6.1 Water scarcity

Water scarcity occurs when the demand for water exceeds the amount available. Water scarcity can lead to water stress, which affects people and environments. Many of the world's water-stressed countries are in Africa.

Types of scarcity

Water scarcity can be either physical or economic. Physical scarcity occurs when where there is not enough water to meet all demands, including those of ecosystems. Economic scarcity occurs when there has not been enough investment in the infrastructure needed to store and transport water to where it is needed.

Water stress

Water stress is the negative effect on people and environments that can result from water scarcity. Africa has the largest number of water-stressed countries. Most of these are found in North Africa.

Reasons for scarcity

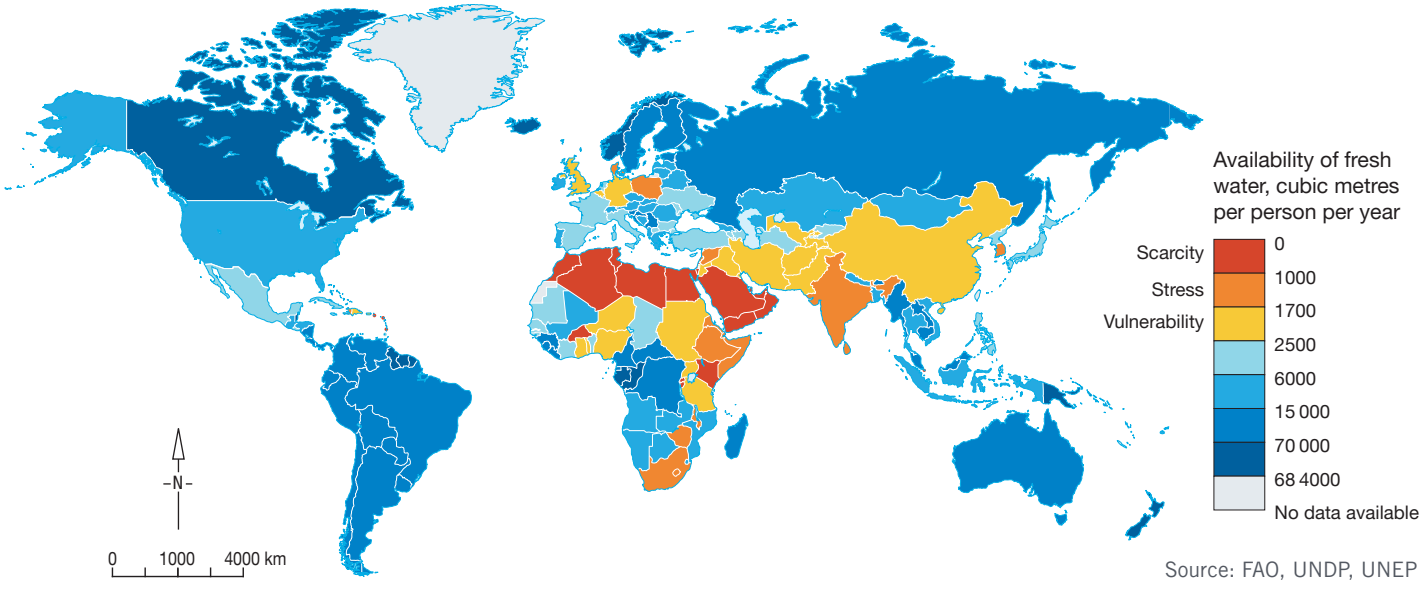
Water scarcity can occur in areas where there is plenty of rainfall. The quality of the water available determines whether there is enough to meet the needs of households, farmers, industry and the environment.

Figure 6.1 shows water availability in the world. Approximately 1.2 billion people, or almost one-fifth of the world's population, live in parts of the world where water scarcity is already a problem, and 500 million people are approaching that situation. Another 1.6 billion people face water shortages due to a lack of infrastructure to extract water from rivers and aquifers. Rapid population growth, urbanisation and increases in water use by households and industry are making the situation worse. The total amount of available fresh water is changing due to climate change, which is causing glaciers to recede, river flows to reduce and lakes to shrink. Many aquifers have been over-pumped and are not refilling quickly.

Effects on water quality

Water scarcity results in people having to rely on unsafe sources of drinking water. Maintaining personal hygiene is difficult. There is often not enough water to bathe or clean clothes properly. Much of the world's fresh water has become too polluted or salty for use in households, industry and agriculture.

6.1 World water availability



Source: FAO, UNDP, UNEP

Contaminated water also increases the risk of infection from waterborne diseases such as cholera, typhoid and dysentery. Water scarcity can lead to diseases such as trachoma (which can lead to blindness), plague and typhus. Contaminated, stagnant water provides a breeding ground for mosquitoes, which are carriers of diseases such as dengue fever and malaria.

The use of wastewater in agriculture is growing and puts people at risk from crop contamination. More than 10 per cent of the world's people consume food grown using wastewater that contains various chemicals or disease-causing organisms.

Solutions

To avoid a global water crisis, industries and cities will need to find ways to use water more efficiently. Farmers will have to increase productivity to meet growing demands for food without greatly increasing their water usage. People need to take personal responsibility and learn how to conserve and protect water resources.

Target 10 of the United Nations **Millennium Development Goals** is to halve the proportion of people without access to safe drinking water and basic sanitation by 2015. Water is an essential resource to sustain life.

