formations stabilise the inner, older sections of reef islands and make the soil richer.

On certain islands the **guano** deposits and associated **phosphate rocks** are mined for fertilisers. **Phosphatic cay sandstones** are not limited to coral reef islands. They are also found on continental, volcanic and raised reef limestone islands, such as Nauru or Ocean Island (Banaba Kiribati). See Figure 1.2.9 on page 20.

Review Questions

1 Describe two reasons why calcium carbonate is an important chemical involved in cay and motu formation.

2 Illustrate two types of sand cays.

3 Explain why linear cays would be more easily damaged than oval cays.

4 How does a motu ridge form?

5 Explain how vegetation can help to make cays and motus more stable.

6 Describe the similarities and differences between beachrock and coral conglomerate.

7 Birds help to make cays and motus more stable in a unique way. Describe how some birds assist in the cementation process.

8 Describe any major cyclone damage that your island has experienced in the last ten years.

9 Have the people of your island taken steps to prevent damage from cyclones? What are they?

Unit 4

A Classification Of Pacific Islands

Learning Outcomes

By the end of this unit you should be able to:

- Describe the important characteristics of the four listed island types, namely:
  - **a** continental islands, and
  - **b** volcanic islands, and
  - **c** high islands with uplifted coral reefs, and
  - **d** low islands.
- Classify your island as one of the four listed types.
- Explain how your island's geological location has affected the way in which it has evolved.
- Explain how limestone is very susceptible to chemical weathering.
- Classify your island within the listed island type.
- Describe these phenomena: fringing reefs, barrier reefs, makatea, and coral reef terraces.

Why Do We Need To Classify Islands?

We have seen the ways in which both **high islands** and **low islands** can form. There is a classification system to help identify and describe islands that have coral reefs. The classification system can help you understand the history of your island.

We now know that most earthquakes occur near tectonic plate boundaries. We also know that islands formed of continental rocks are very stable except where they are close to these plate boundaries. Volcanic islands formed from **oceanic hot-spots** slowly sink as they move away from the active volcanic site. But the rate of sinking is usually so slow that the growth of coral reefs can keep up with it.

Very large upward and downward movements occur in **subduction zones** and associated **island arcs**. In these regions, reefs that were once beneath the sea can be uplifted hundreds of metres above sea level.

The classification system for islands is divided into four parts. These are:

1 Continental islands, which are usually very stable. They may be with or without coral reefs.
2 Volcanic islands, which are formed of **basalts** and other volcanic rocks. These form at **mid-ocean ridges**, hot-spots, or close to subduction zones. These may be with or without coral reefs.
3 High islands with uplifted coral reefs. These islands are either entirely made up of **limestone** or a combination of limestone with volcanic or continental rocks.
4 Low islands formed entirely from the product of their coral reefs.

Continental islands

Continental islands are high and made of lighter rocks of the continental sections of **tectonic plates**. Many are in the middle of a plate, so they are relatively stable and do not show many signs of uplift or **subsidence**.

Australia, the biggest island in this region, is continental, as are the islands of New Guinea, New Caledonia and New Zealand. With the exception of Australia, however, these islands are close to the tectonic plate edges and have therefore experienced uplift.

Figure 1.4.1 Coral reef

FQ I

Coral reefs can be found around **continental islands**. In particular, coral reefs are often found around smaller fragments of continental land mass that are off the coastlines of major land masses. Continental islands also have shallow continental shelf areas surrounding them. These shelf areas can be the location of major reef development. The Great Barrier Reef of Australia is an excellent example of this. Therefore, continental islands can be classified into three categories, depending upon the degree of reef development. These are set out below:

a Continental islands without reefs

High islands in the tropics may not have any reef development. How can this be so? Usually, it is due to the quality of water surrounding the island. Often the water is unsuitable for the growth of coral reefs. For example, there may be a nearby river carrying freshwater and sediment into the sea.

b Continental islands with fringing reefs

Many continental islands in the Pacific have fringing reefs around them. Around headlands, these **fringing reefs** are very narrow. They are wider in bays and on the sheltered sides of the islands.

c Continental Islands with Barrier Reefs

Barrier reefs may form when there are large areas of shallow water adjacent to a continental island. Usually, fringing reefs are close to the shore and barrier reefs are offshore. Many of the islands of eastern Papua New Guinea are of this type, including Rossel and the Louisiades, and most of New Caledonia.

Discussion Questions

❑ What other reasons may account for a lack of reef growth around high islands in the tropics?

❑ What factors may be responsible for the distribution of fringing reef around a continental island? Record your suggestions.

Volcanic islands

Volcanic islands are formed either over a hot-spot or from volcanic activity close to the edge of a tectonic plate. When they are at the edge of tectonic plates, they form island arcs. Young volcanic islands in these island arcs may still be active. Their volcanoes may erupt violently at regular intervals over long periods of time. The eruptions from oceanic hot-spots are usually quieter, with **fissures** and **craters** pouring out enormous amounts of **basaltic lava**.

Examples of volcanic islands associated with hot-spots include the Hawaiʻian chain, the Society Islands of French Polynesia and some of the Cook Islands. Volcanic islands formed closer to plate margins include Fiji and the Sāmoan islands. The islands of Vanuatu are also volcanic.

The classification of volcanic islands in the Pacific region is similar to that of continental islands. It is based on the amount of coral reef development. Some volcanic islands may be too young for coral reefs to have developed. Other volcanic islands may erupt so often that any coral reef that does form is regularly destroyed. As volcanic islands get older, coral reefs are eroded, but fringing reefs may become attached around their shores. Later still, as the islands both erode and sink, they may become surrounded by both fringing and barrier reefs.

This means that volcanic islands can be classified into three groups. These are:

FQ I

a volcanic islands without reefs, and

b volcanic islands with fringing reefs, and

c volcanic islands with barrier reefs.

Volcanic islands without reefs

There can be many reasons why some volcanic foundations do not have reefs. For instance, the volcano may be still active, or its slopes may be unstable and constantly slipping into the sea. Rivers draining the island may also prevent reef growth.

Volcanic islands with fringing reefs

These are most common in the Pacific. Sometimes the fringing reefs are around the entire island, sometimes only in the bays or headlands. See Figure 1.2.9 on page 20.

Volcanic islands with barrier reefs

As can be seen in Figure 1.2.9 on page 20, the slow subsidence of a volcanic island can result in the continued growth of coral reefs. This can later form a barrier reef and be separated from the volcanic island by a lagoon. An example of this can be seen in Figure 1.2.9c.

High islands with uplifted coral reefs

Continental or volcanic islands that approach the subduction trenches may be subjected to violent uplift. Any attached coral reef will be uplifted as well. Coral reefs are made of **calcium carbonate** as they are composed of dead plants and animals. When these coral reefs rise above sea level, they form limestone. **Coral reef limestones** may be geologically very young. After uplift, many features of coral reefs, such as former lagoons, can now be seen many metres above sea level.

Older limestone can be severely eroded by weathering. Limestone is easily dissolved by rainwater trickling down through it. This can make underground caves and very rough and jagged surfaces. Such country is called **makatea** after the Makatea Islands of the Tuamotu Islands of French Polynesia. Other examples include Niue and many of the islands of Vanuatu. See Figure 1.5.2 on page 36.

The classification of uplifted islands is divided into:

a uplifted limestone islands, and

b uplifted high islands with attached coral reefs.

Uplifted limestone islands

In some cases, the old volcanic foundations were completely buried under growing coral reefs before uplift. These islands are made of old reef limestones and may have living coral reefs attached to them. Examples include Tongatapu in Tonga, Ouvea in New Caledonia and the Trobriand Islands in Papua New Guinea. Such islands show there has been geological uplift. They are usually close to major subduction zones.

Uplifted high islands with attached coral reefs

Often the uplifted island still has volcanic or continental rocks at its centre. Both the central volcanic core and the surrounding coral reefs are uplifted. There is usually strong contrast between old volcanic or continental rocks and old coral reef. Old volcanic or continental rocks form deep soils when they erode from streams and rivers running over them. Old coral reefs, with no surface drainage, produce hard, rocky soils. So it is easy to recognize the two different types.

Figure 1.4.2 Niue – coastal view (Niue is a raised coral atoll)

There are many examples of these island types in the western Pacific. The northern part of Papua New Guinea, particularly around the Huon Peninsula, is one of the best known examples of **coral reef terraces** in the world. Here coral reef terraces rise hundreds of metres up the slopes of northern Papua New Guinea. Other examples of coral reef terraces are found in the Loyalty Islands of New Caledonia and many of the Cook Islands.

FQ I

Low islands

Figure 1.4.3 Funafuti, Tuvalu – aerial view of motu

Figure 1.4.4 Funafuti, Tuvalu

There are many ways of classifying low islands. We may use the presence or absence of vegetation, the vegetation type or the nature of the sediment from which the island was formed. Earlier, we examined how **sand cays** and **motus** formed. But there are other types of low island. Below is a more detailed classification system based on the type of sediment and the level of wave energy. We will discuss four types of low island. They are:

a mangrove islands, and

b sand cays, and

c motus and other shingle cays, and

d mixed sand and shingle islands.

Mangrove islands

On some reef tops, the waves are so weak that mangroves can grow. They form what appears to be an island. Although the mangroves trap sediment and build up the reef flat, at most high tides the 'island' is under water.

Sand cays

Sand cays usually form on the **leeward side** of **reef platforms** from the action of refracted waves. (See Figures 1.1.3 on page 10 and 1.5.5 on page 38). They may be completely unvegetated and unstable, or they may be stable if they have forests and permanent freshwater. They usually contain **beachrock**, **cay sandstone** and **coral conglomerate**.

Motus and other shingle cays

Tropical storms can deposit large amounts of coral debris around the reef edge to form motus. In other places, the pattern of waves breaking on a reef edge may cause smaller and more compact shingle cays to form. These usually form only on the windward side of a reef. See Figure 1.2.9 on page 20.

Mixed sand and shingle islands

The islands formed may consist of a windward series of shingle ridges and a leeward deposit of sand especially on small reefs. The **low wooded islands** commonly found along the northern part of the Great Barrier Reef of Australia are a variation of this. These consist of a windward shingle ridge in the shelter of which grow mangroves and a leeside coral cay.

Learning Activities

1. Name the island on which you live or a nearby bigger island.
2. Is there any evidence of coral reef surrounding any part of the island? Explain why or why not.
3. Classify the island using the descriptions given in this chapter, e.g. 'a volcanic island with a fringing reef'. Explain how well the island fits the classification.
4. Calculate how far this island is from the nearest oceanic trench or subduction zone. Refer to Figure 1.0.4 on page 8.
5. Explain how the island's location would have affected the way in which it has evolved.

Review Questions

1. Describe two ways in which volcanic islands can form.
2. Name three South Pacific islands that are volcanic islands.
3. State two reasons why volcanic islands usually have rich vegetation.
4. **a** Describe the characteristics of a high island with an uplifted coral reef.
   b What geological environment would have caused the coral reef to be uplifted?
   c Why would a makatea landform probably exist on the island?
   d List two examples of 'high islands with an uplifted coral reef' that can be found in the South Pacific region.

Unit 5

People And The Island Ecosystems

Learning Outcomes

By the end of this unit you should be able to:

- ❑ Appreciate the delicate balance between the land and its people.
- ❑ Explain why certain animals and plants have become extinct in your community.
- ❑ Describe how your communities have used their environments in the past (i) to their advantage and (ii) to their disadvantage.
- ❑ Discuss the effects of overpopulation, if it exists, in your community.
- ❑ Suggest acceptable ways of overcoming problems associated with overpopulation.
- ❑ Describe pollution problems in your community.
- ❑ Suggest ways to overcome the pollution problems in your community.

This section discusses the ways in which people have changed the island ecosystems. The first arrival of humans on an island has an immediate and drastic effect. High technology has caused even greater changes.

Our Use Of Islands

A place to live

FQ 4

Initially, the islands were used as places to live. The original Micronesian, Melanesian and Polynesian people may have depended on the sea for their food. They brought with them new plants, such as taro, breadfruit and coconuts. In many instances, these species became the dominant vegetation of the islands. Also, more importantly, the people brought animals with them. Poultry and pigs were used for food, and dogs and other animals were used for domestic purposes.

Unfortunately, problem species such as rats were also brought in. All of these were in competition with the native fauna. In many instances, the introduced species took over from the native fauna. These native fauna had originally been very restricted and had little competition.

Figure 1.5.1 Islands provide places for people to live. This is a coastal village on Misima Island in Papua New Guinea.

Islands as sites for mining

FQ 5

Many South Pacific countries have had mining operations, e.g. Papua New Guinea has been mined for gold, copper and oil. From the early 1800s onwards, many Pacific islands were mined for guano. Some of these guano deposits developed into larger mining industries. But many small scale operations, lasting only one or two years, had damaging effects on many islands. Vegetation was removed, new species were introduced, and many existing plant and animal island species became extinct.

Figure 1.5.2 This makatea landscape of Nauru Island was formerly covered by soil and a layer of phosphate. The phosphate rock has been removed by mining. How could such destructive erosion be prevented?

Islands as staging posts

Even the smallest islands have been used as staging posts because of the vast expanse of the Pacific. These islands have been used in the following ways:

a As coaling stations that were used for refuelling ships, particularly in the late 19th and early 20th centuries.

b As cable stations that provided links in worldwide communications.

c As airfields that made trans-Pacific flights possible. (This was particularly true from the 1930s to the 1950s when short haul aircraft were being used. Many atolls provided landing places on routes between the west coast of North America and Asia, New Zealand and Australia.)

d As sites for navigational beacons and, more recently, as weather stations and satellite tracking stations.

All of these examples involve disturbance of the environment. Most operations require clearance of the vegetation. New species can be introduced, ranging from the smallest insects to rats and domestic animals. Often new plants are introduced either accidentally or quite deliberately as food or decorative plants.

FQ 5

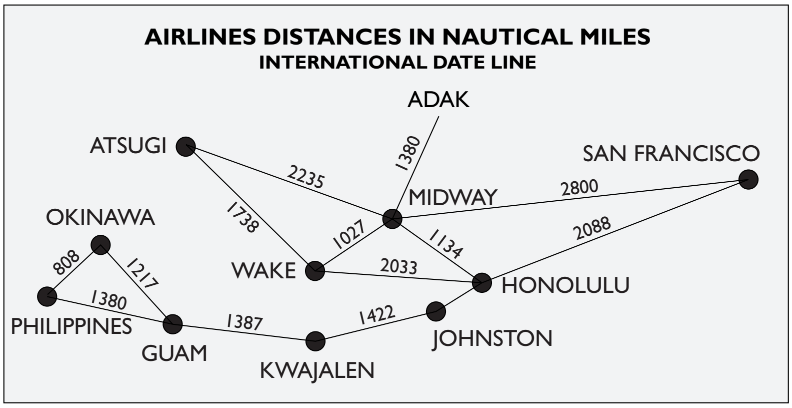


Figure 1.5.3 Islands form important links in communication. This map is on the wall of the military airport at Midway in the Central Pacific. The distances are in nautical miles.

Figure 1.5.4 Some islands like Kure Island in Hawai'i are the base for navigational beacons and stop-over points for aircraft.

Military effects

Some of the most spectacular changes to islands have come from military activity. Many islands were World War II battlegrounds. During this war and since then, many atolls have been used as military bases, particularly by the USA. For example, Santo in Vanuatu was a base for 250 000 US military personnel. Even when bases have been closed down, large areas of concrete (e.g. for runways) often remain on the islands. See Figure 1.5.5 over the page. Finally, atolls have been used as nuclear testing grounds. These have included Bikini Atoll, Christmas Island, Johnston Island, Mururoa Atoll and Fagataufa Atoll. On all of these islands and atolls, native populations were removed and replaced by large military populations.

Figure 1.5.5 Midway Island in the Central Pacific was severely changed during World War II. It is now covered by several concrete military runways.

Islands as tourist attractions

Islands have always attracted people. Over the last 30 years, many Pacific islands have become tourist resorts. Tourism creates similar problems to the original settlements. However, tourists want to see the islands in their natural state. Therefore, for tourism to continue, it is important to conserve the environment. In other words, people need to maintain their island ecosystems rather than further degrade them.

Figure 1.5.6 Tourist resorts are a recent development on many islands. Structures such as hotels change the natural environment dramatically.

The impact of humans on island ecosystems

How have people affected the island environments?

Vegetation

The activities of people have a major effect on the vegetation of an island. The early navigators and settlers of the islands brought with them food crops such as taro, coconuts and some species of Pandanus. In the past century, native woodland has been gradually replaced by artificial forests of coconut palms. Coconut is now typical of the vegetation of many Pacific islands. See Figure 1.5.7 below. One hundred and fifty years ago, coconuts were rare or nonexistent on most of these islands.

Figure 1.5.7 Coconut plantations are now very common on Pacific islands. Although the fruit can float across water, its presence on many islands results from human intervention. The coconut probably originated in the Indo-Malaysian region.

Figure 1.5.8 Cactus-like Yucca plants dominate the vegetation of this Great Barrier Reef island in Australia. It is originally a Central American plant. Why could such plants as the Yucca plant cause problems?

Guano extraction on both reef islands and higher limestone and volcanic islands involved almost the complete removal of the native vegetation. Even more damaging is the use of motus as air fields, military bases and, in some instances, as atomic weapon testing grounds. Many motus were also severely damaged during World War II.

Undoubtedly, some of the pre-existing plant species have disappeared with human interference in the island ecosystem. However, many plant surveys have been undertaken that show that the number of plant species may drastically increase. See Figure 1.5.7 above. Food, economic and decorative plants are brought in deliberately. Sadly, many weeds are also introduced accidentally. For example, at Canton Island in Kiribati where an air strip was built in 1939, the native flora totalled only 14 species. Today, there are more than 150 additional exotic species.

FQ 5

Jalui Atoll in the Marshall Islands was a Japanese base during World War II. The total flora of 289 species on Jaluit Atoll includes no less than 277 exotics. On the atolls of Kiribati, over 290 plant species have been reported. Of these, 8 species were introduced by the original inhabitants but 105 are more recently introduced exotics. On many reef islands, it is now difficult to reconstruct the vegetation as it was at the start of the last century.

Geomorphology

Construction of large installations involves big changes to the surface of the islands. For example, new land areas are formed by the dredging of material from lagoons. Islands are joined together by causeways. Often much of the original morphology of beach ridges and shingle embankments is lost under the construction of these causeways. See Figure 1.5.9 below.

Figure 1.5.9 Much care must be taken with constructions on coral islands. Environmental impact studies must be carried out to determine if the environment can be disturbed.

Engineering works may close or restrict the circulation of water in lagoons. There are many examples of the flora and fauna of lagoons being altered. Corals may die and algae may grow more when the circulation of water in lagoons is altered. Perhaps the most dramatic effects on the geomorphology are seen on atolls used for nuclear testing. New 'lagoons' several hundred metres in diameter were formed from such blasting.

Fauna

The effects on animals have been discussed already. Introduced animals, including dogs, cats and rats, compete with the original fauna of the islands. Sea birds, that nest on the ground are particularly under threat. Flightless rails, which have developed without having to compete with predators, have become extinct on many islands. In some instances, the original fauna has been deliberately removed. Islands used as airports, for example, have problems through collision of planes with seabirds. On Midway Atoll, many of the albatross have been removed to reduce collisions. Introduced higher order animals are rare on atolls, although cattle and goats are found on some.

In some instances, there is an unforeseen chain of events. For example, on the atolls of the Tokelau Group, introduced rats bit holes into fallen coconuts. These coconut microhabitats introduced a problem. The coconuts became breeding areas for dengue fever mosquitoes. Now the World Health Organisation is introducing a fungus to infect and kill mosquito larvae.

In the Caroline and Marshall Islands during World War II, the Japanese introduced the giant Monitor Lizard to kill off the rats. Unfortunately, this lizard also ate birds. The Monitor Lizard became as large a problem as the rats that the lizard had been brought in to control. The cane toad Bufo marinus has been introduced because it is poisonous to the lizards that eat it. Although this introduction has been successful in killing the lizards, the toads have also taken over the freshwater pools. The villagers depend upon these for drinking water. There are still as many rats as ever.

The freshwater lens

Freshwater is the most valuable resource on islands. But its overuse may lead to saltwater intrusion and the decline in general water quality. Further, the sinking of septic tanks and the general disposal of human waste on islands may contaminate the freshwater supply. This in turn may impact on the adjacent marine systems.

The adjacent marine ecosystems

The adjacent marine systems may also be considerably affected by the activities of people on the islands. The sea is often the major source of food. Traditional practices and taboos may have controlled overfishing in the past. However, the introduction of modern fishing techniques and the use of introduced substances can prove to be poisonous to the marine environment.

As already discussed, engineering works may cause changes to offshore water circulation. The flow of contaminated water from adjacent islands may prove to be extremely important. Groundwater, which contains sewerage, will also contain large amounts of nutrients. These nutrients can cause an overproduction of seagrass beds and algae on the adjacent reefs.

However, the effects may be even more far reaching. Some algae, upon which herbivorous fish feed, can cause the build up of a poison called ciguatera. The herbivorous fish will be eaten by carnivorous fish and therefore move up the food chain. The poison can become so concentrated that the fish cannot be eaten by humans. Increases in ciguatera poisoning have been reported from many Pacific islands during the 20th Century.

The carrying capacity of coral islands

The problems of some small islands (e.g. Kiribati) have attracted the attention of many international organisations. Humans are the dominant biotic component of the terrestrial ecosystems. This is especially true for small, isolated, self-sustaining island ecosystems.

Overpopulation is already a problem for many islands that humans inhabit. The general agreement is that island populations had reached their full potential size before contact with Europeans. Pacific islanders were well aware of the dangers of overpopulation and actively controlled their own numbers. Although there was abundant protein from the sea, many Pacific islands used taro as essential staple food. The greater the amount of taro, the greater the carrying capacity of the island. Taro was the major source of starchy carbohydrate and the basic food need.

On isolated Pacific islands, the first contact with Europeans often led to a dramatic decline in the population, largely due to disease. However, in more recent times, the population has been increasing. For example, in the Marshall Islands the pre-European contact population is estimated at about 10 000 inhabitants. Today, there are about 35 000 people living on these islands.

FQ 4

Therefore, the islands have shifted away from being a self-sustaining subsistence economy. Controls used to be exerted through traditional taboos. Now the populations depend upon the importation of food and goods. The cash economy, which in many cases is dependent upon the selling of copra, is leading to a major problem. The carrying capcacity of the islands is being exceeded and further degradation of the ecosystem will occur. The deficit has to be balanced with imported materials.

The islands are also part of the larger global system. Today we hear much about the global climate changes that are a result of the 'greenhouse effect'. This mainly involves an increase in temperature as a result of the build-up of carbon dioxide. Carbon dioxide is produced from the burning of fossil fuels in the Earth's atmosphere. For many islands, the most important result will be a rise in sea level. This may be only approximately 25 cm over the next 50 years or more, and certainly less than a metre even in 100 years. However, for islands that are frequently only a metre or two above sea level, the changes may be very serious. See Figure 1.5.10.

Figure 1.5.10 The coral island ecosystem is very fragile. It can be seriously affected by a small sea level rise produced by the greenhouse effect. However, the surrounding coral reef ecosystem may benefit from greater water depth.

FQ 5

In certain areas, as sea level rises, low islands will be under an even greater threat from tropical cyclones. It is believed that cyclones may increase in frequency and severity. Such storms may lead to an increase in the size of islands as a result of new material being added. The rise in sea level will also result in erosion in other areas. In particular, the older parts of the islands with mature soils may decline. The rise in sea level may result in smaller freshwater lenses.

This succession may go into reverse. Forest vegetations may decline into shrub cover, which in turn may eventually become merely pioneer species. If the carrying capacities of islands are already close to their maximum, the prospects for the new century are even more threatening. Islands are important, especially for the people who live on them. Wise decisions are going to be needed now from all the governments of the region.

Learning Activities

1 On a map or sketch of your island or local region, mark in as many of the following as possible:
   - ❑ where most people live
   - ❑ mining sites
   - ❑ staging posts, airports, harbours, marinas
   - ❑ military bases
   - ❑ main tourist attractions
   - ❑ areas that have involved changes in the geomorphology of the island
   - ❑ areas under agriculture
   - ❑ sewage outlets
   - ❑ areas that have been preserved in their natural state.

2 See if you can find drawings, photos or stories about the way your island looked in the past – for example, 10, 20, 50 or 100 years ago. Compare these old photos or illustrations with the areas as they exist today (perhaps you could speak with the oldest members of the community to find this information).

3 What major changes are likely to occur to your island over the next 50 years?

4 List the best natural features of your island.

5 What steps are being taken to protect these natural features?

6 How can you prevent undesirable changes from occurring?

7 Make a list of animals and plants that have become extinct on your island.

8 Find out if there are any endangered animals or plants on your island.

9 Can you think of any way of saving these animals and/or plants from extinction?

Review Questions

1 List the purposes for which your island has been used over the last 100 years.

2 Discuss one of the ways in which your island's natural resources have been put to good use.

3 Discuss one of the ways in which your island's natural resources have been used in a manner that has not helped your community.

4 Describe one pollution problem that has developed in the marine environment near to your community.

5 Does your community import many goods? Discuss what effect this has on the economy of the community.

6 What steps can be taken to protect the animal and plant populations that are under threat on your island?

7 If the sea rises one metre because of global warming will your community be under threat? If so, what can be done to overcome this problem?

Unit 6

Island Climates

Learning Outcomes

By the end of this unit you should be able to:

- ❑ Define 'climatic elements' and provide examples.
- ❑ Define 'climatic factors' and provide examples.
- ❑ Account for tropical island climates – explain the features of tropical island climates.
- ❑ Describe different types of rainfall experienced in different island types.
- ❑ Describe general features of tropical cyclones in the South Pacific.

Climatic elements are the different parts of climate that we measure. Climate elements include: temperature, rainfall, humidity, and air pressure. Climatic factors are those features in the surrounding environment (at different scales) that cause the specific characteristics of the climatic elements.

FQ 2

Tropical island climates are influenced by factors such as their location close to the equator (low latitudes, up to about 20 degrees north and south of the equator). Temperatures are high throughout the year, with the range in temperature throughout the year being quite small. For example, the annual range of temperatures at sea level at Apia varies from 25°C in July to 26°C in January–March. Daily temperature ranges (i.e. the difference between the hottest and coldest temperatures during the day) are from 5.5°C in January to 6.3°C in July.

Temperature varies more on high islands than on low islands – and the important factor for this variation is altitude. With increasing altitude, temperature goes down very noticeably.

The important factors that influence rainfall (also known as precipitation) in the tropics are the prevailing winds (for islands south of the equator, the prevailing winds are called the South East Trade Winds. The winds come from the south east). These winds are warm (again due to the low latitudes) and moist because they blow over warm ocean waters. The other important factor for rainfall is relief. Mountains act as barriers to prevailing winds. The winds are forced to rise over the mountain barriers, and the air is cooled down as it rises over the mountain. The water vapour in the moving air (wind) cools down at the higher altitude and condenses. Rain falls. When the winds blow over the mountains and flow down the other side, the winds warm again. But they are dry – and, therefore, the amount of rainfall is very low or absent. This type of rainfall is called orographic rainfall. This is a type of rain that will not be present on islands that do not have mountains.

Another type of rain that is influenced by tropical island locations, is convectional rainfall. This type of rainfall is caused by the sun's rays. The sun heats and evaporates water. The water rises as water vapour – but as it rises it cools down and then condenses. Rain falls down. This is the main type of rain that affects low islands.

Depressions are weather systems that develop closer to the equator and move slowly from the north west towards the south east. Depressions are areas of low pressure and are characterised by very unsettled weather. The weather is windy, very rainy and cloudy. This type of weather system brings poor weather conditions to a wide area.

Another important element influencing climate in tropical islands is the humidity. Humidity is the amount of water vapour in the air. Humidity levels depend on temperatures and sunshine.

For Sāmoa, some parts of Upolu and Savai'i have a regular dry season. These are the coastal parts of northern and western Upolu and all of Savai'i (except the south coast). This dry season is usually from May to September.

A climatic feature that can have a huge impact on the environments of all islands (high or low) is an extreme tropical depression – otherwise known as a tropical cyclone. For the islands of the South West Pacific, a tropical cyclone is a tropical low-pressure system with wind circulation that is strong enough to cause gale-force winds near its centre. The wind speeds can reach up to 250 km an hour.

Slightly higher risk of tropical cyclones near the Date Line

9 November 2003

For some South Pacific countries near the Date Line the chances of tropical cyclone activity are slightly higher than normal for the November 2003–April 2004 season, according to NIWA climate scientist Dr Jim Salinger.

"Pacific Island countries that may experience a slightly increased risk over this period are Fiji, Tonga, and Niue," he said. "Tropical cyclones are still very likely throughout the remainder of the South Pacific with a normal frequency of occurrence expected this season."

The last few tropical cyclone seasons were relatively "quiet" except last year, with only six occurrences during 2000/01, five in 2001/02, but increasing to ten last season. There is a slightly higher risk of tropical cyclones in Fiji, Tonga, and Niue this season because of more neutral conditions (i.e. no El Niño or La Niña) that are expected to remain in the tropical Pacific. Total tropical cyclone numbers are expected to be near normal (about nine) over the entire region.

Dr Salinger said, "Tropical cyclones develop in the South Pacific over the wet season, usually from November through April. Peak cyclone occurrence is usually during January, February and March. In seasons similar to the present the highest numbers occur in the region between Vanuatu and Fiji in the South Pacific. Taken over the whole of the South Pacific, on average nine tropical cyclones can occur during the November to April season, but this can range from as few as four in 1994/95 to as many as seventeen in 1997/98 during the very strong El Niño."

For New Zealand the average risk is slightly less than one tropical cyclone passing somewhere near northern New Zealand over the season (i.e. an occurrence is likely in about 2 out of 3 seasons, similar to the present). The highest risk districts are Northland and Gisborne.

Tropical cyclones require huge amounts of energy to survive, and will form only over specific regions of the globe's tropical oceans, where conditions are right for their formation and development. The La Niña and El Niño phenomena alter the patterns of climate, altering the risk of a cyclone in different parts of the South Pacific.

Major tropical cyclones bring extremes of wind, rainfall and sea surges, resulting in river and coastal flooding, landslides, and extensive damage to crops, trees, houses, power lines, ports and roads. Many lives can be lost. For a small South Pacific island country the whole economy can be severely affected. Individual tropical cyclones are, however, rather unpredictable; so most South Pacific islands are exposed to some degree of risk every year and must be always prepared. It only takes one major tropical cyclone striking an island to cause widespread devastation.

Source: adapted from NIWA

Learning Activities

Read the article 'Slightly Higher Risk of Tropical Cyclones Near the Date Line' by Dr Jim Salinger. Then answer these questions.

1. What are the chances or risks of tropical cyclones in November 2003 to April 2004?
2. Which three Pacific nations have more of a risk than usual of tropical cyclones in this period of time?
3. What is the normal number of cyclones for the Pacific region each year?
4. When do tropical cyclones develop in the South Pacific? When is the peak cyclone season?
5. In the period of time that covered 1997–1998, the atmosphere over the Pacific region was heavily influenced by 'a very strong El Niño'. What effect did this have over the number of tropical cyclones? What is the effect on the atmosphere over the Pacific when it is NOT affected by El Niño or El Niña?
6. Where do tropical cyclones form? Why do they form there?
7. What does a tropical cyclone bring? What are some examples of the way tropical cyclones affect islands and the people that live on them?

Unit 7

Island Similarities And Differences

Learning Outcomes

By the end of this unit you should be able to:

- ❑ Draw and interpret climate graphs for different types of island environments (high, low)
- ❑ Interpret maps and photographs of high islands and low islands.
- ❑ Compare and contrast climate and relief of different types of islands (high, low)

Climate

FQ 3

Upolu and Savai'i

Here are the average monthly rainfall and temperature figures for four different climate stations in Sāmoa. Two are located in Savai'i. Two are located on Upolu.

APIA (2 metres above sea level)

Table 1.7.1 Annual rainfall and temperature for Apia

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rain mm	489	368	352.1	211.2	192.6	120.8	120.7	113.2	153.9	224.3	261.7	357.5
Temp°C	27.1	27.4	27.3	27.2	26.9	26.6	26.1	26.2	26.5	26.8	26.9	27.2

AFIAMALU (750 metres above sea level)

Table 1.7.2 Annual rainfall and temperature for Afiamalu

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rain mm	787.5	735	551.2	370.7	394.6	208.1	193.2	168.8	226	353.1	387.8	601.6
Temp°C	22.4	22.4	22.6	22.5	22.1	21.8	21.3	21.2	21.5	21.9	22.1	22.3

ASAU (4 metres above sea level)

Table 1.7.3 Annual rainfall and temperature for Asau

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rain mm	459	355	373	219	85	71	43	92	55	154	197	407
Temp°C	26.8	26.9	27	26.9	26.8	26.5	26.4	26.3	26.5	26.6	26.7	26.7

ASAU FORESTRY (130 metres above sea level)

Table 1.7.4 Annual rainfall and temperature for Asau forestry

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rain mm	517.4	493	471.9	316.4	192.1	99.4	89.9	84.6	104.5	213	291	447.5
Temp°C	25.9	26	26.1	26	25.9	25.6	25.5	25.4	25.6	25.7	25.8	25.8

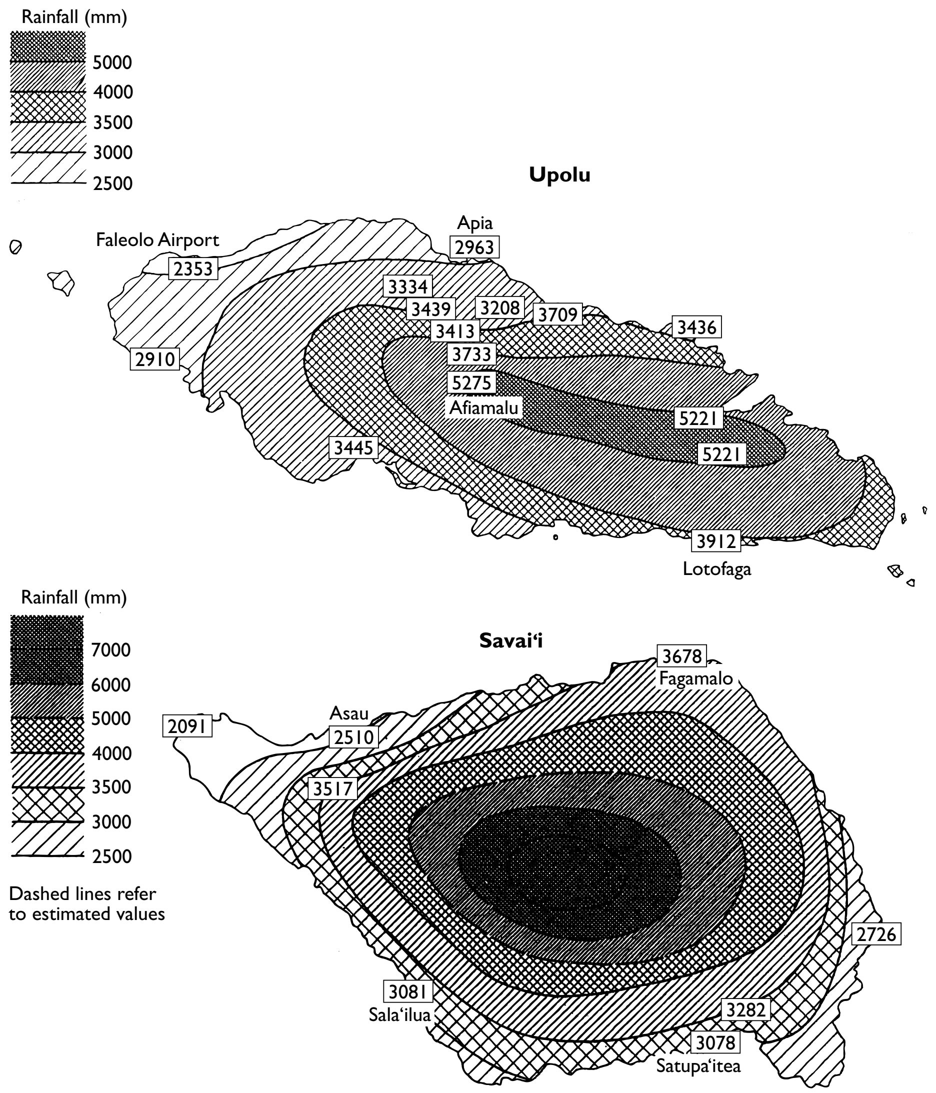


Figure 1.7.1 Upolu and Savai'i rainfall

Source: The Climate Section – Meteorology Division, of the Sāmoa Ministry of Agriculture, Fisheries and Meterology.

Learning Activities

Choose either Upolu or Savaiʻi. Construct climographs for each of the climate stations for which data has been given. After you have drawn them, answer these questions.

1 How are the patterns for temperature (i) the same and/or (ii) different? Give reasons for your answers.

2 How are the patterns for rainfall (i) the same and/or (ii) different? Give reasons for your answers.

3 Study the maps of rainfall distribution for Upolu and Savaiʻi carefully.

- ❑ Why is rainfall on the north-west coast of Savaiʻi the lowest?
- ❑ Why is the rainfall at the centre of Savaiʻi so high?
- ❑ Write generalisations to describe the rainfall patterns for each island.

Tokelau Islands

The climate of the Tokelau Islands group is described as 'tropical, moderated by trade winds from April to November'. What does moderated mean? How do the South East Trade Winds moderate the climate of the Tokelau Islands?

Table 1.7.5 Climate data for the atoll of Fakaofo, Tokelau

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rainfall mm	366	272	227	178	192	182	174	171	186	207	246	323
Temp°C	28	29	29	28	28	29	28	26	28	29	29	29

Source: Craig Thompson, 1987, 'The Climate and Weather of Tokelau', Miscellaneous Publication, New Zealand Meteorological Service 188 (4).

- ❑ December and January are the wettest months of the year.
- ❑ 60% of the total annual rain falls between October and March.
- ❑ There is a lack of variation with air temperatures.
- ❑ Temperatures are relatively uniform all year round.

Learning Activities

1 Use the climate data to construct a climate graph for this atoll of the Tokelau Islands. Compare this climate graph with the one you have drawn for either Upolu or Savaiʻi. Write a paragraph describing any similarities and differences. In that paragraph, account for any differences that you observed.

FQ 3

Relief

Study the topographic maps and the series of photographs that are in the colour section of this textbook. You will be doing learning activities that will develop some of your mapping skills and your interpretation (maps and photographs) skills. Your teacher will be providing you with activities to help you to make comparisons between these specific high and low islands.

Part 2

Population And Settlement

The aims of this strand of geography learning.

Students will recognise and understand:

- ❑ Key patterns and processes associated with population change, distribution and settlement.
- ❑ The impact of population and settlement processes on place and environment – and as they do, take a system approach to the study of settlement.

The achievement objectives of this strand at Year 12 level.

Students will demonstrate knowledge and understanding of:

- ❑ Patterns that are a consequence of the processes of population change, and the processes of population change.
- ❑ Effects of population change and population programmes on people, places and environments.

Key concepts and geographic ideas

The key concepts and important geographic ideas that we will be learning in the topics for this strand are:

Table 2.0.1 Key concepts and geographic ideas

Key Concepts	Geographic Ideas
Process	Processes vary in time and space Some processes encourage concentration, others dispersal
Pattern	Spatial patterns are the result of processes Some spatial patterns are the result of people's organisational structures (social, economic, political)
Change	People, through their decisions and actions, bring about change Some changes are predictable... and others are unpredictable Change can be viewed as good or bad (depending on people's value judgements)
Perspective	Social and cultural groups perceive and interpret their own and other environments in different ways

Introduction

Demography

The study of **population**, its composition and change is known as **demography**. It is carried out by demographers. Geographers are particularly interested in the aspects of demography that relate to places. They seek answers to *where?* questions.

- ❑ Where is a population located? Why there?
- ❑ Why is a population in this place different from a population in that place?
- ❑ Why do people living here have better living standards than people living there?

Before a population can be studied by either a demographer or a geographer, information about that population needs to be collected. The main source of data for any population is known as a **census**.

The World's Population

Figure 2.0.1 High density living in Bangladesh

Figure 2.0.2 High density living in Hong Kong

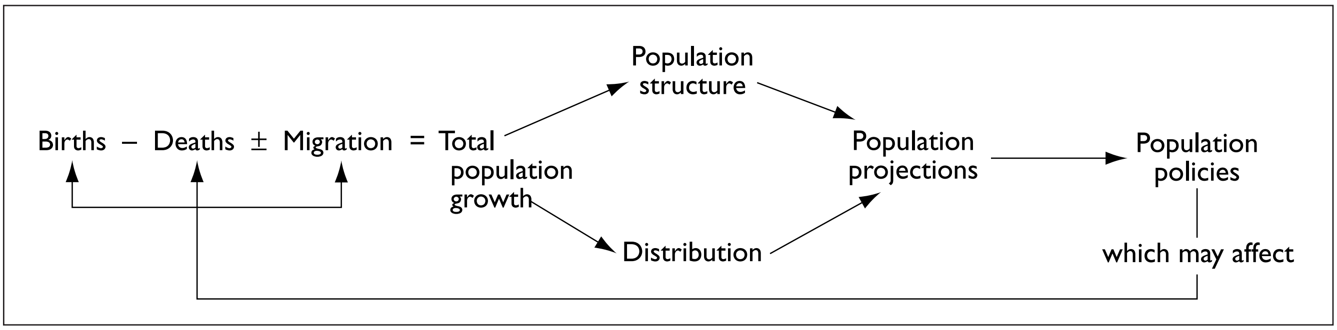


Figure 2.0.3 Population planning

If the rate of present world population growth had been the same since the birth of Christ, there would now be 900 people to every square metre of land. People would be queuing for places in skyscrapers 1.6 km high!

At this moment, there are probably 500 more people in the world than one hour ago. Today there are probably 12 000 more people in the world than yesterday. In less than 40 years, the world population will have doubled itself.

It is estimated that on 11 July 1987 the world population reached 5000 million (5 billion). This was for many people 'A day to celebrate – a day to contemplate'. By the year 2002 the world population was about 6250 million. Recent estimates show the world population passing the 11.6 billion mark by the year 2150.

The world population is obviously growing at a rate that cannot continue without serious consequences. Many of the world's other pressing environmental problems are the result of overpopulation.

- 80% of deforestation results from overpopulation.
- The rapid spread of deserts and the need for irrigation results from overpopulation.
- Most pollution results from the inability to process wastes from increasing populations. A doubling of world population will increase nitrates in all rivers by an average of 55%.
- Many of the creatures that humans share the Earth with are threatened by the rapid human **population explosion**.

Counting in some (more developed) countries is becoming more difficult as people protest about governments knowing too much about them. Protesters object to governments having that sort of information, saying that it may make governments too powerful and able to control people too much. West Germany has been trying to hold a census since 1980, but has had to postpone it twice because of protests. The Dutch Government has also faced protests and now has no plans for holding a census in the future.

