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19 Resource management

19.1 The global distribution of resources

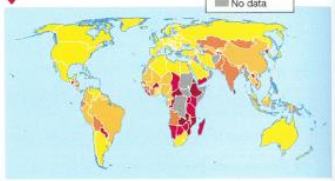
On this spread you will find out about the uneven distribution of food, water and energy

What are resources?

A **resource** is a stock or supply of something that has a value or a purpose. The three most important resources are food, energy and water. Adequate supplies of these resources are essential for countries to develop.

These resources are unevenly distributed across the world. Most HICs have plentiful supplies and enjoy a high standard of living. But many of the world's poorer countries, such as those in sub-Saharan Africa, lack resources and struggle to progress or improve quality of life for their people. As the world's population continues to grow, resource management will present many challenges.

A *Global undernourishment*



Food

Your health is affected by how much you eat and the food's nutritional value. The World Health Organisation (WHO) suggests that we need 2000–2400 calories per day to be healthy. Over one billion people in the world fall below this level and are described as *malnourished*.

A further two billion people suffer from **undernutrition** (malnutrition) – a poorly-balanced diet lacking in minerals and vitamins. This can result in a range of illnesses and diseases. It can also have economic effects. People need to be well fed to be productive at work and contribute to the economic development of their country. Obesity (being overweight) is an increasing problem.

Country	Gross National Product (GNP) per head (US$)	Human Development Index (HDI) Ranking	Water per head (m^3)
Canada	22 480	1	94 000
Australia	20 210	7	185 000
Saudi Arabia	10 120	78	2176
Burkina Faso	1010	171	1535
Niger	850	173	346

B *How water supply relates to development*

Water

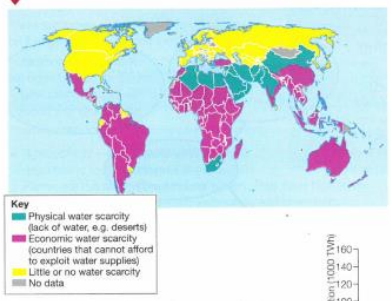
Think about how much water you have used and drunk today. Imagine if you had just one bucket of water to use each day, including water for drinking. Both the quantity and the quality of water are important for our well-being and for economic development (table **B**).

Water is not only essential for people and animals to drink, but is vital for crops and food supply. It is also important as a source of power for producing energy. As the world's population grows, more people are faced with a shortage of water.

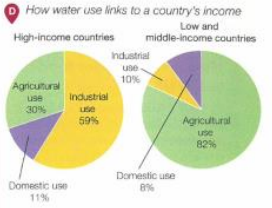
The imbalance in water supply is due mainly to variations in climate and rainfall. Rainwater needs to be captured and stored in reservoirs or taken from rivers or aquifers deep underground. All of these are very expensive and require high levels of investment.

Many of the world's poorest countries, particularly in Africa, have a shortage of water. They become trapped in a cycle of poverty. The UN estimates that by 2025 there will be 50 countries facing water scarcity (map **C**).

C *Projected areas of water scarcity by 2025*



D *How water use links to a country's income*



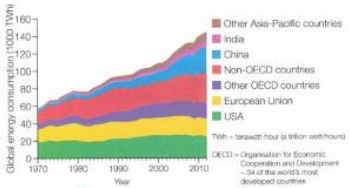
There are significant differences in water use between low/middle and high-income countries (graph **D**). Low/middle-income countries use a higher proportion of water for agriculture compared to high-income countries where most water is used for industry.

Energy

Think of the energy needed in your home and school for light and heat, and to power things like cookers, TVs and tablets. Energy is required for economic development. It powers factories and machinery and provides fuel for transport. In the past many countries could depend on their own energy resources. Today the situation is much more complex, with energy being traded worldwide.

Energy consumption is increasing as the world becomes more developed and demand increases (graph **E**). The world's richest countries use far more than poorer countries in Africa and the Middle East. The Middle East supplies much of the world's oil yet its own consumption is relatively small.

As NEEs become more industrialised, the demand for energy will increase and patterns of energy trading will change.



E *Global energy consumption*

ACTIVITIES

1 a What is a 'resource'?
  b How is 'malnourishment' different to 'undernutrition'?
2 Which parts of the world are suffering extreme undernourishment (map **A**)?
3 Why do some countries suffer from water shortages?
4 Describe the pattern of global energy consumption (graph **E**).

Maths skills

Calculate the percentage increase in global energy consumption between 1970 and 2012 (graph **E**).

Stretch yourself

Describe the pattern of global oil supply and demand. Where is the greatest demand for oil? How is oil transported from regions of supply to regions of demand?