SPOTLIGHT

Water scarcity in Africa

Fourteen countries in Africa already experience water stress. Another eleven countries are expected to join them by 2025. By this time, an additional 50 per cent of the continent's estimated population of 1.45 billion people will experience either water stress or water scarcity. In sub-Saharan countries, nearly 51 per cent of the population (300 million people) lack access to a supply of safe water, and 41 per cent lack adequate sanitation.

6.2 Searching for water in a dry riverbed in northern Kenya

ACTIVITIES

6.1

Knowledge and understanding

1. Explain the difference between *physical* and *economic* water scarcity.
2. Describe the nature and extent of water scarcity in Africa.
3. List the percentage of the world's population that is affected by water scarcity.
4. List the types of water issues that affect people around the world.

Applying and analysing

5. Can places with high rainfall experience water scarcity? Explain.
6. Study Figure 6.1.
   - **a** List the continents experiencing water scarcity, water stress or water vulnerability.
   - **b** List the continents not experiencing water scarcity, water stress or water vulnerability.
   - **c** List reasons for the different answers to parts **a** and **b**.

6.2 Case study: Drought in the Horn of Africa

By late 2011, 13 million people in the Horn of Africa needed urgent assistance due to severe drought and increasing food prices. Unreliable rainfall, lack of water storage infrastructure and reliance on subsistence agriculture mean that water scarcity can quickly turn into a disaster.

The drought of 2011–12

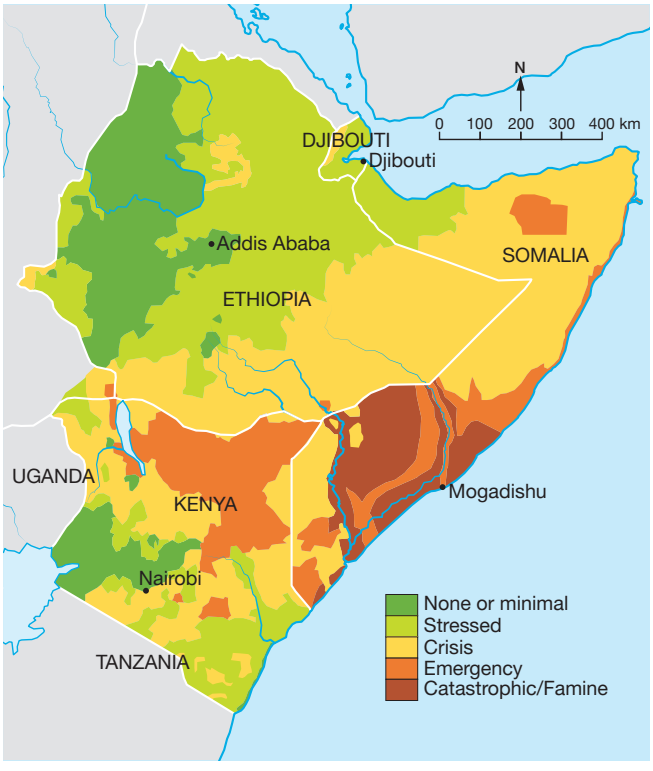
The severe drought affecting the Horn of Africa began after low rainfall levels in 2011 across Kenya and Ethiopia. In Somalia, low rainfall levels were recorded in 2009, 2010 and 2011. In many parts of the Horn of Africa, rainfall was less than 30 per cent of the long-term average. The low rainfall led to crop failures and the death of livestock. As a result, food prices increased sharply. The crisis was made worse by violent rebel activity in southern Somalia.

Families who were strong enough to flee drought-affected regions often travelled on foot for hundreds of kilometres, hoping to make it to a refugee camp. At the drought's peak, overcrowded camps in Kenya and Ethiopia were receiving some 3000 new refugees every day, seeking food and shelter (see Figure 6.3). In total, nearly a million Somali refugees have fled to nearby countries. The extent of the food shortage can be seen in Figure 6.4.

As illustrated in Figure 6.5, rainfall totals for the Horn of Africa, even in the best of years, are well below what is necessary to support agricultural production. The unreliability of the region's rainfall makes the situation worse. Heavy rainfall in early 2012 did not bring an end of the suffering. In fact, it made outbreaks of disease in parts of East Africa more likely. This has worsened the situation for millions struggling to survive the severe drought and rapidly rising food prices.

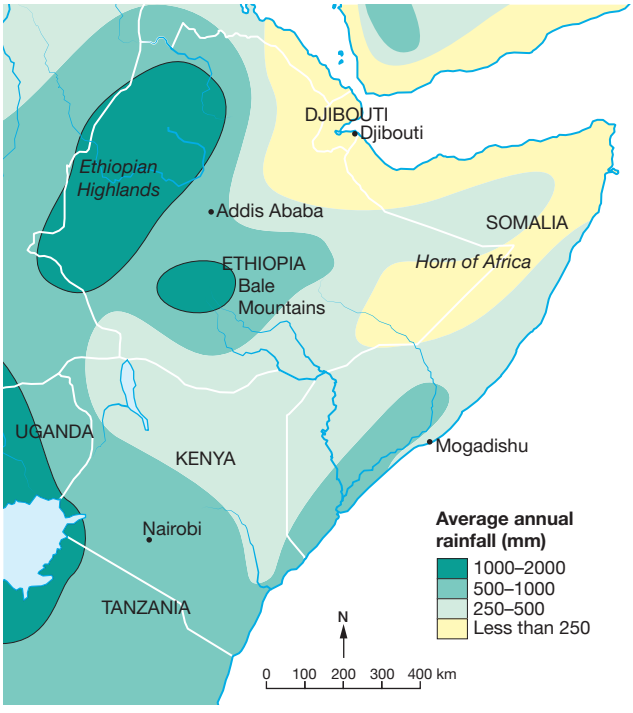
6.3 Children queuing for food in the Somali capital, Mogadishu