There are three methods of counting the population:

- **Census.** These have been taken, mainly for tax reasons, for centuries, but only since the late 18th Century have modern population censuses been taken accurately (e.g. USA 1790, Britain 1801). Many countries have conducted their first censuses only recently (e.g. Ethiopia and Zaire 1984). China conducted major censuses in 1953, 1964 and 1982, but only released the first population figures, accounting for 22% of the world population, in 1979.

- **Registration.** Many countries require that all births, deaths and marriages are registered with the government. In many parts of the world, these records are kept by religious organisations. These are useful for predicting population growth but are generally not thought to be accurate. Steps are being taken by **international agencies** to help poorer countries to improve methods of registration.
- **Sample surveys.** Small parts of a country's population are selected and surveyed closely. The results are then applied to the whole country. Properly done, this can be a very accurate method and is often used by governments to make policy because it is quick and cheap.

Figure 2.0.4 Map of the world showing the world sex ratio. (the surrounding images show different people from around the world in their own living conditions)

Population Structure

Physical

In addition to studying the numbers of people, past, present and future, **demographers** also examine how the population is made up. This is called **population structure**. Populations are made up of people of different ages, **races**, **gender** (or sex), **religion**, occupation or education level. Some of these factors are **physical** and cannot be changed, and others are **cultural** and can be changed. This unit will consider the age, sex, racial structure and religion of the world's population.

Key Words

religion
cultural
ethnic
gender
dependent
population structure
race
anthropologists
demographers

Age Structure

Demographers divide populations into three main groups: those under 15 years, those between 15 and 64, and those aged 65 and older. The reason for these divisions is related to the idea that those aged between 15 and 64 usually work to support the rest of the population. Those outside this age group are known as the **dependant** population group.

In 2001, it was estimated that 63% of the world's population was in the working age group. Table 2.0.2, shows that in some areas of the world, such as Africa, large proportions of the populations are aged under 15. Other areas, such as North America, have larger older dependent populations. In the next 50 years, the world will witness a change from having a large young population to having a large older population. The median age of the world population is predicted to rise from 26.5 in 2000 to 32 by 2025. This will be caused by recent high birth rates dropping rapidly and people living to a greater age.

Table 2.0.2 Age structure of global regions 2001

Region	Percentage of world population	Age groups as percentage of population		
		<15	15–64	>64
World	100	30	63	7
Africa	13	43	54	3
Latin America	9	32	63	5
North America	5	21	66	13
Asia	58	30	64	6
Europe	14.5	18	67	15
Oceania	0.5	25	65	10

Sex Structure

The number of males and females is usually compared using the ratio number of males to every 100 females. In 2002, the world sex ratio was 101.01. This means that there were 101.01 males for every 100 females. In 2025, there are expected to be 100.6 males to every 100 females.

Figure 2.0.4 shows the world sex ratio pattern. It is clear that Asia has a far greater proportion of males in the population. This is because males generally have a higher social status, especially as children. For 20 years, China has had a policy of one child per family. Many parents want that child to be a baby boy because he will look after them when they are old and keep the family line going. It is estimated that so many baby girls have been killed that today China is missing 50 million girls.

Population Rates Of Change

Key Words

death rate
birth rate
natural increase
rate of change

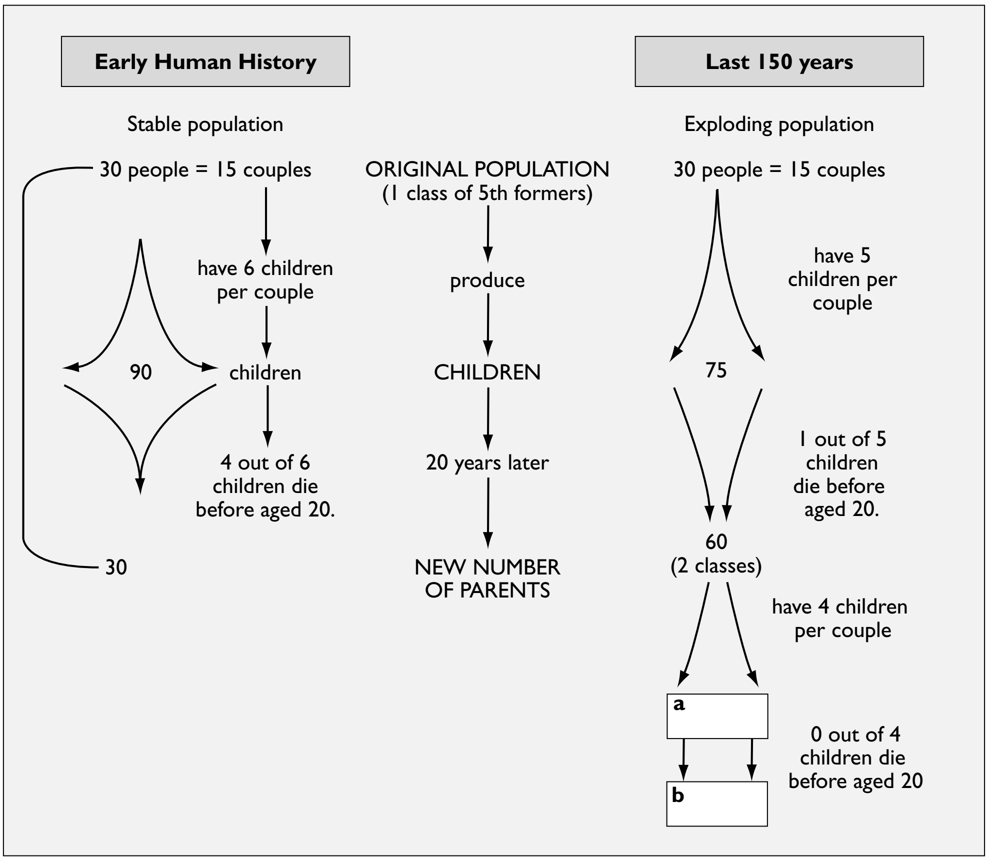


Figure 2.0.5 Changes to the world population

For the majority of human history, the population has increased at a very slow rate. In the last 150 years, it has increased very rapidly. Asia is the region adding the most people to the world's population. Up to the year 2000, it was expected to add nearly 40 million people a year and, up to 2025, it will add about 33 million a year.

World population increases or decreases according to how the **birth rate** and **death rate** compare. Figure 2.0.6 shows that when the birth and death rates are about equal the population will stay about the same. The world population has 'exploded' because the death rate has fallen much more quickly than the birth rate.

Figure 2.0.5 is a model designed to show what happens to a population, about the size of one school class, when the death rate falls very quickly and the birth rate falls slowly.

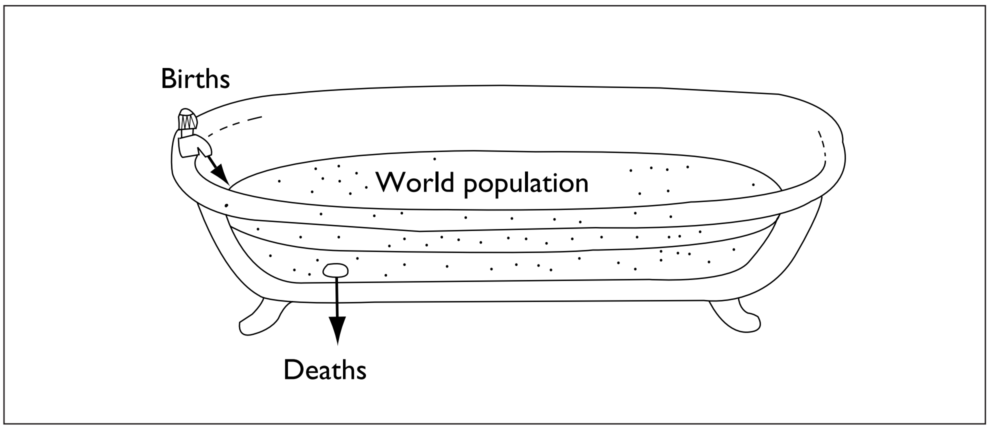


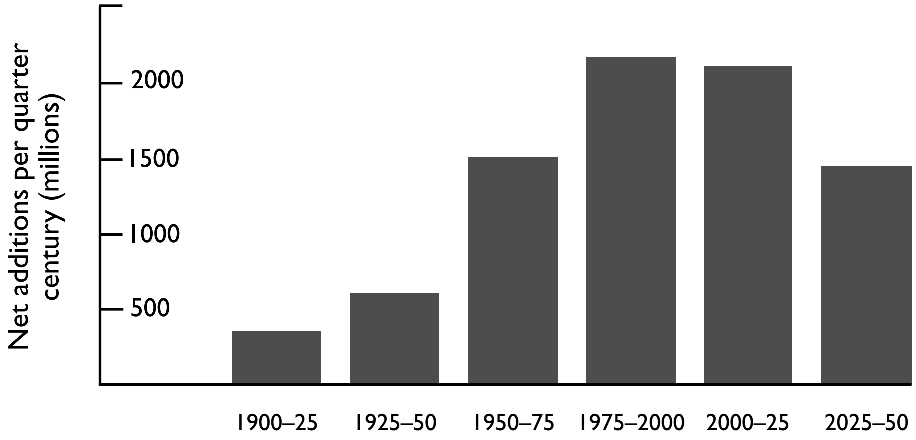
Figure 2.0.6 Births, deaths and world population

Table 2.0.3 Birth Rates for Selected Countries 1991–2001

Country	Crude birth rate: 1987 live births per thousand	Crude birth rate: 1991 live births per thousand	Crude birth rate: 2001 live births per thousand
China	21	23	16
India	33	31	24
Indonesia	31	28	22
Brazil	29	27	18
Bangladesh	44	43	25
Pakistan	44	43	31
Nigeria	46	46	40
Thailand	29	24	16
South Korea	20	20	15
Hong Kong	14	13	11
Nepal	42	40	33
Sri Lanka	25	21	17
Kenya	52	51	29
Uganda	50	49	47
Peru	35	29	24
Mexico	31	30	23
UK	13	13	11
Netherlands	12	13	12
Germany	10	11	9
France	14	14	12
USA	16	15	14

Sources: World Population Data Sheet, Population Reference Bureau

Table 2.0.3 shows how birth rates have fallen in most countries of the world. Because there are still very large numbers of children to reach adulthood (30% of the world's population is aged under 15), there will still be rapid growth of world population for some time yet. In the period from 1975 to 2000, Figure 2.0.7 shows that 210 million people were added to the world population. In the following time period, world population will still grow by more than 200 million, but by fewer than in the previous period. The rate of increase will have slowed.



Source: UNFPA *Annual Report*

Figure 2.0.7 Net additions to world population 1900–2050

The world's population is not growing at the same rate in all parts of the world. Some regions are growing more than three times faster than others. This is mainly because the number of children who die in their first years has been reduced, but people in some parts of the world are still having large numbers of children. The darker areas in Figure 2.0.8 show where there are many more births than deaths (natural increase). The lighter areas show where the birth rate has dropped to match a lower death rate.

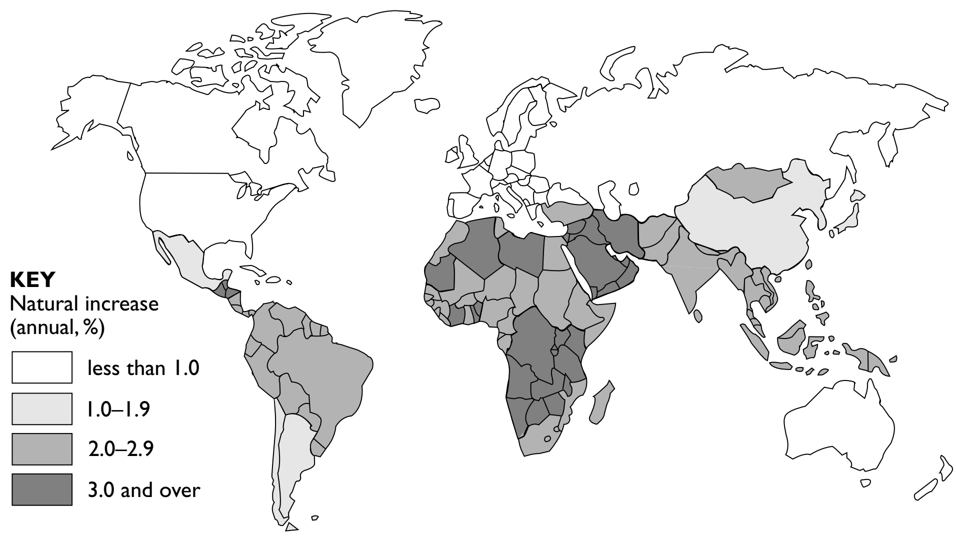
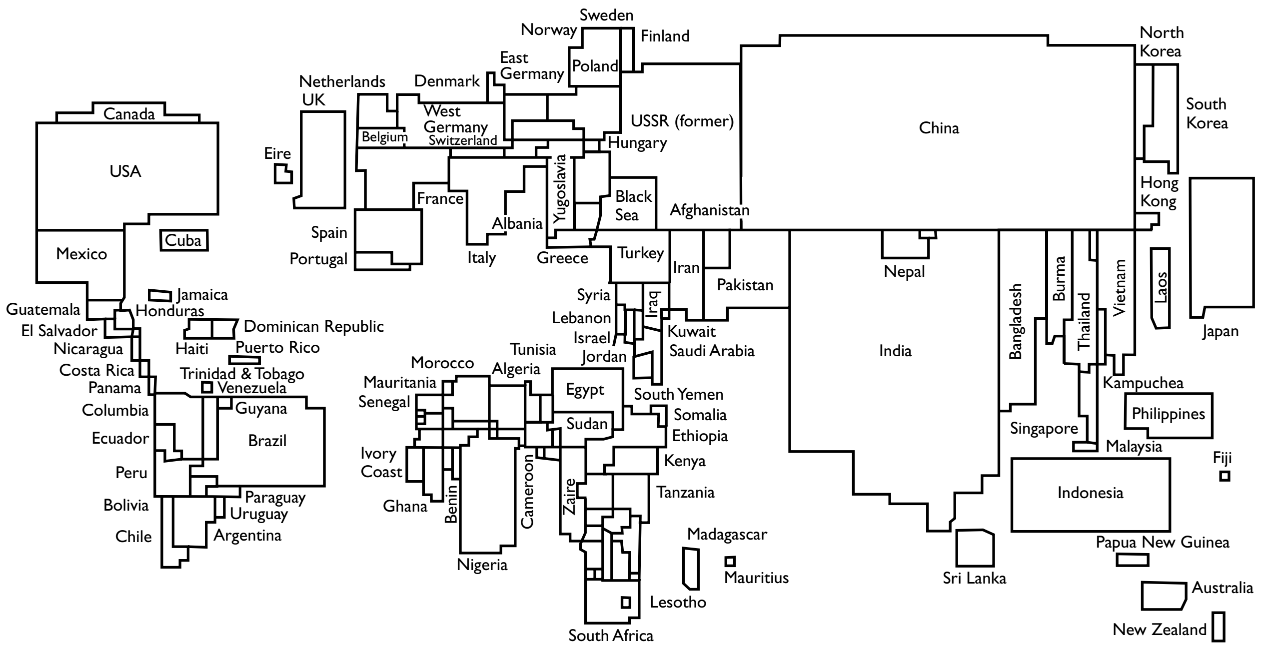


Figure 2.0.8 World population growth rates

Global Population Distribution

World Population Distribution (in the 1980s)



Some of the countries on this map, e.g. Yugoslavia, no longer exist. Refer to a recent Atlas of the World for current information of the nations of the world, and population patterns.

Figure 2.0.9 World population distribution

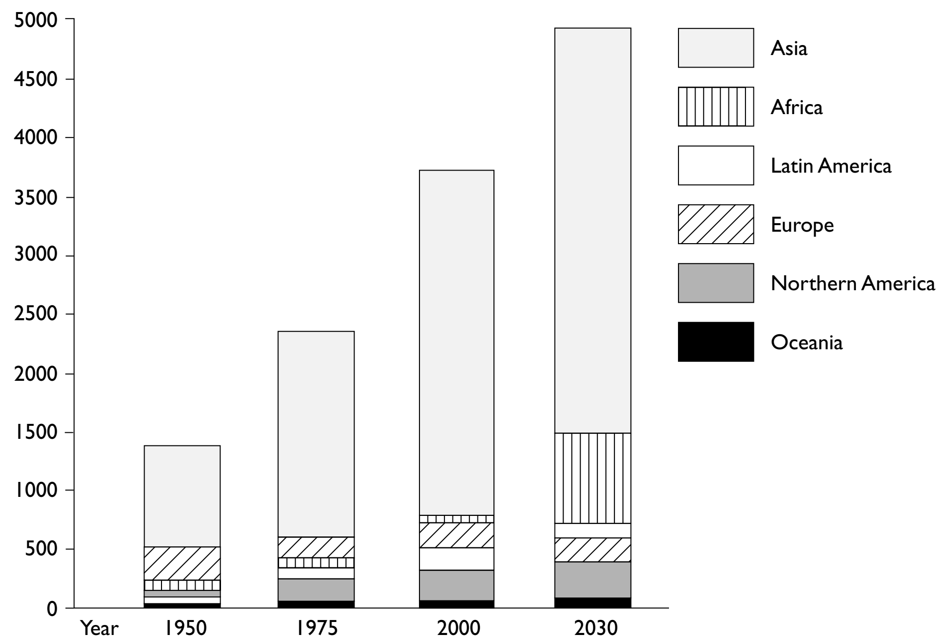


Figure 2.0.10 Percentage distribution of world population by major areas

Figure 2.0.9 shows the population of the countries of the world. The size of each country has been changed to represent the number of people in that country rather than the amount of land it occupies. Some small countries with large populations appear larger than on a conventional world map such as Figure 2.0.8. Other countries with large uninhabited areas appear smaller than usual.

The most obvious pattern shown on Figure 2.0.9 is the large size of China and India and some of the other Asian countries. During the second half of the 20th Century there was a shift of population from the developed world to the developing. Assuming that most developed countries are in Western and Eastern Europe and North America, Figure 2.0.10 shows that a greater percentage of the world's population is living in Asia and Africa each year. This is because the developing countries are growing much faster. In 1950, 67% of the world's population lived in the developing world. By 1980, it was 74% and, by 2025, 83% will live in the developing world.

Figure 2.0.11 World population density

Figure 2.0.11 is the most common type of map used to show where the world population lives. One pattern shown on this map is the large number of people who live near the sea and the smaller number who live inland. Another pattern is that most of the world's population live between 60° north and 40° south (**latitude**).

Why Are People Located Where They Are?

In general, there are limits to the areas in which humans can live. A lack of oxygen at high altitudes restricts settlement to below about 5000 metres **altitude**. Humans can tolerate temperature extremes from about –5°C to 40°C with proper preparation, although normally temperatures between 10°C and 30°C are best. More importantly, people live where they can get the best food.

The greatest concentrations of population are in areas of best plant growth, i.e. flat land, fertile land, warm and wet climates. These areas support more people and so become centres of large populations. The best examples of these are the Ganges river delta and the three major rivers in China.

Cultural factors such as competition for resources, wars and trade force people to **disperse** from these areas.

Population Movement – Migration Patterns

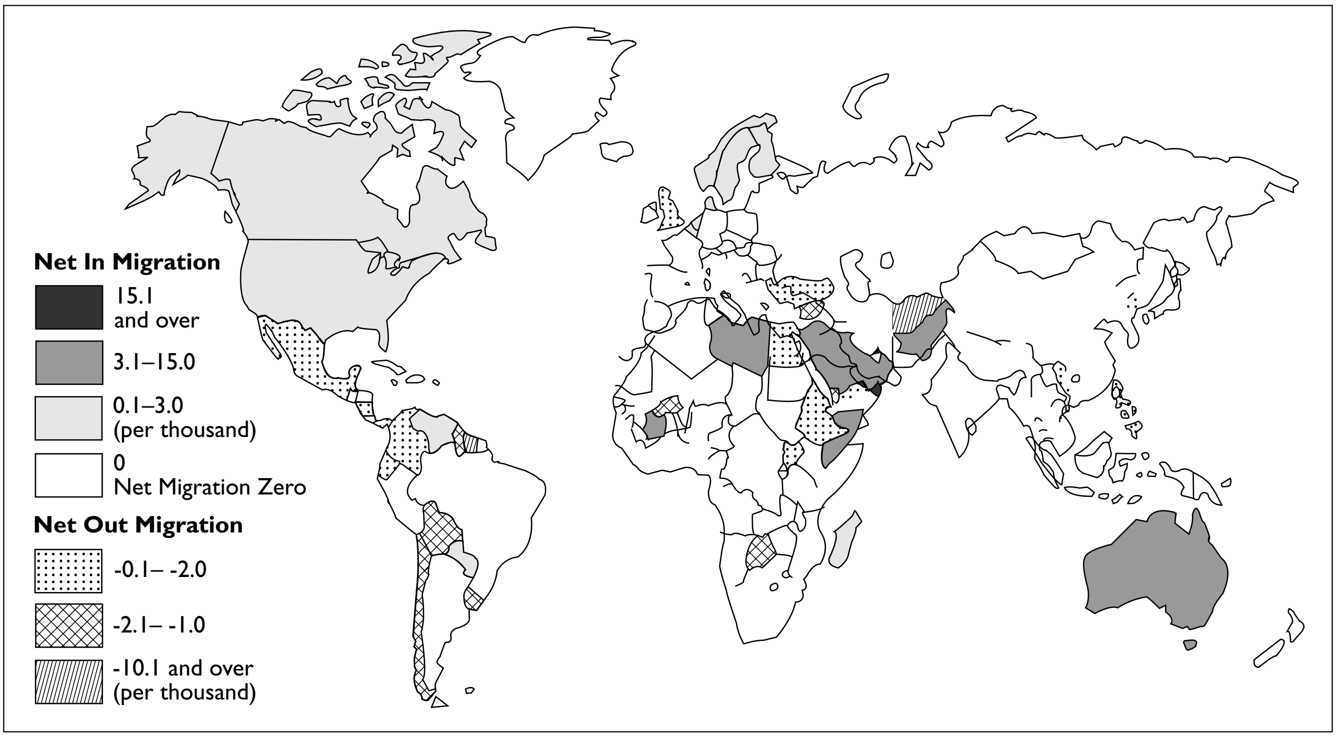


Figure 2.0.12 World annual net migration rates

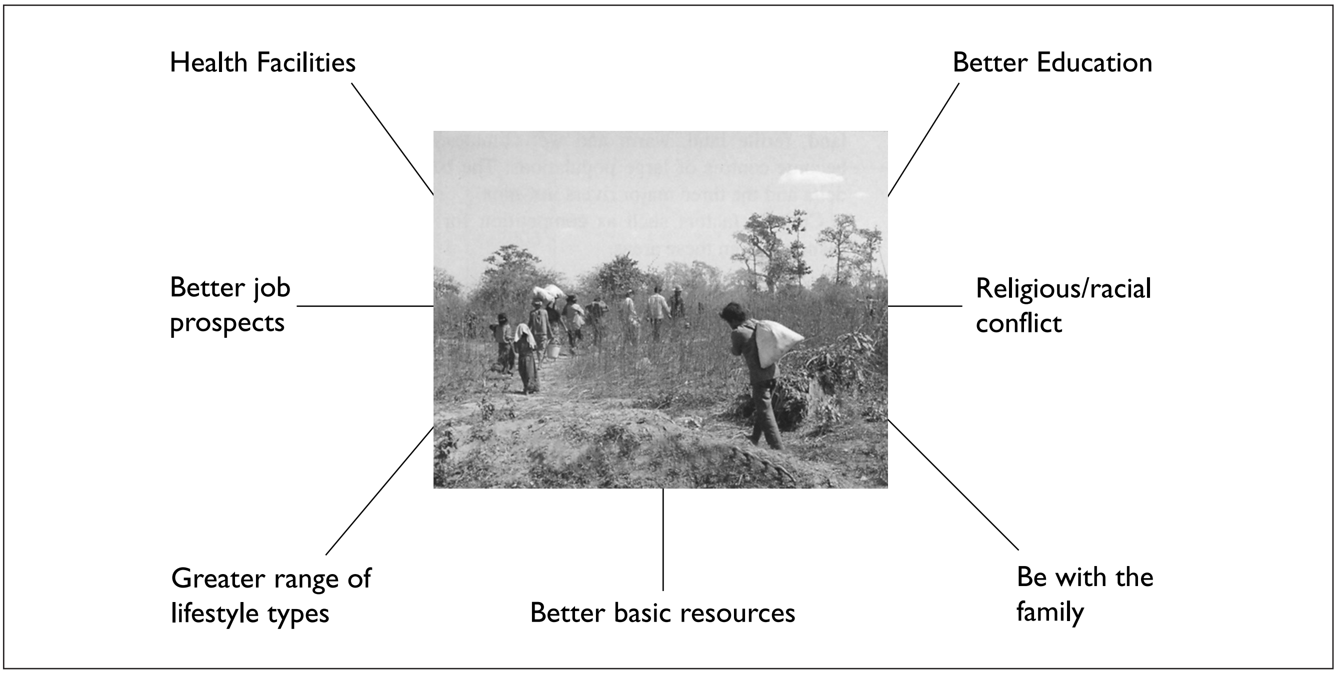


Figure 2.0.13 Reasons for migration

Figure 2.0.13 shows reasons why people migrate. Patterns of **migration** are determined by where people *are able to move to*. This idea is known by geographers as **accessibility**. Some countries allow foreigners in more easily than others. Some countries take in refugees simply because they are neighbours to countries with problems of human suffering. Accessibility can depend on regulations, location or the fact that relatives or friends have already moved to another country.

There are two basic patterns of world migration:

- **From poorer to richer countries**. The Middle East has recently become very wealthy and at the same time has a shortage of labour. An unskilled worker from Bangladesh can earn up to 10 times as much in a rich Middle East country than at home. Also a skilled worker from a poorer Eastern European country that used to be Communist, such as Hungary or Czechoslovakia, can earn four or five times as much in a Western European country such as Germany or France.

These differences make people migrate.

- **From countries involved in conflict to more peaceful areas**. In 2002, some 4.5 million people from Afghanistan conflicts were refugees in other countries. Most had fled to Pakistan, itself already overpopulated. Vietnamese boat people refugees caused massive strain on Hong Kong social services until Hong Kong refused to accept any more.

In recent years, large numbers of refugees have moved out of Bosnia and parts of Africa.

Unit 1 Population Of New Zealand

Learning Outcomes

At the end of this unit you should be able to:

- ❑ Describe the processes of natural increase and migration with reference to theories (in terms of New Zealand).
- ❑ Compare and contrast patterns in these processes with other countries, e.g. Sāmoa.
- ❑ Identify and describe specific population changes in New Zealand.
- ❑ Describe the effects of these changes on different places, environments and people.
- ❑ Evaluate the effects of these changes from a range of perspectives.
- ❑ Explore the effects of population programmes on different people, places and environments.

Historical Overview

It is not possible to fully understand New Zealand's present population geography without understanding the history of its main ethnic groups.

Figure 2.1.1
Maori carving

Tangata Whenua

- ❑ Maori are the descendants of migrants who sailed to New Zealand from **Polynesia** about 700 years ago. As decendants of New Zealand's first permanent settlers, they are also known as **tangata whenua**.
- ❑ Only a little over 200 years ago, all New Zealanders (estimated at about 150 000) were Maori, but by 1896 less than 6% of New Zealand's population were Maori.
- ❑ Maori numbers rapidly declined after the arrival of Europeans. The introduction of guns, the spread of new diseases and the loss of most of their land were the main causes of Maori population decline.
- ❑ Since 1900, the Maori population has been increasing, and the 2001 census recorded over 500 000 people as Maori (14.2% of the total population).

- A Maori cultural revival began in the 1960s and 1970s, with prominent writers and artists achieving widespread and international acclaim. In the late 1970s and early 1980s, Maori set up *kohanga reo* (preschool 'language nests') to save their language. Considered a key to the survival of Maori culture, *Te Reo Maori* is now recognised as an official language of New Zealand.

Figure 2.1.2 Tangata whenua

- Maori culture now has greater official recognition in New Zealand.

  All government organisations have to adopt the principles of partnership originally established by the Treaty of Waitangi in 1840.

  Since the 1980s, New Zealand has started to address long-held, and justified, grievances of Maori throughout the country. Some 'Treaty settlements' are restoring unfairly taken land to its original iwi owners. In other cases, non-land assets are paid as compensation.

  Symbols of Maori culture are used with pride to promote New Zealand overseas.

- Despite these advances, Maori as a whole do not share the benefits of *Kiwi* life to the same extent as Pakeha. Maori, now mainly living in towns and cities, are still generally poorer, less highly educated, less healthy and more likely to be imprisoned than other New Zealanders. In some respects, Maori are trapped on the wrong side of the growing gap between rich and poor in New Zealand.

Europeans

- Most European New Zealanders have British ancestry, but a Dutchman, Abel Tasman, was the first European to sight and name New Zealand in 1642. It wasn't until after Captain Cook's visits between 1769 and 1775 that New Zealand attracted significant British attention. Early interest was focused on extracting seals, whales, timber and flax.

Figure 2.1.3 Government Gardens, Rotorua

- British missionaries followed the sealers and whalers, collecting converts to Christianity. Permanent European settlers were few until after the signing of the Treaty of Waitangi in 1840, when New Zealand became a British **colony**.
- Settlers' demand for land, and Maori determination not to sell, resulted in the North Island's 'land wars' of the 1840s and 1860s. From 1865, British military, economic and political power ensured rapid alienation (confiscation and purchase) of Maori land.
- British colonial society in New Zealand held on to many of the 'mother' country's traditions, but left behind the worst aspects of Britain's rigid class system.
- As European settlement increased, gold mining, sheep farming and, after the invention of refrigeration, dairying dominated the economy. From the 1950s, manufacturing industries grew rapidly. By the end of the 20th Century, most European New Zealanders were living in urban areas and earning a living in service industries.
- In 1907, New Zealand became a *dominion* rather than a British colony, but the Britishness of its majority culture was not really challenged until the 1960s and 1970s. As trade and cultural links with the 'mother' country declined, many European New Zealanders saw themselves as a distinctive *Pacific* people.

- However, by the end of the 20th Century New Zealand's *head of state* was still the British queen, the British *Union Jack* still occupied a quarter of New Zealand's flag, and Britain was still providing more new settlers than any other country. New Zealand's dominant culture was still remarkably British.

Figure 2.1.4 Cricket in New Zealand

Tangata Pasifika

Figure 2.1.5 Church

- After a gap of about 700 years, New Zealand's second wave of Polynesian immigration began in the 1950s, and reached its peak in the 1970s. The 2001 census revealed that just over 200 000 Pacific Islanders, **tangata pasifika**, were living in New Zealand.
- New Zealand's Pacific Island population has its origins in New Zealand's own colonial actions. Between 1901 and 1948, New Zealand gained control over the Cook Islands, Niue, Sāmoa and Tokelau. With the exception of Sāmoa, the people of these island nations were given the rights of New Zealand citizens.

Table 2.1.1 Pacific Island origin

Pacific Island Origin	NZ Population 2001
Sāmoa	114 435
Cook Islands	52 227
Tonga	40 713
Niue	20 148
Tokelau	6204

Figure 2.1.6 Pacific island clothing store

- Migration to New Zealand became an attractive option in the 1960s and 1970s when New Zealand's growing manufacturing industries were short of workers, and natural hazards, rapid population growth and failing economies were making life difficult in the Pacific.
- New Zealand's Pacific Island population has retained its strong church and extended family culture. Despite a sometimes less than welcoming reception in New Zealand, Pacific Island New Zealanders are making a significant contribution to New Zealand's emerging Pacific identity through sport, art, writing, food, fashion and design.

Town And Country

Figure 2.1.7 Auckland City

New Zealand has an international reputation for farming, but its people are among the world's most urbanised. Since 1911, over 50% of the population has been urban. Since 1976 about 85% of the population has been urban.

Table 2.1.2 International urbanisation

Country/Region	2000 Population (million)	2000 % Urban
United Kingdom	59	90
New Zealand	3.7	86
Australia	19	85
Japan	127	79
North America	314	77
Europe	727	75

Urbanisation, combined with the attraction of new migrants to its largest cities, has seen the development of a distinctive lifestyle in New Zealand's main urban centres – multicultural, fast moving, technologically advanced and rapidly adopting the café and apartment culture of Europe and America.

Age And Sex

New Zealand has slightly more females than males. This is mainly because women tend to live longer than men.

NZ male life expectancy = 75.7
NZ female life expectancy = 80.8

New Zealand's population is aging. This means that the percentage of people aged 60 and over is increasing.

The age-sex structure of a population can be presented as a **population pyramid**. This is a special kind of horizontal bar graph that divides the population into five-year age groups and separates males from females. In an aging population, the upper levels of the pyramid grow at the expense of lower levels.

Figure 2.1.8 A sample of the New Zealand population

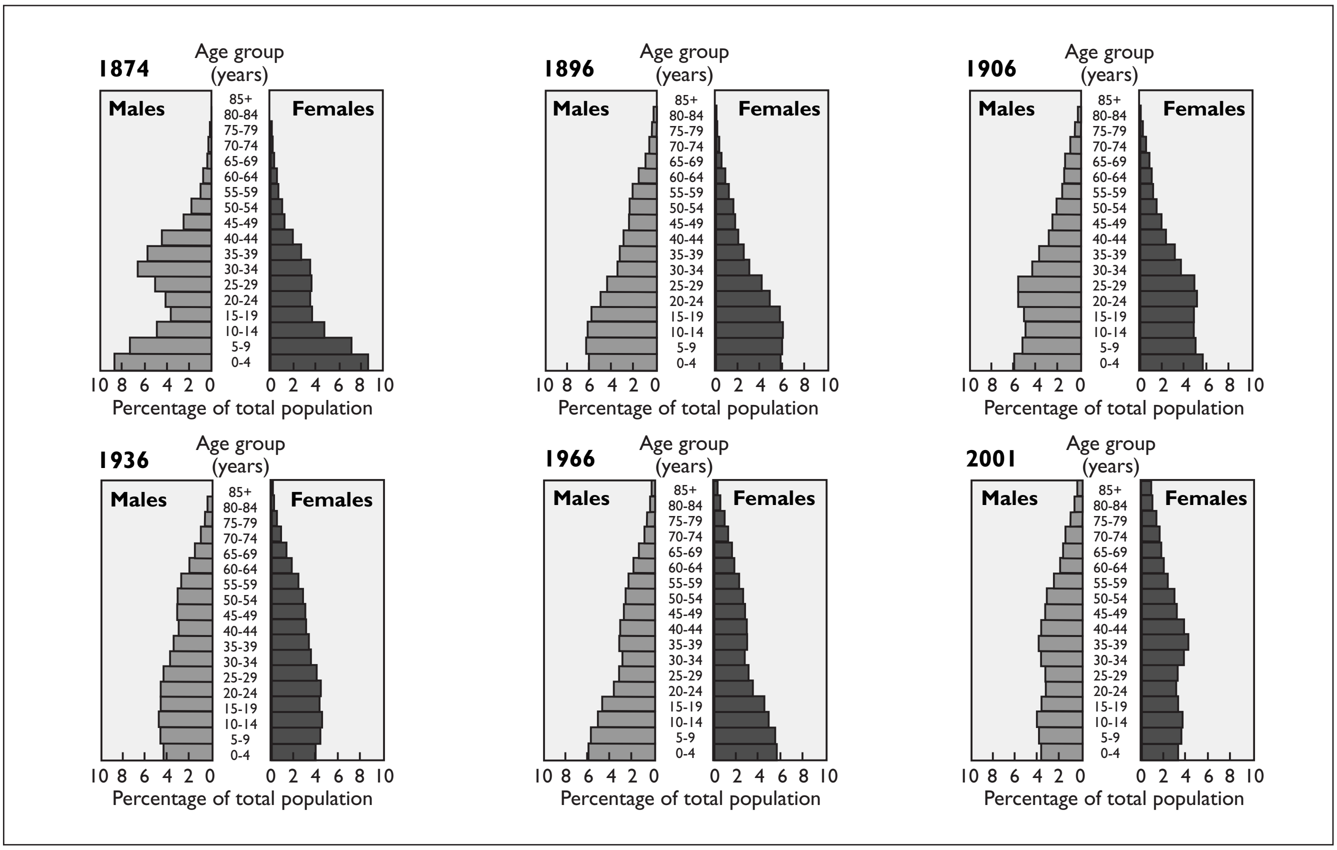


Figure 2.1.9 Population percentages

New Zealand's age-sex structure has changed markedly since Europeans started settling there. In 1858, there were 130 males for every 100 females. This was typical of colonial *frontier* societies in which the emphasis was on hard, physical labour and *breaking in* the land. It wasn't until 1971 that there were more females than males. Today there are 97 males for every 100 females.

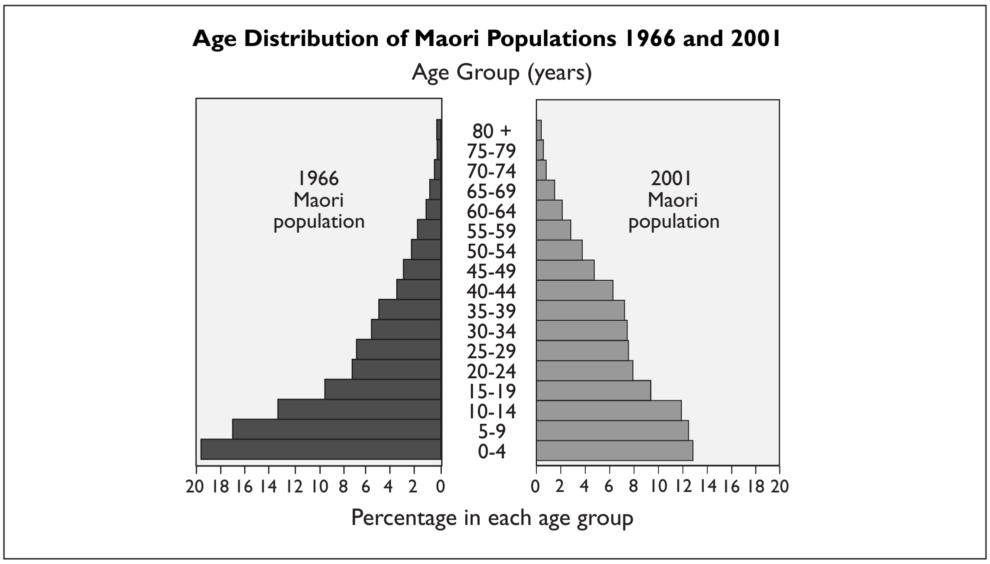


Figure 2.1.10 Age distributions of Maori populations 1966 and 2001

The Maori population has always been more youthful than the European population, but now it, too, is aging.

Key Points Summary

- ❑ New Zealand's population is counted by official census every five years.
- ❑ The census provides statistical data used in planning for the future.
- ❑ New Zealand's population is becoming increasingly multicultural.
- ❑ People of British descent are still dominant, but a Pacific identity is emerging.
- ❑ New Zealand is a highly urbanised society.
- ❑ New Zealand has an aging society.
- ❑ New Zealand is no longer an egalitarian society. The gap between rich and poor is widening.

Population Growth

Table 2.1.3 Selected annual population growth figures

Year	Population on 1 January	Population on 31 December	Growth	Calculation	Annual growth rate (%)
1901	796 359	808 132	11 773	11 773/796 359 x 100	1.48
1951	1 927 700	1 970 500	42 800	42 800/1 927 700 x 100	2.22
1977	3 163 400	3 166 400	3000	3000/3 163 400 x 100	0.09
1996	3 688 700	3 743 400	54 700	54 700/3 688 700 x 100	1.48
2001	3 832 900	3 855 400	22 500	22 500/3 832 900 x 100	0.59

Annual population growth rate = percentage increase in one year

New Zealand's population increased by about three million during the 20th Century, but the rate of growth was not steady. There are several trends:

1900–40	Fluctuating growth rates.
1945–65	Baby boom – high growth rates after World War II.
1965–90	Declining growth rates.
1990–	Increasing growth rates once more.

A population can grow in two ways: either by producing its own growth (natural increase) or by bringing people into the country (migration).

Apart from the baby boom years, New Zealand's natural increase rate has been steadily declining since 1900. Changes in population growth rates have been influenced more by migration, which has had many dramatic ups and downs.

Figure 2.1.11 New Zealand's changing population

Natural Increase

Apart from the postwar baby boom (1945–65) and its 'echo' a generation later, New Zealand's birth rates and **fertility rates** have been in decline since 1880.

There are several reasons for this:

- ❑ **urbanisation** – smaller families are more convenient in towns and cities
- ❑ **contraception** – more available and accepted
- ❑ **lifestyle** – more families have two working parents and have children later.

The smaller *echo* boom occurred in the early 1990s as baby boom babies of the 1960s started having their own children.

New Zealand is likely to follow the European trend of birth rates falling below **replacement levels**. Several European countries (e.g. Italy, Russia) are now experiencing zero or negative population growth.

Death rates have been slowly and steadily declining (except during war years).

- ❑ **Birth rate** – number of births per 1000 people.
- ❑ **Death rate** – number of deaths per 1000 people.
- ❑ **Natural increase** – births minus deaths.
- ❑ **Fertility rate** – number of births per woman of child-bearing age (19–49 years).
- ❑ **Replacement levels** – the fertility rate required to replace those that die each year.

On average, New Zealanders are living longer than ever before thanks to better living standards, advances in medical knowledge and technology, and welfare state health services. The average (median) age of New Zealanders was 20 years in the 1880s, 34 years in 2001, and is expected to reach 46 years in 2051.

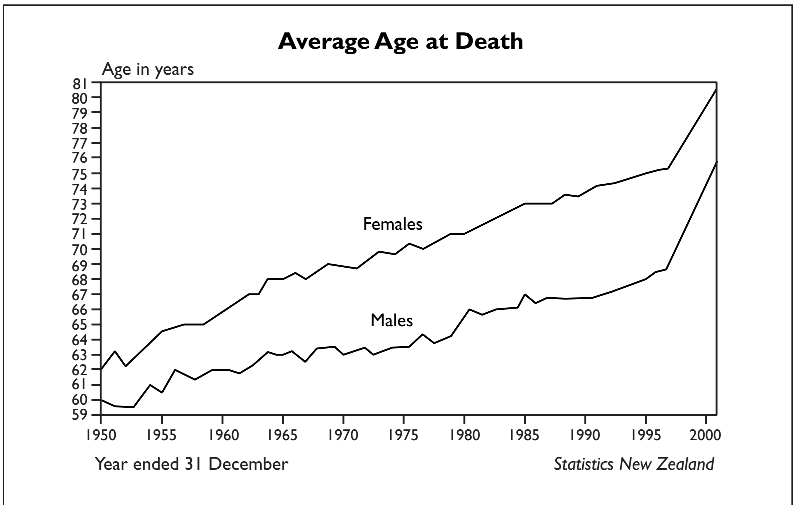


Figure 2.1.12 Average age at death

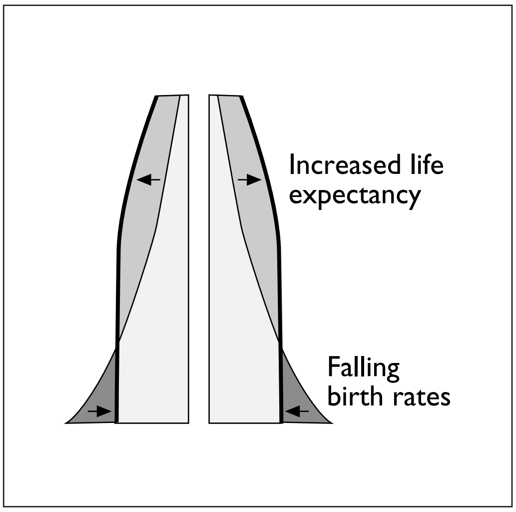


Figure 2.1.13 Population pyramid

Each of these changes affect the shape of a population pyramid.