Practice question

Describe the global inequality in the supply and consumption of *either* food *or* water *or* energy. *(6 marks)*

14:39
07/06/2019

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19.2 Provision of food in the UK

On this spread you will find out about the opportunities and challenges faced by the UK in the provision of food

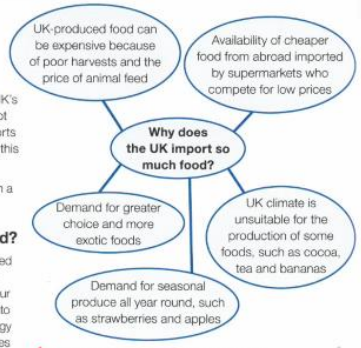
How is demand for food changing in the UK?

By 2037 the population of the UK is expected to rise to 73 million (from 64 million in 2015). This will increase the future demand for food. Despite the UK's efficient and productive farming sector the UK is not self-sufficient for food supplies. In fact the UK imports about 40 per cent of the total food consumed and this proportion is increasing.

Diagram **A** shows reasons why the UK imports such a high proportion of its food.

What is the impact of importing food?

Map **D** shows the distances travelled by foods imported to the UK – known as **food miles**. Transporting food by air is very expensive. Importing food also adds to our **carbon footprint** – the emission of carbon dioxide into the atmosphere. This comes from producing the energy for commercial cultivation, and from transport by planes and lorries.



A *Why is the UK not self-sufficient in food?*

Importing high-value foods: vegetables from Kenya

The growing of vegetables such as mangetout is Kenya's biggest source of income (photo **B**). The cost of air freight to keep produce fresh is very high. UK customers are prepared to pay higher prices for vegetables when they are not in season in the UK.

Kenyan farmers only earn a fraction of the price of the vegetables in a UK supermarket (table **C**). Two-thirds are casual labourers with no job security or benefits and are paid very little.

B *Vegetables produced in Kenya*

Stage	Price per tonne (£)	% of final price
Producer	630	12
Exporter	290	6
Packaging	280	5
Air freight/handling	1040	20
Importer	620	12
Supermarket	2500	45
Total price	5360	100

C *Price breakdown for one tonne of Kenyan mangetout*

Maths skills

Draw a pie graph to show the breakdown of the price of imported mangetout.

How is the UK responding to the challenges?

There is concern about the UK's dependency on foreign food imports and the need for greater food security. This has led to a growing interest in sourcing food locally to reduce carbon emissions (page 274). People are being encouraged to eat seasonal foods produced in the UK.

There are two major recent trends in UK farming:

- *Agribusiness* – intensive farming aimed at maximising the amount of food produced. Farms are run as commercial businesses. They have high levels of investment, and use modern technology and chemicals.
- **Organic produce** – grown without the use of chemicals. Organic food has become increasingly popular, although higher labour costs often make it more expensive. Organic food production is often associated with buying local produce and producing seasonal foods (page 274).

D *Distances travelled by UK imported food*

Lynford House Farm – an agribusiness

Lynford House Farm in East Anglia is a large arable farm of 570 hectares. As an agribusiness it has high inputs of chemicals, machinery and other investments.

- The flat, fertile land is intensively farmed to maximise productivity and profitability.
- The main crops are wheat, sugar beet and potatoes which are well suited to the fertile soils and a warm, sunny climate.
- Chemicals are widely used as pesticides and fertilisers.
- Machinery costs are high but make the farm efficient. It only employs a small number of workers.
- The farm has invested in a 54-million litre reservoir to tackle frequent water shortages in this dry area.

Riverford Organic Farms

Riverford Organic Farms began as an organic food and dairy farm in rural Devon. It supplied local people with fresh boxes of food delivered weekly. The company now delivers boxes of vegetables around the UK from its regional farms in Devon, Yorkshire, Peterborough and Hampshire. These farms help Riverford to:

- reduce food miles
- support local farmers
- provide local employment
- build a strong link between grower and consumer.

ACTIVITIES

1 Why does the UK import 40 per cent of its food?

2 **a** If a pack of mangetout costs £2 in a UK supermarket, how much money does the producer receive (table **C**)?

b How much money does the supermarket receive?

c Why do you think the producer receives such a small share of the retail price? Is this fair?

3 Which foods travel over 9000 kilometres to reach the UK (map **D**)?

4 How is the UK dealing with the problems of importing food?

Stretch yourself

How has foreign travel and migration affected the demand for, and supply of, food in the UK?