6.4 Food shortage crisis in the Horn of Africa, October 2011



Source: FAO, OCHA

6.5 Rainfall in East Africa

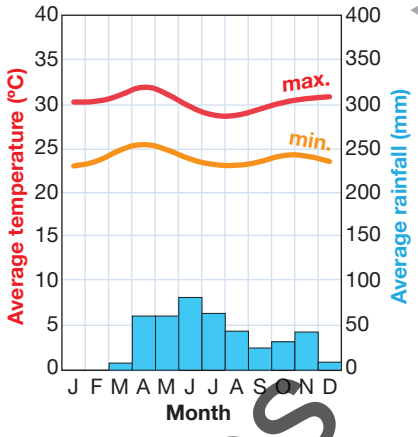


Source: *Heinemann Atlas* Fifth Edition

Rainfall in the Horn of Africa

The climate of East Africa reflects the region's high altitude and the rain-shadow effect caused by the Bale Mountains and Ethiopian Highlands. The mountains block the eastward movement of the monsoon. As a result, the lowlands of northern Kenya and Somalia are extremely dry. Mogadishu, for example, receives about 400 millimetres of rainfall a year (see Figure 6.6).

The climate in the Bale Mountains and the Ethiopian Highlands is tropical. There is rain during most of the year. The Highlands have a single wet season, from June to September.



6.6 Climate graph for Mogadishu

International response

Although violence disrupted aid delivery in some areas, international relief operations were ready by mid-2011. By November, the efforts of the international aid agencies had significantly reduced **malnutrition**. Aid agencies then turned their attention to recovery strategies, including the construction of irrigation canals and the distribution of seed. The United Nations requested US$2.5 billion to fund its relief program. Australia contributed $80 million, and non-government organisations appealed to the public for donations.

Long-term strategies to minimise the impact of future droughts include:

- building water-storage **infrastructure** such as **dams**
- improving transport infrastructure to move food from areas of surplus to areas of need
- implementing more sustainable and water-efficient forms of agriculture.

ACTIVITIES

Knowledge and understanding

1 Discuss the nature and scale of the suffering experienced in the Horn of Africa during the famine of 2011–12.
2 To what extent was the crisis linked to water scarcity in the Horn of Africa?
3 Outline the international response to the crisis. What do you think can be done to minimise the impact of future droughts?

Geographical skills

4 Study Figure 6.4. Describe the areas of the Horn of Africa that experienced *emergency* and *catastrophic/famine* status in October 2011. Is there a link between these areas and the location of rainfall? Explain.
5 Study Figure 6.5. Describe the distribution of rainfall in the Horn of Africa.
6 Study Figure 6.6. Using data from the climate graph, describe the climate of Mogadishu.

6.3 Managing water resources

The distribution of fresh water resources in Africa is uneven and unreliable. Areas such as the Sahara and the Sahel in the north, and the Kalahari in the south, suffer from long periods of drought, while the tropical belt of mid-Africa has plenty of water.

The problem

Water scarcity has always been a problem in Africa. Africa's share of the world's population is 14 per cent, yet its share of global fresh water is about 10 per cent. With its population projected to double from just over 1 billion in 2012 to 2 billion in 2050, the situation can only get worse.

- Most Africans living in rural areas do not have safe and reliable access to water. On average, Africans use only 30 to 40 litres of water per day for domestic consumption.
- More than 300 million people in Africa still lack access to safe water and adequate sanitation. In sub-Saharan Africa, just 51 per cent of the population have access to safe water and 45 per cent to sanitation.
- Africa is a dry continent. More than 40 per cent of Africa receives less than 200 millimetres of rainfall a year. Drylands and deserts together cover 60 per cent of the entire land surface.

The challenges

The water-related challenges facing Africa are enormous.

- To meet its 2015 Millennium Development Goals, Africa needs to reduce the proportion of people without access to safe water by 50 per cent.
- Africa needs to increase the area of irrigated land by 50 per cent if it is to meet its 2015 African Water Vision target.
- To meet the increased demands of agriculture, hydro-electric power, industry, tourism and transportation, Africa has to increase the development of its water resources by 25 per cent by 2025.
- Africa has to manage droughts, floods and **desertification** more effectively.
- It is a priority is to restore the environment through the supply of sufficient water for environmental sustainability and the conservation of watershed ecosystems.