Dependency

It is important to keep in mind that as people get older they move up through three levels of a population pyramid.

- ❑ **children** (0–15)
- ❑ **working-age** (15–65)
- ❑ **elderly** (65 and over)

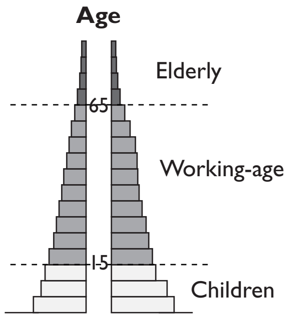


Figure 2.1.14 Three levels of the population pyramid

Children and the elderly are known as **dependants**. The proportion of dependants to the working-age population is known as the **dependency ratio**.

For many years, New Zealanders accepted that children and the elderly could **depend** on the support of working-age people. Taxes paid on their incomes paid for health care, education and pensions for the elderly. As each generation moved up through the 'population pyramid', they had their turn at providing for dependants.

Providing For The Elderly

Figure 2.1.15 Meals on wheels (this is a service for elderly people who live alone. Someone brings their meals to their home)

Different cultures treat and provide for their elderly in different ways. Here are some examples:

- ❑ The older you are the higher your status in society.
- ❑ Old people are out of touch with the modern world.
- ❑ Families are responsible for their elderly.
- ❑ People need to look ahead, not look after the elderly.
- ❑ Elderly people have great experience and wisdom.
- ❑ Elderly people should live with their extended families.
- ❑ Elderly people are the responsibility of the government.
- ❑ The elderly should live in retirement villages, or 'old folks homes'.
- ❑ The elderly should look after themselves.

New Zealand is a multicultural society, and all of the above can be found there to some extent. Overall, it would be fair to say that, since the establishment of the welfare state in the 1930s, most New Zealanders have grown up expecting the government (funded by taxpayers) to provide for them in their old age.

Problems Facing An Aging Population

When the *baby boom* generation reaches retirement age, there will be a dramatic increase in the proportion of elderly people. By 2051, 26% of New Zealanders are expected to be over 65 years of age. The decrease in child dependency will not be sufficient to compensate.

With improved (but expensive) medical care, New Zealanders can expect more years of old age than ever before. Who will pay the increasing medical bills?

As women generally outlive men, many women face the loneliness of old age without the company of their husbands. Who will look after them?

Is it fair to assume that a smaller working-age population will provide for a much larger dependent population?

Table 2.1.4 Population features

Population features	2001	2031 (estimated)	2051 (estimated)
Children	23%	17%	16%
Working-age	65%	61%	58%
Elderly	12%	22%	26%
Dependants	35%	39%	42%
Dependency ratio	0.54 (35/65)	0.64 (39/61)	0.72 (42/58)

Migration

Table 2.1.5 Examples of annual natural increase in New Zealand

Year	Births	Deaths	Natural Increase (births – deaths)	Birth Rate (births per 1000)	Fertility Rate
1930/31	28 822	13 145	15 677	19.06	2.56
1960/61	62 779	20 892	41 887	26.95	4.31
1975/76	56 639	25 114	31 525	17.60	2.27
1995	57 791	27 960	29 831	16.14	2.04
2001	55 799	27 825	27 974	14.47	2.01

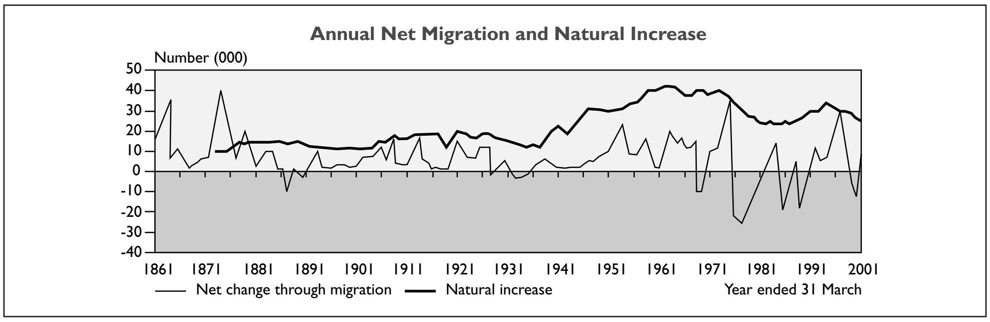


Figure 2.1.16 Annual net migration and natural increase

With falling birth rates since the 1960s, migration is becoming a more important influence on New Zealand's population growth rates.

Migration flows are affected by war, economic conditions, the cost of international travel and government immigration policy.

New Zealand's *net migration* varies considerably from year to year. It has usually enjoyed net migration gains, but in times of economic difficulty there have been net migration losses. This happened in the late 1880s, the 1930s and towards the end of the 20th Century.

Since about 1970, net migration losses have been more frequent, reflecting New Zealand's economic situation. In 1978 and 1979, net migration losses were so great they exceeded natural increase. As a result, New Zealand's population actually *decreased* for the first time ever in peacetime. (The population fell during the two world wars when thousands of soldiers left to fight overseas.)

To boost population growth, recent government policies have sought to attract greater numbers of immigrants, targetting the young (under 40 years), well educated and wealthy.

New Zealand had traditionally received immigrants from Britain and other English-speaking countries. Criticised for what was really a *whites-only* immigration policy, migrants are now sought from a wider range of countries, including Asia. In 1988, New Zealand received nearly 4000 migrants from Asia. In 2001, the number was 28 000.

The success of recent immigration policies has been reduced by:

- increased emigration, particularly to Australia, where New Zealanders have free right of entry
- political opposition in New Zealand to increased immigration from Asia
- not providing jobs for immigrants.

Migration – movement of people from one place of residence to another.

Internal migration – movement of people within a country.

External migration – movement of people between countries.

Immigration – movement of people into a country.

Emigration – movement out of a country.

Net migration – immigration less emigration.

An Aging Population

Apart from the **baby boom** years, New Zealand's population has been **aging** since 1896. This means that the percentage of elderly people (aged over 65) is increasing.

This has happened for several reasons:

- falling birth and fertility rates
- increased life expectancy (people living longer)
- emigration of young adults.

Solutions for an aging population

Between 1984 and 1999, New Zealand governments cut back on the welfare state. Debates continued about how large a role government should have in looking after the elderly. The choices are:

- Government continues to provide for the elderly
  – working-age people pay greater taxes.
- Individuals provide for their own old age
  – working-age people save a lot more for their old age.
- Families take responsibility for looking after their elderly
  – working-age people have less to spend on themselves and their children.
- A combination of two or all of the above.

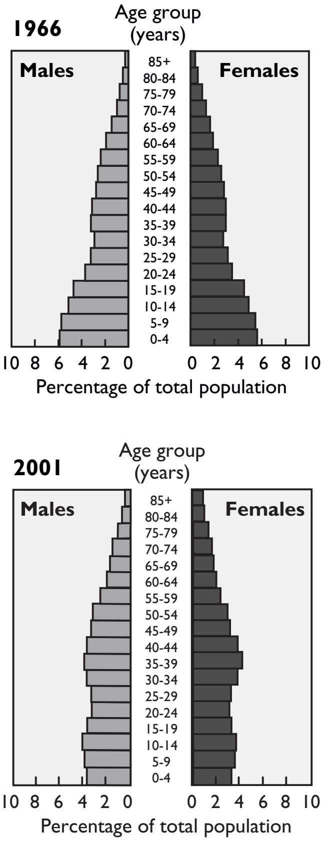


Figure 2.1.17 Population pyramids

Key Points Summary

Population Growth = natural increase + net migration

- ❑ For most of the 20th Century New Zealand's birth and fertility rates have been falling. This has reduced the impact of natural increase on population growth rates. Today, population growth in New Zealand is mainly influenced by external migration.
- ❑ At the end of the 20th Century, population growth rates were increasing in response to new government immigration policies.
- ❑ New Zealand's aging population is increasing the country's dependency ratio. This will have an impact on people's living standards.
- ❑ This century the government is unlikely to provide as much for the elderly as it did for most of the 20th Century. New types of provision will be needed.

Population Distribution

There are two important generalisations that can be made about New Zealand's **population distribution**:

1 It is unevenly distributed across the country.

2 It is constantly changing.

We will look first at where most New Zealanders live today, and why they live there. Then we will look at how and why the population distribution is changing.

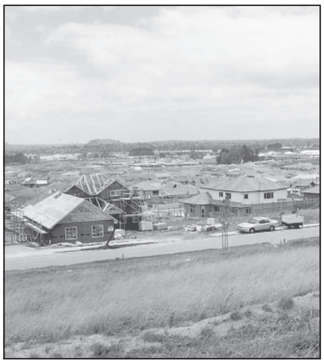


Figure 2.1.18 Suburbs

Where Do New Zealanders' Live?

The 2001 census revealed that:

- ❑ 75% of the population lived in the North Island
- ❑ 86% of the population lived in urban areas (Auckland alone accounted for 31% of the total population).

These population distribution maps indicate that most people live:

- ❑ within 25 km of the coast
- ❑ in lowland areas.

Population Distribution Factors

Population distribution patterns are affected by three types of factors:

- ❑ natural (relief, climate, soils and minerals)
- ❑ economic (employment, trade)
- ❑ cultural (social services, lifestyle).

As a general rule, people live where there is employment and they can make a living.

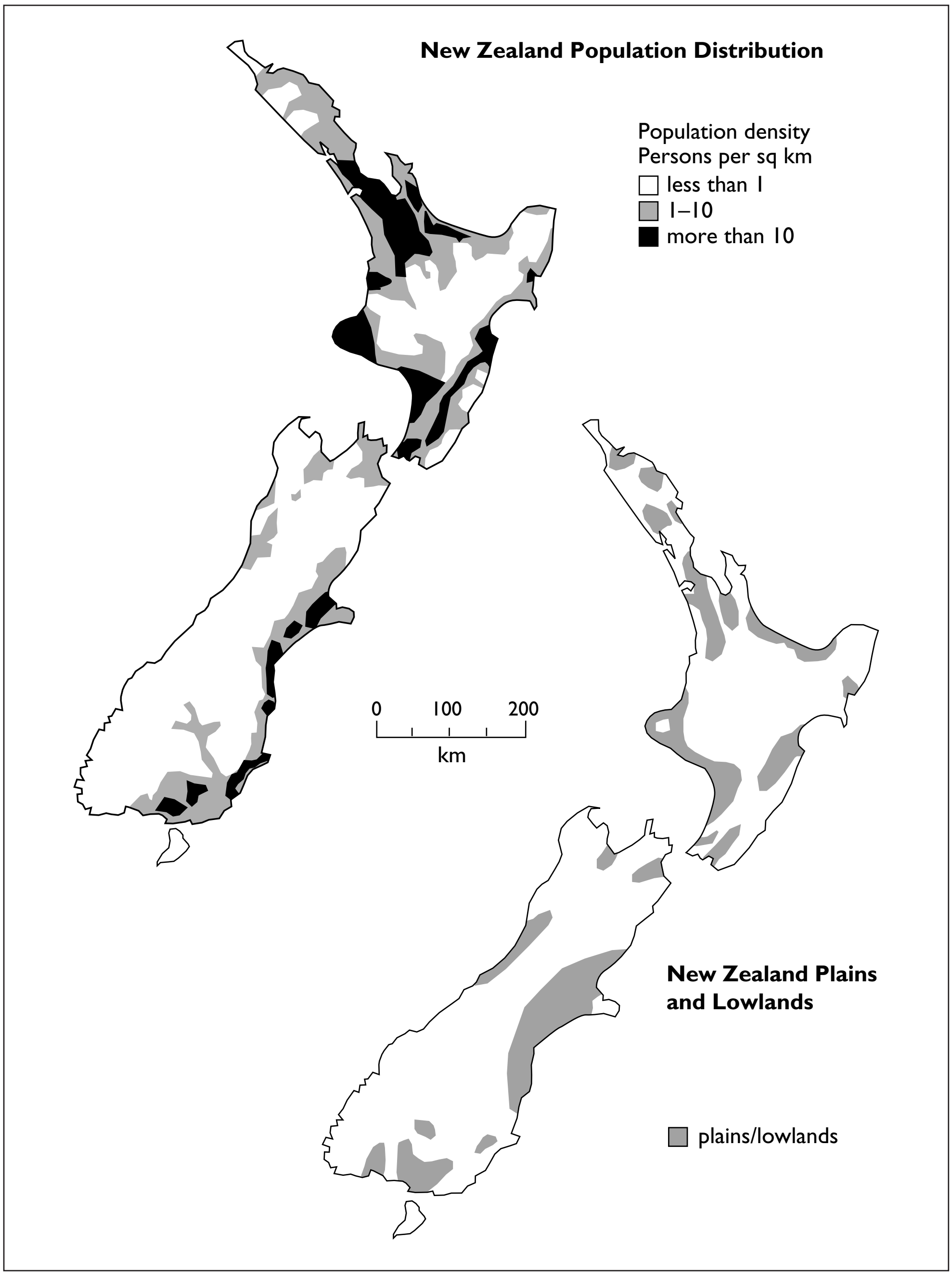


Figure 2.1.19 New Zealand population distribution

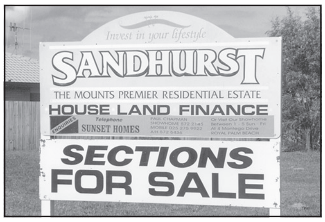


Figure 2.1.20 Land sales

In pre-European days, Maori lived by the sea and major rivers and lakes. These provided food and transport. They lived mainly in the warmer North Island.

Since the mid-19th Century New Zealand's economy has been based on farming and exports. Flat and fertile land was ideal for intensive farming and became fairly densely populated.

Nearby coastal settlements with safe harbours became important shipping ports and population centres. Of New Zealand's top ten cities today, only Hamilton, Palmerston North and Rotorua are not port cities.

Mineral deposits such as coal and gold also attract industry and settlement.

Since 1911, most New Zealanders have lived in urban areas where jobs in manufacturing and service industries have grown rapidly.

Larger cities provide a greater range of educational, health and recreational facilities. Increasingly, people are being attracted to the bright lights of the big cities.

Figure 2.1.21 Rural depopulation

Population Movement

There have been several important internal migration trends during the 20th Century:

- northward drift
- rural depopulation
- suburban sprawl.

Rural depopulation

- Changes in technology have reduced the demand for farm labour, and farm workers and their families have been forced to move to towns and cities to find work. In many rural areas, this has triggered a cycle of decline that has lead to the closure of schools, hospitals, banks and other vital services, causing even more people to leave.

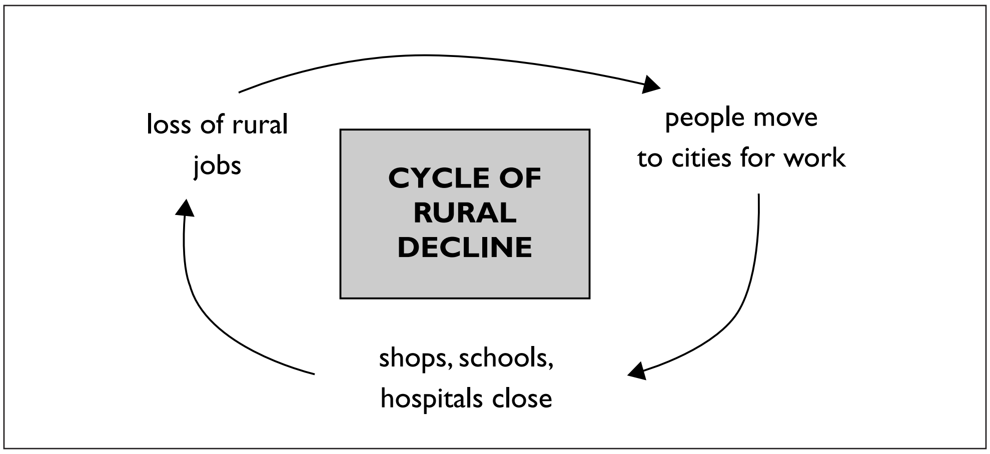


Figure 2.1.22 Cycle of rural decline

- Rural depopulation has been occurring for much of the 20th Century. It was increased by the **downturn** in the rural economy (1980s) and government economic policies (1980s and 1990s) that resulted in the closure of many public services in rural areas.
- The migration of Maori from remote rural areas to towns and cities is one of the most dramatic population movements in New Zealand's history. It was triggered by the need for labour in urban factories during World War II, and continued by economic growth and rural poverty after the war.
- In 1951, 20% (23000) of Maori were urbanised. By 1971, the figure was 58% (133 000) and by 2001 the figure had nearly caught up with the national average of 86%.

Northward Drift

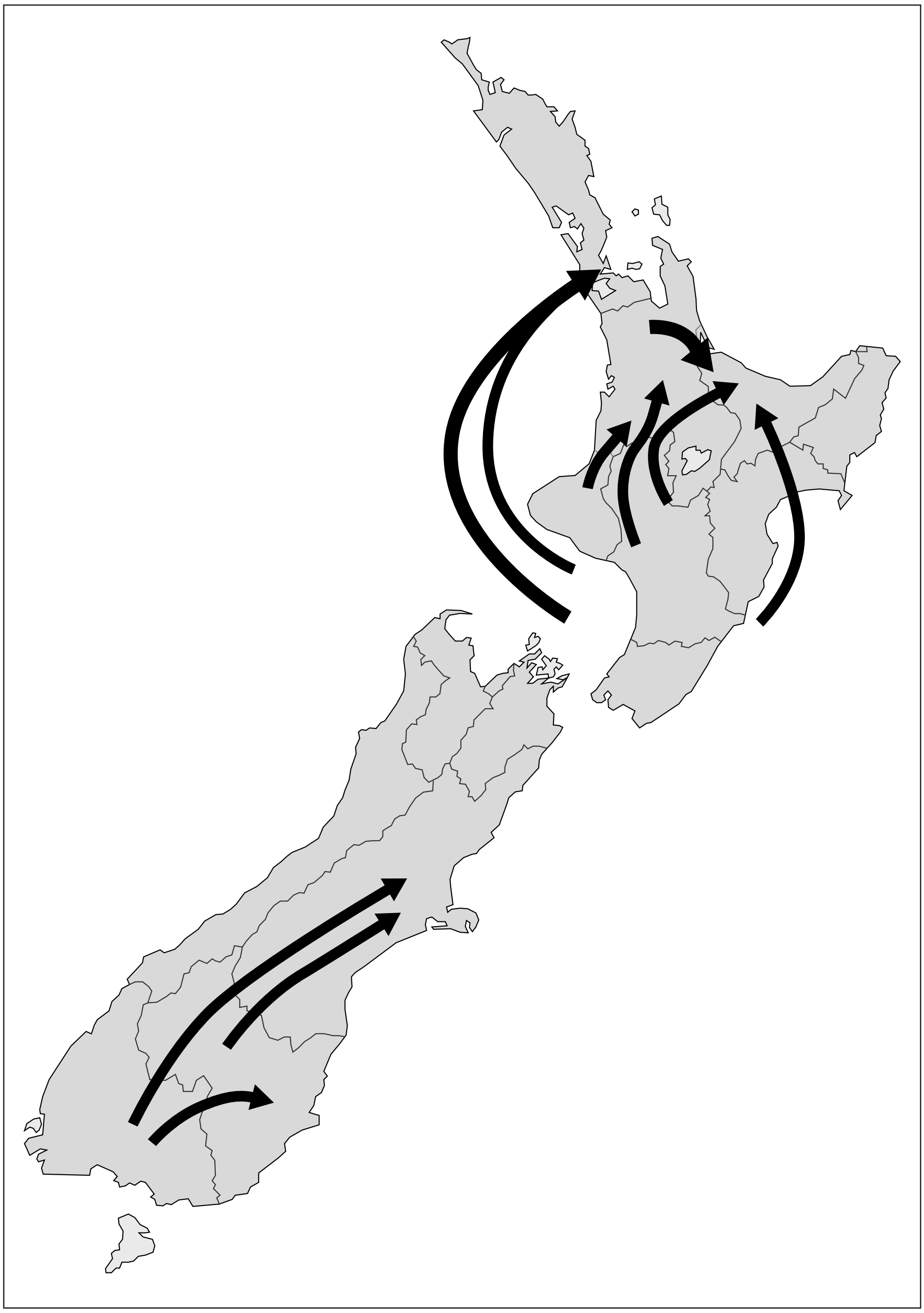


Figure 2.1.23 Northward drift

- Since the end of the 19th Century South Island gold rushes, there has been a steady flow of people moving from the South Island to the North Island. Since about 1900, the North Island has had a greater share of the population.
- There has been a northward drift within, as well as between, the North and South Islands. The top half of the South Island (Nelson, Marlborough, Tasman and Canterbury) are growing, but most of the rest of the South Island has a declining population.
- Auckland and the Bay of Plenty are growing fastest in the North Island.

Figure 2.1.24 Retirement village advertisement

Figure 2.1.25 Suburban Sprawl

Suburban sprawl

- ❑ Electric tramways brought the first wave of suburban development to New Zealand's largest towns and cities. After 1930, trams lost their appeal as private motor cars became more popular.
- ❑ Rapid urbanisation after 1950 and the development of motorways resulted in the spread of low-density residential suburbs around Auckland and Wellington. This suburban sprawl has generated a rapid increase in commuter traffic, traffic congestion and the loss of quality farming land, particularly in Auckland.
- ❑ Early suburban developments generally housed middle- to high-income European families, leaving the inner suburbs for those on lower incomes, many of them Maori and Pacific Islanders.

Recent Trends

Since the 1980s, some new trends emerged:

- ❑ Increasing transport costs saw the **gentrification** of old, inner-city suburbs. Middle- and high-income earners moved in and renovated character houses, and low-income families were squeezed out to new and cheaper housing in the outer suburbs.
- ❑ New light industries moved to the urban fringe to take advantage of the open spaces and low-wage, semi-skilled and unskilled workforce available in the spreading outer suburbs.
- ❑ Urban containment policies to restrict urban sprawl and encourage higher-density urban living, e.g. **in-fill** housing in spacious middle-class suburbs and inner-city apartment living.

Figure 2.1.26 High density urban living

Figure 2.1.27 Lifestyle block

- ❑ A southward *counter* drift out of Auckland for lifestyle reasons. Places like the Bay of Plenty, Nelson and Queenstown provide quieter, sunnier, pollution-free and less stressful living conditions, especially for retired people.
- ❑ Rural **lifestyle blocks** on urban fringes have become popular for high-income earners seeking an urban lifestyle in rural surroundings. For many of these 'Queen Street farmers', farming their 10 acre (4 ha) blocks is more of a hobby than a job.

The Future

New Zealand's present population geography has been shaped over many years.

Where New Zealanders will live in the future, how quickly the population will grow, where immigrants will come from, and what will happen to differences in New Zealanders' living conditions will depend largely on present and future government policies.

New Zealanders elect their government every three years. How they deal with these important issues is in their hands. It is important that voters and politicians have a good understanding of New Zealand's population geography.

Key Points Summary

- ❑ Natural, social and economic factors affect New Zealand's uneven population distribution pattern.
- ❑ 75% live in the North Island, 86% live in towns and cities and nearly one-third live in Auckland.
- ❑ The main population movements have been northwards and away from rural areas.
- ❑ Rapid urbanisation, especially in Auckland, is bringing about a rearrangement of urban residential patterns and people movements.
- ❑ Differences in living conditions are increasing in New Zealand, both between and within regions. Extremes of wealth and poverty now exist in cities and remote rural areas.

Comparisons With Global Patterns

What are the overall patterns of global population, and how are global patterns similar or different to New Zealand?

Copy and complete this table – use brief sentences to make comparisons between global, worldwide patterns and the patterns that you have learned about in New Zealand.

Table 2.1.6 Patterns of global population

Population features and processes	Global pattern	Patterns in New Zealand
Population growth		
Natural increase, mortality and fertility		
Migration (Internal and International)		
Distribution and settlement		
Dependency		

Learning Activities

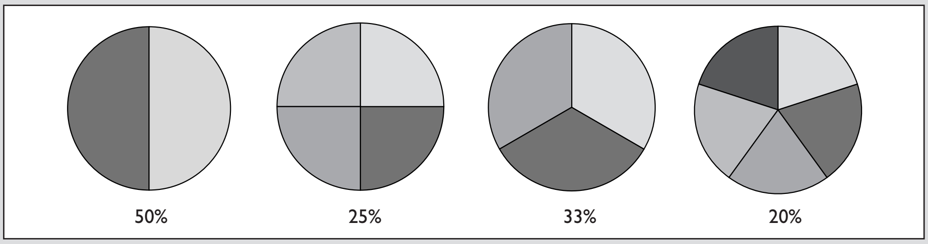
Section A

Skill – Pie Graphs

A pie graph tells you at a glance how a population is made up and the proportion of each group within it. If you want to know the percentage of each 'slice' or segment, and they are not shown on the graph, you can either estimate them or measure them.

Estimating

To make reasonably accurate estimations, you need to be good at recognising some basic proportions. The best way to achieve this is to practise dividing circles into halves (50%), quarters (25%), thirds (approximately 33%) and fifths (20%).

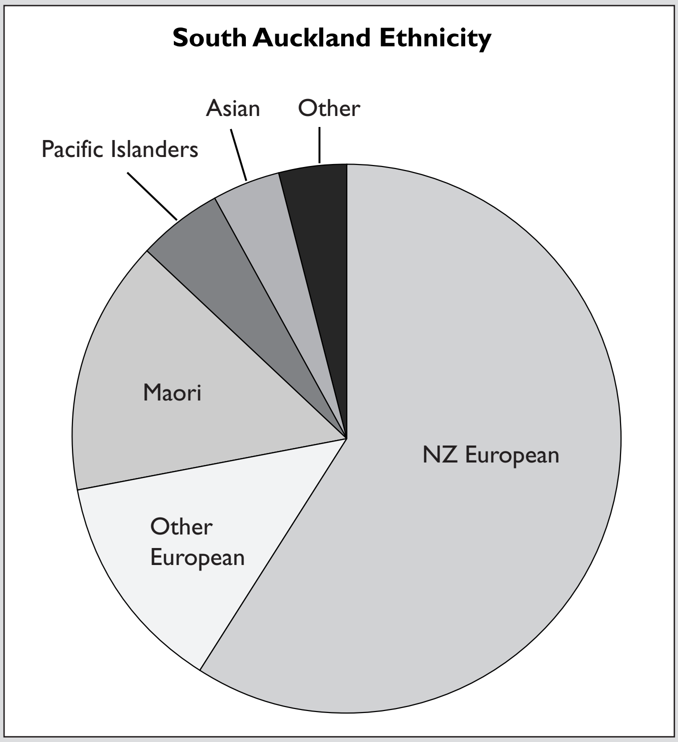


If you can draw these proportions quickly and reasonably accurately, you will have little trouble recognizing them on pie graphs and estimating percentages.

Measuring

Measure the angle of a sector with a protractor and divide the number of degrees by 3.6 (a calculator may be handy!). This gives you the percentage share for that sector. If you have been accurate, the percentages of all the sectors of a pie graph should add up to 100.

Try out your estimating and measuring skills on this pie graph.



1 Match up the descriptions with the terms.

a census	**A** original New Zealanders (Maori)
b population	**B** study of populations
c statistical data	**C** official count of the population
d ethnicity	**D** increasing percentage of town-dwellers
e multicultural	**E** people living in a particular place
f tangata whenua	**F** ruled by a foreign power
g colony	**G** numerical information
h urbanisation	**H** cultural/racial origin
i demography	**I** preparing for future needs
j planning	**J** made up of many cultures

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

a The census is carried out every ten years.

b Tourists from overseas are included in New Zealand's census.

c About three-quarters of New Zealanders are of European descent.

d The Maori population has been declining since 1900.

e About 50% of New Zealand's Pacific Island population has Sāmoan ethnicity.

f About 85% of New Zealanders live in rural areas.

g New Zealand women can expect to live longer than its men.

h There are more men than women in New Zealand.

3 Find evidence in this unit to support this important geographic idea:

People living in groups develop a common way of life, or culture, which influences the way they view their environment.

4 Compare the first wave of Polynesian migration to New Zealand with the second wave in the second half of the 20th Century. In what way are they:

a similar? **b** different?

5 Mini-research: Watch the TVNZ news that comes on Televise Sāmoa. Find evidence of New Zealand's multicultural society. See how many different ethnic groups you can see or hear a reference to. Write a conclusion to summarise what you have learned from this exercise.

6 Prepare arguments to support *and* oppose this statement:

New Zealand is a Pacific nation, not a European one.

7 Write a geographic paragraph to describe the composition of New Zealand's population. (Remember the GREED approach to paragraph writing.)

Section B

1 Match up the descriptions with the terms.

a growth rate	**A** moving from country to country
b natural increase	**B** proportion of children and elderly
c fertility rate	**C** people moving into a country to live
d baby boom	**D** increasing proportion of elderly
e replacement level	**E** births minus deaths
f external migration	**F** how quickly a population is growing
g immigration	**G** average number of births per woman
h net migration	**H** period of higher than usual birth rates
i aging population	**I** births required to match deaths
j dependency ratio	**J** immigration less emigration

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

a The baby boom years followed World War I.

b Urban lifestyles have had much to do with declining birth rates.

c New Zealand has never experienced sustained negative population growth.

d Migration is now the key factor in New Zealand's population growth.

e New Zealand now receives migrants from a wider range of countries than ever before.

f New Zealand's death rate is rising again.

g New Zealand's population pyramid will continue to broaden its base.

3 Find evidence in this unit to support this important geographic idea:

Change in one part of a cultural environment may induce further changes.

4 Find the answers to the following questions in the text.

a By how much is the percentage of children expected to fall between 2001 and 2031?

b By how much is the percentage of elderly expected to rise between 2001 and 2031?

c What is expected to happen to the dependency ratio between 2001 and 2031?

5 New Zealand's recent migration statistics are shown in the table.

a Explain the meaning of immigration and emigration.

b How were the figures in the *Net Migration* column calculated?

c Draw a line graph of net migration between 1987 and 2001.

d Describe the main trend(s) of your graph.

Table 2.1.7 *New Zealand migration statistics*			
Year	**Immigration**	**Emigration**	**Net Migration**
1987	1 321 729	1 317 372	4357
1988	1 554 992	1 555 949	-957
1989	1 669 637	1 687 935	-18 298
1990	1 701 056	1 702 689	-1633
1991	1 772 524	1 757 948	14 576
1992	1 809 885	1 806 947	2938
1993	1 898 769	1 890 689	8080
1994	2 057 005	2 041 212	15 793
1995	2 235 246	2 214 845	20 401
1996	2 464 732	2 436 106	28 626
1997	2 680 980	2 685 800	-4820
1998	2 719 694	2 720 401	-707
1999	2 876 903	2 854 011	22 892
2000	3 121 610	3 136 804	-15 194
2001	3 293 714	3 260 363	33 351

6 Prepare arguments to support *and* oppose this statement:
New Zealand can solve its aging population problem by raising the retirement age.

7 Write a geographic paragraph to describe and explain significant changes and issues related to New Zealand's population size and structure. (Remember the GREED approach to paragraph writing.)

Section C

1 Match up the descriptions with the terms.

a population distribution	**A** unacceptably low living standards
b urban	**B** 'cradle to grave' care for everyone
c rural depopulation	**C** fair and equal opportunity for all
d downturn	**D** where people live
e poverty	**E** squeezing in more houses
f suburban	**F** towns and cities
g in-fill housing	**G** urban area that dominates a country
h egalitarian	**H** worsening economic situation
i welfare state	**I** away from the city centre
j primate city	**J** loss of people from country areas

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

- **a** 75% of the population live south of the Cook Strait.
- **b** 71% of New Zealanders live in Auckland.
- **c** Most New Zealanders live within 25 km of the coast.
- **d** The top half of the South Island is growing faster than the rest of the island.
- **e** Maori are now more urbanised than the population as a whole.
- **f** Suburban sprawl is giving way to in-fill housing and apartment-living in large cities.
- **g** Differences in living conditions amongst New Zealanders are narrowing, and New Zealand is becoming a more egalitarian society.

3 Find evidence to support this important geographic idea:

Some processes encourage concentration, some encourage dispersal.

4 Find the answers to the following questions in the text.

- **a** What percentage of the population lived in the South Island in 2001?
- **b** When did urban New Zealanders become the majority of the population?
- **c** When did North Islanders become the majority of the population?
- **d** Which three of New Zealand's top 10 cities are not by the coast?
- **e** What effect did the *rural downturn* of the 1980s have on New Zealand's population distribution?

5 Projected Regional Population Change, 1996–2021:

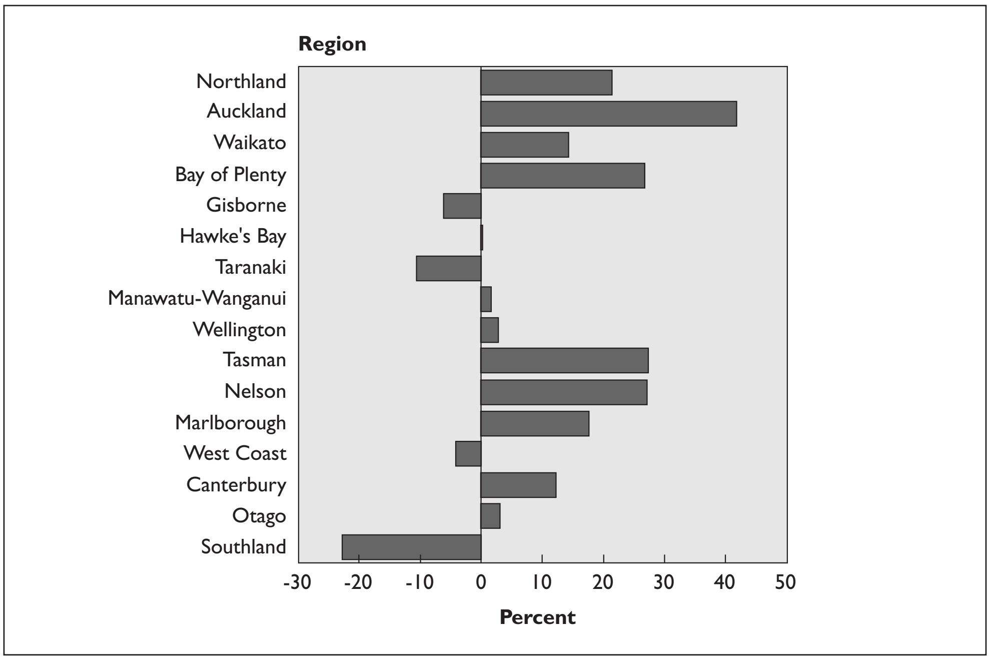


Figure 2.1.28 Population change

- **a** Which region will grow most rapidly?
- **b** Which region will experience the greatest decrease?

Unit 2

Population In Asia

Learning Outcomes

At the end of this unit you should be able to:

- ❑ Describe the processes of natural increase and migration in terms of different populations in Asia.
- ❑ Compare and contrast patterns in these processes with other countries, e.g. Sāmoa.
- ❑ Identify and describe specific population changes in Asia.
- ❑ Describe the effects of these changes on different places, environments and people in Asia.
- ❑ Evaluate the effects of these changes from a range of perspectives.
- ❑ Explore the effects of population programmes on different people, places and environments in Asia.

The People Of Asia

3.3 billion people, over 50% of the world's population, live in Asia.

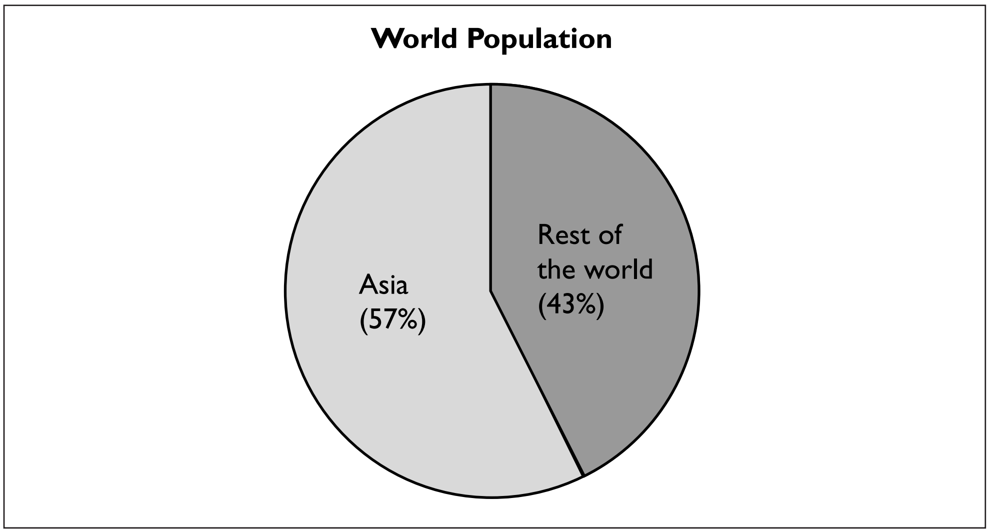


Figure 2.2.1 Percentage of the world's population living in Asia

Six of the world's most populated countries are found in Asia.

Table 2.2.1 World's most populous countries

Country	Population (millions)
China	1273
India	1029
USA	278
Indonesia	228
Brazil	174
Pakistan	145
Russia	145
Japan	126
Bangladesh	131
Nigeria	126

It is impossible to generalise about Asia. What is true for Bangladesh or Laos almost certainly won't apply in Japan or Singapore.

Many people use the term 'Asian' to describe people from Asia, but it is not a useful term. Asia's population is as varied as it is vast.

- **Appearance:** There are some physical differences between people whose ancestors originated from East Asia (e.g. China, Japan, Korea), West Asia (Pakistan, northern India) and South Asia (southern India, Sri Lanka). There has been intermixing of Asia's peoples for thousands of years, and these groupings are not considered to be strictly racial.
- **Language:** Asia is characterised by its **diversity** of languages. Chinese, the most common Asian language, has many different forms and dialects. Hindi, the second most widely spoken Asian language, is one of 18 major languages and over 1600 variations and dialects spoken in India.
- **Religion:** The main religions are Hinduism (mainly in India), Buddhism (mainly in Tibet and South-East Asia), Islam (mainly in Pakistan, Bangladesh, Malaysia, Indonesia), Confucianism (mainly in China), Shinto (in Japan) and Christianity.
- **Rural/urban:** In the small Himalayan nation of Bhutan, 94% of the population live in **rural** areas. At the other extreme, Singapore's population is 100% **urban**. Overall, just over two-thirds (68%) of Asia's population is rural. (In comparison, about 20% of New Zealand's population is rural.)

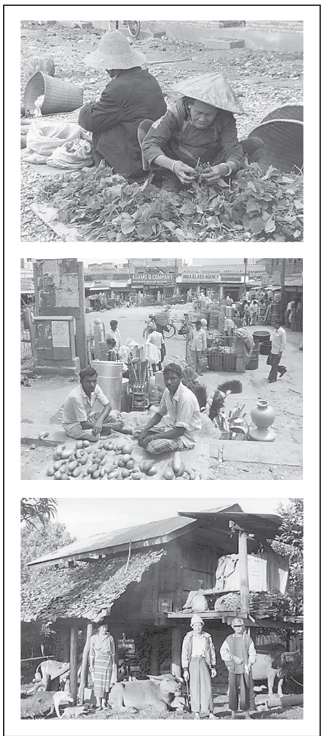


Figure 2.2.2 People of Asia

Skill – Internet Research

Have a go at using the Internet with the websites and research activities shown in the table.

Table 2.2.2 Internet research

URL	Website of:	Research Activity
www.un.org	**United Nations** (official site)	*Update population figures of Asian countries.*
www.gov.sg/metsin	**Meteorological Services Singapore** (official site)	*Check out the monsoon with Singapore's weather forecast.*
www.timesofindia.com	**Times of India** newspaper (official site)	*Look for monsoon-related news stories. (Best to do this between June and September during south-west monsoon.)*
www.wunderground.com	**Weather Underground** – weather statistics from all over the world	*Check out the weather for Asian cities. Compare with other times of the year.*

- **Age:** At one extreme is Laos with a small proportion of the population over 60 and 45% under 15. Japan's population structure is dominated by older people. Overall, Asia has a fairly **youthful population** with about 30% aged under 15, and 8% aged over 60. (In comparison, New Zealand has 23% under 15 and 12% over 60.)

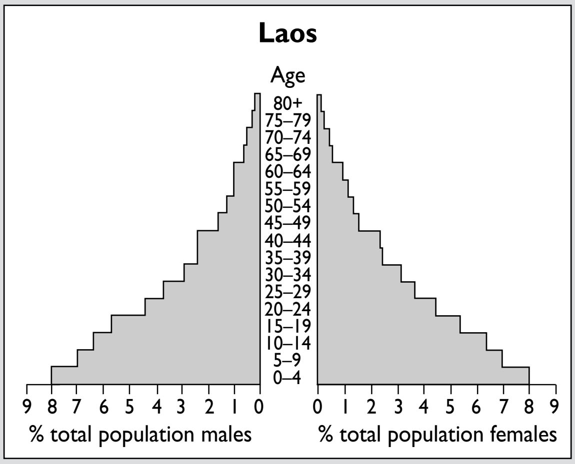


Figure 2.2.3 Population of Laos

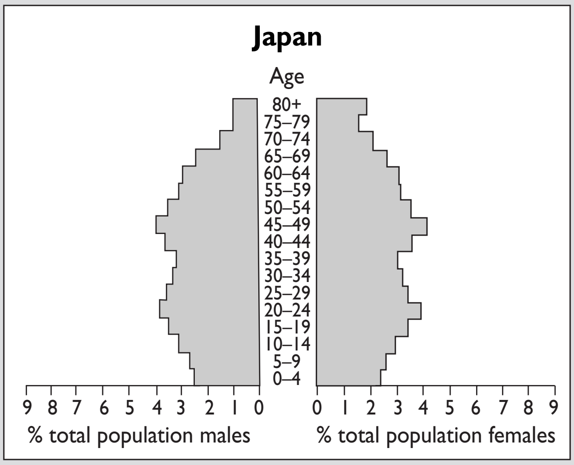


Figure 2.2.4 Population of Japan

Key Points Summary

- Asia is a region of great natural and cultural contrasts.
- Over half the world's population lives in Asia.
- Its population geography is influenced by its natural features, especially monsoon rains.
- Most people live on coastal and alluvial plains where soils are fertile and sufficient fresh water is available.
- Asia's population is predominantly rural and youthful.