A contemporary response

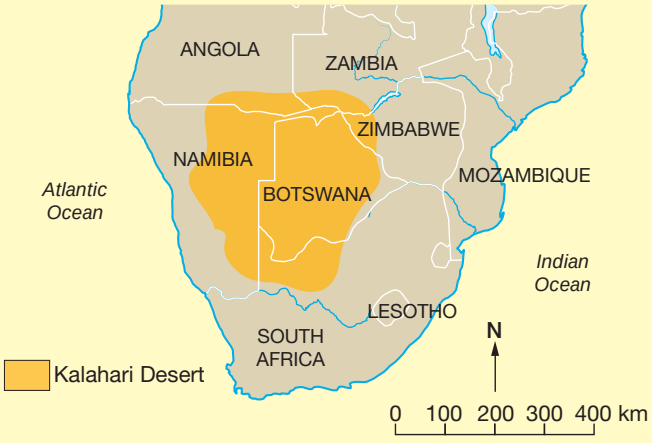
There are three broad approaches to water management. The first approach involves capturing and storing more water. This is the main approach taken by most African governments. The second involves realising that people need to conserve water in order to get more use out of every drop; for example, through efficient irrigation techniques. Thirdly, people need to do things differently with the water available; for example, include building reclamation or recycling plants such as the one in Namibia shown in Figure 6.7. Africa's groundwater stocks are enormous, but they could be depleted if they are used faster than they can be replenished. Sustainable approaches to water management will be essential.

6.7 Water reclamation in Namibia. Water is re-used for irrigation and domestic consumption.

SPOTLIGHT

The San people of the Kalahari

The San people (sometimes referred to as the Bushmen of the Kalahari; see Figure 6.8) are the indigenous people of southern Africa. Traditionally, they have lived as hunter-gatherers, hunting game with poisoned arrows. In their dry environment the San get their water from baobab trees, plant roots (as shown in Figure 6.9) and the desert melons. They often store water in springbok bladders and the blown-out shells of ostrich eggs. They also dig sip wells—holes that they dig in the earth and fill with soft grass. A reed is used to suck water from the hole, and send it bubbling up the reed to fill an ostrich egg.



6.8 For more than 20 000 years, the San have occupied a vast territory spanning parts of modern-day South Africa, Zimbabwe, Zambia, Botswana, Namibia and Angola.

6.9 San Bushman drinking sap squeezed from a tuber

ACTIVITIES

6.2

Knowledge and understanding

1 List the water-related challenges facing Africa.

2 Explain how the San people of the Kalahari learnt to live with water scarcity; that is, with having only a small amount of water.

Applying and analysing

3 Explain how the three broad approaches to water management will help ease Africa's water problems.

Geographical skills

4 Study Figure 6.8. Name the countries in which the Kalahari Desert is located.

5 Study Figure 6.9. Describe the living conditions of the San people with the help of Figure 6.9 and the information in this unit.

6.4 Increasing water supply

The global demand for water will continue to increase as the world's population heads towards 7.9 billion in 2025. Not only will we need to increase the amount of fresh water available, we will also need to use existing supplies more carefully.

Solutions

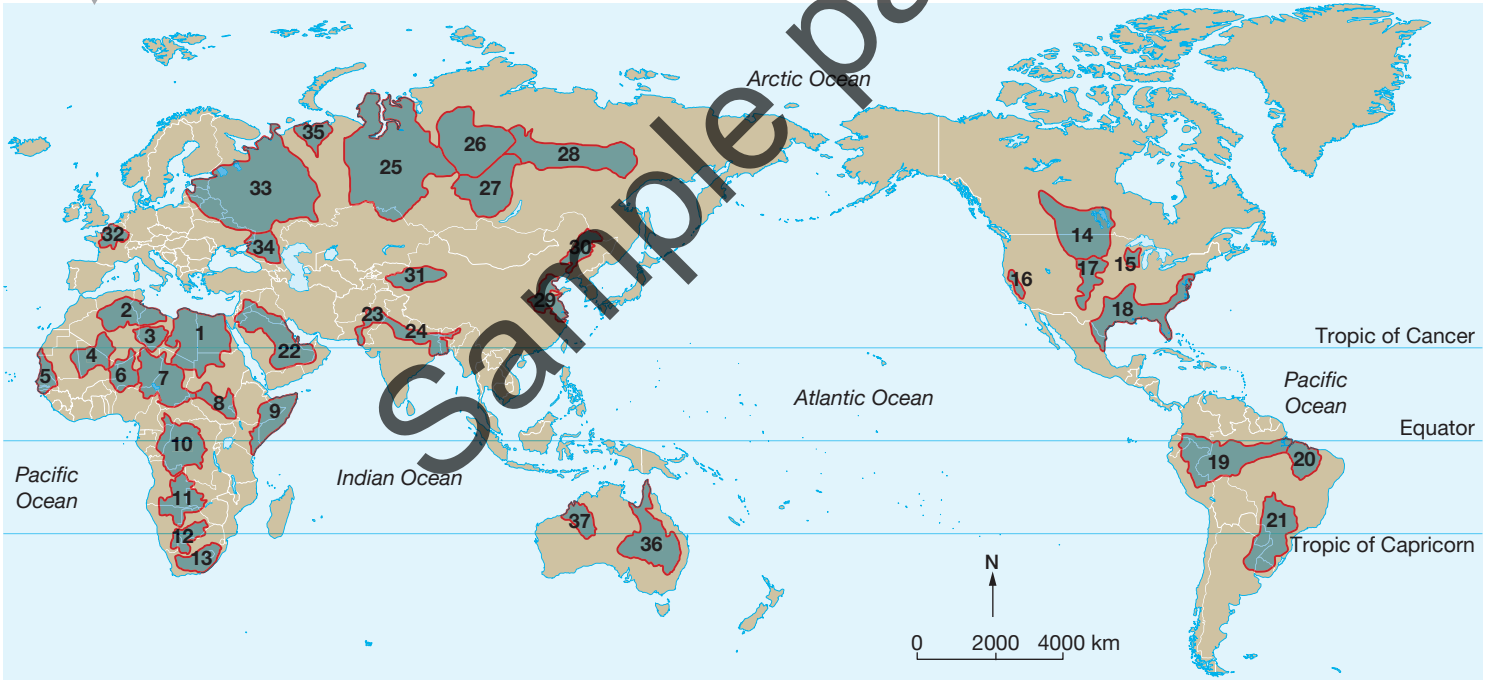
Different ways of increasing the water supply are:

- extracting more groundwater
- building dams and reservoirs
- transporting water
- desalination.

Extracting groundwater

Most aquifers are a renewable resource unless the groundwater they contain either becomes contaminated or is removed faster than it can be refilled by rainfall. At present, water tables in many places are falling because water is being withdrawn faster than the rate of natural recharge.

6.10 The world's large aquifer systems



Source: WHYMAP

Large aquifer systems

1 Nubian Aquifer System
2 North-west Sahara Aquifer System
3 Murzuk–Djado Basin
4 Taoudeni–Tanezrouft Basin
5 Senegalo-Mauritanian Basin
6 Iullemeden–Irhazer Aquifer System
7 Chad Basin
8 Sudd Basin
9 Ogaden–Juba Basin
10 Congo Intracratonic Basin
11 Northern Kalahari Basin
12 South-east Kalahari Basin
13 Karoo Basin
14 Northern Great Plains Aquifer
15 Cambro-Ordovician Aquifer System
16 California Central Valley Aquifer System
17 High Plains–Ogallala Aquifer
18 Gulf Coastal Plains Aquifer System
19 Amazonas Basin
20 Maranhao Basin
21 Guarani Aquifer System
22 Arabian Aquifer System
23 Indus Basin
24 Ganges–Brahmaputra Basin
25 West Siberian Artesian Basin
26 Tunguss Basin
27 Angara–Lena Artesian Basin
28 Yakut Basin
29 North China Plain Aquifer System
30 Songliao Basin
31 Tarim Basin
32 Parisian Basin
33 East European Aquifer System
34 North Caucasus Basin
35 Pechora Basin
36 Great Artesian Basin
37 Canning Basin

The world's **deep aquifers** are a largely untapped potential source of additional groundwater (see Figure 6.10). Tests indicate that some of these aquifers hold enough water to support billions of people for centuries. Unfortunately, deep aquifers are not considered a renewable resource because they have taken millions of years to reach their current state and cannot be replenished on a human timescale. In addition:

- little is known about the impact that withdrawing this water would have on the geology of the area
- some deep aquifers underlie more than one country, which makes them a potential source of conflict
- the cost of tapping this resource would be very high.

Dams and reservoirs

A dam is a structure built across a river to control the river's flow. The dammed water creates a lake, or reservoir, behind the dam. The main purpose of a dam is to capture and store water run-off. The water is then released when needed to control floods, generate electricity (**hydro-electricity**) or supply water for irrigation and for towns and cities. Reservoirs also provide opportunities for recreational activities such as swimming, fishing and boating.

There are now more than 45 000 large dams worldwide (22 000 of these are in China). Together, they capture and store about 14 per cent of the world's surface water run-off, provide water for almost half of all irrigated crop land, and supply more than half of the electricity used in 65 countries. These dams have increased the reliable availability of water for human use by nearly one-third.

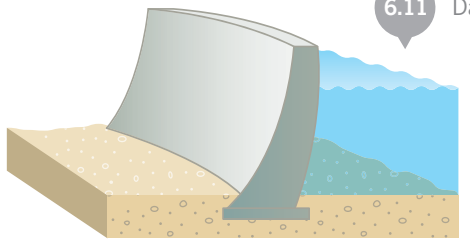
Large dams have both benefits and drawbacks. While they greatly increase water supplies in some areas, they also disrupt ecosystems and displace people.

Dams can be classified into different types according to their structure (see Figure 6.11).

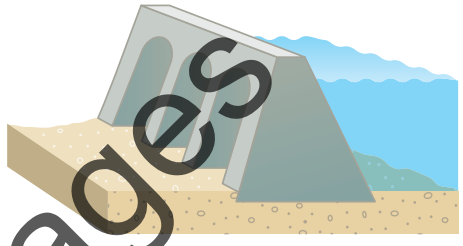
Transporting water

Water can be transported over long distances using dams, pumps, tunnels, pipelines and lined canals, or **aqueducts**. The California Water Project in California, USA, is one of the world's largest water transfer projects. It moves water from water-rich northern California to water-poor southern California, where it is mainly used in agriculture. In Australia, the Snowy Mountains Scheme takes water from the Snowy River, on the eastern side of the Great Dividing Range, and diverts it westwards into the Murray and Murrumbidgee river systems, where it is used for irrigation. There are some people in Australia who argue in favour of building large dams in northern Australia and piping the water south into the Murray–Darling river system.