Figure 2.2.5 Asian youth

Figure 2.2.6 Asian population growth

Population Growth And Development

The key factor in population growth in Asia is **natural increase**.

Between the 1950s and 1970s, *high* birth rates and *falling* death rates in many Asian countries caused a **population explosion**.

Asia's population is currently growing at a rate of about 2.0% per annum, but the rate is slowing.

There are some important differences in growth rates *between* countries. The fastest population growth rate is in Laos (2.48% p.a.) and the slowest is in Japan (0.17% p.a.)

Age structure

Countries with high birth and death rates have **youthful** populations, with high proportions of young people (0–15 years) and low proportions of elderly people (over 60 years).

Birth and death rates

- Definitions:

Birth rate = number of live births per 1000 people per year

Death rate = number of deaths per 1000 people per year

Natural increase rate = birth rate – death rate

- *Example:* Country X, total population = 10 000

Births	= 400	Birth rate	=	40 per 1000		
Deaths	= 100	Death rate	=	10 per 1000		
Natural increase (NI)	= 300	NI rate	=	30 per 1000	=	3.0%

In Asia, large families have traditionally been popular as they:

- ensure that several children will survive infancy
- provide extra help on the family land
- provide security for parents in their old age.

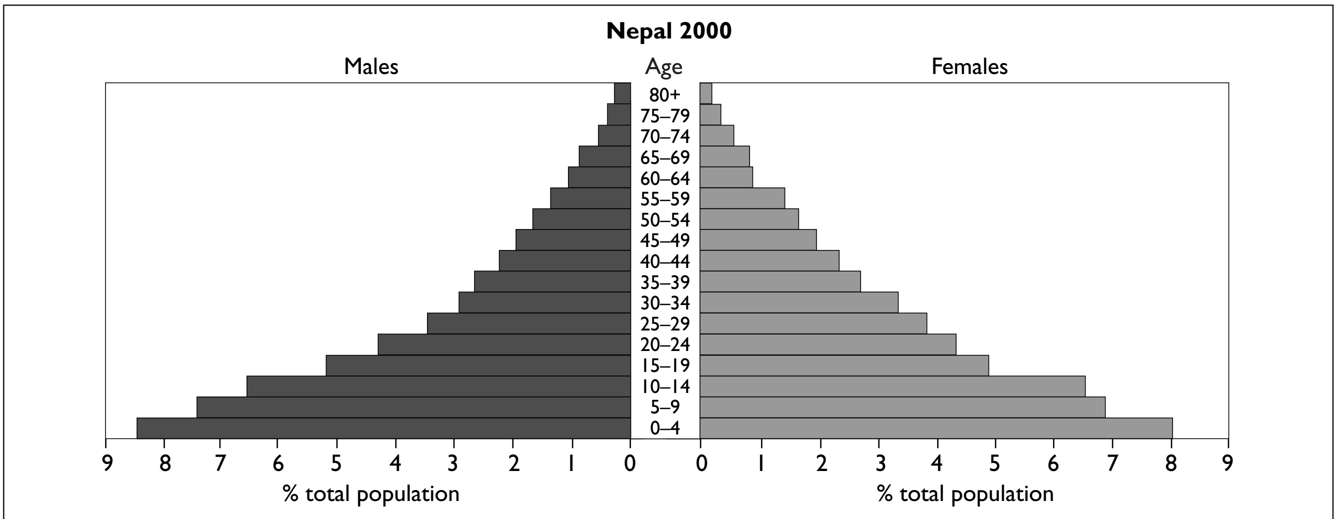


Figure 2.2.7 Age structure in Nepal 2000

A youthful population can sometimes be an advantage (high levels of energy and creativity), but generally the disadvantages outweigh the advantages. Countries with youthful populations are usually poor.

Disadvantages of a youthful population

- High dependency levels put pressure on health and education services.
- Likelihood of even greater population growth in the future as children become adults and have their own families.
- Insufficient work available when children reach working age.

Population growth and development

There is a strong **correlation** between high birth rates and poverty as uncontrolled population growth can trap a country in a state of poverty.

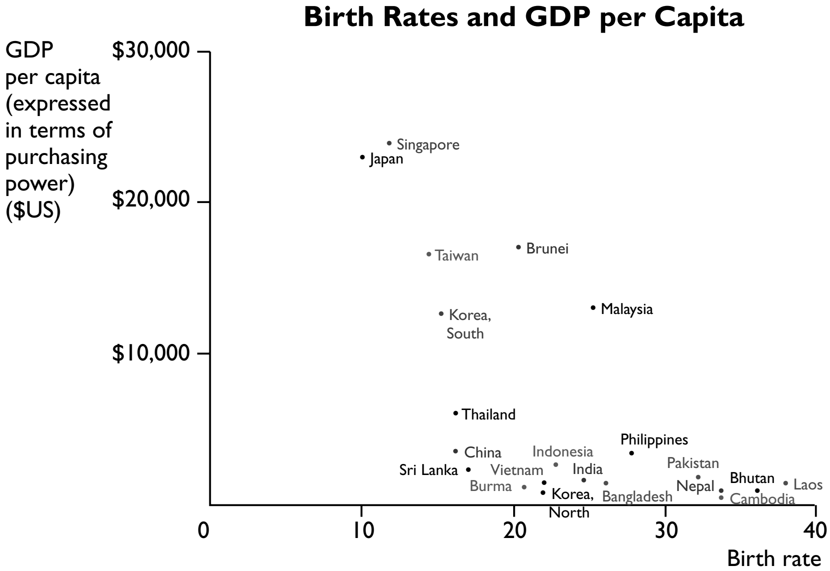


Figure 2.2.7 Birth rates and GDP per capita

Is poverty the cause of high birth rates? Are high birth rates the cause of poverty? Are countries wealthy because they have low birth rates? Do countries have low birth rates because they are wealthy?

The evidence suggests that improving living standards is the only sure way of reducing birth rates. Most Asian countries have adopted policies for both economic development and population control.

Economic development

Improvements in agriculture and the development of modern industries became the focus of the economic policies of most Asian countries after the World War II. However, if development makes the rich richer and the poor poorer, it will do little to reduce birth rates.

Countries such as Japan and South Korea benefited from huge US investment to get their economic development under way after the World War II. China's economic development, based on strict communist principles, has been slower, but its benefits appear to be more evenly shared. Its economy is expected to 'take off' in the 21st Century. India's economic development has been uncertain, and Bangladesh, Bhutan, Nepal, Laos, Cambodia and Myanmar are lagging behind the rest of the region.

Population control

A variety of population control policies have been adopted by Asian countries in their efforts to reduce birth rates and support economic development.

Cultural factors have to be taken into account in applying population control policies.

Table 2.2.3 Different countries' population policies

Country	Population Policies
China	1980s–early 1990s: Strict 'one child per family'. Late 1990s: One-child policy relaxed slightly.
Japan	1950s: **Contraception**, abortion encouraged. Focus on economic development. 1990s: No official policy, but Japan is now more *pro*-birth because of its very low birth rates.
Singapore	1960s: 'Two-child families' promoted through tax cuts and subsidised housing. 1990s: Three-child families promoted for the wealthy.
India	1950s–1970s: Family planning widely promoted using contraception and sterilisation. Some forced sterilisations caused resistance to government policies. 1980s–1990s: Greater emphasis on health and education.

All countries have had some success in reducing birth rates during the second half of the 20th Century, but some have been more successful than others. In Japan, China and South Korea, birth rates were reduced very quickly.

Table 2.2.4 Birth rate reductions

Country	1960–65 birth rate per 1000	1990–95 birth rate per 1000	2001 birth rate
Pakistan	48.4	39.4	31.2
India	42.0	27.5	24.8
China	37.8	18.3	15.9
South Korea	39.6	15.5	15.5
Japan	17.2	9.5	10.0

Population policy problems

Societies that traditionally value early marriages and large families may take several generations to accept changes.

In India, some birth control programmes were made compulsory during the 1970s. This was strongly resented and the government was defeated at the next elections.

China's 'one-child' policy increased **female infanticide** as male children were culturally more desirable. Allowed to have only one child, some parents killed baby girls at birth and tried again for a boy.

Singapore found that it was mainly their better-educated and wealthier citizens who reduced their family sizes. Since 1987, Singapore has targeted its population policies at the poor. Three or more children are encouraged only for those who can 'afford it'. This has drawn criticism from human rights organisations.

Japan's population is now **aging** so quickly it faces major problems with providing for its increasing percentage of elderly people. Singapore, South Korea, China and even Thailand now have some concerns about aging populations. The population pyramids below show that both China and Japan have aging populations, though Japan's population is aging more rapidly than China's.

If birth rates fall too quickly, a population may find itself short of workers 15–20 years later.

Since the 1994 International Conference on Population and Development (organised by the United Nations), population policies have focused more on population *quality* rather than just *quantity*. Targetting poverty, health, education and women's rights is seen as more effective than a narrow focus on birth control.

Demographic transition

A long-term change of birth and death rates is known as **demographic transition**. Demographers have identified four stages of demographic transition and have developed a **model** to illustrate how countries progress from one stage to the next.

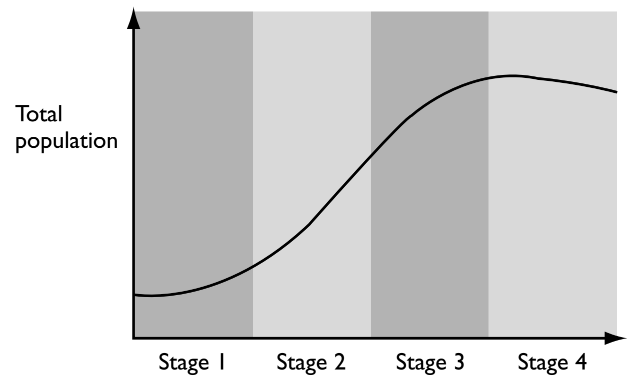


Figure 2.2.9 Four stages of demographic transition

Table 2.2.5 Four stages of demographic transition				
Stage	**Birth Rate**	**Death Rate**	**Natural Increase Rate**	**Social and Economic Characteristics**
1	High	High	Low	Traditional rural society, mainly poor farmers with large families.
2	High	Falling	Rising	Population explosion due to improvements in medicine and agriculture. Growth of towns.
3	Falling	Low	Falling	Industrialisation and rapid urbanisation. Smaller families. Improved education.
4	Low	Low	Low	Highly urbanised, technological society. Small families. High levels of education.

Note: This is a theoretical model that may not fit the experience of every country.

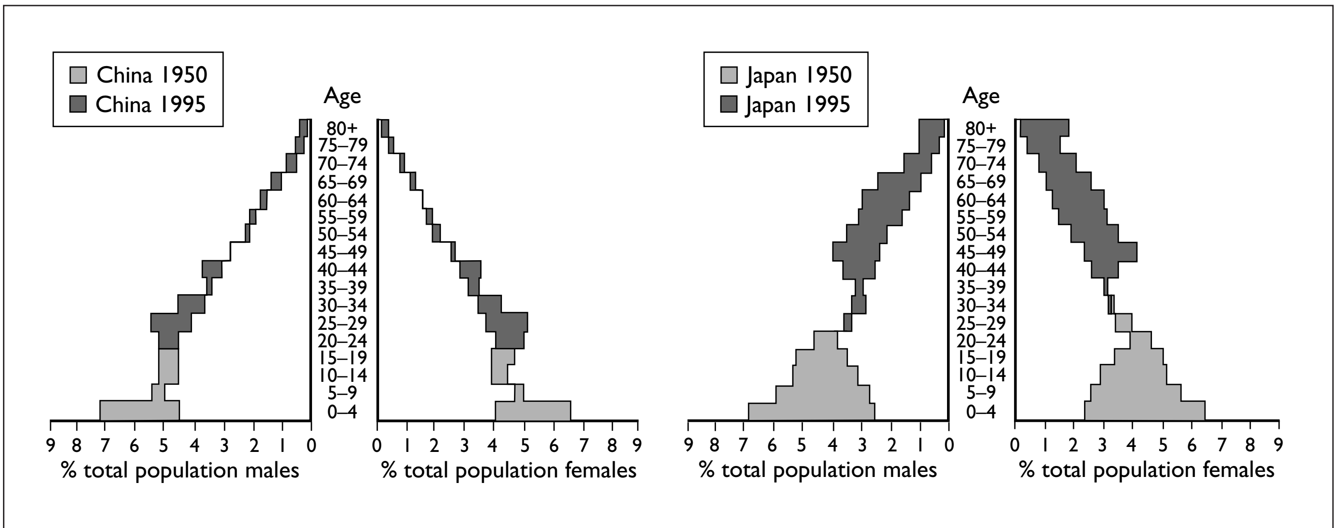


Figure 2.2.10 Male to female ratio comparisons of China and Japan

Each stage of the transition is linked to social and economic changes.

At the start of the 20th Century, most Asian countries were at Stage 1 of the model. By the end of the 20th Century, most Asian countries were at Stages 2 and 3. Japan was at Stage 4, with several other countries close behind.

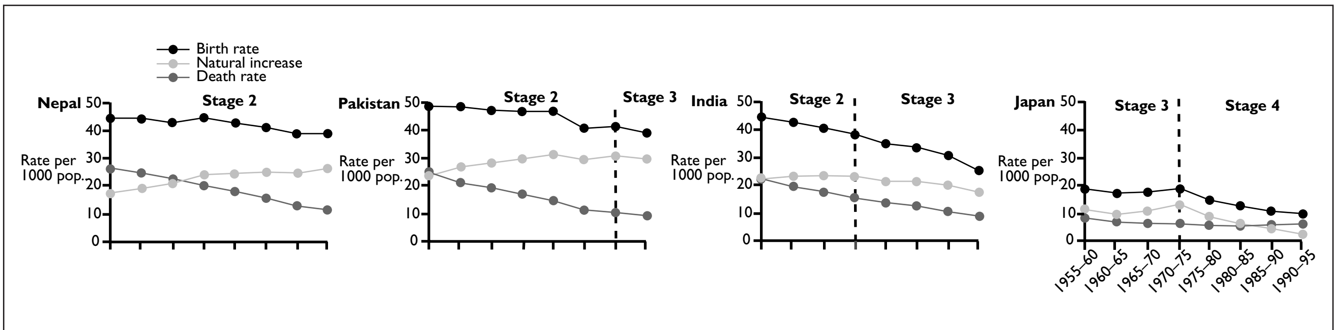


Figure 2.2.11 Comparisons between Asian countries of birth and death rates

Skill – Using a Geographic Model

All models simplify reality. They can be used to:

- ❑ present complex natural or cultural processes so they are easier to understand
- ❑ test the validity of ideas
- ❑ make predictions.

There are several types of models used in geography:

- ❑ solid (3-D) models – relief models, wave tanks
- ❑ flat (2-D) models – maps, graphs, diagrams
- ❑ mathematical models – relationships expressed as mathematical formulae
- ❑ computer models – computer modelling has revolutionised the use of models in geography.

Use the demographic transition model for the following exercises:

1 Identify the appropriate demographic *stage* for the following countries:

Table 2.2.6 Identifying demographic stages

Country	Birth Rate per 1000	Death Rate per 1000
Brunei	20.4	3.3
Bhutan	35.7	14.0
Sri Lanka	16.5	6.4
South Korea	14.8	5.93
China	15.9	6.7

2 Which two countries do not fit the model very well? Why don't they fit?

3 Predict what will happen to birth and death rates in Bhutan and China in the future.

4 Does the model help your understanding of Asia's population?

Key Points Summary

- ❑ High rates of natural increase (high birth rates and falling death rates) have been responsible for most of Asia's population growth.
- ❑ Countries with high birth rates are generally poorer than those with low birth rates.
- ❑ Asia's population growth rate is gradually declining, but there is considerable variation in rates between countries.
- ❑ Most Asian countries have youthful populations, but economic development and social policies are changing population age structures. Some countries are now aging rapidly.
- ❑ Policies to control population growth have been implemented, with varying degrees of success.

Migration – Moving From Place To Place

Moving from place to place

Differences in living conditions cause population movements as people seek to improve their lives.

The main movements of people in Asia are:

- internal migration – from rural areas to urban areas
- external migration – **refugees**, economic migrants.

Moving to the cities

Throughout Asia, urban populations are growing much more quickly than rural populations. This rapid **urbanisation** is partly accounted for by natural increase, but is mainly the result of widespread **internal migration**.

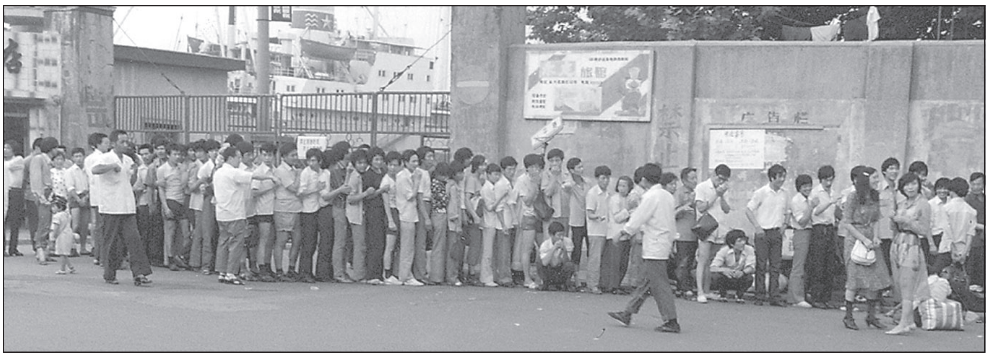


Figure 2.2.12 Moving to the city

Poverty is the strongest *push factor* in the flow of people from rural areas to cities, so it is not surprising that urban growth rates are greatest in Asia's poorest countries.

Table 2.2.7 Population growth rates of Asian countries

Country	Annual Urban Population Growth Rate (%)	Annual Rural Population Growth Rate (%)	Human Development Index
Cambodia	4.04	1.44	0.422
Pakistan	4.25	1.85	0.453
Malaysia	3.35	0.40	0.834
Japan	0.43	–0.55	0.940

External migration

External migration has not significantly affected population growth in Asia, as the numbers involved are relatively small. Some population movements are worth noting, however.

Economic Migrants

- During the 1980s and 1990s, wealthy business people from Singapore, China/Hong Kong, Taiwan and South Korea have been attracted to Europe, North America and Australasia.

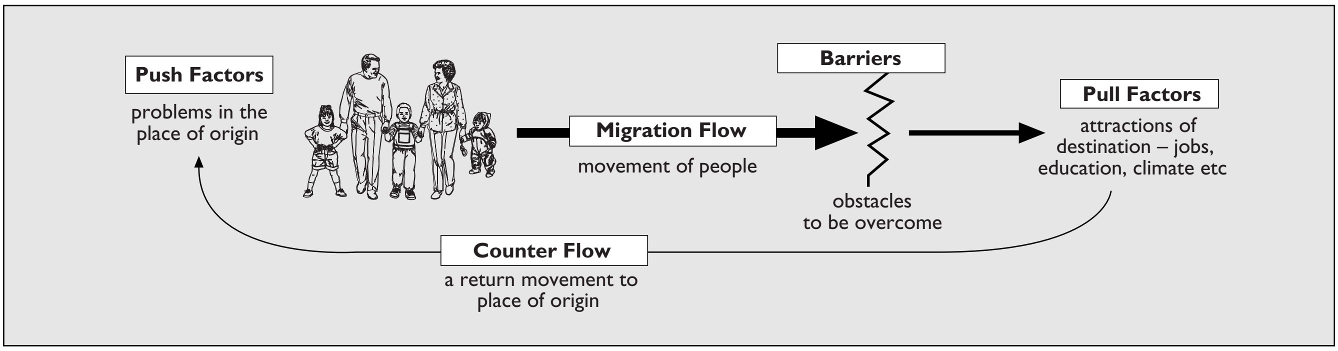


Figure 2.2.13 A migration model

- *Chinese* migrants were attracted to California, Australia and New Zealand during 19th-century gold rushes. Some remained and established Chinese communities in those countries. Influential Chinese business communities have been established in Malaysia, Singapore and Indonesia.
- *Indians* have migrated to such places as South Africa, East Africa, Malaysia/ Singapore and Fiji since about 1860. They moved for economic reasons, often to work as **indentured labourers** on British colonial plantations and farms. Many settled permanently and these countries now have significant Indian communities. After the World War II many Indians migrated to Britain, where there was a serious labour shortage.
- '*Brain drain*' migration of Asia's top scholars to European and North American universities has been occurring since the 19th Century. The majority do not return as they have better job prospects (with much higher salaries) overseas. The loss of vital medical, technical and commercial expertise is a serious concern for Asia.

Figure 2.2.14 Chinese migrants

Refugees

- Since the end of the World War II Asia has been almost continuously affected by violent conflict in one part of the region or another. There have been large-scale movements of people seeking refuge from the conflicts shown in the table below.

Table 2.2.8 Origins and destinations of refugees

Location	Year	Cause of Conflict	Destinations
India	1947–48	Partition of India into two independent countries, India and Pakistan.	Serious violence erupted when millions of Hindus and Muslims found themselves on the 'wrong' side of a new international border. Millions hurriedly fled their homes.
Vietnam	1963–73	American opposition to communism led to 10 years of US military action in Vietnam.	Since the end of the war, hundreds of thousands of Vietnamese 'boat people' have tried to escape by sea, heading for any country they could get to, in any boats they could find.
Cambodia	1975–91	Genocide against the Cambodian people by dictator Pol Pot followed by Vietnamese invasion.	At the end of 1997, there were 77 000 Cambodian refugees still living in Thailand and Vietnam.
Sri Lanka	1975–present	Civil war between the ruling Sinhalese majority and a Tamil minority who want independence.	At the end of 1997, there were 66 500 Sri Lankan refugees living in India.
Afghanistan	1979–present	Civil war, then invasion by the Soviet Union (1979–89), drought, then rule by fundamentalist Islamic Taliban until 2001 US-led military campaign in Afghanistan.	In 1990, there were 3.3 million Afghan refugees sheltering in Pakistan. By 2002, some 4.5 million Afghans were refugees in other countries.

Figure 2.2.15 Refugees during the Vietnam War

- ❑ At the end of the 20th Century, there were approximately five million displaced people (refugees and asylum seekers) living far from their homes in Asia. Continuing conflict and political instability in Sri Lanka and Myanmar were adding to the problem.

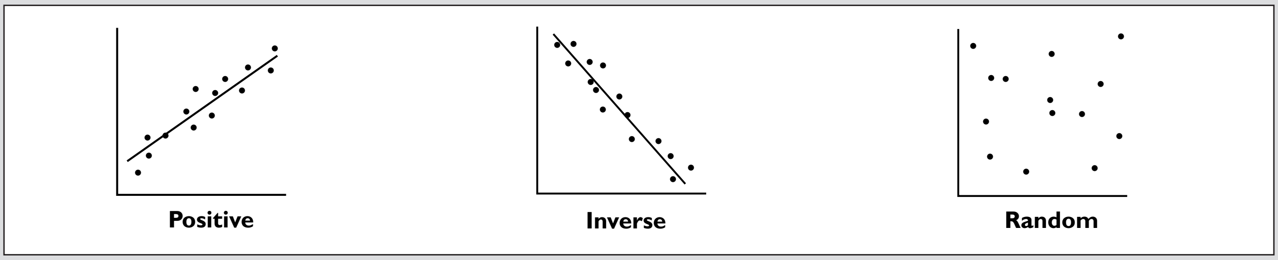
Key Points Summary

- ❑ There are major differences in living conditions both within countries and between countries.
- ❑ There are many possible reasons for differences in living conditions, but one thing is clear: the gap between rich and poor is widening.
- ❑ Differences in living conditions are a major cause of migration.
- ❑ The largest migration flows in Asia have been from rural areas to urban areas. Rural poverty has been the main push factor.
- ❑ Urbanisation rates have been fastest in the poorest countries of Asia and have led to serious urban poverty.
- ❑ External migration of refugees and economic migrants, although on a smaller scale, is still significant.

Skill – Interpreting a Scatter Graph

A **scatter graph** allows the relationship between two **variables** to be studied. If the scatter of points on the graph appear to line themselves up in a particular direction, then you can assume there is a relationship between them. A straight (or smoothly curved) **best-fit line** (or **trend line**) can be drawn through the points to summarise the relationship. The closer the points are to the best-fit line, the stronger the relationship between the variables.

- A 'positive' relationship slopes up to the right. As one variable increases, so does the other. For example, in New Zealand you would expect a positive relationship between daily *temperature* and *ice cream sales*. The higher the temperature, the higher the ice cream sales.



- If the scatter of points slopes down from the left, the relationship is 'inverse' or 'negative'. An increase in one variable means a decrease in the other. For example, you would expect an inverse relationship between *car prices* and *car sales*. The higher the price, the lower the sales.
- If the scatter appears to be random, you can assume there is little or no relationship. Can you think of two variables that would have no relationship?

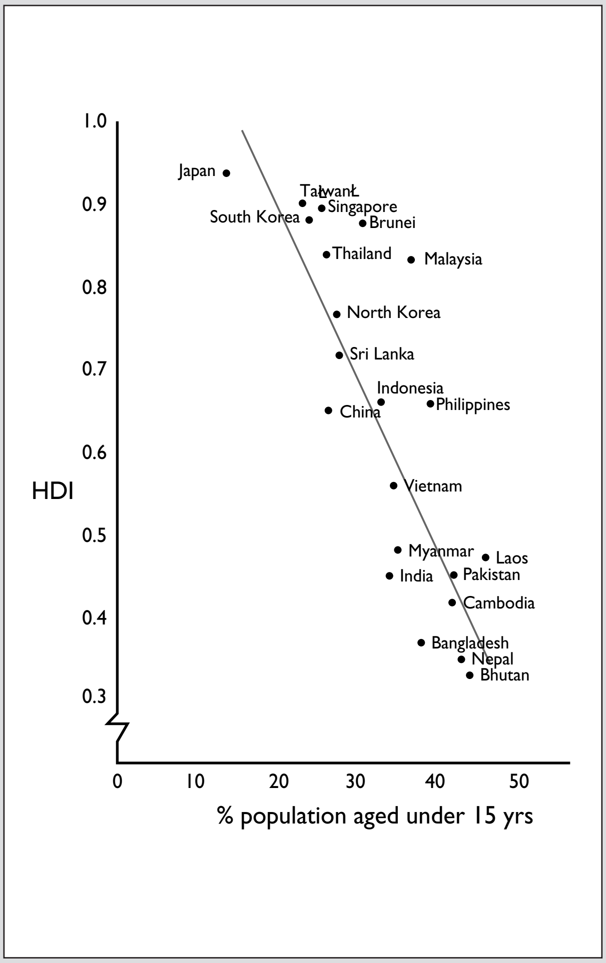
This scatter graph shows a the relationship between *living standards* (Human Development Index) and the *youthfulness* of a population (percentage under 15 years old). Because Malaysia is a long way from the best-fit line, it is known as an **outlier**.

1 Is the relationship positive, inverse or random?

2 Is the relationship *very weak*, *weak*, *fairly strong* or *very strong*?

3 Is the relationship what you would expect? Try and explain it.

4 Complete these sentences: *Malaysia and ___________ are outliers on this graph because they have ___________ living standards than countries with similar percentages of ___________. For example, Malaysia and ___________ both have approximately 37% of their population aged under 15 years, but Malaysia's Human Development Index is ___________ and ___________'s is only 0.37.*



1 Match up the descriptions with the terms.

a natural increase	**A** an increasing proportion of elderly people
b correlation	**B** practice of killing female babies
c aging	**C** Chinese strategy for population control in 1980s
d demography	**D** method of birth control
e youthful population	**E** births minus deaths
f birth rate	**F** improvement in a country's economy
g contraception	**G** relationship between variables
h population explosion	**H** the study of population
i one-child policy	**I** rapid population growth
j female infanticide	**J** number of babies born in a year per 1000 people
k economic development	**K** population with a high proportion of young people

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

- **a** The population explosion in Asia between the 1950s and the 1970s was caused by immigration on a massive scale.
- **b** Countries with high birth and high death rates have aging populations.
- **c** High levels of youthful dependency put pressure on health and education services.
- **d** Low birth rates are usually associated with poverty.
- **e** Economic development in Asia has been uneven.
- **f** Bangladesh, Bhutan and Cambodia are among the poorest nations in Asia.
- **g** A cultural preference for boys increased male infanticide in China in the 1980s.
- **h** Population policies that focus only on birth control are more likely to be successful.

3 Find evidence in this unit to support this important geographic idea:

Changes in one part of a cultural environment may lead to further changes.

4 Find answers to the following questions in the text.
  a Which countries in Asia have the highest and lowest birth rates?
  b Why do many families in Asia have large families?
  c Why do the disadvantages of a youthful population usually outweigh the advantages?
  d What evidence is there that poverty is the cause of high birth rates?
  e By how much did India, China and Japan reduce their birth rates between the 1960s and the 1990s?
  f What changes have there been to population control policies in Asia in recent years?
  g What are the social and economic characteristics of populations at Stage 2 of the demographic transition model?
  h Suggest reasons why Stage 3 countries typically have smaller families.
5 Draw a bar graph to show the changes in birth rates in Pakistan and South Korea between 1960–65 and 1990–95 (see table 2.2.4 on page 88).
6 Prepare arguments to support and oppose this statement:
  High birth rates are the cause of poverty in Asia.
7 Write a geographic paragraph to describe and explain significant changes and issues related to population size and structure in Asia. (Remember the GREED approach to paragraph writing.)

Figure 2.2.16 Asian classroom

Comparisons With Global Patterns

What are the overall patterns of global population, and how are global patterns similar or different to Asia?

Copy and complete this table – use brief sentences to make comparisons between global, worldwide patterns and the patterns that you have learned about in Asia.

Table 2.2.9 Comparisons with global population patterns

Population Features and Processes	Global Pattern	Patterns in Different Parts of Asia
Population growth		
Natural Increase, Mortality and Fertility		
Migration (Internal and International)		
Distribution and Settlement		
Dependency		

Unit 3

Population Of Sāmoa

Learning Outcomes

At the end of this unit you should be able to:

- ❑ Describe the processes of natural increase and migration in Sāmoa.
- ❑ Compare and contrast patterns in these processes with other countries, e.g. New Zealand.
- ❑ Identify and describe specific population changes in Sāmoa.
- ❑ Describe the effects of these changes on different places, environments and people.
- ❑ Evaluate the effects of these changes from a range of perspectives.
- ❑ Explore the effects of population programmes on different people, places and environments.

A Very Important Notice!!

The learning activities that will help you to achieve the learning outcomes above will be provided by your teacher. These activities will help you to process the information in this section of this chapter.

Population Growth

The Department of Statistics is responsible for carrying out a census of population and housing every five years. The information from the census forms is processed in many different ways. The Department of Statistics uses this information to summarise patterns (based on age, gender and even location) at different scales. For example:

- ❑ at the national scale
- ❑ on the regional scale (that is the four different regions of Apia Urban Area, North West Upolu, Rest of Upolu, and Savai'i)
- ❑ at the level of each Faipule District
- ❑ each village.

In the Sāmoa census taken on 5 November 2001, the total population of Sāmoa was 176 848. Of these, 134 024 lived in the regions of Upolu, and 42 824 lived in the region of Savai'i.

This table provides summary information about the fertility, mortality and structure of the population of Sāmoa.

Table 2.3.1 Fertility, mortality and structure of the population of Sāmoa

Crude birth rate	29 (based on 1991–95 figures)
Crude death rate	5 (1991–95)
Total fertility rate	4.8 (1992)
Teenage fertility rate (15–19)	26
Infant mortality rate	22 (1991–94)
Life expectancy at birth for males	70 (1996)
Life expectancy at birth for females	74 (1996)
Sex ratio	109
Dependency ratio	72
Median age	21.6

Source: Adapted from 'Pacific Island Populations', South Pacific Commission for the International Conference on Population and Development, revised edition 1998

- Sex ratio: Number of men per 100 women. Sex ratios over 100 indicate that there are more males than females. Sex ratios under 100 indicate more females than males.
- Dependency ratio: Number of economically-dependent people per 100 working people. The ratio of economically-dependent people in a country's population to its productive proportion. This is usually expressed as a ratio of young (0–14 yrs) plus the old (60+ or 65+).

For statistical and administrative reasons, Upolu is often divided into three regions. These regions are called: the Apia Urban Area; North West Upolu; and the Rest of Upolu. Savai'i is considered a region on its own.

The total population for each region in the 2001 Census was:

Apia Urban Area	–	38 836
North West Upolu	–	52 714
Rest of Upolu	–	42 474
Savai'i	–	42 824

The population of each Faipule District, and its region, is shown in the Table 2.3.2:

Table 2.3.2 Population of the Faipule districts

Region and its Faipule Districts	Total Population	Percentage of District to Region
Apia Urban Area (AUA)		
Vaimauga West	26 494	68.22
Faleata East	12 342	31.78
North West Upolu (NWU)		
Vaimauga East	6990	13.26
Faleata West	15 046	28.54
Sagaga La Falefa	9463	17.95
Sagaga Le Usoga	4921	9.34
Aana Alofi 1	5271	10.00
Aana Alofi II	3034	5.76
Aana Alofi III	5161	9.79
Gagaemauga 1	2828	5.36
Rest of Upolu (ROU)		
Safata	5913	13.92
Siumu	2160	5.09
Falelatai and Samatau	2988	7.03
Lefaga and Faleseela	3713	8.74
Aiga I Le Tai	4508	10.61
Falealili	4528	10.66
Lotofaga	1897	4.47
Lepa	1409	3.32
Aleipata Itupa I Luga	1230	2.90
Aleipata Itupa I Lalo	3384	7.97
Anoamaa East	4282	10.08
Anoamaa West	4438	10.45
Vaa O Fonoti	1666	3.92
Gagaemauga II	358	0.84
Savaiʻi		
Faasaleleaga I	5920	13.82
Faasaleleaga II	2800	6.54
Faasaleleaga III	2632	6.15
Faasaleleaga IV	1597	3.73
Gagaemauga I	1562	3.65
Gagaemauga II	609	1.42
Gagaemauga III	1751	4.09
Gagaifomauga I	1392	3.25
Gagaifomauga II	1920	4.48
Gagaifomauga III	1458	3.40

(cont.)

Region and its Faipule Districts	Total Population	Percentage of District to Region
Vaisigano East	2533	5.91
Vaisigano West	1586	3.70
Falealupo	902	2.11
Alataua West	1622	3.79
Salega	3725	8.70
Palauli West	3201	7.47
Palauli Le Falefa	3416	7.98
Satupaitea	1831	4.28
Palauli East	2367	5.53

Source: Dept of Statistics, Census of Population of Housing 2001

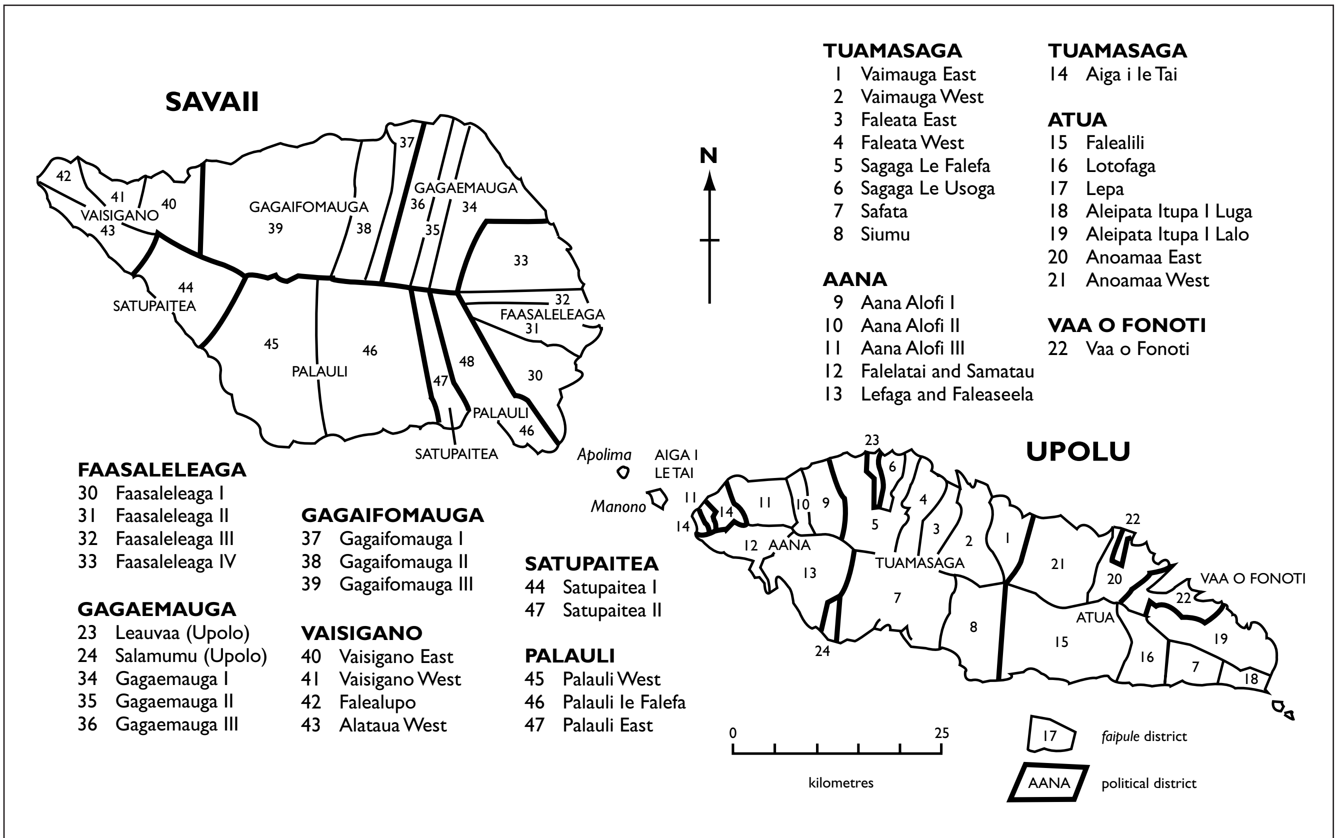


Figure 2.3.1 Political and Faipule districts

The following table shows the population numbers between 1956 to 2001. The last column shows the percentage change in population in that period of time between censuses.

Table 2.3.3 Population between 1956 and 2001				
Year	**Male**	**Female**	**Total**	**Average annual % increase since previous census**
1956	49 863	47 464	97 327	2.8
1961	58 785	55 642	114 427	3.3
1966	67 842	63 535	131 377	2.8
1971	75 950	70 677	146 627	2.2
1976	78 639	73 344	151 983	0.7
1981	81 027	75 322	156 349	0.6
1986	83 247	73 911	157 158	0.1
1991	84 601	76 697	161 298	0.5

Source: from 'Sāmoa: Mapping the Diversity' by R Gerard Ward and Paul Ashcroft

In the 1950s and 1960s, the rate of population increase was very high. Although natural increase was high (reaching 4% per year in the mid-1960s), the actual percentage change in total population was lower. This is because of emigration.

For example, between 1961 and 1966, 4500 people emigrated from Sāmoa to New Zealand, and 3000 emigrated to American Sāmoa and the United States. This is the reason why national population growth rates began to decrease or to fall.

Natural increase

The following table shows the reported births and deaths in Sāmoa between 1991 and 1999. The natural increase totals have been calculated for some of these years in the table.

Table 2.3.4 Reported births and deaths in Sāmoa between 1991 and 1999			
Year	**Total Births**	**Total Deaths**	**Natural Increase**
1991	1082	191	891
1992	2751	260	2491
1993	3962	299	3663
1994	4182	361	3821
1995	4941	317	4624
1996	4966	352	
1997	3642	495	
1998	3441	368	
1999	2464	226	

Source: Dept of Statistics, Annual Statistical Abstract 1999–2000

It is important to know that not all births (or deaths) that happen in Sāmoa are reported and recorded. The Department of Justice and the Department of Health collect and record this information – but sometimes people do not go to these Departments to get birth or death certificates. These are the kinds of records that provide the information (or data) in the table above.

Migration – internal

There have been significant changes in patterns of internal migration over the years.

The Sāmoan people have always moved around. One of the main reasons for moving within Sāmoa is usually economic – that is, people move from one part of Sāmoa to another because they see different economic opportunities. For example, in the 1950s, the chances to earn cash increased with the development of commercial banana and cocoa farming in certain parts of Upolu and Savai'i.

With internal migration, people often followed 'channels of kinship'. This means that they would take advantage of their family ties to move from areas of less opportunity to places where resources and economic prospects were better.

The extensions to roads in the 1960s and 1970s meant that there was better access to Apia (for the export and local markets). This reduced relative economic disadvantages, and so migration between rural areas declined and the migration along the road networks to Apia increased. Rural to rural migration tends to be from villages further away from Apia to the villages close to Apia, e.g. the north west of Upolu. The census from the past few years show that some Faipule Districts are decreasing in population numbers. This is due to migration.

Migration – external, international

Migration to countries such as New Zealand and the United States has had a huge impact on the population of Sāmoa. Because of this type of migration, the population growth rate is much less than the birth rate and natural increase. In 1990–91, about 154 000 Sāmoans (including people originally from American Sāmoa) were living in New Zealand, the United States and Australia. It has been estimated that 45% of the Sāmoans in the world live outside of Sāmoa and American Sāmoa. They have either emigrated from Sāmoa and American Sāmoa, or are the children and grandchildren of Sāmoans who have emigrated from the Sāmoas.

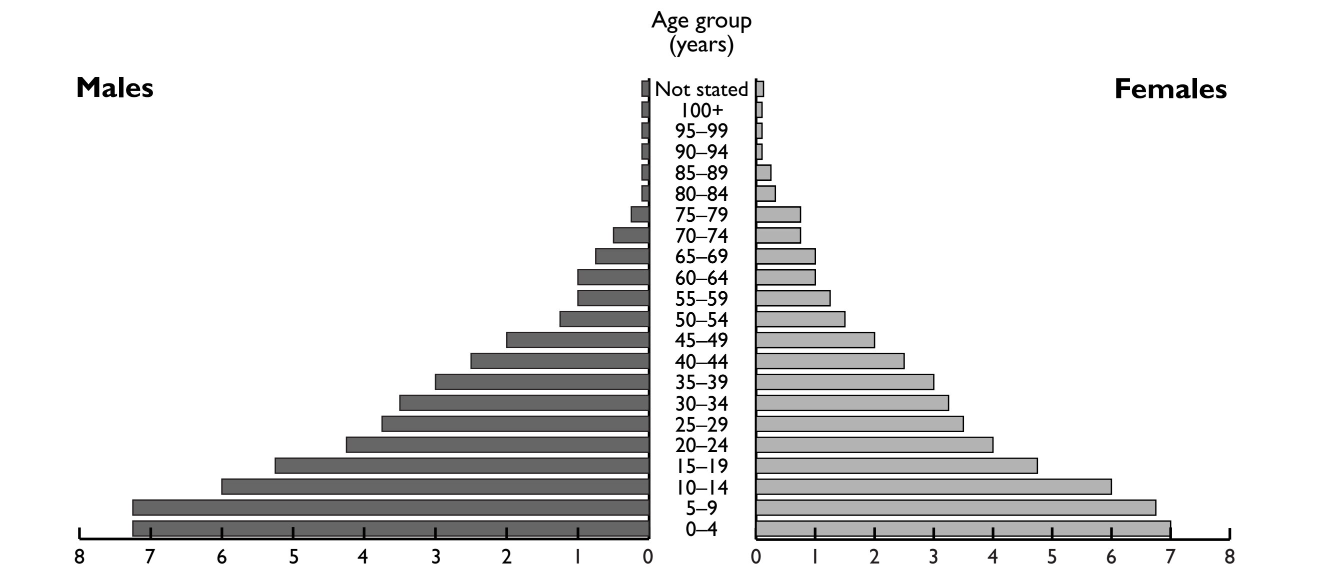
The following table shows international migration for Sāmoa between 1991–2000. The information is collected from forms that all international arrivals, and international departures must fill out and hand in. When arrivals and departures are counted, the length of stay in Sāmoa is not counted.