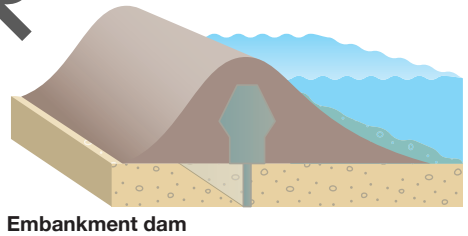
6.11 Dam types



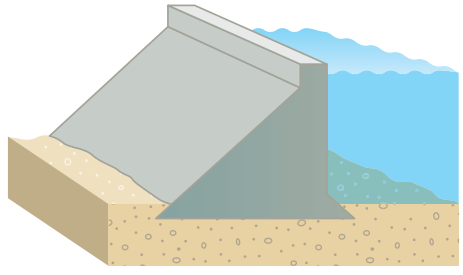
Arch dam
This has a curved shape. The inside of the curve faces downstream.



Buttress dam
This has a series of buttresses located on the side of the dam facing downstream.



Embankment dam
This is made of a huge pile of rocks and earth. The dam relies on its sheer bulk to hold back the water.



Massive dam
This is built of concrete and relies on its size and weight to withstand the pressure of the stored water.

DID YOU KNOW?

- Worldwide, big dam construction has displaced up to 80 million people from their homes and flooded an area of productive land equivalent to twice the size of Victoria.
- Only 21 of the earth's 177 longest rivers run freely from their source to the sea.

SPOTLIGHT

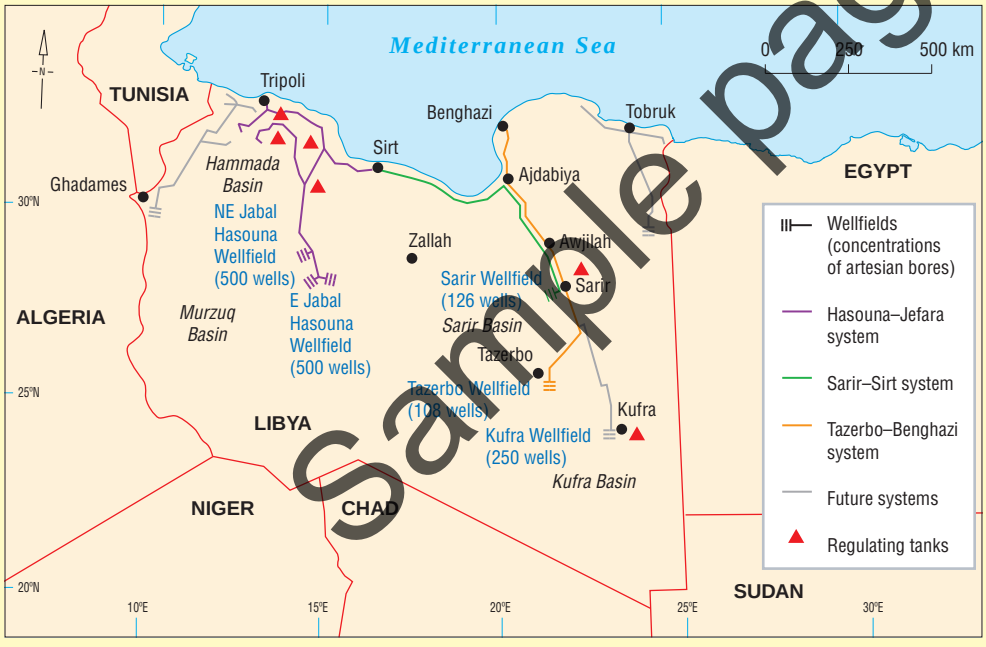
Securing Libya's water supply

While drilling for oil in Libya in the 1960s, engineers discovered huge reserves of water in aquifers beneath the Sahara Desert. This vast store of water had accumulated over some 70 000 years, much of it at a time when rainfall in northern Africa was much higher than it is now (see Figure 6.13).

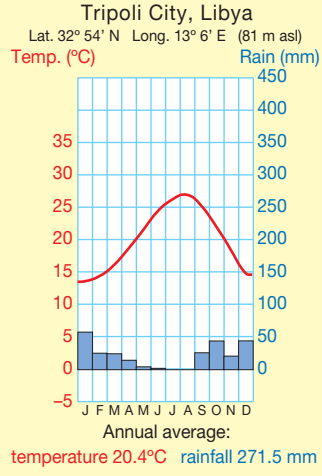
To develop its economy, Libya needed to use this water. In the 1970s, the country made huge profits by exporting oil to the countries of the developed world. Much of this money was invested in the Great Man-Made River Project. Construction started in 1983 and is still in progress. When completed, the project will improve access to water for over five million people and will irrigate dry areas so that the country can become self-sufficient in food production. The project will also generate electricity, which will help to promote industrial development.

To extract the water, more than 1300 wells, most over 500 metres deep, have been dug, and a network, some 3500 kilometres long, of pipelines 4 metres in diameter has been partially built and is still under construction. Three major reservoirs (at Ajdabiya, Sirt and Benghazi) store 35 gigalitres of water. The project has made 135 000 hectares of land available for production. Large quantities of fruit and vegetables, as well as 270 000 tonnes of crops and 760 000 tonnes of fodder, are now grown on irrigated land.

6.12 Libya's Great Man-Made River Project. Libya is a hot, dry country. The rainfall that does fall is limited to a narrow coastal zone. Seventy per cent of Libya's five million people live in the coastal cities of Tripoli and Benghazi.