Table 2.3.5 International migration for Sāmoa between 1991 and 2000

Year	Arrivals	Departures	Net Arrivals/Departures
1991	96 933	99 820	-2887
1992	104 692	106 695	-2003
1993	106 771	104 694	
1994	109 769	109 572	
1995	109 736	114 160	
1996	118 443	120 300	
1997	111 636	114 750	
1998	125 231	127 907	-2676
1999	132 875	170 173	
2000	135 947	144 110	

Source: Adapted from Dept of Statistics, Annual Statistical Abstract 1999–2000

Population Structure



Source: *Dept of Statistics, Census of Population and Housing 2001*

Figure 2.3.2 Population structure

This chart or table contains information on the number of males and females in five year age groups for Sāmoa. It was used to construct or draw the population pyramid above.

Table 2.3.6 Number of males and females in Sāmoa

Age Group	Male	Female	Total
0–4	13 643	12 402	26 045
5–9	13 035	11 895	24 930
10–14	10 961	10 042	21 003
15–19	9494	8130	17 624
20–24	7561	6744	14 305
25–29	6917	6292	13 209
30–34	6552	5719	12 271
35–39	5380	5009	10 389
40–44	4631	4230	8861
45–49	3542	3299	6841
50–54	2539	2545	5084
55–59	2218	2201	4419
60–64	1835	1825	3660
65–69	1453	1523	2976
70–74	1036	1236	2272
75–79	731	908	1639
80–84	312	368	680
85–89	80	160	240
90–94	18	46	64
95–99	5	22	27
100+	1	5	6
Not stated	186	117	303
TOTAL	92 130	84 718	176 848

Source: Dept of Statistics, Census of Population and Housing 2001

Here is information or data for the male and female five-year age group populations for Upolu and Savai'i. Compare the population structures of each island – drawing population pyramids for each island will be very helpful for making these comparisons.

Here are some points to consider when you compare the population structures of each island:

- ❑ Are the population pyramids for Upolu and Savai'i youthful or aging? Give specific reasons for your answers.
- ❑ For each population, what are the differences between males and females throughout the different age groups?
- ❑ Carefully divide each population pryamid into three groups – those aged 15 and under; those aged 16–59; and those who are aged 60 and over. What are the differences and similarities between Upolu and Savai'i for each of these broad age groups? What do you think are some of the reasons for the differences and similarities?

Table 2.3.7 Number of males and females on Upolu

Age Group	Male	Female	Total
0–4	10 236	9334	19 570
5–9	9721	8727	18 448
10–14	8128	7496	15 624
15–19	7344	6385	13 729
20–24	6054	5412	11 466
25–29	5427	4917	10 344
30–34	5112	4436	9548
35–39	4097	3824	7921
40–44	3503	3222	6725
45–49	2672	2491	5163
50–54	1882	1883	3765
55–59	1628	1638	3266
60–64	1321	1343	2664
65–69	1008	1099	2107
70–74	681	904	1585
75–79	497	640	1137
80–84	219	263	482
85–89	60	123	183
90–94	15	35	50
95–99	4	18	22
100+	0	4	4
Not stated	135	86	221
TOTAL	69 744	64 280	134 024

Table 2.3.8 *Number of males and females on Savai'i*			
Age Group	**Male**	**Female**	**Total**
0–4	3407	3068	6475
5–9	3314	3168	6482
10–14	2833	2546	5379
15–19	2150	1745	3895
20–24	1507	1332	2839
25–29	1490	1375	2865
30–34	1440	1283	2723
35–39	1283	1185	2468
40–44	1128	1008	2136
45–49	870	808	1678
50–54	657	662	1319
55–59	590	563	1153
60–64	514	482	996
65–69	445	424	869
70–74	355	332	687
75–79	234	268	502
80–84	93	105	502
85–89	20	37	57
90–94	3	11	14
95–99	1	4	5
100+	1	1	2
Not stated	51	31	82
TOTAL	22 386	20 438	42 824

Source: Dept of Statistics, Census of Population and Housing, 2001

Population Distribution

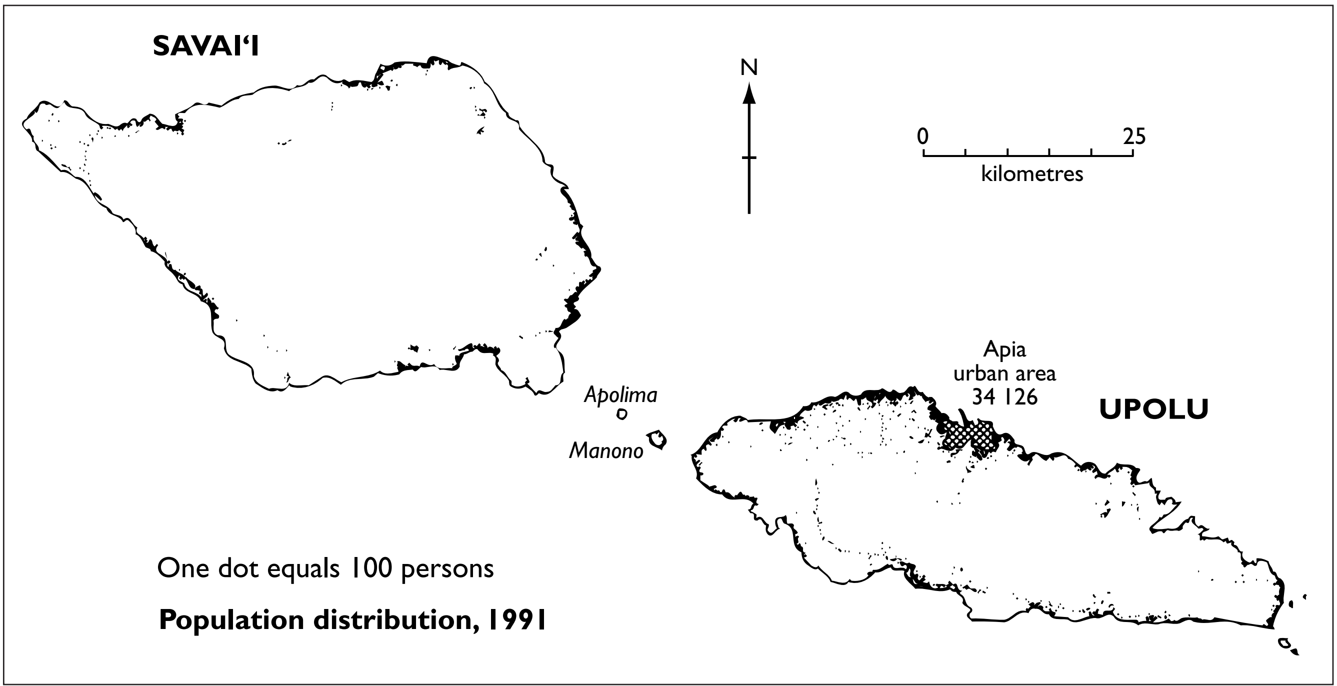


Figure 2.3.3 Population distribution of Sāmoa

Population density

The population density of Sāmoa is 60. This means that if all the people in Sāmoa were spread out (distributed) equally, then in every square kilometre there would be 60 people. This figure has been calculated by: 176 848 (the total population) divided by 2935 km^2 (the total land area).

Historical development

- Many Sāmoans lived inland (and not on the coastal areas) up until the 19th Century. People lived in settlements that were often small and dispersed. The houses in the settlements were not close together. (When buildings and houses in a settlement are clustered together, the settlement pattern is called nucleated. The villages that we have in Sāmoa today are nucleated.)
- Some inland areas of Upolu and Savai'i were not very suitable for human settlement because the freshwater supplies were very poor. This was another factor that influenced the size of settlements.
- During the 1830s and 1840s, most people moved to the coast. This may be because the people wanted to be closer to European shipping and trade – and moving to the coastal areas increased the accessibility to these goods and services. It could also be that the missionaries encouraged people to live on the coastal areas.
- So from the 1840s to mid-1950s, the distribution of population in Sāmoa was mainly coastal, with only a few inland villages and settlements.
- After locating mainly on coastal areas, travel between villages was mainly done by sea. The transport of copra and other goods (especially agricultural products) was done by shipping – and so this form of transport encouraged coastal settlements even more.

- In the 1950s, the pattern of settlement in Sāmoa began to change when roads began to be built and a roading network developed. Changes in the use of building materials (for example, corrugated roofing for roofs and water tanks) meant that people could collect and store rain water. People were able to develop more agricultural land inland, and live there, because of the improvements in accessibility (due to the roads) and water supply.
- Increasing and moving agricultural land inland resulted in the expansion of commercial farming of crops such as banana, cocoa and taro. Houses began to be built along the inland roads, closer to farm lands and plantations.
- Through the 1960s to the early 1990s, many villages divided into parts – 'tai' (coastal) and 'uta' (inland). The patterns of settlement has become one where the inland part of the village often has more people living there than the older, coastal village.
- Urbanisation is a very important feature of the population distribution of Sāmoa. The only urban area in Sāmoa is Apia, which is also the capital. Between 1956 and 1971, the population of Apia grew from 18 153 to 30 261. In 1981, the population had grown (but not as quickly as before) to 33 170. In the census of 2001, the population of Apia was 38 836.
- Officially, the urban area of Apia is made up of the Faipule districts of Vaimauga West and Faleata East. The growth rate (mainly due to in-migration) is low – however, the movement of people to villages close by has been significant. These areas show high levels of population growth, but these changes are not counted as urban growth because they were not located in Vaimauga West and Faleata East.

Comparisons With Global Patterns

What are the overall patterns of global population, and how are global patterns similar or different to Sāmoa?

Copy and complete this table – use brief sentences to make comparisons between global, worldwide patterns and the patterns that you have learned about in Sāmoa.

Table 2.3.9 Comparisons between Sāmoan and global population patterns

Population Features and Processes	Global Pattern	Patterns in Sāmoa
Population growth		
Natural Increase, Mortality and Fertility		
Migration (Internal and International)		
Distribution and Settlement		
Dependency		

Part 3

Environmental Issues

The aims of this strand of geography learning.

Students will recognise and understand:

- ❑ The effects of people's actions on patterns and processes within a physical environment or systems.
- ❑ Different perspectives on the use and management of a physical environment or system.

The achievement objectives of this strand at Year 12 level.

Students will demonstrate knowledge and understanding of:

- ❑ policies and practices that have changed a physical environment
- ❑ different perspectives of the physical environment being studied.

Key concepts and geographic ideas

The key concepts and important geographic ideas that we will be learning in the topics of this strand are:

Table 3.0.1 Key concepts and geographic ideas

Key Concepts	Geographic Ideas
Change	People, through their decisions and actions, bring about changes Change happens at different rates and scales
Pattern	All spatial patterns are the result of processes
Perspectives	Social and cultural groups perceive and interpret their own and other environments in different ways As groups of people change the way they see and use resources, they will change the way they see and use environments

Introduction

From our study of the physical environments of islands in the tropical Pacific, we know that the islands of Sāmoa are quite large, high islands. Our islands are much larger than the atolls of Tokelau and the Cook Islands. However, that is a relative comparison. If we compare the islands of Sāmoa to continental islands such as Papua New Guinea, New Zealand or even Japan, the islands of Sāmoa are quite small in comparison. If we compare our islands to the continents, our islands become even smaller.

The physical environments that we find in Sāmoa are very important places. Our island environments have shaped the way our ancestors settled and lived here. Our population has grown, and together with the ever-increasing changes in technology, we have had an enormous impact on the physical environment of the islands of our country. The changes that have taken place in the physical environment are affecting the way we live now – and will affect the way we live in the future even more. These changes are not always sustainable, they are often negative and they sometimes negatively affect some groups of people more than others.

Environmental issues are one of the most significant types of geographic issues. Environmental changes will affect how people live. Environmental changes will also affect the natural resources in the environment.

Environmental Issues Or Natural Resource Management Concerns

Here is a summary of the different environmental issues and problems for high islands and low islands. As you read through it, ask yourself if any of these issues are relevant to the community that you live in.

Table 3.0.2 *Environmental issues facing high and low islands*			
Sector	**Problems**	**Possibilities**	**Recommendations**
Water			
High Islands	Most islands depend upon running water for their supply of drinking water, supplemented by water tanks. Problems include pollution of water sources as a result of forest clearing in high areas, the unregulated use of agrochemicals and the use of rivers and streams for disposal of wastes.	Recycle and reuse water. Undertake further drilling to tap new sources of water.	Establish and protect by legislation the catchment areas necessary to sustain water supply. Begin taking measures to conserve water including grey water systems and tertiary treatments.
Low Islands	Depend largely on rainwater and wells, which are inadequate supply. Dangers of contamination and overuse.	Drill for new water sources and increase catchments and storage facilities.	Develop affordable desalination systems and appropriate storage tanks and pumping systems.
Energy			
High Islands	Heavily dependent on imported fuel supplemented by hydro-electric power and minor use of solar energy. Use of firewood still widespread, especially in rural areas. Damming of rivers for hydro-electric supply affecting regular supply of water for other uses. Use of firewood expected to increase and could result in increased deforestation.	Selectively develop hydro-electric power as well as solar energy for power. Substitute fuels other than wood for cooking.	Investigate all sources of practical electrical energy including means such as wave energy, particularly for long-term benefits. Introduce and enforce energy-conservation measures.
Low Islands	Highly dependent on expensive imported fuels.	Find renewable and economical sources of electrical energy.	Explore solar means for generating electrical energy and agroforestry for producing firewood. Enforce energy conservation measures.

(cont.)

Sector	Problems	Possibilities	Recommendations
Fisheries	Extensive artisanal activities with some pelagic fishing but most islands still dependent on imported canned fish. Extensive over-fishing plus damage to fish stocks from dynamiting, coral crushing and fuel poisoning.	Develop: deep sea fishing, e.g. commercial fishing, especially tuna; mariculture/aquaculture; local processing of fish products.	Effectively police illegal fishing practices. Encourage research into mariculture and fish-processing techniques.
Traditional Agriculture			
High Islands	Subsistence agriculture still predominates. Shifting cultivation of land results in increased losses of forests, causing soil erosion and water pollution.	Change ways land is used (perhaps combining forestry with agriculture).	Investigate multiple uses of land, e.g. agroforestry systems.
Low Islands	Narrow food base exists because of poor soils, salt atmosphere and shortage of water.	Increase variety of crops, improve fertility of soil.	Investigate and promote: (i) suitable crops that are drought resistant and (ii) organic methods to improve soil fertility.
Coastal Marine Management	Coastal commercial and population pressures causing increasing destruction of coral and marine life. Also, in some islands there is extensive ecological damage resulting from mining and forestry activities.	Redistribute island populations to ease harmful impacts on the coastal areas.	Control coastal-zone use through proper coastal-zone planning and effective environmental-impact studies. Control interior activities to cut down discharge of dangerous materials, including sediments, into coastal and marine areas.
Forestry			
High Islands	The relatively few islands with extensive forest cover see its rapid depletion due to increasing demand for timber and other wood products. Indiscriminate clearing of forest areas quite common, causing rapid loss of fertile soil, decrease in wildlife populations and contamination of water supply.	Reforestation. Seek substitutes for wood products.	Legislate to control export logs and unprocessed forest products. Set aside areas as forest reserves. Encourage use of non-commercial timber species.

(cont.)

Sector	Problems	Possibilities	Recommendations
Low Islands	Limited forest cover. Main wood source is coconut. Scarcity of wood for domestic use. Threat of near depletion of entire wood supply.	Reforest depleted areas.	Seek and reforest with tree species suitable for timber and fuel wood.
Land Management	In most islands, there is a lack of formal land-use plans, and most lands still operate under 'customary tenure'. Under such tenure, land is often used for unsuitable purposes, e.g. agriculture instead of water catchment. Absence of proper land planning has given rise to over concentration of harmful activities in certain areas.	Exercise proper planning for appropriate tourism, agriculture and other developments. Decentralise commercial industries.	Legislate for and implement adequate land-use planning techniques.Educate officials and land owners on the better use of their lands.
Protected Areas	Several areas have established protected areas but there is need to establish more in order to safeguard features and resources unique to these lands.	Preserve unique resources for local use and pride and long term economic returns from increased tourism.	Create institutional frameworks and pass legislation for establishing protected areas, e.g. marine parks and sanctuaries, bio-sphere reserves.

Source: Pacific Islands: Origin and Ecology, by David Hopley and John O'Brien, UNESCO 1993

Defining Important Terms

There are two words or terms that must be defined here. This is because they have a specific meaning in this topic. In other words, while these terms have a number of different meanings, they are being used in very specific ways in this topic. It is very important that you have a clear understanding of these terms as they are being used here.

Policies

Policies are a special type of plan that organisations (for example, businesses, schools and governments) use to guide their actions or the way they do things. Policies are carefully discussed, planned and written up. Members of that organisation are supposed to follow the policies – if they do not, there are often serious consequences. As plans, policies have written into them the consequences that must be followed if people do not follow the policy.

Policies are formal, often written, documents. They are more than rules and regulations. Governments and government departments have developed plans and policies that direct how groups of people (including themselves) are to use and manage natural resources and the physical environments that they come from.

In this topic, we are going to broaden our definition of policies to include the rules and regulations that traditional organisations and groups (for example, village fono and extended aiga or family) have developed and used to guide the way people must use natural resources and the physical environments that they live in. These are not always written down in a formal document or piece of paper.

It is important to think about policies from the past and the present and to compare them. Comparing the past with the present can help us to find out what is best for the future.

Practices

Practices are the habitual actions and customs that people do. Practices are not done just once – they are done regularly, much like habits are done regularly. Practices that affect the physical environment are the regular actions, activities and habits that groups of people do in that environment, and with the resources that are found there. Some of these practices use the resources. Some practices might conserve or take care of the resources and environment.

It is important to think about environmental practices from the past and the present and to compare them. Comparing the past with the present can help us to find out what is best for the future.

Unit

1 Geographic Patterns And Issues

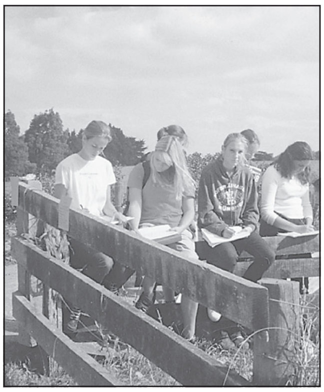


Figure 3.1.1 Students analysing the environment

Identifying Global Patterns

The term *global pattern* refers to any natural or cultural feature that is widely distributed around the world. The pattern is usually presented in map form.

Global patterns may be:

- ❑ land-based, e.g. vegetation types, mountain ranges, sports events
- ❑ ocean-based, e.g. fish species, ocean currents, shipping/sailing routes
- ❑ air-based, e.g. temperatures, winds, airline routes
- ❑ all three together, e.g. telecommunications links.

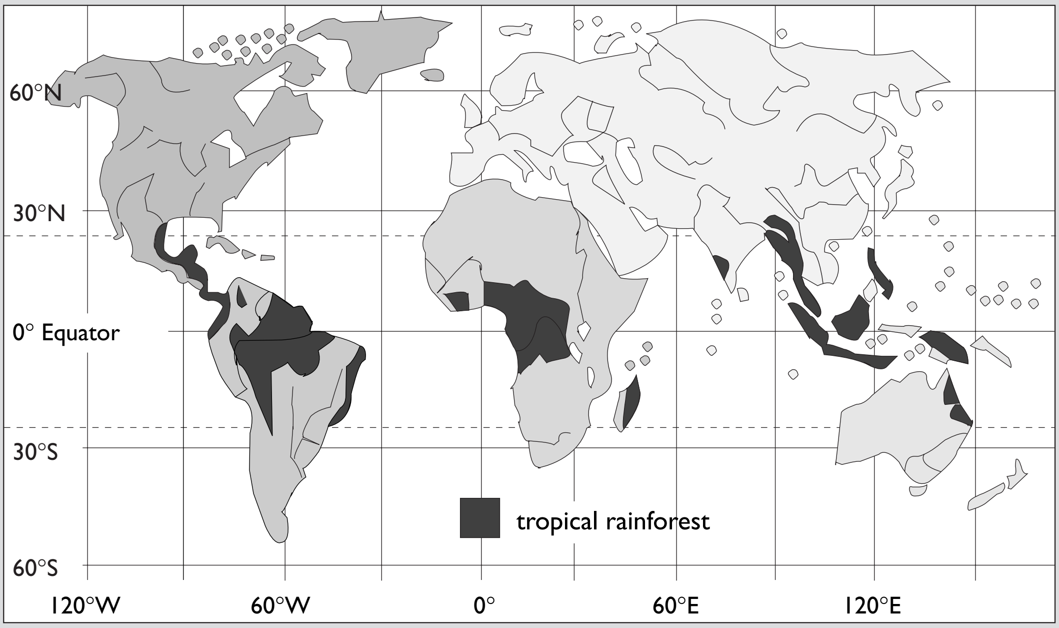
The world section of an atlas will have plenty of examples of global patterns.

Selecting A Global Pattern

In selecting a global pattern, you should consider the following points:

- ❑ Is the mapped feature widely distributed around the world?
- ❑ Is the distribution pattern clear?
- ❑ Can you name individual elements or examples within the pattern?
- ❑ Can you describe and explain the links between elements of the pattern?
- ❑ Is there sufficient information available to help explain the pattern?
- ❑ Is the pattern related to a specific geographic idea?

Case Study – The Global Pattern of Tropical Rainforests



The distribution of tropical rainforests presents a clear global pattern with nearly all the forests located within the tropics, i.e. between latitudes 23.5° North and South of the equator. These dense, evergreen forests are 'linked' by their common climate characteristics – they are all found in areas with high temperatures and high rainfall all year round. These conditions promote continuous and vigorous vegetation growth making tropical rainforests the most biologically productive and diverse ecosystems on earth.

Tropical rainforests are found in five continents – Africa, Asia, Australia, North America and South America. The largest and most famous tropical rainforest is the Amazon rainforest in South America. There are still large tropical rainforests in Asia.

Tropical rainforests have provided many vital resources for people, including rubber, nuts, timber and medicines. Sometimes described as the 'lungs' of the earth, they play an important role in balancing oxygen and carbon dioxide levels in the atmosphere.

The global pattern of tropical rainforests is changing through the process of deforestation. In the Amazon region, tropical rainforests are being cut down for timber, and cleared for mines and agriculture. As roads are cut through the forest, settlers from other parts of Brazil soon follow and more forest is cleared.

Applying geographic ideas to a pattern

You should be able to apply at least two of the following geographic ideas to your selected pattern:

Table 3.1.1 Geographic themes and ideas

Theme	Ideas	Examples
Location, distance and accessibility	The location of a feature may be expressed in different ways.	Latitude and longitude; grid references.
	Distance may be measured in terms of length, time or cost.	Travel times.
	Location and distance affect accessibility, which may alter as a result of technological change.	International telephone call rates.
	Location or distance may be an advantage or a constraint.	How New Zealand's remoteness affects its tourist industry.
Patterns, processes and regions	A range of natural and cultural processes operate in the environment.	Migration is a cultural process; continental drift is a natural process.
	Processes produce patterns – some processes encourage concentration, some encourage dispersal.	Urbanisation is a cultural process that encourages the concentration of people; emigration is a process that encourages dispersal.
Interaction	Interaction takes place in both natural cultural environments to establish patterns.	Interaction between colliding and tectonic plates produces features such as fold mountains and ocean trenches.

Contemporary geographic ideas

An *issue* is an event or sequence of events that people have a range of opinions on. Some issues, such as disputed international borders, are highly *contentious*. They may cause very heated debate and can lead to conflict. Issues are sometimes more about values rather than facts.

A *contemporary* issue is one that is being debated at the present time – now! It is likely to feature in a daily newspaper. Some issues are both contemporary and *historical* – they have been around for a long time and never seem to be fully resolved. Political issues in Northern Ireland and Palestine/Israel are two such examples, as are Treaty of Waitangi issues in New Zealand.

A *geographic* issue is one that is related to *people* and *places*. Geographic issues can usually be presented in map form and they can vary in *scale*. Geographic issues can be local, regional, national, international or even global.

Selecting an issue

In selecting a contemporary geographic issue, you should consider the following points.

- ❑ Is there a wide range of opinions or viewpoints being expressed about it?
- ❑ Is the issue really contemporary?
- ❑ Is sufficient information available to help you understand the issue and form your own opinion about it?
- ❑ Can you apply several geographic ideas to it?

Describing an issue

In describing an issue, you need to establish a *range* of opinions. This may be a simple case of those in favour of a particular action and those opposed to it. Or there may be some strongly in favour and strongly opposed. There may be more than two possible responses, and not a simple 'yes' or 'no'.

People's opinions on an issue are referred to as *value positions*. What people value can be affected by their background, their culture, age, sex or even their personality. Value positions can be shown graphically by placing them along a *continuum* separating two extreme positions. This is also known as a *bi-polar analysis*, as there are two *poles*, one at either end of the continuum line. You have to use your judgement in correctly positioning people along the line.

Relative positions are usually more important than *absolute* positions. In other words, where people are positioned in relation to others is more important than precisely how far along the line they are placed.

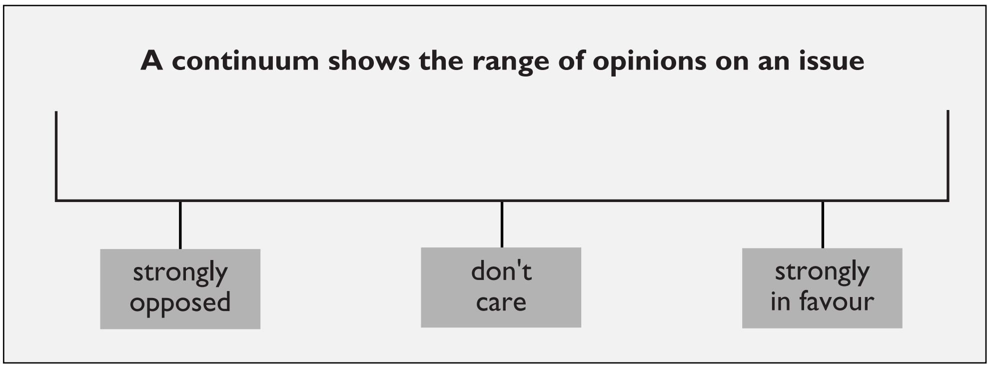


Figure 3.1.2 Range of opinions on an issue

Unit 2

Choosing A Physical Environment

Learning Outcomes

By the end of this unit and the next, you should be able to:

- ❑ Explain how and why a specific ecosystem is of national significance.
- ❑ Describe practices and policies of the past and present that have affected a specific (case study) ecosystem.
- ❑ Evaluate the effects of these changes.
- ❑ Explain different perspectives about a specific physical environment
- ❑ Explain what different groups of people want for a specific ecosystem.
- ❑ Explain how these specific wants may conflict, and evaluate the processes for addressing these conflicts.

In this topic, at this level (Year 12) you will be studying a specific type of physical environment.

The three environments that have been selected for this topic are:

- ❑ Mangroves
- ❑ Rainforests
- ❑ Inshore Marine.

Figure 3.2.1 Inshore marine

Figure 3.2.2 Inshore marine

Figure 3.2.3 Mangroves

Figure 3.2.4 Rainforest

You must choose one environment for your study. This is something that your school's geography department and geography teachers will decide. Such a decision will often be influenced by the resources that are available to your school and teachers.

Unit 3

Developing Studies Of Environmental Issues

Here is a chart that outlines the focusing questions for this topic, and provides guidelines to students and teachers for the development of this topic.

Table 3.3.1 Focusing questions

Focusing Questions	Supporting Questions	Content Areas	Suggestions for Sources of Information
Which policies and practices from the past and the present have affected the case study environment?	Did people in the past have rules about how this environment was to be used, who could use it, what it could be used for and when? (describe) Are there specific policies or Acts or agreements in the present that control how this environment is to be used? (describe)	Government environmental policy. Localised, formal agreements with non-governmental organizations about the use of the case study environment. Details of the policies/ rules. Examples of the practices that were allowed by the policies/ rules (past and present).	Invited speakers, from environmental NGOs (e.g. Siosiomaga Society, SPREP, Ministry of Natual Resources and Environment, etc). Traditional/past: as a part of field study, students interview key people in community.

(cont.)

Focusing Questions	Supporting Questions	Content Areas	Suggestions for Sources of Information
What are the causes and effects of changes in the case study environment? How and why have these changes occurred?	What are the important physical systems in this environment, and how do they interact to produce this specific environment? Where is this environment located and why is it there? Are there other environments like this one around Sāmoa? Are the reasons for their locations the same? What changes have occurred – and what are the reasons for these changes?	Describe the climate, relief and other features of the case study environment. Explain how the interactions of these elements resulted in the case study environment. Map locations of this environment in Sāmoa. Identify changes in this case study environment – and the reasons for the changes. Explain how the changes have affected the interactions.	Consult with Science teachers, for resources/ textbooks in science department on: inshore marine, mangrove and rainforest environments in Sāmoa. Teacher research into the case study environment at SPREP, Siosiomaga Society, public library, Ministry of Natural Resources and Environment.
How and why is the case study environment important at different scales? Are there differences in the reasons for why the case study environment is important for different people? If so, how can these differences in perspective be explained?	How and why is the case study environment important to (i) people that live at or close to the case study environment (ii) in other parts of Sāmoa (iii) for Sāmoa as a nation. Are there different points of view about the case study environment and its resources? What are the views, and who holds these views? Why do people hold the views that they have (i.e. what are their reasons).	Natural benefits of the case study environment (e.g. to the geology, structure, climate, soil, animal and plant life, etc). The traditional uses/ benefits of the environment to people that live there. Identify, and then compare, the different points of view and then explain them.	Student field work – survey. Speaker, from environmental organisation and government departments. Speaker, from local community. Televise Sāmoa and other media. Environment week campaigns.
How and why do different people want to use the case study environment today? Which of the viewpoints is the most sustainable, and why?	What are the arguments for and against these different uses? Which use is most sustainable? What makes that viewpoint sustainable?	Compare and contrast different viewpoints. Debate and discuss these as a class and/or in the form of an essay, piece of writing.	Speaker. Field study/geographic inquiry.

Field Work

Field work is an important learning technique in the subject of geography. Learning about an environmental issue in your community and in Sāmoa will be strengthened by field work. Turn to the next chapter of this textbook (Field Studies) for guidance on developing a geographic inquiry on an environmental issue.

Part 4

Resources And Their Uses

The aims of this strand of geography learning.

Students will recognise and understand:

- ❑ The operation of *systems of production* associated with the use of renewable and non-renewable resources interacting with the physical environment to form patterns in particular places.
- ❑ People's decision-making about the management of resources.

The achievement objectives of this strand at Year 12 level.

Students will demonstrate knowledge and understanding of:

- ❑ Farming and mining as systems of production.
- ❑ The effects of change (e.g. technology, markets, climate change) and sustainable management practices on farming and mining.

Key concepts and geographic ideas

The key concepts and important geographic ideas that we will be learning in the topics for this strand are:

Table 4.0.1 Key concepts and geographic ideas

Key Concepts	Geographic Ideas
Location	Location can be given in absolute terms or by reference to the position of something else. The reasons why something is located where it is can be explained by different physical and cultural factors.
System	The inputs, through-puts and outputs of a system make it dynamic. A system is a set of natural and cultural elements that are linked together and interact to form a whole. A system can be made up of smaller sub-systems, e.g. a farm is a sub-system of the economic system or the economy.
Sustainability	People can make careful decisions with the intention of minimising the effects of human interactions throughout a system. Informed value judgements are made about the development of environments for the benefit of future generations and other groups of people.
Perspectives	As groups of people change the way they see and use resources they will change the way they see and use environments. Cultural landscapes bear the imprints of different peoples' appraisals and use of the earth's environments.

Introduction

What Are Systems Of Production?

A **system** is the way something operates. Cars have systems, schools have systems and farms have systems. Most systems studied in geography can be divided into four parts.

- **Inputs.** These include all the *elements* required to make the system work, e.g. ingredients, equipment, energy and skill in a biscuit factory.
- **Processes.** These include all the *actions* required to make the system work, e.g. ploughing and harvesting on a farm
- **Outputs.** These include all *products* of the system, including wastes, e.g. shoes, wages and scrap leather from a shoe factory.
- **Feedback.** This includes all outputs that affect the further operation of the system, e.g. profits reinvested in the factory, experience gained by workers.

Processes are sometimes known as through-puts, operations or transformations.

Here's a simple example of a systems diagram:

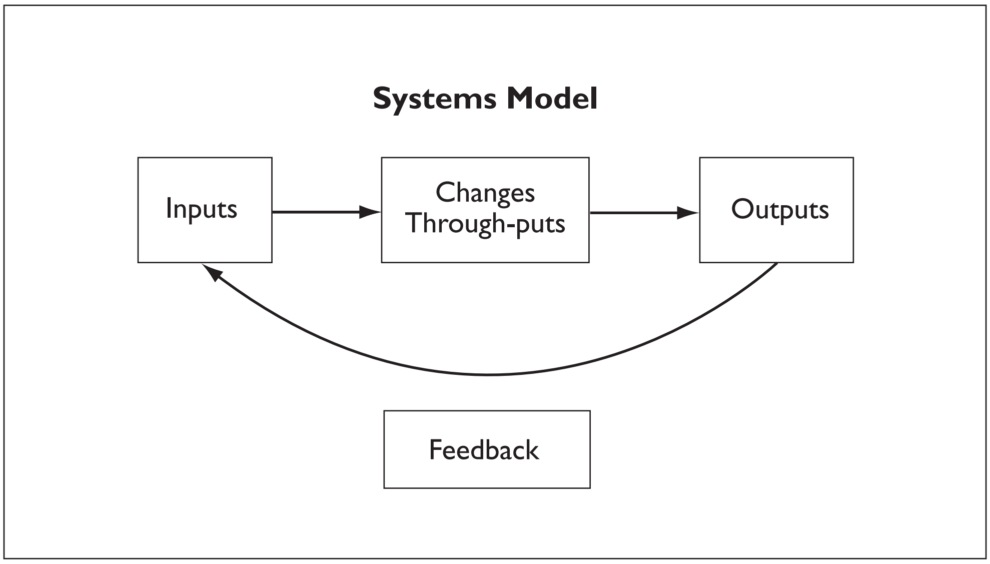


Figure 4.0.1 Systems model

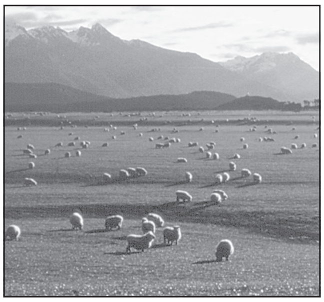


Figure 4.0.2 Sheep farm

What Are Renewable And Non-Renewable Resources?

A **resource** helps you do something. Paints and brushes are resources used by artists. Tractors and fences are resources used by farmers. There are many kinds of resources and they can be classified as:

- **Natural resources**, which are provided by nature, e.g. timber, gold, air.
- **Cultural resources**, which are made by people, e.g. computers, scissors, money.

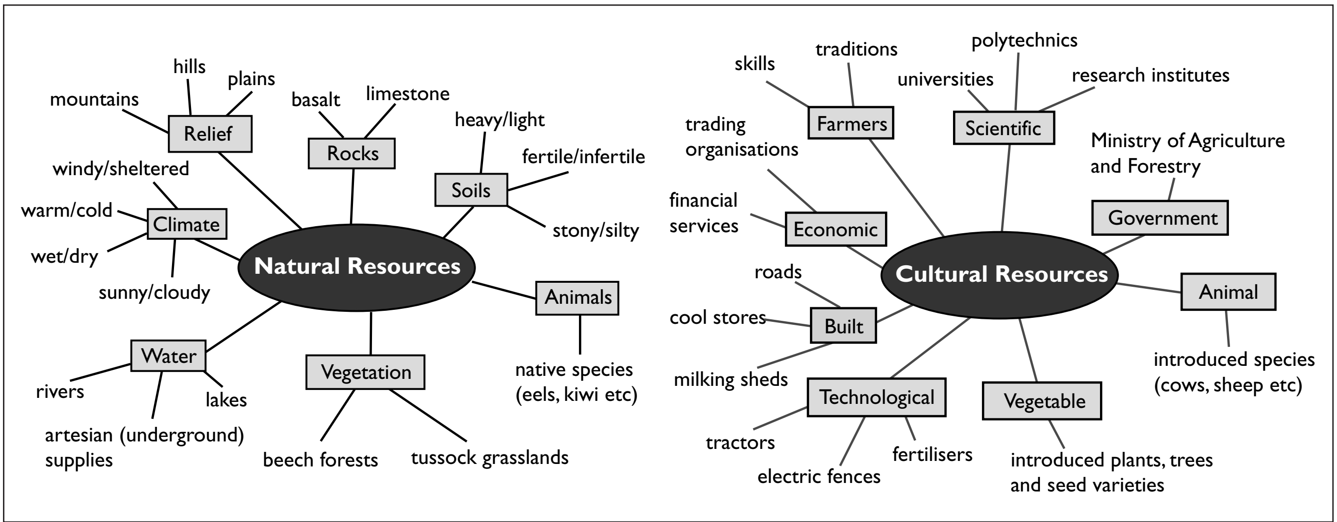


Figure 4.0.3 Natural and cultural resources

Natural resources can be further classified as:

- **Renewable resources**, which, after being used, can naturally replace or restore themselves, e.g. air, water, soil, vegetation, sunshine.
- **Non-renewable resources**, which, after being used, will not naturally replace or restore themselves, e.g. coal, gold. Once a gold deposit has been mined, it has gone forever.

Figure 4.0.4 Renewable and non-renewable resources

Renewable resources may not naturally replace, restore or replenish themselves if their use is not properly managed. Most renewable resources need **sustainable management** to guarantee their future availability. For example, the natural fertility of soil may not be *sustained* if the same crop is grown on it year after year. Other renewable resources, such as energy from the sun, are more easily sustained.

Some renewable natural resources are not sustainably managed on farms. In some areas, soils require the application of large quantities of chemical **fertilisers** (made from non-renewable resources) to keep them productive. This sustains production but not the long-term health of the soils.

Unit 1

Farming Systems

Farming is when human beings use a combination of resources to grow crops or raise livestock (animals). There are many different systems for growing crops such as rice, wheat (used to make flour), corn, vegetables and fruits. There are also many different systems for raising animals like cows, pigs and chickens. The process of cultivating land to grow crops and raise livestock is also called agriculture.

Some countries, such as New Zealand, have more types of farming systems than Sāmoa because they are:

- bigger in area
- have a range of climates
- have a range of soil types and relief.

We will look briefly at New Zealand and its different types of farming in order to better understand how and why farming can be so different.

Farming In A Large Temperate Pacific Nation – New Zealand

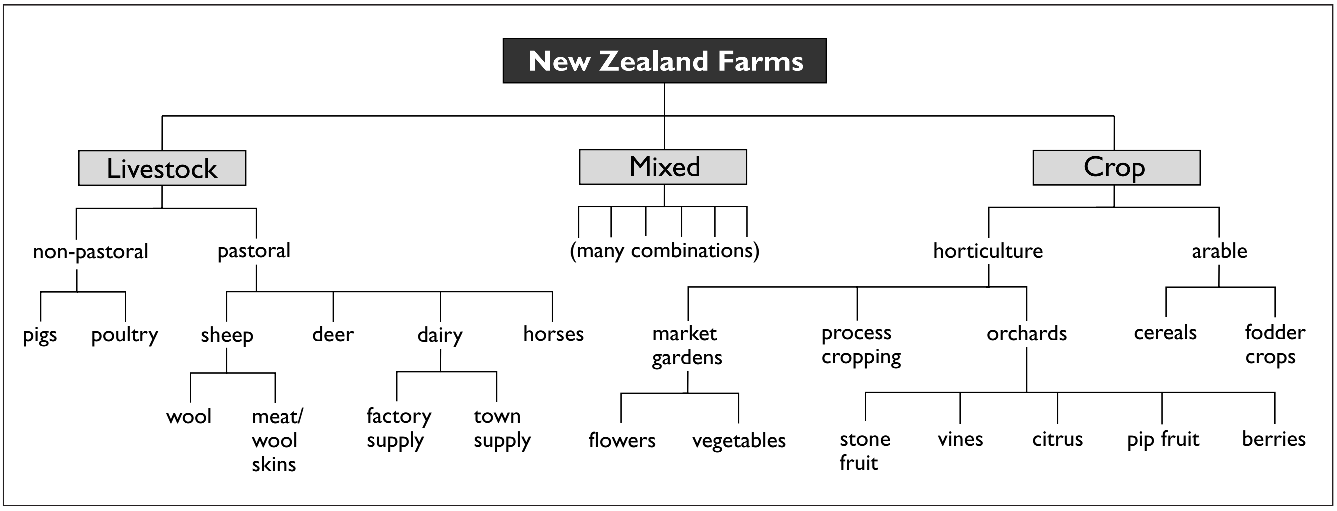


Figure 4.1.1 Farming in New Zealand

Farming in New Zealand

In 2000, New Zealand had 26 different farm types (excluding forestry) and over 60 000 farms, covering 52% of the country.

New Zealand farms can be classified as **livestock farms** (animals), **crop farms** or **mixed farms** (livestock and crop). Each of these classes of farm can be subdivided into a wide range of farm types. For example, livestock farms are either **pastoral** (grow grass for grazing) or non-pastoral (without grass). Pastoral can be subdivided into sheep farming, dairy farming, beef farming, horse breeding, deer farming and so on. Then there are different types of dairy farming, and so it goes on!