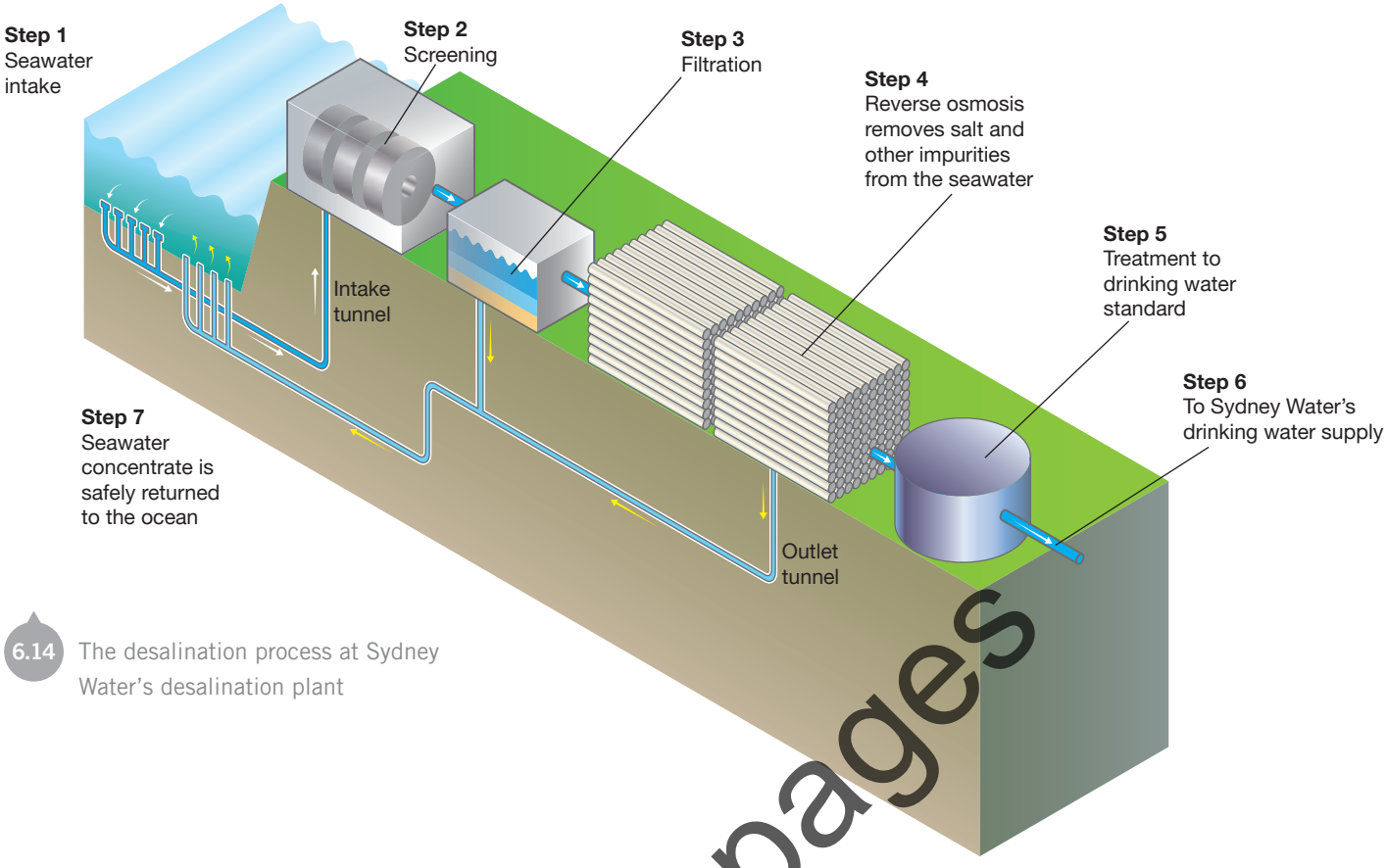
6.13 Climate graph for Tripoli



Desalination

Desalination is a process that involves removing the dissolved salt from ocean water. The process most commonly used is called **reverse osmosis**. This involves forcing water, under high pressure, through a filter that is fine enough to remove the salt. Today, there are more than 14 500 desalination plants operating in more than 125 countries. Australia has six desalination plants either operating or under construction. Desalination is an energy-intensive process that is very expensive.

Desalination plants are very expensive to build and operate, and they use enormous amounts of electricity. They can have a serious impact on nearby marine ecosystems from either the toxic chemicals used to kill algae or the **brine**, or concentrated seawater by-product, that has to be dumped back into the sea. When operated at capacity, Sydney's desalination plant (see Figure 6.14) supplies 15 per cent of Sydney's water needs. A large wind farm has been built to provide **green energy** for the plant.



6.14 The desalination process at Sydney Water's desalination plant

ACTIVITIES

6.3 6.4

Knowledge and understanding

1 List the ways in which the supply of water in an area can be increased.
2 State the condition under which groundwater can be considered a renewable resource.
3 Outline the potential benefits and dangers associated with extracting water from the world's deep aquifers.
4 State the role played by dams.
5 Identify the infrastructure needed to transport water.
6 Study Figure 6.14. Explain the process of desalination.

Applying and analysing

7 Discuss, as a class, the various options outlined in this unit for increasing water supplies. List the benefits and costs of each approach. Decide which is the most beneficial in terms of:
   a the economic benefits
   b minimising the environmental impact.
8 Study Figure 6.11. Identify the type of dam pictured in Figure 6.16 (Unit 6.5).
9 Study Figure 6.13. Describe the climate of Tripoli. Explain why water extraction, storage and transport are essential in Libya.