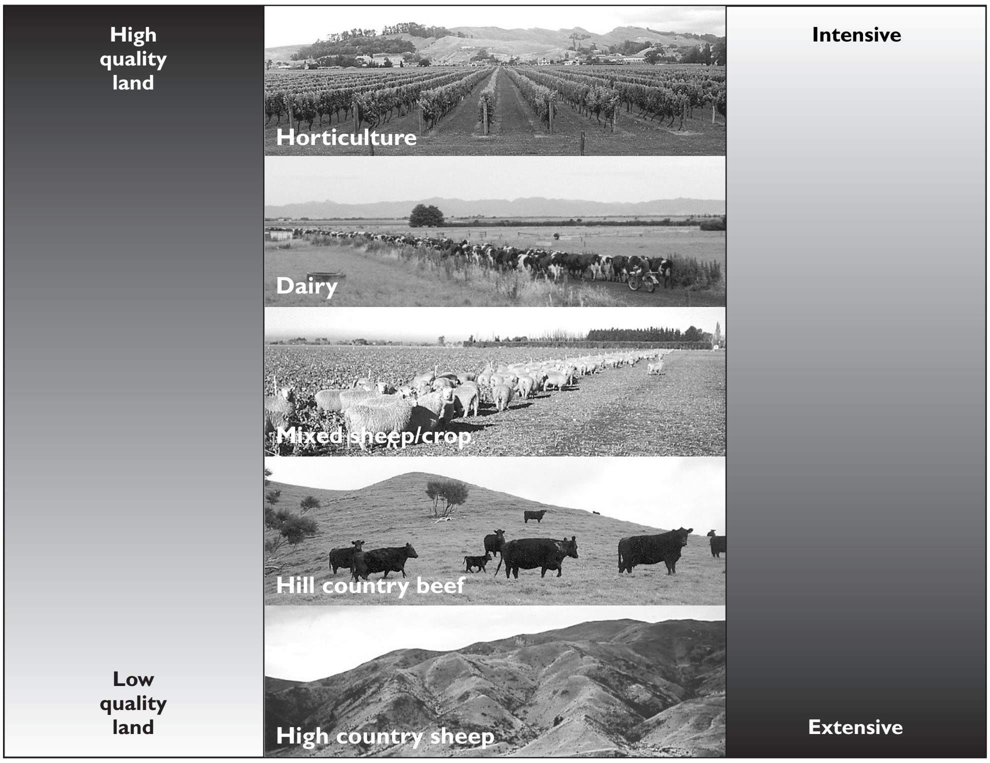


Figure 4.1.2 Farming in New Zealand

Each type of farm has a different operating system.

The diversity of farming systems in New Zealand reflects the wide range of natural and cultural resources available for farming here.

Farms in areas with the best natural resources pay a high price to use the land and so have to be very productive and efficient if they are to be profitable. They are usually relatively small with high inputs and outputs per hectare. They are known as **intensive** farms, e.g. horticultural farms.

Farms in areas with poorer resources are usually larger and have low inputs and outputs per hectare. They are known as **extensive** farms, e.g. high country sheep farms. They have low **stock ratios**, i.e. few animals per hectare.

Farm distribution

A map of New Zealand farm types reveals some clear patterns. For example, nearly all extensive farming is found on the eastern side of the country. The reasons why farm types are located in particular areas are called **location factors**.

Different farming systems have different resource requirements. Farming systems can be matched with some key natural resources (location factors):

- ❑ flat land
- ❑ plenty of sunshine and rain
- ❑ fertile soils
- ❑ close to population centres.

Farms whose products (usually vegetables) have to be sold *fresh* in the markets every day are known as market gardens. They need to be located close to towns and cities.

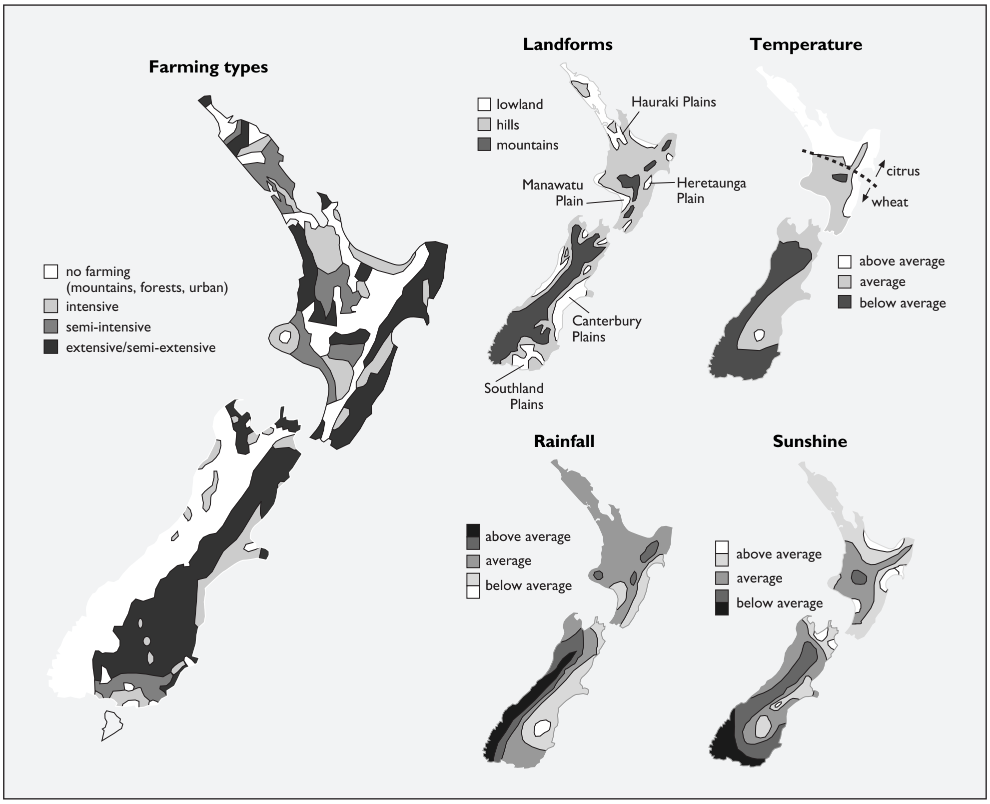


Figure 4.1.3 Types of farms in New Zealand

Farming changes

New Zealand's farm geography is constantly changing, and it will continue to change in the future. Economic, technological, environmental and cultural developments will continue to affect what farms produce, how they operate and where they are located.

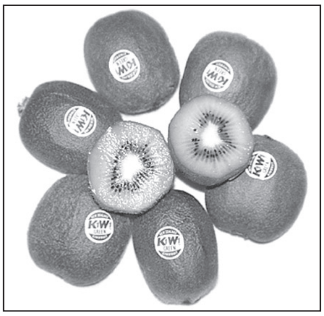


Figure 4.1.4 Kiwifruit

Some changes are the result of trade and economic developments.

- The successful overseas marketing of kiwifruit and deer products in the 1970s and 1980s has seen the rapid spread of kiwifruit orchards and deer farms.
- Changing export prices for dairy products and lower prices for sheep products during the 1990s saw many Southland farms converting from sheep farming to dairy farming.

Technological developments have been a major influence on New Zealand farming ever since *refrigeration* made it possible to start selling frozen meat to Europe in 1882. Other technological developments have brought further changes to where and how farming occurs in New Zealand.

Figure 4.1.5 Irrigation

- *Fertilisers* allow farming on infertile land.
- *Irrigation* allows farming in areas that are otherwise too dry.
- *Greenhouses* allow crops to be grown in areas that would otherwise be too cold.
- *Hydroponics* allow crops to grow without soil.
- *Zero grazing* techniques allow dairying to be carried out in barns, without grass and natural light – the cow equivalent of battery hen farming.
- *Genetic engineering* may bring even greater changes in the future.

Environmental concerns are very gradually changing farming practices in New Zealand. New Zealand is likely to lose its 'clean and green' image unless major changes are made. A few farmers are turning to organic farming, while others are reducing their use of chemical sprays. Overstocking of animals, excessive use of chemical fertilisers and soil erosion are causing serious damage to New Zealand's soils. Most farmers are being encouraged to improve their environmental standards, but progress is still very slow.

Cultural developments have also influenced farming patterns in New Zealand.

- In pre-European times, Maori agriculture was based on local pockets of horticulture, growing kumara, yams and taro. These crops were introduced from tropical Polynesia and were difficult to grow in cooler New Zealand. Simple digging sticks were the main farming tools. Rock mounds, which absorbed heat from the sun, were used to raise ground temperatures for kumara cultivation.

Figure 4.1.6 Pioneer cultivation

- European settlers introduced to New Zealand a new range of crops (e.g. wheat and barley), pastoral farming and a wide range of farming implements. In the 1840s and 1850s, most of New Zealand's farm produce came from Maori farms. After the 'land wars' and land confiscations of the 1860s, the best farmland was occupied by European New Zealanders, who have dominated farming in this country ever since.
- Immigrants from *Yugoslavia* introduced vineyards and wine making.
- Many *Chinese* immigrants became successful market gardeners.

Key Points Summary

- ❑ New Zealand offers farmers a wide variety of natural and cultural resources.
- ❑ All farms make use of renewable resources, but careful management is required to sustain them.
- ❑ New Zealand has a wide variety of farming systems, but pastoral farming has dominated since European settlement began here.
- ❑ Farms range from small and highly intensive horticultural farms to large and extensive high country sheep stations.
- ❑ The geography of farming in New Zealand is constantly changing, and will continue to change in response to economic, technological and social developments.

Farming In A Smaller Tropical Pacific Nation – Sāmoa

Compared to New Zealand, farming or agriculture in Sāmoa is based on a small range of crops and only a few systems have developed.

The system of farming that involves the most people in Sāmoa is *mixed subsistence cash cropping*. This means that for the majority of families involved with farming (or agriculture), a variety of crops are grown – some for the people to use themselves, and the rest for selling to earn money. The crops that are grown are usually taro, bananas, cocoa and coconuts. Many farming families will also have chickens and pigs, and a few will have cattle (cows).

A smaller number of people are involved with commercial farming. They grow one or two crops – this is called monoculture. The main reason for growing the crops is to sell and to make a profit. This type of farming is a type of commercial farming – called *plantation agriculture*.

The six main crops that are grown in Sāmoa are coconuts, taro, cocoa, taamu, banana and breadfruit.

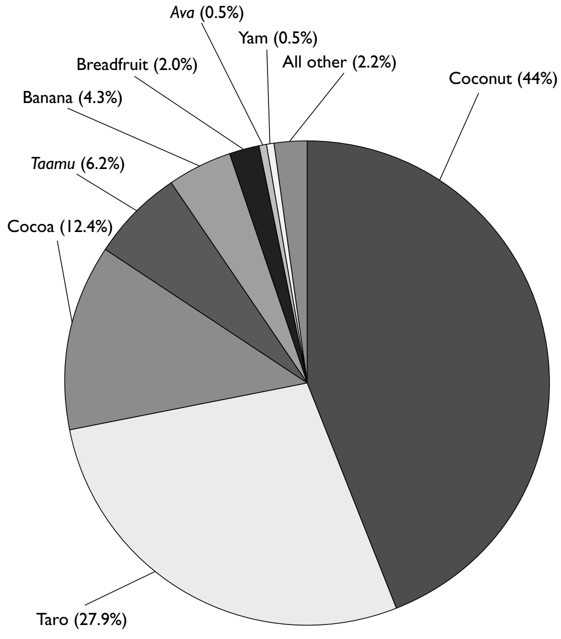


Figure 4.1.7 Percentage of Farmland Under Cultivation (excludes commercial farms or plantations), 1989

Source: adapted from Sāmoa: Mapping the Diversity, by R. Gerard and P. Ashcroft page 100

Much of the livestock that is raised in Sāmoa is for household use – that is, families raise a few pigs, chickens and perhaps cows, for their own use (and not for commercial reasons). There are some cattle farms. It was estimated in 1990 that there were 10 000 cattle on cattle farms owned by WSTEC (Western Sāmoa Trust Estates Corporation), government, companies, groups and individuals. There are also several commercial piggeries (pig farms) and chicken farms (for eggs). The main market for this farmed livestock is Apia. It has been estimated that, in the early 1980s, about 68% of the meat eaten in Sāmoa was imported from countries such as New Zealand, the USA and Australia.

Source: Ward and Ashcroft, Chapters 8 and 9.

Extra Points

In Sāmoa:

- There is NOT a diversity of farming systems.
- There are two sectors that produce crops and raise livestock: the household (families in rural areas) and the commercial sector.
- The two main systems of farming or agriculture are: (i) mixed subsistence cash cropping (done by households, mainly using customary land), and (ii) commercial plantations (done by government, companies and individuals using freehold or leased land).
- Farming has been helped by the development of a good system of roads – this means that people can transport the outputs of their farms easily and quickly to the market.
- The main market is Apia – this is also the point of departure for many products that are exported overseas.

Unit 2

Banana Farming In Sāmoa

Learning Outcomes

At the end of this unit you should be able to:

- ❑ Describe and explain how banana farming operates as a system of production.
- ❑ Account for the location of banana farms in Sāmoa.
- ❑ Describe the resources used in banana farming and explain how they are managed.
- ❑ Describe the technology used in banana farming and evaluate any positive or negative effects this has.
- ❑ Compare and contrast different perspectives people may have of banana farming, and any issues and problems that are involved.

Bananas

Global

- ❑ Scientists believe that bananas originated in Malaysia because that is where the most varieties of banana are found. Bananas were probably the first fruit farmed by human beings.
- ❑ The banana is the fruit of the genus *Musa* of the family *Musacecae*. Most bananas in the export trade are the Cavendish variety.
- ❑ The banana plant is not a tree – it is a gigantic herb that grows from an underground stem or rhizome to form a false trunk 3–6 m high. (It may look like a tree trunk but it is not a real one because it is not hard and woody.)
- ❑ Bananas grow in tropical places where the climate is hot and sunny, and there is plenty of rain. For example, central and south America, parts of Africa, SE Asia and, yes, the Pacific!

- About 20% of the 65 million tonnes of bananas grown each year are exported and are part of international world trade. This means that 80% of all the bananas that are grown in the world are used within the countries they are grown in. For example, Brazil and India are the two biggest banana producing countries but hardly any of their bananas are exported to other countries. Ecuador, in South America, is the number one exporter of bananas in the world.
- Bananas are the fourth most important staple crop in the world.
- World trade in bananas is dominated by three transnational companies – Del Monte, Dole, and Chiquita. These three companies take care of 70% of the world banana trade.

Sāmoa

- Bananas are grown widely in Sāmoa. It is an important food crop for local consumption.
- Some bananas are exported – these are green bananas. The main export countries are New Zealand and American Sāmoa. The main market for banana farmers is the local or domestic market.
- Some bananas are processed within Sāmoa for the domestic market. They are made into banana chips.
- Bananas are the fifth largest crop in Sāmoa (in terms of the area of farming or agricultural land).
- Bananas are grown either as a single crop or planted with coconuts, cocoa, taro or other food crops.
- Bananas used to be a very important export crop for Sāmoa. Exporting bananas to New Zealand began in 1928 when Sāmoa was under New Zealand administration. Shipping was very regular to New Zealand, because there was a passenger service once a fortnight. This is the service that transported the export bananas to New Zealand.
- Banana exports peaked in the 1950s and then began to decline through the 1960s. The main reasons for the decline were:
  - **a** some areas stopped farming bananas to focus on other crops such as cocoa
  - **b** effects of pests such as scab moth and bunchy top disease. This caused problems for fruit quality
  - **c** changes in transport technology. In the 1960s, Sāmoa began to be served with air transport. The need for the regular passenger shipping route declined. This had the effect of reducing the transport of bananas for export.
- When taro farming declined in the early 1990s (due to the Taro Leaf Blight that appeared in the middle of 1993 and spread rapidly throughout Sāmoa by the end of that year), the importance of banana increased. The demand for banana within Sāmoa (the domestic market) increased.
- The government is providing support to encourage the re-establishment of the banana export market.

Location Of Banana Farming

Historically

When commercial banana farming for export began in Sāmoa in the late 1920s, at first banana farming was only located in northern Upolu because these areas had road access to Apia (where the bananas were shipped). Later, banana farming spread to southwest Upolu and eastern Savai'i because of the use of boats to transport the fruit to Apia. As the road network was developed, more areas set up banana farms or plantations.

Present day location factors

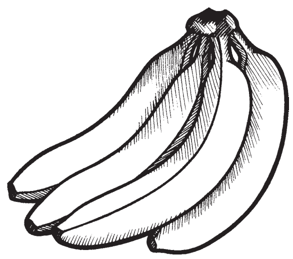
The location and distribution of commercial banana farms (or plantations, as they are often called) is affected by climate, relief, soils, population distribution, technology and trade.

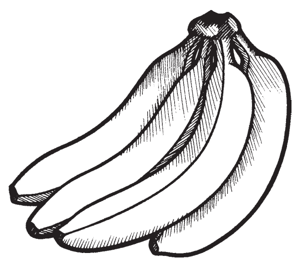
Soils
- deep, loose, highly fertile, well-drained
- high organic matter, nitrogen and potash.

Relief
- flat to gently sloping land (to minimise soil erosion, make weeding and harvesting easier).

Climate
- humid, tropical climate needed
- temperatures of 25–30°C
- annual rainfall of 1500–2000 mm.

NATURAL





CULTURAL

Economic
- domestic and export prices of banana influence increase/decrease of land for banana growing
- income from farming in Sāmoa is not taxed
- tariffs for imported inputs (pesticides, equipment, fertlisers, etc) are low.

Technology and Technical Support
- The Crops, Research and Extension Divisions of the Ministry of Agriculture provides advice
- The University of the South Pacific, School of Agriculture has a tissue culture laboratory and offers research advice
- The Department of Trade and Commerce and Industry provides information about banana production and marketing
- The Sub-Regional Office of the Food and Agricultural Organisation (FAO) is based in Apia – it can access worldwide information.

Infrstructure
- Sāmoa has a very good network of roads on both Savai'i and Upolu
- Apia is the main port, with well-equipped storage facilities as well as cargo handling and stevedoring
- the infrastructure in Sāmoa can easily support increases in the amount of bananas grown and distributed to domestic and export markets.

Population
- plentiful supply of labour (Sāmoa has a youthful population)
- the Apia urban area is a major domestic market as well as a port for exporting.

Land
- ten acre blocks of land that are suitable for commercial banana production are available for secure lease from Sāmoa Land Corporation (SLC). The SLC is sub-dividing land that used to be part of the Western Sāmoa Trust Estates Corporation (WSTEC) at Tafaigata, inland from Apia.

Figure 4.2.1 Banana farm location factors

Growing Bananas – Managing Nature

The stages in the natural life cycle of the banana are:

- vegetative growth (when a shoot grows upwards out of the soil and develops the leaves that form the trunk and crown of a banana plant or 'tree')
- flowering (when from within the crown of very long leaves, a spike grows out and then downwards and many small yellowish flowers appear. The spike of flowers becomes a bunch of bananas. The tree then dies)
- reproductive growth (when the mature underground stem produces new shoots about every six months).

The banana plant is a giant herb that grows from an underground stem to form a false trunk. Unlike a real tree, the trunk of the banana is made up of the base of leaf sheaths that grow outwards as long leaves at the top of the trunk.

Initial planting

When a banana plantation is first started, the land is cleared. Then, banana sword suckers or pieces of corm (underground stem) are carefully prepared and planted in holes that are spaced 2.5 metres by 3.5 metres. The spacing is important to prevent crowding of banana plants. It takes about 39 weeks (or 10–12 months, depending on the altitude of the banana plantation – slightly cooler temperatures will slow growth and development) before a planted corm develops its first mature plant. A mature plant is one that has produced a bunch of bananas. A mature banana plant will produce one bunch of bananas before it dies.

Pruning

The life of a matured, underground stem can continue for many years. It will send out shoots that have the potential to be new plants regularly. In banana farming, the weaker shoots are cut down or pruned, so that only strong ones can grow into fruit-producing plants. This pruning is also important for reducing crowding of plants. Too many plants growing from the same place means increased competition for the soil nutrients for good growth and fruit. Frequent pruning is needed.

Weeding

Weeds grow quickly in tropical climates. Weeds can be a big problem when a banana plantation is first established because the shoots from the corms are small and can be easily overcome if weeds are not controlled. Weeds are cut down by knife, or chemicals are sprayed on the surface of the land around the plantings. Weeds also have to be controlled when the mature plant is cut down after the bunch of bananas has been harvested. This is another time when the growth of shoots needs to be protected.

Protection from disease

There are a number of diseases that can affect banana plants. When bananas are grown in a plantation it is often as a monoculture – that is, bananas are the only crop being farmed. Some farmers might cultivate or grow other smaller crops around the banana plants (e.g. taro). The problem in both cases (especially for the first) is that, when one plant becomes infected with a disease such as black leaf or fungus, it spreads very quickly through the whole plantation. This is why farmers use chemicals (pesticides) to protect the crop, and regularly check their plants.

Applying fertiliser

The farmers that want to produce high quality bananas (the better the quality of the fruit, the better the price they can sell the bananas for) need to have lots of water and tropical temperatures all year around. Banana farmers do not really need to worry about these natural inputs. However, the production of high quality bananas also involves controlling weeds (to maximise plant growth), protecting the plants from diseases and insect pests and making sure the plants have high quantities of nutrients. Banana plants use very large amounts of soil nutrients. When the natural nutrients of the soil are used up (and this happens quite quickly), farmers must help nature along by supplying extra 'plant food'. This is done by applying fertilisers.

Harvesting and export inspection

The bunches of bananas are carefully cut down and transported either directly to a domestic market or to a central point for inspection (for those farmers that have been trying to grow for export). The bananas are inspected for cracked skins, bruising, mealy bugs, length (they must not be longer than six inches) and maturity (they must not be more than three-quarters mature). Bananas that pass inspection are cut (from a bunch into hands), washed and cured before they are shipped. Due to the very high standards that must be met for export, about 60% of the bananas that are checked are rejected and cannot be exported.

The Banana Farming System

Banana growing can be seen as a system with inputs, processes, outputs and feedback.

BANANA FARMING SYSTEM

INPUTS – Natural
- sunshine – high sunshine hours
- rainfall – 1500–2000 mm annually
- temperature – 25–30°C
- relief – flat to gently sloping
- soil – deep, good drainage, very fertile.

INPUTS – Cultural
- land tenure – if customary, then permission needed; leasehold, from government; freehold, then check legal title
- planting material – sword suckers, corms
- labour – at least 125 labour days (for the different activities needed)
- management skills – financial planning, budgeting, crop husbandry and harvesting
- advice and technical support
- implements and tools – mist blower, knapsack sprayer, scab moth injector, truck
- chemicals – vydate, calixin, gramoxone, tilt, misting oil, tridex, engine oil, petrol
- infrastructure – road network, shipping, agricultural inspection (for export quality).

→

PROCESSES/ CHANGES
- establish the plantation (clear the land)
- planting of suckers and corms
- crop husbandry processes: weeding, fertilising, pest control, pruning, checking
- harvesting
- transportation to market
- inspection for export
- selling to market (export, local or domestic, banana chip factory).

→

OUTPUTS
- bananas (mainly Cavendish; misiluki) – with high levels of management, fertiliser and chemicals, one acre of land can produce about 10 000 kilograms of bananas from a 10 acre holding
- suckers and pieces of corm for new plantings
- human – increased experience and improved skills
- profits
- chemical runoff into streams and river systems
- soil run-off
- used plastic bags, and other implements
- cut down banana plants.

FEEDBACK
- suckers and corms
- profits – used to buy new equipment, chemicals, etc
- decaying stems of old banana plants (organic fertiliser/mulch).

Figure 4.2.2 Banana farming system

Banana Farming And Renewable Resources

Growing bananas in Sāmoa depends on the use of several kinds of renewable resources – especially the soil, water, sunshine (and, with that, temperature) and people. Yes, people and their knowledge and skills are a renewable resource! 'People renewable resources' can also refer to the financial services and government programmes that support and encourage banana growing.

Here are some points about how these important renewable resources can be sustained:

- The heavy use of chemicals to try to produce high quality, even export-quality bananas is a concern because of the longer term consequences for other parts of Sāmoa, and other groups of people besides banana farmers. Better bananas might be the short term consequence – which can only be good for farmers. But if contamination of waterways and supplies is an issue (and environmentalists say that there is evidence of the damage of chemical run-off in the in-shore marine environment), then there could be pressures from others on banana farmers to control and even reduce the use of chemicals that they use.
- Soil erosion is a concern, although the risk of soil erosion from the heavy tropical rains is less after the plants have grown into full mature plants.
- There is a market in New Zealand for organically grown bananas. Bananas are a very popular fruit in countries like New Zealand – these countries cannot grow bananas because their climates are not suitable. There are people in New Zealand who want to eat fruit and vegetables that have not been grown with the use of chemicals. Organic specialty bananas, such as the Goldfinger variety, achieve very good prices. There is one commercial farmer in Sāmoa who is exporting such bananas to New Zealand. This not only shows that there is another economic opportunity for banana farmers but also that there could be ways to grow bananas that have less of an effect on some of the renewable resources that are needed.

Technology And Banana Farming

- Commercial banana farming needs high levels of chemical inputs – pesticides, fertilisers and weed killers. Applying these chemicals over the plantation (which could be 10 acres in size) requires tools and implements such as knapsacks, sprayers, misters and so on. Chemicals, tools and implements are examples of technology. These technologies are very necessary for the commercial farming of banana.
- Other changes or developments of technology may influence farmers' decisions about growing bananas. In other words, changes in technologies for processing, transporting and treating bananas can encourage banana production.

  For example:

  a If a High Temperature Forced Air (HTFA) disinfestation plant were built in Apia, it would make it easier to eradicate the mealy bug infestation and allow bananas to be exported at a more advanced stage of ripeness.

b If a banana processing plant or factory were built in Sāmoa that turned banana into banana puree, then farmers could sell their bananas to this local food processor. This is an attractive alternative to exporting because it reduces the need for farmers to grow high quality bananas. They could reduce the costs of growing bananas if they used fewer chemical inputs. Another advantage of local processing is banana exports could avoid trying to meet the strict quarantine rules of export countries.

Banana Farming – Environmental Issues

Problems caused by the environment

Commercial farming is a monocultural activity. As has been mentioned before, when there are large areas planted in the same crop, there is an increased risk of the rapid spread of pests and plant diseases. There may be living organisms in the environment that will naturally thrive on banana plants. The effects will be greater if there are lots of banana plants located and growing together.

Environmental problems caused by banana farming

Chemical pollution is a major problem for the environment that is a consequence of banana farming. This is because of the heavy use of pesticides and fertilisers that farmers use in order to produce high quality bananas for the domestic, and especially the export, markets.

Another environmental problem is soil erosion. Commercial banana plantations do not provide the same dense vegetation cover that the natural rainforest does. This leaves the soil more at risk of being washed away. Soil and chemicals are washed away into the water systems, and eventually enter the inshore marine environment. This has been a major environmental concern, because of the effects on coral reefs and other marine life.

Soil erosion also results in a loss of soil fertility, increasing the need for the application of more artificial fertiliser on the banana farms or plantations.

Another environmental problem is the effect of clearing natural vegetation for plantations in water catchment areas. When water catchment areas are cleared of dense natural vegetation, more rainfall washes off the land and into the river and stream systems. This reduces the amount of rain that is absorbed through the soil into the ground water system. Water that is retained in this way in a catchment area means a more constant and regular supply of water for the water systems that supply human settlements – including Apia and the Apia Urban Area.

Clean, Green And Profitable?

Organic production

There is a market for organically grown bananas in places like New Zealand. There are more and more people there that are willing to pay more money (i.e. higher prices) for fruit and vegetables that have NOT been treated with chemicals. Consumers that want to eat organically grown fruit and vegetables want to be healthy and want to be careful about the environment as well. If farmers are willing to learn different methods to produce organic bananas (and to meet the strict import requirements of New Zealand), this could be a type of farming that would earn a good income as well as be more economically sustainable for farmers, and more environmentally sustainable for the physical environment of Sāmoa.

Cultural Perspectives

Figure 4.2.3 Cultural perspectives on banana farming

Key Points Summary

- ❑ For the commercial production of bananas in Sāmoa, careful management of the natural and cultural inputs is necessary.
- ❑ Banana growing is best suited to flat or gentle sloping land with fertile, well drained soils, high temperatures throughout the year and abundant rainfall.
- ❑ Bananas are a staple crop in Sāmoa and, even though taro production has improved since the devastating Taro Leaf Blight of the 1990s, the demand for bananas is very strong. So the domestic market is strong but most of all, reliable
- ❑ There is a good, reliable demand for green bananas from the Pacific Islands community in New Zealand. American Sāmoa is also a good reliable market for green bananas. The export market is sound.
- ❑ Economic factors have had a very important influence on the growth and decline and then growth again of banana farming in Sāmoa.
- ❑ Government encouragement and support by way of technical advice, tax incentives, low tariffs on imported inputs (therefore controlling how expensive these inputs will be for farmers), relatively inexpensive land lease opportunities and low interest loans are the major cultural inputs to encourage banana farming at present.
- ❑ Environmental issues and concerns (related to the chemicals used for production) do not seem to be very strong or commonly shared.
- ❑ Transport networks (good systems of roads and shipping) are also a key cultural input in the banana system.

Learning Activities

Section A

1 Match up the descriptions with the terms.

a resource	**A** farming of animals
b feedback	**B** organisation of resources for production
c renewable resource	**C** protects a resource for future use
d intensive farms	**D** outputs that affect the efficiency of a system
e sustainable management	**E** helpful object or material
f livestock farming	**F** farms with high inputs and high outputs per hectare
g system	**G** resource which naturally replaces itself

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

  a Dairy cows are a natural resource.
  b Sand is a non-renewable resource.
  c The use of chemical fertilisers on a farm is an example of sustainable management.
  d Sunshine is a natural input in most farming systems.
  e Dairying is an example of extensive farming.
  f Technological developments have been a major cause of farming change in New Zealand.

3 Find evidence to support this important geographic idea:

  Cultural processes interact with the natural environment to establish patterns in particular places.

4 Find the answers to the following questions in the text.

  a What is a non-renewable resource?
  b What percentage of New Zealand is used for farming?
  c What is a mixed farm?
  d Why are some areas farmed more intensively than others?
  e Which farm types dominate areas of flat land? Why?
  f Which farm types are located only in sunny areas? Why?
  g Where are market gardens typically located? Why?

5 What conclusions can you draw from the table of 1996 New Zealand farming data?

Table 4.2.1 New Zealand farm data 1996

Farm Type (excludes forestry)	% of total farmland	Number of farms	Average farm size (ha)
All farms	100	62 629	228
Sheep & beef	74	16 215	588
Dairy	14	16 465	123
Vegetables	1	2780	49
Kiwifruit	0.2	1722	16
Other	10.8		

Figure 4.2.4 Sheep yards

6 Write a geographic paragraph to describe and explain the general pattern of farming types in New Zealand. (Remember the GREED approach to paragraph writing.)

Section B

1 Decide which of these statements are true or false. Explain why the false statements are incorrect.

- ❑ The Pacific nations are New Zealand's main source of bananas.
- ❑ Banana farming takes up 20% of the agricultural land in Sāmoa.
- ❑ A banana farming system in Sāmoa has no negative feedback.
- ❑ Pruning banana shoots is not a necessary operation on a banana plantation – farmers do it to make the farm look tidy.
- ❑ The taro blight in the 1990s had a major influence on banana production in Sāmoa.
- ❑ The main reason for the decline of commercial banana farming in the 1960s was an outbreak of a disease.
- ❑ Banana plants require high levels of fertiliser.
- ❑ Only 25% of bananas that are put forward by farmers for export are rejected

2 **a** What evidence would you use to prove that banana farming is an intensive land use?

b What are the main location factors for the distribution of commercial banana plantations in Sāmoa?

c Why do banana shoots have to be pruned regularly?

d Besides cutting shoots, how else do banana farmers control the growth of bananas?

e Give examples of positive and negative outputs in a banana system.

f Is banana farming becoming more or less dependent on renewable resources?

3 Write geographic paragraphs to describe and explain:

- ❑ how banana farms function as a system
- ❑ the environmental issues that are related to banana farming in Sāmoa.

4 Write a geographic paragraph to discuss how sustainable banana farming is.

5 Find evidence in this topic on banana farming for this important geographic idea:

A system is a set of natural and cultural elements that are linked together and interact to form a whole.

6 Mini-research:

- ❑ Investigate the price, availability and quality of bananas in your local market. Find out how growers feel about the commercial benefits of growing bananas.
- ❑ Find out if people you know in your community have different perspectives on the environmental effects of commercial banana farming.

Section C

1 Find a copy of 'Sāmoa: Mapping the Diversity' by Ward and Ashcroft, and look for the map titled: *Proportion of agricultural households growing bananas, 1989*.

Answer these questions:

a What kind of information does this map give about the location of banana farming in Sāmoa?

b Discuss the strengths and weaknesses of this map, in providing information about the location of banana farming in Sāmoa. List these in your workbooks.

c Write a generalisation based on the map about the location of banana cultivation in Sāmoa.

2 Examine a growing, mature banana plant. Draw and then label the different parts of the plant. Look closely at the ground around the plant and see if you can identify or find signs of shoots growing up from the underground stem. Clearly show, on your sketch, the patterns on the trunk that show that it (the trunk) is really made up of tightly bounded leaves.

Unit 3

Mining Systems

What Is A Mineral?

A mineral is an inorganic (neither animal nor vegetable) material produced by natural processes. For the purposes of your Geography course, we will consider only minerals that:

- have a use and have economic value
- can be extracted from on or below the earth's surface
- are non-renewable.

Figure 4.3.1 Mining vehicle in action

Gold, silver, ironsand and copper are examples of true minerals.

Limestone, coal, oil and gas are not strictly minerals. Coal, oil and gas are **hydrocarbons**, which originate from plants that have decomposed in swamps, and limestone which originates from corals once living under the sea. For economic purposes, however, they are given mineral status and so are included in this study. On the other hand, water, a true mineral, is *not* included as it is a *renewable* resource.

The extraction of minerals is usually referred to as **mining**. The extraction of low-value rocks for construction purposes is usually called **quarrying**. The oil and gas industry use neither term. They simply refer to oil or gas *extraction*.

Figure 4.3.2 Open-cast copper mine

Mineral Extraction

Commercial mineral extraction occurs when:

- a mineral resource is identified
- there is an economic demand for it
- a mining company has a legal right and the financial, human and technical resources to profitably extract it.

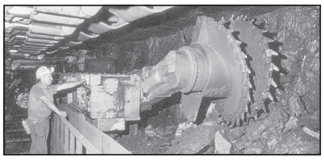


Figure 4.3.3 Underground coal mine

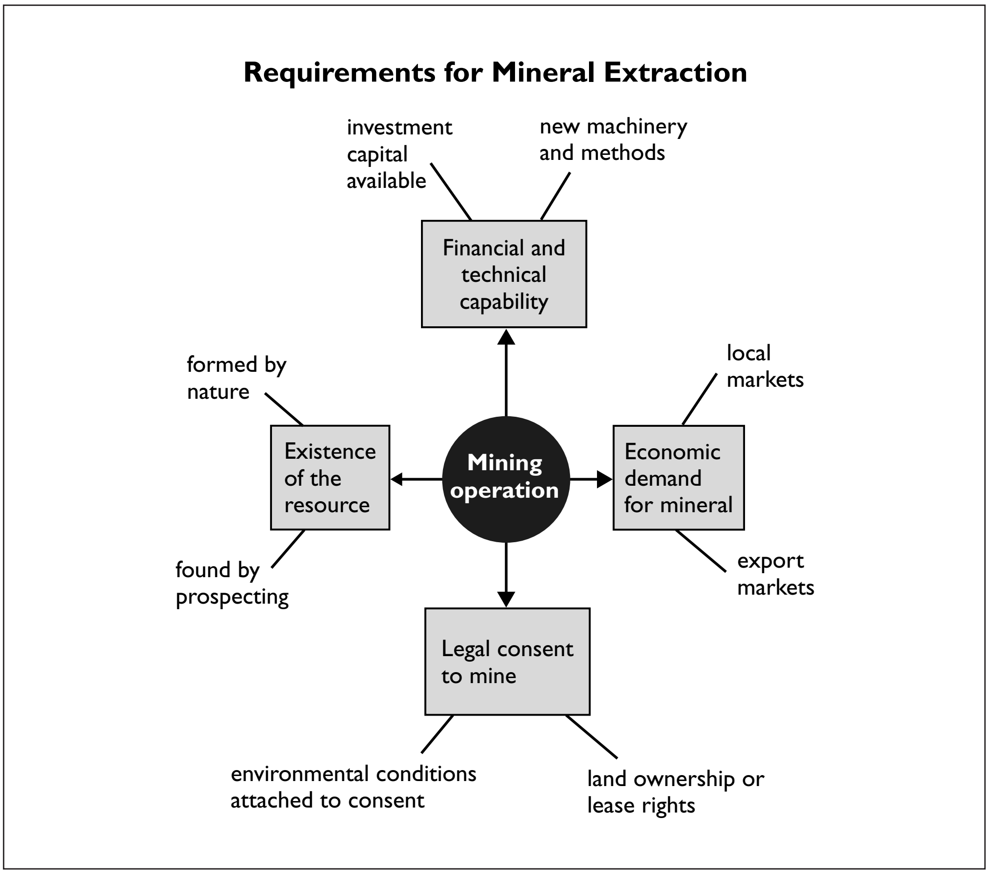


Figure 4.3.4 Requirements for mineral extraction

A Mining System

All mines are different, but they do have much in common. A typical modern mining system has the following components.

Table 4.3.2 Modern mining system components

Inputs	Processes	Outputs
Natural: Mineral to be extracted Overburden Climate **Cultural:** Scientific knowledge Human expertise and labour Machinery Finance Land ownership or consent	**Prospecting:** Geological surveys Rock sampling Mineral tests **Extracting:** Accessing the mineral(s) Removal of mineral(s) **Limited processing (on site):** Separating target mineral from host rock Grading, washing, stockpiling **Rehabilitation:** Restoring landscape (as close as possible) to previous condition	**Mineral:** Gold, copper, etc Waste products **Environmental:** Landscape changes Pollution – air, soil, water **Human:** Experience, expertise Health effects Cultural effects on local communities

Table 4.3.2 Feedback

Positive	Negative
Profits ploughed back into mine to improve its productivity, e.g. new machinery	Pollution (noise, dust, visual) requires costly controls
Further employment opportunities	Health of workers impaired by noise, dust, radioactivity, etc

Types Of Mines

There are two main types of mines:

- **open-cast** mines – to extract mineral deposits at or near the surface
- underground mines – to extract minerals deep below the surface.

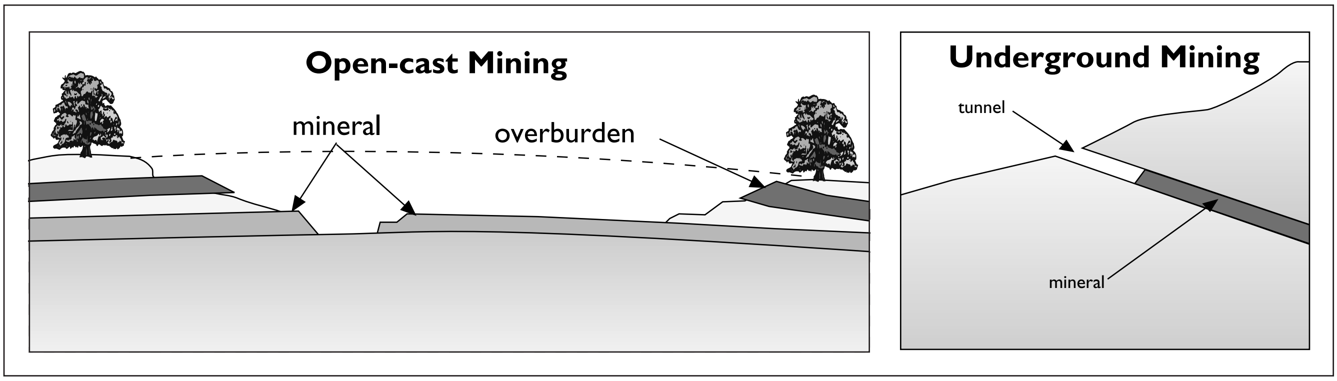


Figure 4.3.5 Types of mining

Extraction processes vary also according to the nature of the mineral(s) being extracted:

- *Physical composition:* hard rock (e.g. iron ore), loose rock (e.g. ironsand, gravel), liquid (e.g. oil) or gas (e.g. natural gas).
- *Mineral concentration:* high concentration (e.g. iron ore), low concentration (e.g. copper), or trace concentration (e.g. uranium).
- *Land- or water-based:* land-based (e.g. coal mine), river (e.g. alluvial gold), offshore (e.g. oil/natural gas).

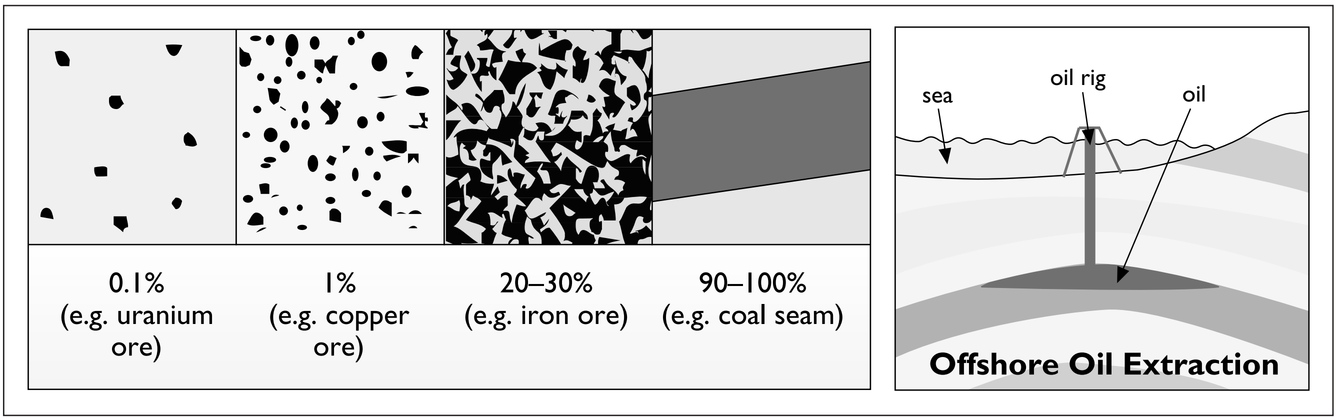


Figure 4.3.6 Mineral concentration and land or water-based extraction

Unit 4

Uranium Mining In Australia

Learning Outcomes

At the end of this topic you should be able to:

- ❑ Describe and explain how uranium mining operates as a system of production.
- ❑ Account for the location of uranium mines in Australia.
- ❑ Describe the resources used in uranium mining and explain how they are managed.
- ❑ Describe the technology used in uranium mining and evaluate any positive or negative effects this has.
- ❑ Compare and contrast different perspectives people may have of uranium mining, and any issues and problems that are involved.

Origins Of Australia's Minerals

Australia's mineral wealth is the result of its varied geological history. Some of its rocks are over 2.5 billion years old and many have been folded, faulted, buried and metamorphosed (changed by heat and pressure) to produce a remarkable wealth and variety of valuable minerals.

Many of its mineral resources lie in its oldest rocks to the west, buried deep beneath layers of younger sedimentary rocks.

Australia's reserves of hydrocarbons – oil, gas and coal – were formed in large **basins** of sedimentary rocks. Extraction of oil and gas from basins that extend beyond the present day coastline presents a major technological challenge.