Investigating

10 Investigate the California Water Project. What has been the environmental cost of the undertaking?
11 Study the Spotlight box 'Securing Libya's water supply'. Using the internet, find another example of a large-scale water transfer project. Present your findings as an oral report supported by a multimedia presentation.
12 Investigate one of Australia's desalination plants. Why was it built? Is it necessary? What are the environmental impacts of the plant?

6.5 Big dam projects

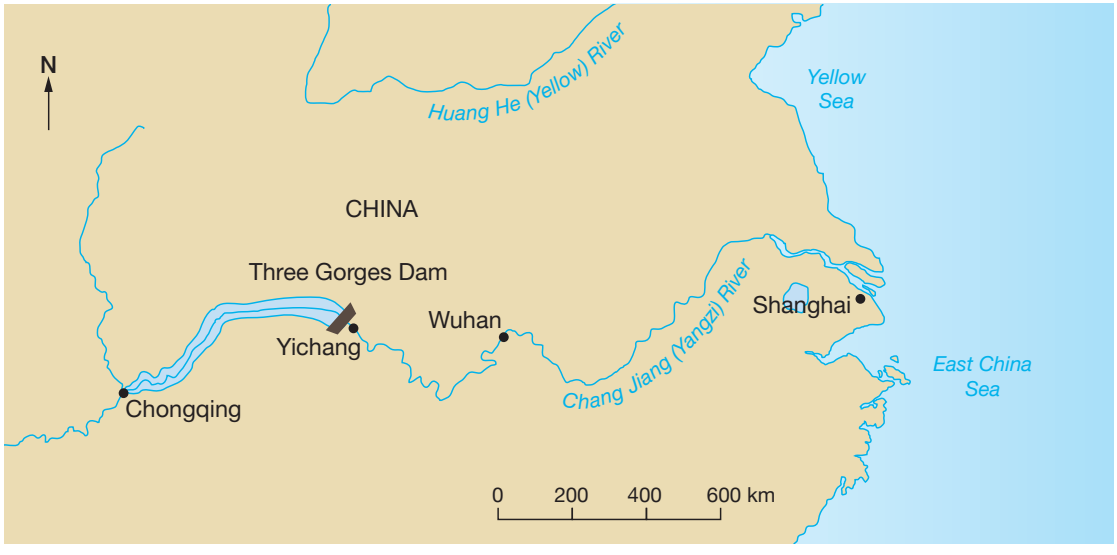
Water shortages have increased the pressure on governments to fund engineering solutions. The infrastructure needed to store and transport water is very expensive and its construction often has significant social and environmental costs. The construction of dams can also contribute to international tensions when a river system flows through more than one country.

Arguments for big dams

- Stored water meets the needs of people and promotes economic growth.
- Dams supply secure and reliable water for irrigation, both upstream and downstream.
- Dams provide protection against drought.
- Destruction caused by flooding to downstream settlements and farms is reduced.
- Food production and industrial output increase.
- Reservoirs can be used to promote aquaculture.
- Hydro-electric power stations generate renewable electricity without producing greenhouse gases.
- Reservoirs can be used for recreational activities such as boating and fishing.

Arguments against big dams

- The seasonal pattern and volume of river flow is changed.
- The release of very cold water from deep in the dam disrupts the ecology of the river.
- Reservoirs flood large areas of fertile agricultural land and wildlife habitat.
- People's livelihoods are disrupted and communities are destroyed.
- Fish are prevented from swimming upstream or downstream.
- Water is lost through evaporation, especially in large, shallow dams.
- Less water is available for downstream users.
- The pressure created by the weight of the dam wall and body of water can cause earthquakes.
- Historic and culturally significant sites can be flooded.
- Damming rivers cuts off the supply of fertile sediments to the flood plain, resulting in reduced fertility and soil depth.
- Reduced sediment flows can increase coastal erosion.
- Sediment or soil is trapped behind the dam. The amount of sediment increases and reduces the amount of water the dam can store.
- The reduction in the volume of fresh water reaching river estuaries degrades the habitat where 80 per cent of the world's fish breed.



6.15 Location of the Three Gorges Dam, China

6.16 China's massive Three Gorges Dam

Three Gorges Dam

China's massive Three Gorges Dam project, shown in Figure 6.16, was built to provide hydro-electricity, stop seasonal flooding and ensure a reliable water supply for surrounding regions. However, the project cost just under $US39 billion (way over budget), and 1.24 million residents and 13 000 farmers were forced to move. The 600-kilometre-long reservoir formed behind the dam flooded an area of 632 square kilometres containing more than 1300 important archaeological sites and some of China's most spectacular landscapes.

DID YOU KNOW?

Scientists have suggested that dams have increased the time taken by the earth's rotation by eight millionths of a second since the 1950s. This is because of the shift of water from oceans to reservoirs.

ACTIVITIES

Knowledge and understanding

1 Explain why the construction of large dams can be controversial.

Applying and analysing

2 Construct and annotate a sketch of a dam. Note the arguments for and against big dams: the upstream, downstream and wider effects.

3 Write a short report about the following statement: 'The advantages of large dams outweigh any disadvantages.' Include in your response examples from dams you have studied.

Investigating

4 Undertake internet research to locate an example of a big dam project. Write a report outlining the proposed benefits of the project and note the concerns of any groups opposed to the undertaking.