Figure 4.4.1 Off-shore oil rig

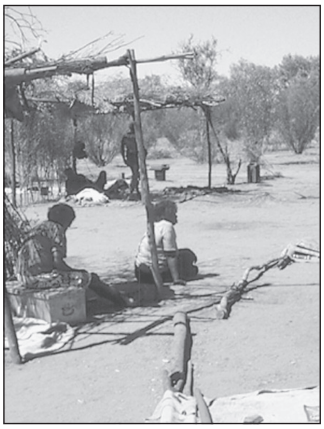


Figure 4.4.2 Aboriginal mineral extraction

Aboriginal Mineral Extraction

Aboriginal people have made use of mineral resources in Australia for 40 000 years. In pre-European times, sharp stone fragments were used as tips for tools and weapons and some softer minerals were used for painting on bodies and rock walls.

Limited technology restricted their use of minerals to those that were easily extracted on or near the surface. Small-scale mineral extraction by Aboriginal people had little impact on the natural environment.

European Mineral Extraction

The discovery of mineral resources in Australia by Europeans followed on from their settlement and exploration of the country. From 1850 to 1900, mineral extraction was concentrated in the goldfields of Victoria, New South Wales and Western Australia.

The period from 1900 to 1950 was relatively quiet for mineral exploration, except for the discovery of opals in South Australia and the opening of the Mount Isa mines in Queensland.

Since the 1950s, mineral exploration and extraction has boomed in Australia, with Western Australia leading the way.

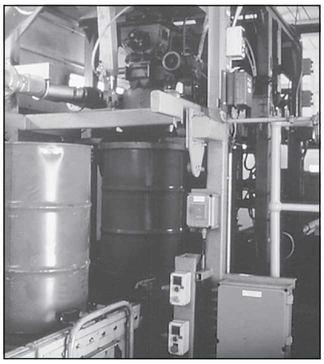


Figure 4.4.3 Uranium oxide in steel drums

Mineral Extraction In Australia Today

Australia is a mineral superpower! It has the world's largest economically recoverable resources of **bauxite**, lead, mineral sands (ilmenite, rutile and zircon), silver, uranium and zinc.

Australia is in the world's top six for resources of coal, cobalt, copper, gold, iron ore, lithium, manganese ore, nickel, diamonds and opals.

Australia is the world's largest exporter of black coal, iron ore, bauxite, lead, diamonds, zinc and mineral sands. It is the second largest exporter of alumina and uranium, and the third largest exporter of gold.

In 2001, the mining industry accounted for 26% of Australia's exports of goods and 4% of its Gross Domestic Product (GDP).

Table 4.4.1 Australia's mineral exports 2001

Mineral	Present Uses	2000 Production Value	Employment
Gold	Industrial and bullion	$A4862 million	8114
Iron ore	Iron and steel making	$A3820 million	6040
Oil and gas	Transport fuels, other energy uses, plastics industry	$A9065 million	651
Coal	Electricity generation, iron and steel industry, domestic heating	$A8308 million	26 017

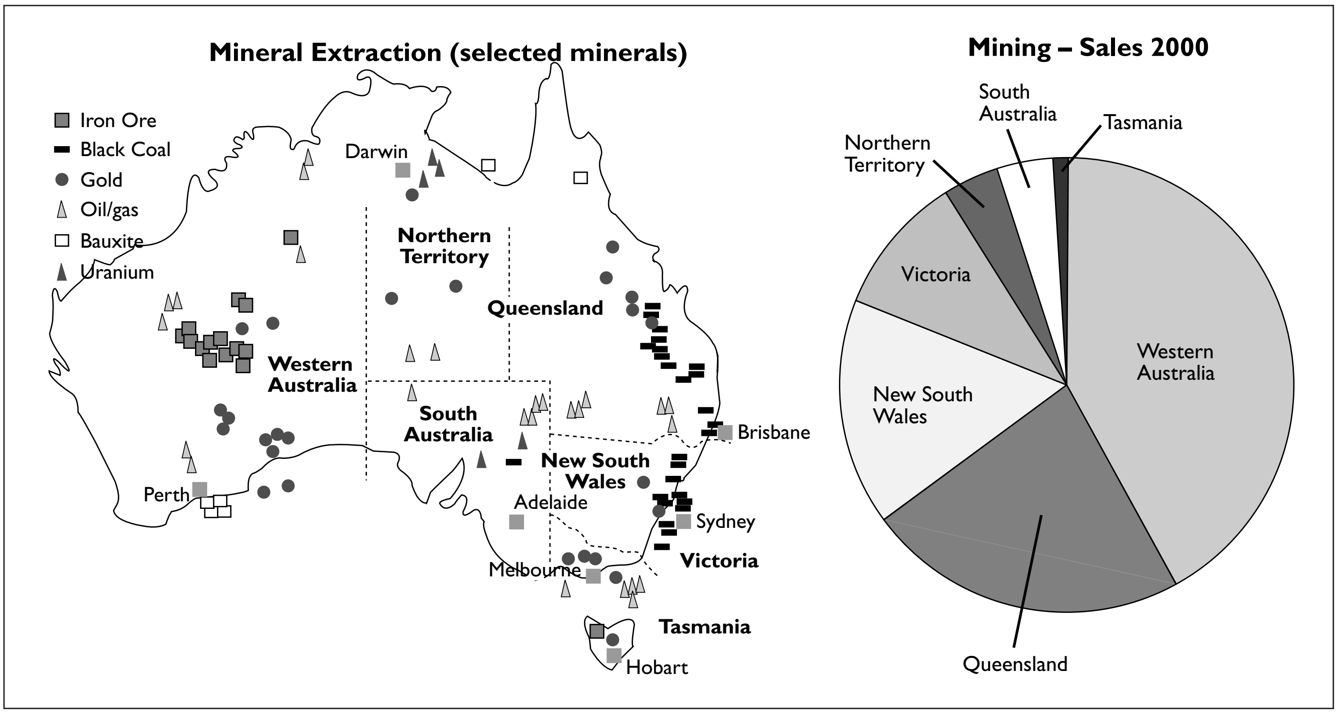


Figure 4.4.4 Australia's mineral extraction and sales

Recent Changes In Mining

As the best and most accessible mineral deposits are mined out, mining companies have to choose between:

- ❑ using new technologies to mine previously uneconomic deposits in existing mines
- ❑ moving on to other known but less accessible reserves elsewhere
- ❑ **prospecting** for new reserves.

Each of these options is expensive and as a result mines are:

- ❑ getting larger
- ❑ using more sophisticated technology
- ❑ employing fewer people
- ❑ increasingly owned by large multinational companies.

Mining companies are having to respond to the environmental, health and safety, cultural and moral issues that confront them. Public relations and political lobbying are now vital functions of modern mining companies.

Mining Issues

Environmental issues: Mining operations usually require the movement of huge quantities of rock and earth and inevitably have major environmental impacts. Mining operations are now expected to be more environmentally responsible.

Health and safety issues: Using explosives and large machinery, often in dark and/or dusty conditions, has always made mining dangerous.

Cultural issues: Under the 1993 Native Title Act, large areas of land were returned to Aboriginal ownership. Much of this land is rich in minerals and had been leased from the government by mining companies. There is continuing tension between Aboriginal landowners and the ambitions of mining companies.

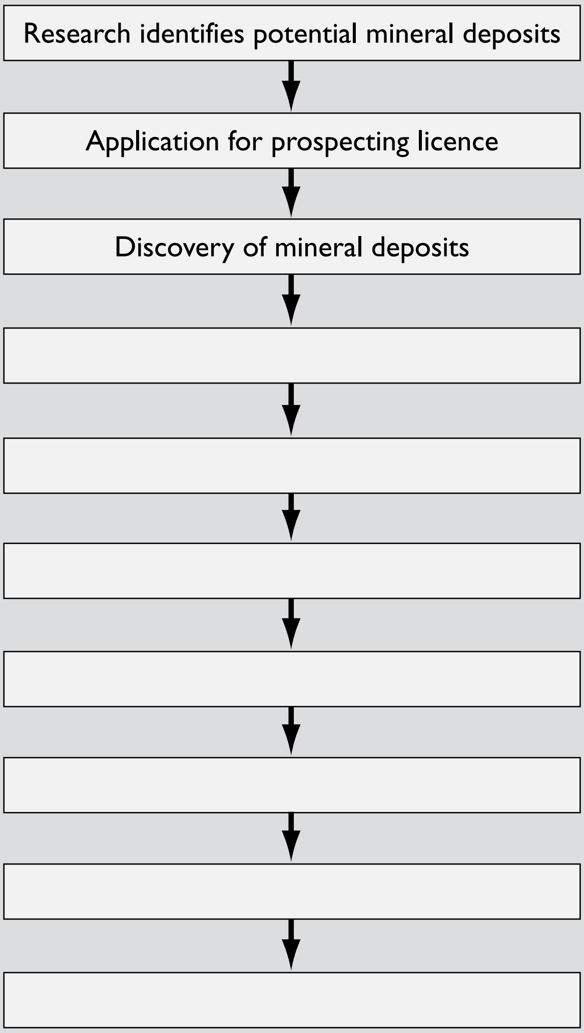
Moral issues: Australia has the world's largest deposits of uranium, the raw material for nuclear fuel and weapons. For many Australians opposed to nuclear power and nuclear war, uranium mining is a moral issue.

Skill – Drawing Flow Charts

A flow chart is a simple but effective technique for showing the links between a series of events.

This flow chart to show the sequence of mining processes has not been completed. Copy and complete the chart, using the stages listed.

Mining begins; Assessment of commercial viability; Rehabilitation of mine environment; Mining ends; Application for mining licence and other resource consents; Mine construction; Raising of capital to finance mining operation



Key Points Summary

- ❑ Minerals are inorganic, non-renewable resources extracted from on top of or below the earth's surface.
- ❑ Mining can be underground or open-cast.
- ❑ In New Zealand, the main minerals mined are coal, oil and gas, ironsand and gold.
- ❑ Australia is a mineral superpower with large-scale mining of coal, iron ore, oil and gas, bauxite, uranium and gold.
- ❑ Mining operations are controversial, often involving environmental, safety, cultural and moral issues.

1 Match up the descriptions with the terms.

a hydrocarbon	**A** the search for mineral deposits
b open-cast mining	**B** originates from organic matter
c prospecting	**C** raw material used for making aluminium
d bauxite	**D** surface extraction of a mineral.

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

a Australia is the world's largest exporter of uranium.

b Pre-European uses of minerals in Australia were for tools and ornaments.

c As mineral deposits become less accessible, mines get smaller.

3 Find evidence in this unit or text to support this important geographic idea:

People's appraisal and use of resources depends on such things as their environment, social systems, values, technology and economic and political ideology.

4 Find the answers to the following questions in the text.

a Why might coal and oil not be considered as true minerals?

b What conditions are required before commercial mineral extraction can take place?

c Why can Australia claim to be a mineral superpower?

d Which mineral extraction industry is more important to Australia – coal, or oil and gas? Give reasons for your choice.

e What four issues are currently causing changes in the mining industry?

5 Investigation: What mining products do you use in your daily life? Which mineral type would most affect you if its extraction was banned throughout the world? Report on how your lifestyle would change if it was no longer available.

6 Write a geographic paragraph to describe major changes that have occurred in mineral extraction in Australia. (Remember the GREED approach to paragraph writing.)

Figure 4.4.5 Uranium mine

Uranium

Uranium is a mineral that occurs almost everywhere, but usually in very small quantities. The average concentration of uranium in the earth's crust is about two parts per million (0.0002%). It occurs also in the sea but at even lower concentrations.

Rocks with much higher uranium concentrations (uranium **ores** or **orebodies**) can be mined commercially. Concentrations of less than 1000 ppm (0.10%) are too expensive to mine unless they are associated with other precious minerals, such as copper or gold. About 25% of the world's known and recoverable uranium reserves are in Australia.

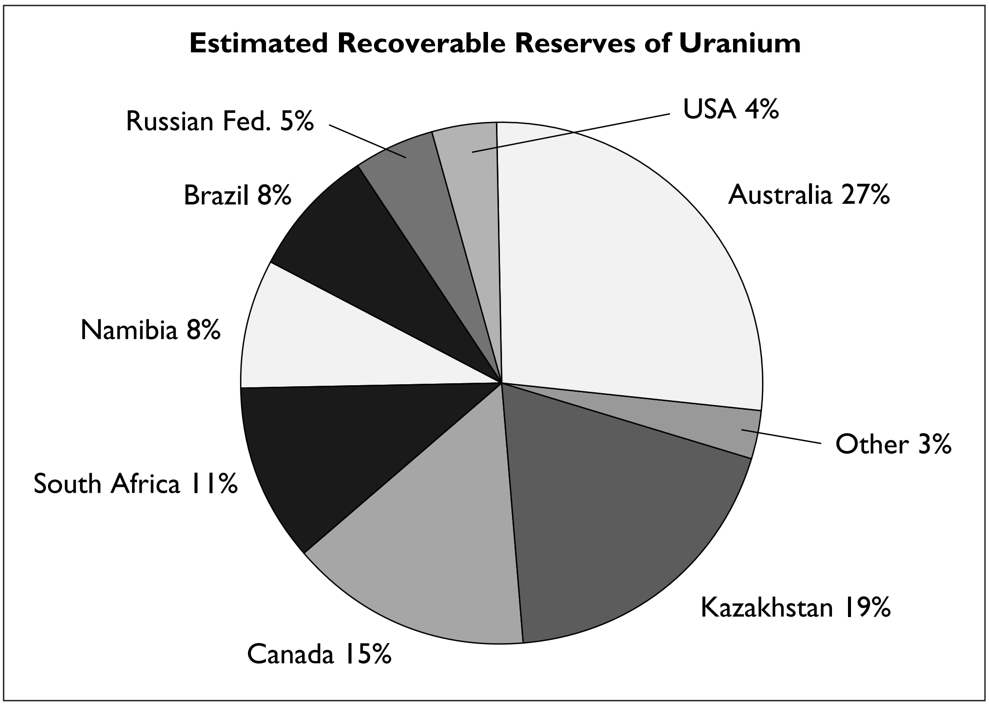


Figure 4.4.6 Estimated recoverable reserves of uranium

Uranium ore is processed to produce concentrated uranium oxide (U_3O_8). Processing is usually carried out at, or near, mine sites.

Uranium's radioactive properties and its use for nuclear weapons and nuclear energy has made it a highly controversial mineral. In Australia, uranium's controversy has been increased by its occurrence on Aboriginal land.

Uranium has only become valuable as a mineral since the first atomic bomb in 1945 during World War II. This explosion confirmed to scientists the theory that huge amounts of energy could be released if uranium atoms were split apart.

Uranium is a very high grade energy source. About 20 tonnes of coal is needed to get as much energy as the nuclear fission of 1 kilogram of uranium.

Most of the world's mined uranium (and all of Australia's) is used to generate electricity in nuclear power stations. Nuclear energy currently provides about 17% of all the electricity that is made in the world.

Australia does not generate any nuclear power – but it does mine and export uranium to countries that do. In 2001–2002, Australia produced 7000 tonnes of uranium oxide – this earned Australia $A350 million. Australian uranium is only sold to countries that will use it for peaceful reasons, e.g. for generating electricity.

Location Of Uranium In Australia

Uranium in concentrations high enough to mine are found in Australia's older sedimentary rocks. They are absent in the younger rocks of the Great Dividing Range and along the east coast.

Uranium prospecting started in Australia in the 1940s and mining began at Rum Jungle (Northern Territory) in 1954. Several other mines opened in the next five years in Queensland, South Australia and Northern Territory. This first phase of uranium mining ended in 1971 with the closure of Rum Jungle mine.

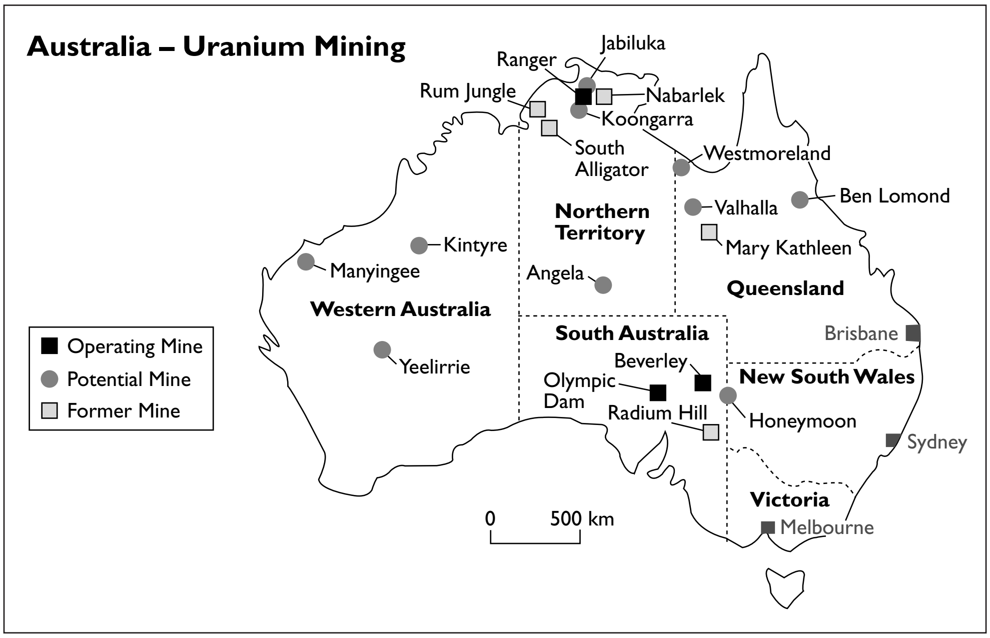


Figure 4.4.7 Uranium mining locations in Australia

The export of uranium for peaceful purposes (electricity generation, medical use) was permitted in 1977, but only under strict government supervision. Nabarlek mine (Northern Territory) opened in 1979, followed by Ranger (Northern Territory) in 1980. Nabarlek was in production for only 143 days but its stockpile of ore was processed until 1988.

From 1983 to 1996, environmental and cultural concerns persuaded the Labour government to restrict uranium mining to three mines only – Nabarlek (now closed), Ranger and Olympic Dam (South Australia).

Olympic Dam, Australia's first underground uranium mine, had been proposed in the 1970s, but mining did not begin until 1988. It has the largest known uranium orebody in the world, but it is 350 metres below the surface! In 2001, it produced about 50% of Australia's uranium.

In 1996, the Liberal-National government allowed more uranium mines. Today there are three operating uranium mines – Olympic Dam, Ranger and Beverley. Two new mines are being developed – Honeymoon and Jabiluka. There are nine other potential mining sites elsewhere in Northern Territory, Queensland, South Australia and Western Australia.

Operating An Open-Cast Uranium Mine

There are five distinct processes involved in open-cast uranium mining:

1. **Stripping** overburden to expose the orebody.
2. **Winning** (extracting) the ore (usually 0.1–0.4% uranium).
3. **Milling** the ore to produce concentrated uranium oxide (U_3O_8).
4. Disposing of the **tailings**.
5. **Rehabilitation** of the mine site.

Ranger is located in Northern Territory, about 230 km east of Darwin. Its orebodies were discovered in 1969. Ranger 1 orebody was mined from 1980 to 1995 and Ranger 3 from 1997. Ranger 2 orebody is not available for mining because it is close to sacred Aboriginal sites.

Figure 4.4.8 Ranger open-cast uranium mine

Table 4.4.2 Inputs, processes and outputs of uranium mining

Inputs	Processes	Outputs
Natural *Relief, climate and drainage:* Gentle slopes Tropical monsoon climate; 1500 mm annual rainfall (90% during monsoon season Nov–Apr) Magela Creek and seasonal swamp land in mining area *Uranium reserves:* Ranger 1 = 59 000 tonnes of U_3O_8 Ranger 3 = 53 000 tonnes of U_3O_8 **Cultural** *Human:* Mine owned by Energy Resources Australia Ltd (ERA) Employees: technical and administrative *Plant and other structures:* Ore stockpiles, crushers and grinders, leaching tanks, milling plant, tailings dam Administration buildings, roads, sewerage, etc *Machinery:* Drilling rigs, detonators, excavators, dump trucks *Settlement:* Mining town of Jabiru established to house employees in this remote area *Mining Rights:* 7680 ha leased from Kakadu Land Trust (Aboriginal owners) Mining permitted by the government Subject to environmental conditions, including the establishment of Kakadu National Park Subject also to export controls designed to ensure approved peaceful uses of the uranium	*Overburden stripping:* Overburden removed to expose orebody Topsoil stockpiled for later rehabilitation of the site *Ore winning:* Ore is loosened with explosives, removed by excavators and trucked to stockpiles to await milling Benches (steps) are cut into the mine as it deepens and ramps provide vehicle access *Ore milling:* Ore is crushed and ground to fine powder and water added to make a **slurry** Thickened slurry (excess water removed) pumped to leaching tanks Leaching tanks add sulfuric acid to dissolve uranium oxides and other minerals Solids (which still contain most of the uranium) are removed to tailings dam Solution filtered and a series of chemical and physical processes extract the uranium before it is heated and dried to a dark green-grey powder Finished product, uranium oxide concentrate (U_3O_8), packed in drums and sealed for shipment *Site rehabilitation:* When the mine is worked out the mining company is required to return the site to close to its original state	*Uranium:* 1998 = 4059 tonnes of U_3O_8 All output is exported to nuclear energy producers overseas *Environmental effects:* During mining: ❑ Massive movement of rock and soil ❑ Noise, dust and visual effects ❑ Water discharges ❑ Increased radioactivity from uranium concentrate and from tailings After mining: ❑ Changed landscape ❑ Potential for long-term radioactivity of buried tailings Health effects: ❑ Exposure to increased levels of radiation (during milling and from tailings) ❑ Danger from use of explosives and use of heavy machinery *Financial:* 2001 sales = \$A232 million Wages paid to employees and profits to mining company shareholders Royalty of 4.25% of mining company's gross sales and annual rent of \$A200 000 paid to Kakadu Land Trust *Extra employment opportunities:* Job opportunities in service industries in Jabiru, and in tourism at Kakadu National Park *Social Impacts:* 1997 *Kakadu Regional Social Impact Study* concluded that uranium mining brought no measureable benefit to local Aboriginal people

Table 4.4.3 Feedback	
Positive (improves productivity)	**Negative (reduces productivity)**
Profits – used to buy new plant or machinery, e.g. $A53 million spent on increasing the ore-handling capacity of the mill from 3000 tonnes p.a to 5000 tonnes p.a. Health and safety policies – reduce injuries and increase productivity, e.g. Ranger was the first Australian mine to receive five star safety rating from the National Safety Council.	Pollution – requires expensive remedial action or changes to operations to satisfy environmental controls Adverse cultural impacts – adverse impacts on local Aboriginal people increases opposition to uranium mining and may lead to tighter controls on mining operations.

The Uranium Extraction System

Rock containing uranium is mined from the ground using either the opencast or underground methods. The rock that is mined is called **ore**. The ore is then milled. Milling is the process that extracts the uranium from the ore. Extracted uranium is sold as yellowcake. This whole process involves a series of steps.

Figure 4.4.9 Processing plant

Figure 4.4.10 Ranger mine and processing plant

Step One: Exploration

- ❑ Early prospectors roamed the bush to gather samples of rock, relying on experience to find the uranium-bearing rock.
- ❑ Today more modern methods are used:
  - **a** radon gas detection (radon is a radioactive gas given off by decaying uranium)
  - **b** radiation detectors in aircraft
  - **c** Landsat images from space satellites which show geological features.
- ❑ Testing is done in a grid pattern with core samples being taken at regular intervals.

Step Two: Extraction

Open-Cast Mining

Open-cast mining at Ranger occurs in a series of stages:

- ❑ The topsoil and overburden are removed and stockpiled (see STEP FOUR for later rehabilitation).
- ❑ The exposed ore is mined by blasting with explosives, which creates a series of benches as mining goes deeper into the ground.
- ❑ Some rock is left between the benches creating ramps so that the ore, once loaded into trucks, can be hauled to the top of the open-cast pit.

Underground Mining

Underground mining at Olympic Dam is occurring in a series of stages:

- ❑ Access to the underground uranium seams has been gained by excavating a gradually sloping tunnel called a **decline**.
- ❑ At the bottom of the decline, a series of access tunnels have been drilled to allow extraction of the ore to occur.
- ❑ The ore face is drilled and blasted, breaking up the ore, which is then transported to the surface.
- ❑ Tailings are stored above ground to be returned underground when extraction has been completed.

Leach mining

Leach mining (or in-situ leaching) is carried out at the Beverley uranium mine. It is a new method of mining and occurs in a series of stages:

- ❑ Uranium-dissolving chemicals are pumped through **permeable** uranium-bearing rocks and sands.
- ❑ The chemicals are pumped down boreholes into the ore body and then pumped back up again now carrying the dissolved uranium.

Step Three: Milling

The milling operation extracts the uranium from the ore and is the same for both open-cast and underground mines. The milling of uranium extracted by leach mining will be the same in principle as in Figure 4.4.15 but will begin at Stage 4 because the uranium will arrive in slurry form.

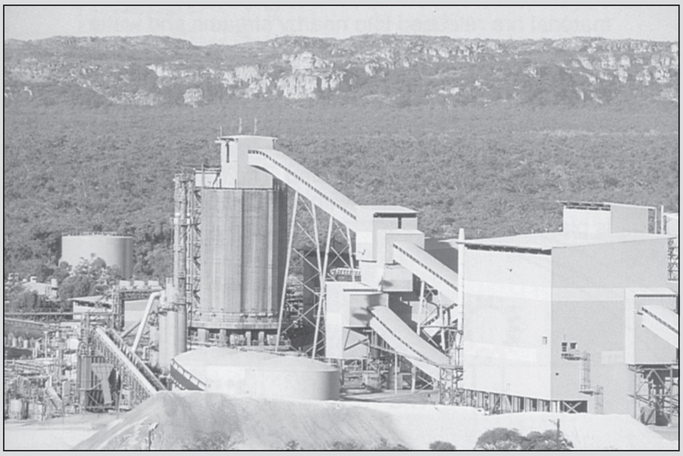


Figure 4.4.11 Processing plant

Figure 4.4.12 Rod and ball mills at Ranger's processing plant

(cont.)

Figure 4.4.13 Yellowcake

Figure 4.4.14 Drummed yellowcake ready for export

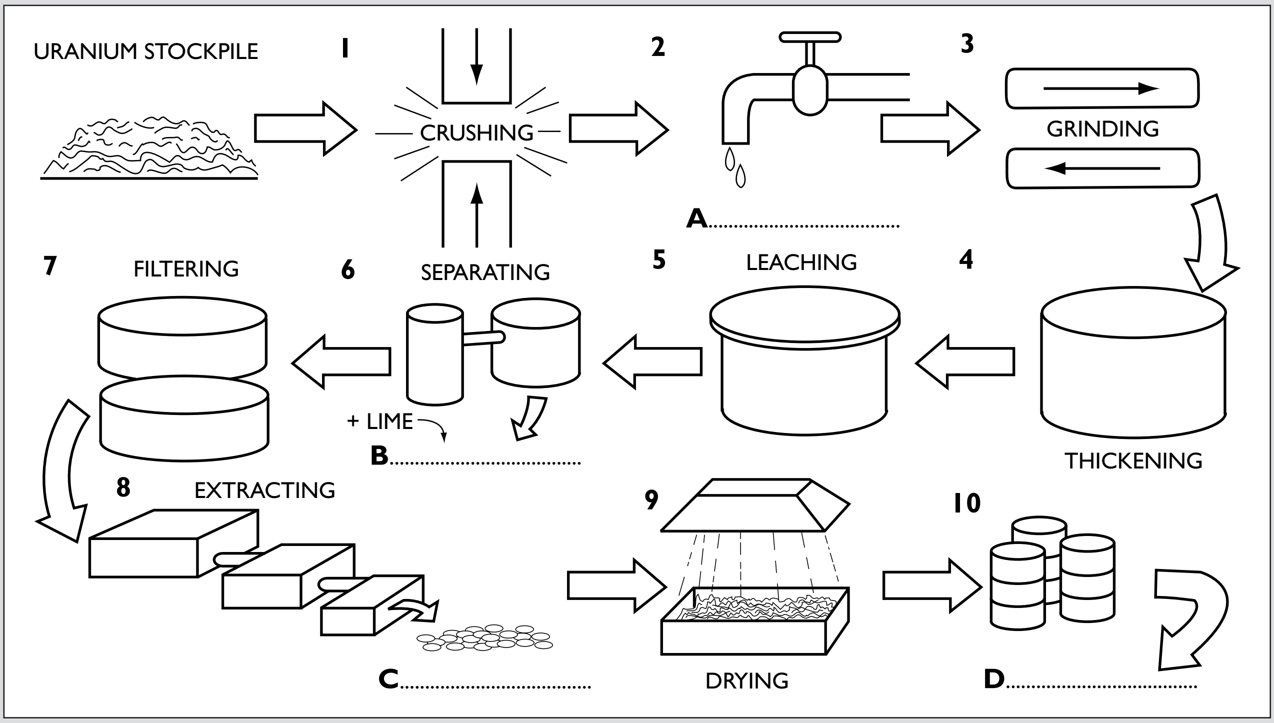


Figure 4.4.15 Uranium mining process

Step Four: Managing waste

- ❑ There are millions of tonnes of tailings. Each tonne of ore mined produces only three kilograms of uranium.
- ❑ Some of the tailings contain elements that can remain radioactive for 200 000 years. One such element, radium, releases the radioactive gas radon. This can be a health hazard if it escapes into the atmosphere.
- ❑ To keep the radium isolated, tailings are covered in two metres of water. The storage areas are called *tailings dams*.
- ❑ The dams are carefully controlled because any water that leaks through the bottom of the dams or escapes in any other way could release dangerous amounts of radiation into rivers, underground water systems or into the air as dust when it dries.
- ❑ Some liquid wastes with low enough levels of radioactive material are released into nearby streams and water systems.
- ❑ At the completion of the mine site's extraction life, the area is rehabilitated. In underground mining, the tailings are returned to the shafts as backfill (e.g. Olympic Dam). In open-cast mining, tailings dams are covered with clay then topsoil, and vegetation is planted. The mine pits are landscaped and filled with topsoil and vegetation is planted.

Learning Activities

1 Copy and complete the table below.

Table 4.4.4 Mining system

Mining system	Advantages	Disadvantages
Open-cast		
Underground		
Leach		

2 Using Figure 4.4.15, construct a flow diagram. Use the order of events shown in Figure 4.4.15 and add to each heading the description that best fits it from the list below.

- ❑ The uranium is packed in 200 litre drums and sealed for transportation to the *market*.
- ❑ The thickened slurry is pumped to leaching containers where, using sulphuric acid, the uranium ore is dissolved over 24 hours.
- ❑ Water is added, creating a slurry.
- ❑ The uranium is extracted from the slurry, leaving a bright yellow chemical called *yellowcake*.
- ❑ *Slurry* is ground even finer and lime is added.
- ❑ The uranium concentrate is filtered to remove any remaining solids.
- ❑ The yellowcake is heated to 700°C and dried to a coarse green powder made up of 98% uranium.
- ❑ The broken ore is crushed to a finer material.
- ❑ The slurry is thickened.
- ❑ The uranium solution is separated from the non-uranium-bearing rock which exits the process as *tailings*. These tailings are neutralised by the addition of lime.

3 On Figure 4.4.15 on page 162, there are *four* missing words (A, B, C and D). Fill in the gaps using the four words in italics in the list for Activity 2.

4 Construct a SYSTEMS DIAGRAM of Figure 4.4.15 on page 162 based on Figure 4.0.1 on page 127. Make sure you show what the inputs, processes, outputs and feedback are for this system.

Olympic Dam Underground Mine

Olympic Dam mine is located at Roxby Downs, 560 km north of Adelaide, South Australia. In 1975, the world's largest uranium deposits were found 350 metres below the surface while prospecting for copper!

The uranium ore is low grade (0.06%) but is economic to mine because of the copper, gold and silver it contains. 75% of the mine's revenue comes from copper, 20% from uranium and 5% from gold and silver. The uranium is sold to nuclear energy suppliers overseas.

Being an underground mine, there are some important differences in its operation compared to Ranger.

- ❑ There is no overburden to strip.
- ❑ The uranium ore is crushed underground, but milled on the surface.
- ❑ Rock waste and coarse tailings are used to backfill the mine. (Fine tailings are placed in a surface tailings dam.)

Production reached 4350 tonnes p.a. of U_3O_8 in 2001.

Where geological conditions allow it, '*in situ* leaching' (ISL) is an alternative extraction process that bypasses Stages 1 and 2 pages 160–161 and makes rehabilitation much easier. Most American uranium mines use this leach method of extraction.

Leach mining involves pumping an acid solution into permeable uranium-bearing rocks underground. It dissolves the uranium *in situ* (i.e. in the ground) and the solution (now containing the dissolved uranium) is pumped back to the surface for milling into U_3O_8. This process is used at the Beverley mine in South Australia. There are plans to use it in some future mines such as Honeymoon.

Managing The Use Of Uranium Mining Resources

Uranium mining resources are the inputs of uranium mining systems. There are several factors that control (either directly or indirectly) the use of these resources.

Controls on the use of uranium mining resources

Economic factors: Uranium mining is a commercial operation. The profitability of Australian mining companies depends on the prices it gets for its uranium and its ability to control production costs. The price of uranium is determined by supply and demand on the world uranium market, but higher prices can be achieved by offering long-term supply contracts to customers. Strong demand and high prices will increase the use of uranium mining resources through prospecting, mine development and uranium production.

Political factors: Uranium is a controversial mineral and uranium mining is subject to changes in government policy. Some governments, influenced by environmental, moral and cultural concerns, have restricted uranium mining. Others have focused more on the economic benefits of uranium exports and encouraged uranium mining. Political lobbying is an important activity for the uranium mining industry.

External regulations: Some mining resources are directly controlled by state or federal government regulations. For example, mines have to comply with health and safety requirements, and have to complete Environmental Impact Studies before mining rights are granted. Australia's trade in uranium is affected by international agreements to prevent the spread of nuclear weapons. There are strict controls on who Australia's uranium mining companies can sell their uranium to, what it can be used for, and how it can be transported.

Technological factors: Improving uranium mining technology means that reserves once considered uneconomic to mine can now be mined profitably. New technology is often very expensive and encourages large-scale, long-term mining. It also reduces the number of workers required to operate a mine.

Environmental factors: Increasing public concern about environmental issues is persuading uranium mines to improve their environmental performance.

Uranium Mining And Non-Renewable Resources

Uranium is a non-renewable resource. Once a uranium orebody has been extracted, it will not renew itself at that site. The mining operation moves on elsewhere.

Uranium mining requires the use of other non-renewable resources, such as the chemicals used in milling, fuel and machinery.

Uranium mining makes limited use of some renewable resources, including human resources and water. People employed by uranium mines pass on their expertise to other workers, and mines make use of rain, river and ground water in their operation.

Skill – Describing trends

When looking at statistics that show change over time, it is often more important to recognise trends rather than focus on particular figures. For example, a mine's production statistics may show an increase in some years, but the longer term trend may be one of decline as its reserves of uranium are worked out. (Uranium is a non-renewable resource, remember.)

Let's look at uranium production trends for the Ranger mine during the 1990s.

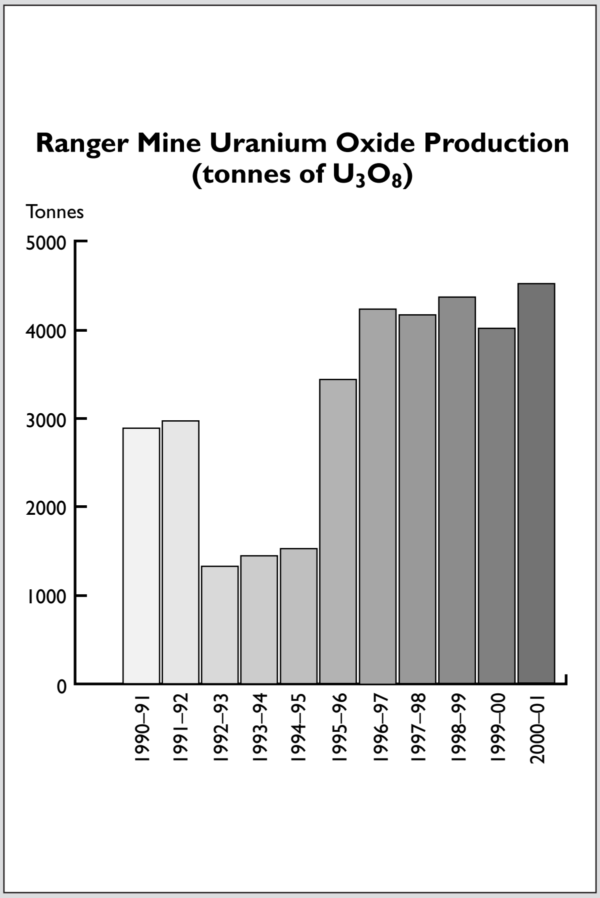


Figure 4.4.17 Ranger mine production

1 a How much uranium was produced by Ranger mine in 1990–91?

  b How much uranium was produced by Ranger mine in 1998–99?

2 Which description best fits the trend for Ranger mine during the 1990s?

  steady rise, fluctuating decline, highly fluctuating rise, steady decline, fluctuating rise

3 Are the effects of the following events evident in the uranium production trends at Ranger?

  a 1992–95 Mining on a campaign basis – six months mining/six months milling

  b 1993–95 Low prices for uranium in overseas markets

  c 1995 Ranger 1 pit worked out

  d 1996 All-year milling begins

  e 1997 Ranger 3 pit opened

  f 1997 Ranger mill capacity increased to over 4000 tonnes per year

4 Predict uranium production trends at Ranger from 1999 to 2009. Give reasons for your prediction.

Key Points Summary

- ❑ Australia holds about 27% of the world's recoverable uranium reserves.
- ❑ In 2002, uranium mining was taking place at three mines – Ranger, Olympic Dam, Beverley – but several other mines are proposed.
- ❑ There are several systems for uranium mining – Ranger is open-cast, Olympic is underground, and leach mining is used at Beverley.
- ❑ Uranium mining is a controversial issue because of uranium's radioactivity, its use for nuclear power and nuclear weapons, and its occurrence on Aboriginal land.

Finding A Balance Between Costs And Benefits

People depend on the resources of the natural environment for their well-being. All large-scale economic activities contribute to a society's living standards, and they all impact on the natural environment. How much they benefit society and how much they affect the environment varies greatly. Some economic activities bring short-term benefits but cause long-term damage to the environment. Others are more 'environmentally friendly'.

Finding an appropriate balance between *economic benefits* and *environmental costs* is never easy as there are so many opinions about where to 'draw the line'. When people's jobs and lifestyles are affected, decisions are even harder to make. In the end, people and society have to make **value judgements**.

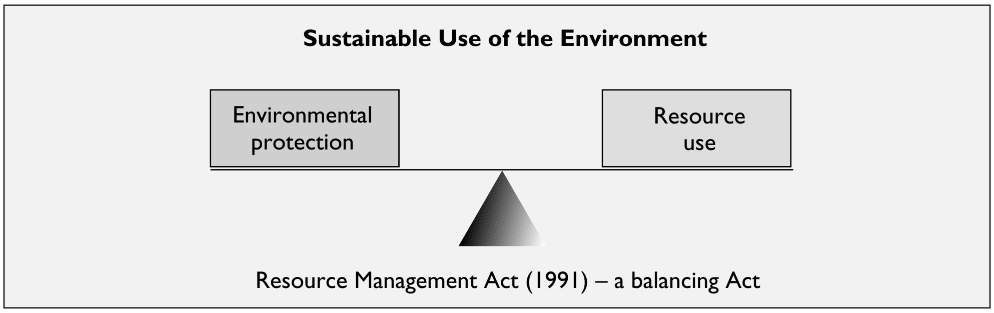


Figure 4.4.18 Sustainable use of the environment

Uranium Mining – Environmental Issues

There are two sets of environmental problems related to uranium mining.

1. The environment causes problems for uranium mining, e.g. heavy **monsoon** rains in Northern Territory.
2. Uranium mining causes problems for the environment, e.g. contamination of streams.

Uranium mining, whether open-cast or underground, has a major impact on the environment. Although there have been significant improvements in the environmental performance of Australia's uranium mines since the 1980s, uranium mining is still a contentious issue in Australia.

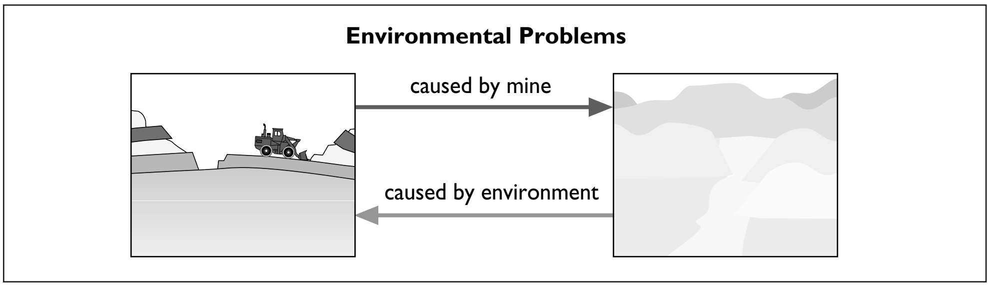


Figure 4.4.19 Environmental problems

Skill – Making a visual summary

An effective way of summarising information and ideas is to present it visually, with a minimum of words. *Visual summaries*, using key words, symbols and linkages, are sometimes known as *structured overviews*, *mind maps*, *star diagrams* and other names. Preparing a visual summary is a thought-provoking process that can itself improve understanding of a topic.

Written information in books is usually organised into a hierarchy of chapters, headings and sub-headings in a *linear* sequence, one after the other. Visual summaries often have a *radial* structure with key facts and ideas radiating out from the centre. The main idea or topic is placed in the centre and information becomes progressively more detailed each step away from the centre.

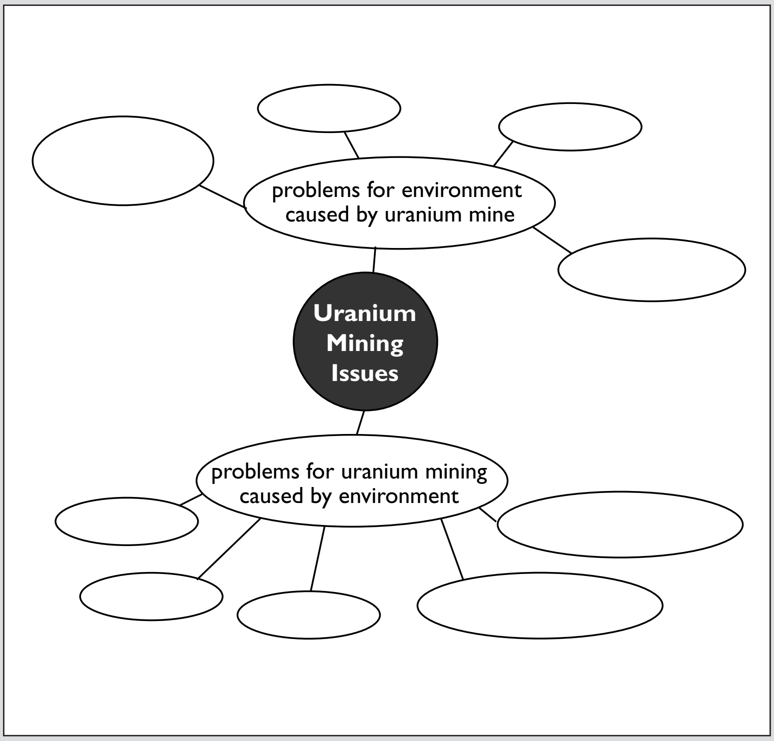


Figure 4.4.20 Uranium mining issues

Table 4.4.5 Problems caused by the environment

Problems	Causes	Possible Remedial Measures
Low concentrations of uranium in ores increases cost of extraction.	Natural occurrence	Technological developments make large scale uranium recovery from low-grade ores economic Recovery of other minerals (e.g. gold, copper) from uranium ores can make low-grade ore extraction economic
Great depth of some uranium ore deposits increases cost of extraction, e.g. Olympic Dam deposits 350 m below surface.	Ore found in very old rocks covered by younger sedimentary deposits	Technological developments make large-scale extraction of uranium from very deep ores economic Recovery of other minerals (e.g. gold, copper) from very deep uranium ores can make low-grade ore extraction economic.
Threat of **bushfires**	High temperatures, low rainfall	Fire-fighting service at mine
Lack of water in central and western areas, e.g. Olympic Dam	Desert and semi-desert climate with low and unreliable rainfall, e.g.160 mm p.a. at Olympic Dam	Deep bores extract water from Great Artesian Basin Water conservation

(cont.)

Problems	Causes	Possible Remedial Measures
Northern areas experience extreme seasonal variation in rainfall. Either too much or too little! Nov–Apr: heavy rain and floods require treatment and disposal of large quantities of contaminated water from mine site; danger of **tailings dam** failure/leakage. **Dry season** from May–Oct causes potential for water shortages	Reversal of monsoon winds NW winds bring 90% of rain in wet season SE winds bring dry conditions	Reinforcement of tailings dams to withstand flood conditions Excess water stored in reservoirs for use in dry season Take water from underground sources in dry season Campaign mining – extract ores in dry season, mill ores in wet season

Table 4.4.6 Problems caused by uranium mining

Problems	Causes	Possible Remedial Measures
Radioactive tailings	Milling of uranium leaves behind substantial volumes of low-level radioactive tailings Mining and crushing of uranium releases radon, a radioactive gas	During mining: ❑ Hold tailings under water in tailings dam. After mining: ❑ Place de-watered tailings in disused mine pit (or underground shaft), cap with clay and rock and revegetate. ❑ Contour tailings cover to reduce erosion. ❑ Monitor radiation levels ❑ Containment of tailings should last at least 1000 years.
Workers' health and safety hazards	Exposure to noise and radiation in the mill In hot, dry conditions blasting, excavation and large trucks all generate dust (possibly radioactive)	Limit workers' exposure to radiation through training, limited access, protective clothing and equipment Dust control with water sprays Install radiation detection equipment in all mines, and good ventilation systems in underground mines
Risk of contamination of streams, swamps, lakes and Aboriginal living areas	Heavy monsoon rain in northern areas is hard to contain within the mine site	Strict water management systems required: Water with low-level contamination collected and used for dust control, irrigation etc Water with high-level contamination water (from mill, tailings dam etc) is recycled on-site
Disturbance of natural ecosystems	Vegetation and ground disturbance, especially for open-cast mining	Rehabilitation of landforms and replanting of vegetation Employ environmental scientists, e.g. Ranger mine has 30 employed in its Environmental Division.

Clean, Green And Profitable – Is This Possible?

The Fox Inquiry (1975–77), commissioned by the federal government, supported properly regulated and controlled mining of uranium in the Alligator Rivers region of Northern Territory. It reported that:

> 'The hazards of mining and milling uranium, if those activities are properly regulated and controlled, are not such as to justify a decision not to develop Australian uranium mines.'

The Fox Inquiry also recommended the establishment of a Kakadu National Park, despite there being four mineral leases in the region at the time – Ranger, Nabarlek, Jabiluka and Koongarra.

It was decided that Kakadu National Park and the proposed uranium mines were to be developed side by side, presenting a major environmental challenge to the mining companies.

To protect the new national park, the federal government appointed a *Supervising Scientist* and set up the *Alligator Rivers Research Institute* to help develop environmental protection measures for uranium mining, and to monitor its environmental effects.

In 1981, Kakadu National Park was listed as a World Heritage site for its outstanding natural and cultural values. These include extensive wetlands and wilderness, 40 000 years of continuous Aboriginal habitation, prolific Aboriginal rock art and an outstanding variety of landscapes, plants and animals.

Resource 1: Australian Mining Industry View

Urban inhabitants unfortunately do not regard mining as a legitimate or desirable business, despite its contribution to Australia's export income (over $A8000 million, nearly one-third of all exports) . . . The minerals industry's critics generally oppose [mineral] exploration on the basis that . . . mining practices have stayed in the style popular around the late 1800s. Somehow ignorance is bliss for these idealistic believers, who are reminiscent of the members of the Flat Earth Society!

The public who elect the politicians that ultimately respond to community pressure groups, must be made to realise the importance of the following fundamental truths.

- The products of the minerals industry are essential for any quality of life.
- Mineral resources do not exist until someone finds them.
- The area affected by actual mining is infinitesimal (0.2% of Australia's land area).
- Today's exploration/mining companies are more environmentally sensitive than most members of the public.
- Access to land and security of tenure are fundamental pre-requisites for the development of a minerals industry.

[Aboriginal] Native title is a major impediment to the development of the Australian minerals industry . . . considering that Aborigines only make up a few per cent of the population.

Source: M. J. Lawrence, 'Public Perception of a Minerals Industry – An Australian Perspective' (abridged), 1997 New Zealand Minerals & Mining Conference Proceedings, page 13–21

Resource 2: An Aboriginal View

All the reasons to stop Jabiluka:

- The Mirrar people, Aboriginal traditional owners of the area, are unequivocally opposed to the project.
- . . . Sacred sites will be disturbed by any exploration or mining in the Jabiluka area.
- The cultural values for which Kakadu National Park is recognised as a World Heritage area are under threat.
- The 1997 Kakadu National Park Regional Social Impact Study found there was no benefit to the Aboriginal people of the region from mining.
- Mining operations at Jabiluka would result in an additional 20 million tonnes of radioactive tailings stored at the Ranger mine which the Mirrar believe will lead to terrible sickness throughout their country. These tailings retain almost all their radioactivity for hundreds of thousands of years.
- Ranger has been plagued with significant water management problems since the mine began and regularly releases contaminated water into Kakadu against the wishes of Aboriginal people . . .
- The Jabiluka orebody is a worker health and safety hazard due to its high radioactivity . . .

Source: The facts of Jabiluka, Gundjehmi Aboriginal Corporation, www. green. net. au/gundjehmi

Nabarlek was mined out in the 1980s and Ranger 1 was mined out in 1995. Ranger 2 will not be mined due to the presence of sacred Aboriginal sites. Mining began at Ranger 3 in 1997. The mining company has plans to transport uranium ore from a new mine at Jabiluka to the existing mill at Ranger.

By 1999, in the opinion of the Supervising Scientist, Ranger mine had no significant environmental impact on Kakadu National Park. Despite this, there remains considerable opposition to current and future uranium mining among Aboriginal groups and environmentalists.

Key Points Summary

- The environment causes a variety of problems for uranium mining and uranium mining causes a variety of problems for the environment.
- The uranium mining industry has improved its environmental performance in recent years, but, given its controversial nature, its environmental impacts will continue to be closely monitored.
- The change of federal government in Australia in 1996 boosted the confidence of the uranium mining industry, but alarmed those who oppose uranium mining.
- Uranium mining in Kakadu National Park highlights the difficulty of balancing the interests of its Aboriginal people, environmentalists and mining companies.

Learning Activities

Section A

1 Match up the descriptions with the terms.

a 1977	**A** mining town
b stripping	**B** open-cast mine
c ISL	**C** mix of water and uranium ore to assist milling process
d milling	**D** start of uranium mining in Australia
e Ranger	**E** export of uranium for peaceful purposes permitted
f slurry	**F** removal of overburden
g Jabiru	**G** process that converts uranium ore to uranium oxide (U_3O_8)
h 1954	**H** modern uranium extraction method.

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.

a Olympic Dam was the first open-cast uranium mine in Australia.

b The Australian Labour government stopped uranium mining between 1983 and 1996.

c Uranium ore is usually processed into uranium oxide near the mine site.

d The 1997 Kakadu Regional Social Impact Study concluded that uranium mining benefited Aboriginal people.

e Kakadu National Park was established as one of the conditions of developing the Ranger uranium mine.

f ISL mining is also known as leach mining.

3 Find evidence in this unit to support this important geographic idea: *People, individually or collectively, through their decisions or actions, may bring about change*.

4 Find the answers to the following questions in the text.

a What proportion of the world's uranium reserves are in Australia?

b What concentration of uranium is usually required for it to be mined commercially?

c What makes the extraction of low-grade uranium ore from a depth of 350 metres commercially viable at Olympic Dam mine?

d Why is uranium mining controversial?

e Why is the Ranger 2 orebody not mined?

f What is done with rock tailings at Olympic Dam mine?

g How is uranium mining in Australia controlled by external (from outside the mine) regulations?

h What was unusual about the way Nabarlek was mined?

5 Mini-research: Use the Internet to find out the latest information on uranium mining in Australia.
   - ❑ Check out mining at Ranger, Beverley and Olympic Dam mines.
   - ❑ What is the latest on the proposed Jabiluka mine?

   Try the following websites:

   www.environment.gov.au/ssg/ssg.html – this is the home page of the Supervising Scientist Group, which monitors uranium mining on behalf of the Australian government.

   www.uic.com.au – this is the website of the Uranium Information Centre in Australia. It is funded by companies involved in the exploration, extraction and export of uranium.

6 Write a geographic paragraph to describe how a uranium mining operation functions as a system. (Remember the GREED approach to paragraph writing.)

Section B

1 Match up the descriptions with the terms:

a value judgements	**A** containment area for uranium mine wastes
b dry season in northern Australia	**B** natural hazard in uranium mining areas
c monsoon	**C** releases health-threatening radiation
d radon	**D** decisions based on personal beliefs
e campaign mining	**E** radioactive gas
f tailings dam	**F** May–October
g bushfire	**G** seasonal mining
h radioactive	**H** season of heavy rainfall

2 Decide whether the following statements are true or false. Explain why the false statements are incorrect.
   - **a** The Fox Inquiry concluded that uranium mining was not hazardous.
   - **b** The government appointed a Supervising Scientist to monitor environmental effects of uranium mining.
   - **c** The Alligator Rivers Research Institute was established to find out more about the habitats of alligators and crocodiles.
   - **d** Jabiluka mine was mined out in 1995.

3 Find evidence in the text of this unit to support this important geographic idea:

   People's appraisal and use of resources depends on such things as their values, technology and economic situation.

4 Why do you think Kakadu National Park was established?

5 Describe three ways the natural environment can cause problems for uranium mining. Explain how each problem could be resolved.

6 Write a geographic paragraph to explain why different groups of people have different perceptions about the environmental impact of uranium mining in Australia. (Remember the GREED approach to paragraph writing.)

7 Making a visual summary.

a Complete this visual summary of uranium mining issues in Australia using information from this unit.

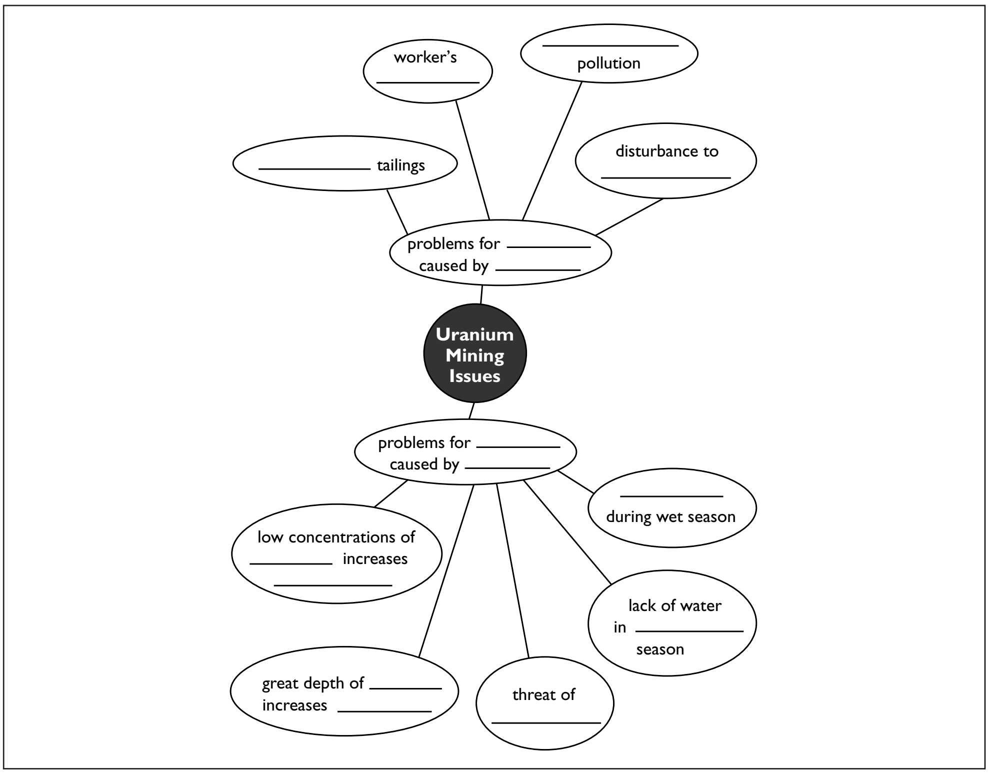


Figure 4.4.21 Uranium mining Issues summary

b Find two examples of visual summaries from earlier units in this book. Which one do you think is the most effective? Give reasons for your choice.

c Convert the Key Points Summary from page 171 into a visual summary.

Section C

1 Copy and complete Table 4.4.7 (below) into your workbooks.

2 List the resources in uranium mining in the first column.

3 For each resource, decide which is renewable and which is non-renewable. Tick the correct box.

4 Write 2–3 sentences to justify your decision in the last column.

Table 4.4.7 Uranium mining resources

Resources	Renewable?	Non-renewable?	Reason/justification

5 Uranium is used in small amounts – that is, only very small amounts are needed. Uranium that has been used can be reprocessed so that it can be used again. Does this mean that uranium is a renewable mineral resource? What is the difference between reusable, renewable and recyclable?

6 Have a class discussion about the definitions of these terms.

7 Write a paragraph to summarise your answers.

Part 5

Field Studies

The aims of this strand of geography learning.

Students will recognise and understand:

- ❑ The purpose of field work in education through geography.
- ❑ Apply methods used in geographic field work.

The achievement objectives of this strand at Year 12 level.

Students will demonstrate knowledge and understanding of:

- ❑ The reasons why field work is important in investigating geographic concepts at a local scale.
- ❑ The geographic inquiry process.

Key concepts and geographic ideas

In this strand, the key concepts and geographic ideas that will be explored are the ones that the field study is based on. Field studies are not a complete or separate topic in themselves. Instead, field studies are a teaching and learning approach that is very important in geography. Field studies are usually integrated into a topic or unit of study.

Introduction

This unit will provide guidance to teachers and students. It is important that students have at least one main field study experience at this level of learning geography (Year 12). A field study would be one of the major learning activities for students' study of the environmental issues that relate to the case study environment that they will study in Part 5 of this textbook.

Some points about geographic field work:

- Geography field work takes place outside of the classroom.
- The purpose or aim is NOT:
  - **a** to get out of the classroom
  - **b** to do a field study because it is in the exam prescription (i.e. for the sake of doing one)
  - **c** to go for a swim in a river or the sea
  - **d** meet friends.
- The purpose or aim of a field study should be based on developing students' understanding of selected geographic concepts and related geographic ideas
- One of the names for the process of fieldwork is 'geographic inquiry'. A geographic inquiry is also sometimes called a geographic investigation. It may seek answers to a question or a problem. It's purpose may be to test a hypothesis. It may explain an issue.
- The sequence of events (the steps or stages) in this process are:
  - **a** planning
  - **b** data collection and recording
  - **c** data processing
  - **d** presentation of techniques
  - **e** evaluation.
- A geographic inquiry investigates a geographic topic. The topic should help develop understanding of selected geographic concepts.
- A geographic topic can explore these questions:
  - **a** Where are things located and why are there?
  - **b** What are the spatial patterns and how did they get there?
  - **c** What is this place and how do people perceive it?

- ❑ A geographic inquiry applies geographic methods and follows an accepted set of procedures or steps.
- ❑ A geographic inquiry uses a range of skills – these include thinking, practical and social skills. For example:
  - **a** **Thinking Skills**: analysis, hypothesis testing, problem solving
  - **b** **Practical Skills**: measuring, sketching, interviewing, designing and using surveys
  - **c** **Social Skills**: working co-operatively in groups, approaching people for information and help, following protocols.

Unit 1 Geographic Inquiry

Learning Outcomes

At the end of this unit and the next you should be able to:

- ❑ Describe the key geographic concepts in a field study.
- ❑ Use evidence from a local field study to explain a geographic idea.
- ❑ Explain how and why a field study provided better evidence than from secodary sources.
- ❑ Describe the steps of the geographic inquiry process.
- ❑ Apply the geographic inquiry process to a field study in your local area.

Carrying out your own geographic inquiry is a true test of your geographic abilities. Rather than learning from the results of other people's work or accepting their conclusions, your own inquiry allows you to find things out for yourself and to draw your own conclusions.

An inquiry (sometimes called an *investigation*) may seek answers to a question or problem. It may be to test an *hypothesis* or explain an issue. A *geographic* inquiry:

- ❑ investigates a *geographic topic*, one which involves *where* things are located, spatial patterns and places; a useful general rule is that anything geographic can be mapped
- ❑ applies a geographic method and follows an accepted set of procedures or *steps*
- ❑ uses a range of geographic *skills*, including thinking, practical and social skills.

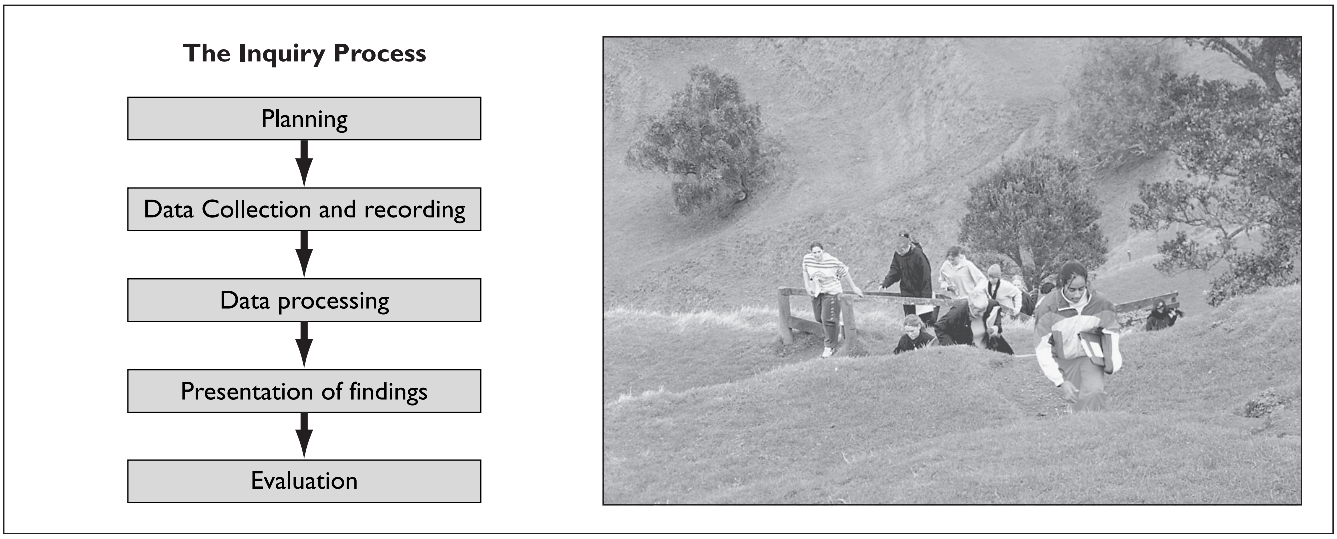


Figure 5.1.1 The inquiry process

A successful geographic inquiry is usually hard work but satisfying. As far as this book is concerned, we have saved the best until last. By now, you should have assembled the necessary skills and knowledge to launch your own inquiry.

It is preferable to enlist the support of other students and work in a small group of about three or four people. This will not only allow you to share the workload, but will also develop your ability to work *co-operatively* in a group.

On occasions, you may require some *direction* from your teacher. Your teacher won't do the work for you, but can give you some suggestions to help you on your way.

Figure 5.1.2 Working in a group

Selecting An Inquiry Topic

In selecting a topic, you should consider the following points.

- ❑ Is the topic clearly *geographic*?
- ❑ Is it of interest to your whole group?
- ❑ Is it manageable by your group?
- ❑ Will you be able to gather the data you require in the time available?

Try to relate your inquiry to some important geographic ideas. They may help you find a focus for the inquiry, or develop an hypothesis to test. It will also help ensure that your inquiry is geographic. (Refer to the lists of ideas introduced earlier in this unit.)

Make sure your whole group is interested and motivated by the topic you choose. It will make it much easier to work as a group.

It is better to tackle a small local issue or problem, rather than attempt to find the answers to the world's problems. It's better to complete a small inquiry than to tackle something major but fail to finish. You will be assessed on how you handle all steps in the inquiry so it is important to complete it.

Unit 2

Developing A Field Study On Environmental Issues

These are the focusing questions for this strand at this level. These questions should be asked when preparing for field work.

1 What are the key concepts that are central to this field study?
2 What are the steps or stages of geographic enquiry, and how were these used to plan the field study?
3 What happened at each stage of the geographic enquiry when the field study was carried out?
4 What generalisations can be made from the findings or results of the field study/geographic inquiry? How can these generalisations be related to geographic ideas ?

Here are two examples of field studies for the Environmental Issues topic of the Year 12 Geography course. The examples can be helpful to developing a better understanding of *how* to develop a geographic inquiry that is based on key concepts, geographic ideas as well as to some of the focusing questions for the Environmental Issues strand.

These examples have not been trialled yet. The way they have been written up (the format) is supposed to be helpful to teachers and students, in their efforts to develop their own field studies.

Example One

Table 5.2.1 Rainforest field study

Topic: Perceptions of the Rainforests at Tafua Peninsula		
Key Concept: PERSPECTIVES		
Main Geographic Ideas: Social and cultural groups perceive and use their own and other environments in different ways		
Hypothesis: All the groups that are involved with this issue want to protect this rainforest environment		
Steps:		
Planning	*Where* . . . is Tafua and its rainforests? *Who* . . . is involved with making a decision about the Tafua rainforests? *What* . . . does each group want to do with this environment? *Why* . . . does each group want to do what they want to do? *When* . . . did the use of the Tafua rainforest become a big issue? *How* . . . do people feel about this issue?	**Action Plan** ❑ Develop questions (use 5W and 1H approach) that will help the research. ❑ Find out what different people in our community know about the Tafua rainforest issue, and find out their perspective on this issue. ❑ Make decisions about how this information will be collected and recorded. ❑ Make a decision as to how this will be presented, e.g. as a written report, as an oral presentation or speech or as a visual poster/chart. ❑ Also make a decision about how the field study will be evaluated, e.g. as a group discussion, followed by paragraph writing in workbooks.
Data Collection and Recording	Students in the class will work in groups of 3–4 students. Each group will develop no more than 5 research questions. They will design a survey sheet – and each person in the group will go out and interview 5 people. Answers from each interview will be recorded on the survey sheet.	❑ The questions from the planning stage will be used to develop a short answer survey. ❑ The class will revise interviewing and surveying techniques with the teacher. ❑ Surveys will be carried out in students' own time and recorded on their sheets. ❑ The group will meet and put together all their survey forms and try to summarise them.

(cont.)

Steps:		
Data Processing	In groups: the summarised data or information will be analysed. Graphs and tables will be drawn (i) to identify patterns and (ii) to show findings. For Q5, prepare lists of perceptions and compare them to other groups lists.	❑ If each person in a four member group surveys five people, the total for the group will be 20. If the class all agreed on the survey questions, then all groups can put their results together and can have a much larger sample size. ❑ The data for Q1–4 can be calculated into percentages, and graphs such as pie graphs, column graphs and percentage bar graphs can be drawn. ❑ Write generalisations about people's knowledge and views of the issue (based on Q5).
Presentation of Findings (Conclusions)	Apply the geographic idea and hypothesis to the results of the field study. Discuss, as a group, if the results support the hypothesis and the geographic ideas. Present the results in the way that you agreed upon in class before the data gathering began.	❑ Write a field report.
Evaluation: ❑ of process ❑ of results/findings/ conclusions.	Have a group discussion about: ❑ how well the field study was planned (e.g. 'what can we do better next time?') ❑ the data collecting/records methods (e.g. were they good enough? If not, why not?) ❑ the results: do they make sense? Do they relate to the hypothesis and geographic idea clearly? If not, why not?	After the discussion, write brief paragraphs to summarise what you think were the strengths and weaknesses of the field study.

Example Two

Table 5.2.2 Mangrove field study		
Topic: Changes in the Vaiusu Mangrove Forests		
Key Concept: CHANGE		
Main Geographic Ideas: ❑ People, through their decisions and actions, bring about changes ❑ Change happens at different rates and at different scales		
Hypotheses: **1** The main cause of change for the Vaiusu mangroves is land filling/land reclamation **2** Changes to the mangroves at Vaisusu has been very rapid over time.		
Steps:		
Planning	❑ In groups and as a class, make decisions on what data or information is needed. ❑ Also make decisions about the methods that will be used to get this data. ❑ Discuss with teacher how the results are to be presented. ❑ Also make plans on when the field study will be evaluated (and how), e.g. the teacher may decide she/he will prepare the evaluation.	❑ Information about the changes at Vaiusu: – visit Vaiusu mangroves and make observations – invite someone to speak to the class either before or after the visit to Vaiusu – interview people that live in the area. ❑ Information about the rate of change/change over time. – interview people that live in the area (particularly older people) – interview/speak to members of your own family about their memories and knowledge of Vaiusu Bay.
Data Collection and Recording	❑ class to work co-operatively in groups of 3–4 people ❑ help organise a class trip to the mangrove forests at Vaiusu ❑ ensure the group has the materials that are needed for the field study.	❑ Listen to the speaker and make notes. ❑ Study maps of the area – and then draw précis maps showing land use (based on observations). ❑ Walk around the area and make sketches of what is observed. ❑ Label clearly. ❑ Make careful notes of main points from each interview.
Data Processing	This will take place back at the classroom after the field work/field trip. It may continue at home for homework. Group discussions of the findings.	❑ Construct neatly labelled sketches and maps. ❑ Write up interview and speaker notes – and study/discuss.

(cont.)

Steps:		
Presentation of Findings (Conclusions)	Results are to be written up as a group chart. Results are related to the hypothesis and main geographic ideas.	Chart presentation to the class
Evaluation: ❑ of process ❑ of results/findings/ conclusions.	Teacher conducts the evaluation. In groups, students to have a discussion based on the evaluation form that the teacher has given out (it should be based on the steps/ methods that you followed, your results, etc).	Each group are to fill in the evaluation form that your teacher hands out.The teacher will collect them all in and provide the class with feedback at a later date.

Figure 5.2.1 Mangrove forest

Appendix 1

Focusing Questions for Physical Environment (Part One, pages 5–49)

Achievement Indicators	Focusing Questions
	1 What are the main types of islands found throughout the Pacific region? **2** What processes produced the physical environments of high islands? Of atolls? **3** What are the similarities and differences between high island and atoll environments? Why and how are they the same/different? **4** How and why have the physical environments of high islands and atolls influenced traditional ways of living? **5** What are examples of human activities today that (i) affect and (ii) are affected, by the physical environments of high islands and atolls? How and why are these important?

Key Vocabulary

Vocabulary	Collocations	Derivations
absence		absent
adjacent		
affect		
alter		
arc		
associate		associated with
benefit		
boundary		
characteristic	the important characteristics of	characterise
classify	a classification of islands	classification
circulate		circulation
commercial	commercial farming	
current		
damage		
decline		
dense		density
degree	different degrees of risk	
destroy		destruction, destructive
disturb		disturbance
dominant		dominate
enormous		
estimate		
exist		existing, non-existent
extinct		
indicate		
interact		
interval	at regular intervals	
introduce	the introduction of new methods	introduction
involve		
link		
location		located
minor		
navigator		navigation
occur		occurrence
penetrate		
recent		
relatively	relatively large	
remote		
remove		removal
rim		
severe	severely affected	severely
shelter		
sites		
specific		
stable		stabilisation, unstable
stationary		
technology		technological
vary	islands vary in terms of	variation, variety, varying, various, variable
violent	violent storms	violently

Topic Specific Vocabulary

Part 1 Physical Environments
Introduction

Unit 1 High And Low Islands Of The Pacific Ocean
plate tectonics

Unit 2 The Moving Earth And The Origin Of The Oceanic Islands
collide
convection
crust, crustal
mantle
molten
subsidence
subduction
lubricated, lubrication
volcano, volcanism

Unit 3 Formation Of Low Islands: Cays And Motus
shoreward, seaward
coarse, fine
constant, constancy
sediment
wave refraction
deposit
linear

Unit 4 A Classification Of Pacific Islands
susceptible
phenomena
oceanic
continental shelf
hot-spot
erode
debris
windward, leeward

Unit 5 People And The Island Ecosystems
pollution
overpopulation
staging posts
military
contaminate
predators
guano
morphology
exotic

Unit 6 Island Climates
altitude
prevailing

Unit 7 Island Similarities And Differences
climograph
moderate

Part 2 Population
Introduction
consequence
spatial
concentration
dispersal
migrate
accessibility

Unit 8 Population Of New Zealand
decendants
compensation
urban
rural
structure
census
multicultural
elderly

Unit 9 Population In Asia
gap
global
correlation
policy
transition
model
validity
expertise
refugees

Unit 10 Population In Sāmoa
international

Part 3 Environmental Issues
Introduction
perspectives
sustainable
practices
policies

Unit 11 Geographic Patterns And Issues
issue
contentious
contemporary
value

Unit 12 Choosing A Physical Environment

Unit 13 Developing Studies Of Environmental Issues

Part 4 Resources And Their Uses
Introduction

Unit 14 Farming Systems
interact
system
factor
diversity
subsistence

Unit 15 Banana Farming In Sāmoa
staple
transnational
monoculture
nutrient

Unit 16 Mining Systems
extract
mineral
inorganic

Unit 17 Uranium Mining In Australia
controversial
rehabilitation
tailings

Part 5 Field Studies
Introduction

Unit 18 Some Points About Geography Field Work

Unit 19 A Geographic Enquiry
inquiry
investigation

Unit 20 Developing A Field Study On Environmental Issues
research question
survey

Useful structures

Describing processes:

- *As a result* of these temperatures and pressures, the rock materials become soft and plastic.
- These *in turn* may develop into barrier reefs and atolls *as* the volcanic core subsides and is eroded.
- *When* these waves crash on to a reef, they can cause massive damage.
- This sweeping *action* of the waves may *form* a coral cay.
- These convection *currents* can *force* magma through cracks in the lithosphere to the surface

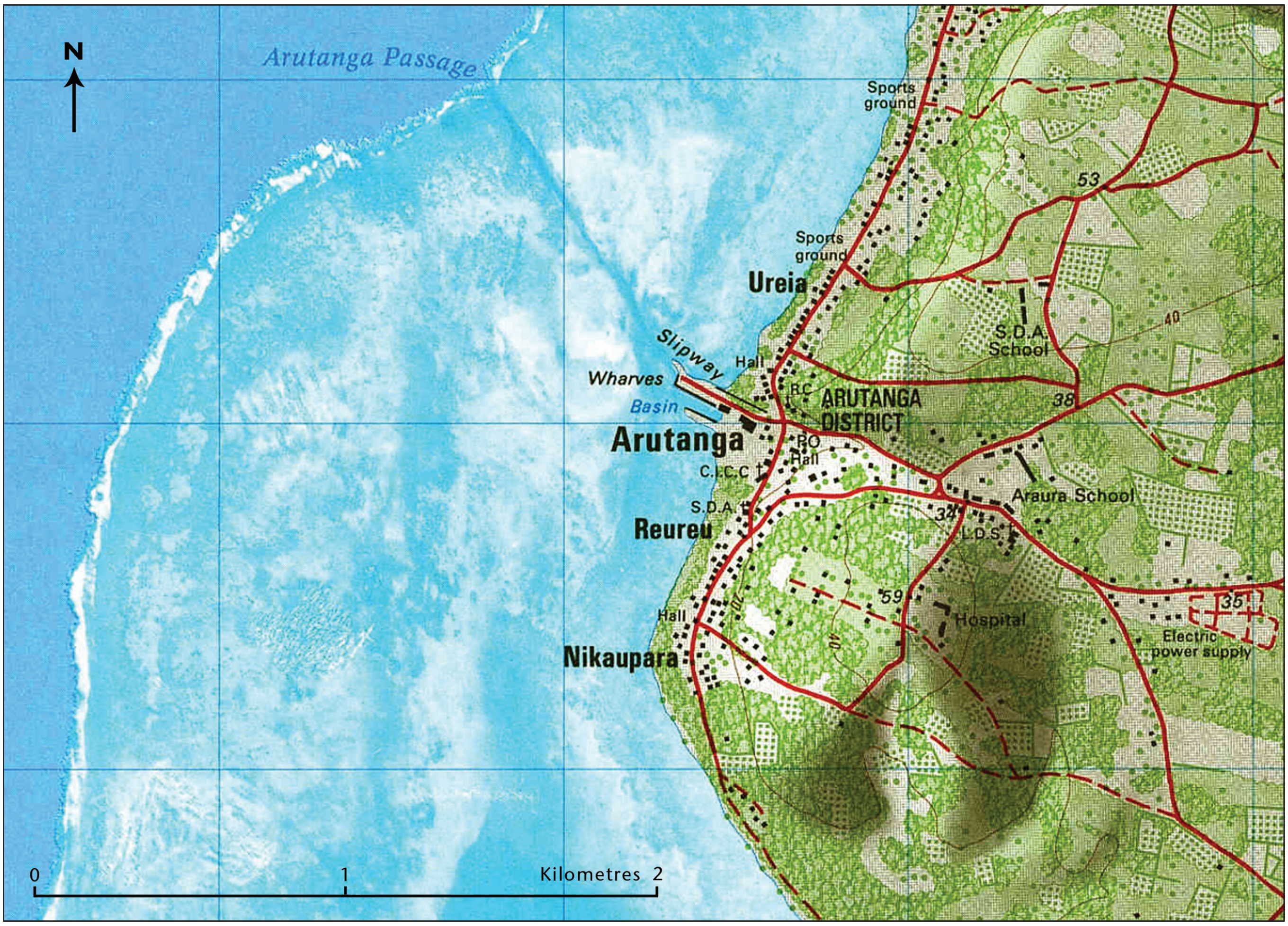
Expressing quantity:

- About 85% of New Zealanders live in rural areas.
- Over half the world's population lives in Asia.
- Most people live on coastal and alluvial plains.
- Asia's population is predominantly rural and youthful.
- . . . high proportions of young people.
- . . . an increasing percentage of elderly people . . .

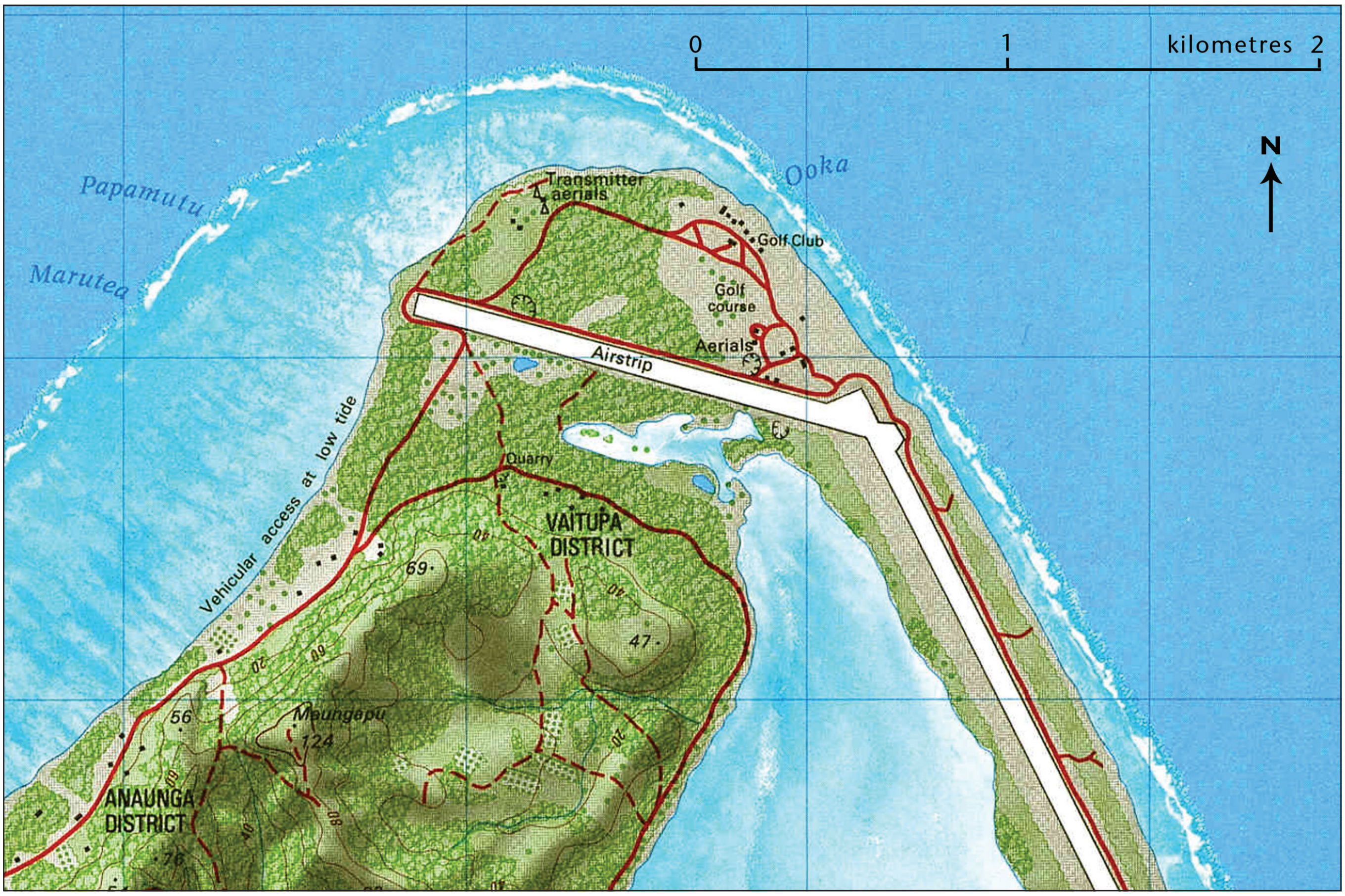
Apia urban area

Salelologa, Savai'i

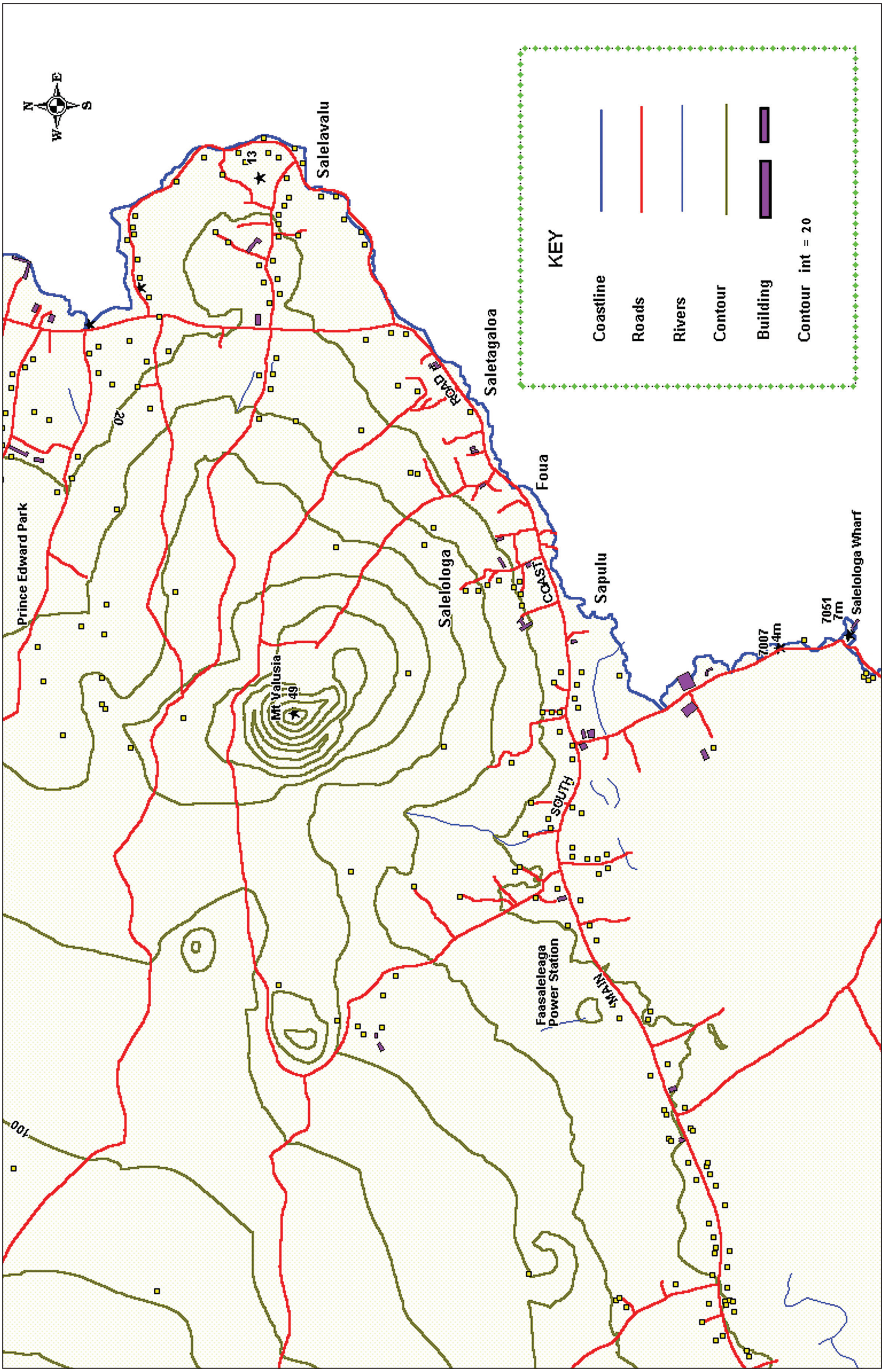
Topographic map of Aitutaki, Cook Islands



Arutanga, Aitutaki



North coast, Aitutaki



Topographic map of Salelologa, Savaii