Practice question

Explain the UK's attempts to respond to changing demands for food. *(4 marks)*

14:39
07/06/2019

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19.3 Provision of water in the UK

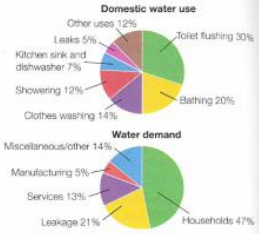
On this spread you will find out about the opportunities and challenges faced by the UK in the provision of water

What are the demands for water in the UK?

Think about all the ways you use water, for washing, drinking, flushing the toilet, cleaning and cooking. Almost 50 per cent of the UK's water supply is used domestically. But 21 per cent is wasted through leakage (graph **A**)!

The Environment Agency estimates that the demand for water in the UK will rise by 5 per cent by 2020 because of:

- the growing population
- more houses being built
- an increase in the use of water-intensive domestic appliances.



A *How the UK uses water*

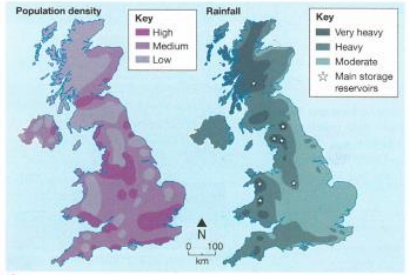
How far does the UK's water supply meet demand?

The main sources of water in the UK are rivers, reservoirs and groundwater aquifers. The UK currently receives enough rain to supply the demand, but rain doesn't always fall where it is most needed (map **B**).

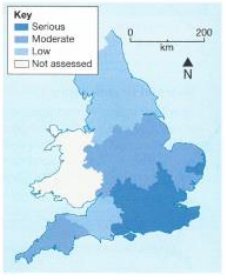
- The north and west of the UK has a **water surplus** where supply exceeds demand. There is high rainfall, lower evaporation rates and plenty of potential reservoir sites. These areas have a relatively low population density.
- The south and east of the country has a **water deficit** where demand exceeds supply. This is the most densely populated part of the country and has the lowest annual rainfall.

Water stress (where demand exceeds supply) is experienced in more than half of England (map **C**). The south east of England ranks very low in the world in terms of water availability. The situation is made worse in times of drought, such as in 2010–12.

Did you know?
Every person in the UK uses an average of 150 litres of water per day.



B *UK population density and water supply*



C *Water stress in England*

Saving water can help to manage water supplies. Savings can be made by:

- the use of domestic water meters
- increasing the use of recycled water
- more efficient domestic appliances.

Waste water (**grey water**) from people's homes can be recycled and put to good use. It can be used to irrigate both food and non-food plants. The phosphorus and nitrogen in the water are an excellent source of nutrients.

Water transfer

In 2006 the government proposed to establish a water grid to transfer water from areas of water surplus to areas of water deficit. The enormous cost of such an engineering project has stopped it happening. Water is currently only transferred via the Rivers Tyne, Derwent, Wear and Tees to as far south as Yorkshire.

There is a growing need to increase **water transfer** in order to meet demand (map **D**). But there is opposition to large-scale water transfer because of:

- the effect on the land and wildlife – river habitats would need to be protected
- the high costs involved
- the greenhouse gases released in the process of pumping water over long distances.

Managing water quality

Water quality is just as important as water quantity. Much has been done to improve the quality of the UK's rivers and water sources. The Environment Agency manages water quality by:

- monitoring the quality of river water
- filtering water to remove sediment
- purifying water by adding chlorine
- restricting recreational use of water sources
- imposing strict regulations on the uses of water.

But some groundwater sources have deteriorated as a result of pollution due to:

- leaching from old underground mine workings
- discharge from industrial sites
- runoff from chemical fertilisers used on farmland
- water used for cooling in power stations released back into rivers.

D *Water transfer schemes in England and Wales*

ACTIVITIES

1 a Name the most densely populated areas of the UK (map **B**).
b Describe the distribution of rainfall in the UK.
2 How do the maps in **B** account for the areas of serious water stress (map **C**)?
3 a Name the proposed major water transfer schemes (map **D**).
b Explain how these could help solve the problems of water supply and demand in the UK.

Stretch yourself

Imagine you're a farmer living in a water deficit area. Investigate how water transfer could help your business. Think about how water transfer could have an impact on the environment.

Practice question

Evaluate the issue of large-scale water transfers in the UK. *(6 marks)*

14:39
07/06/2019

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19.4 Provision of energy in the UK

On this spread you will find out about the opportunities and challenges faced by the UK in the supply of energy

How is the UK's energy demand changing?

Despite increasing demand for electricity in the UK, energy consumption has fallen in recent years. This is due mainly to the decline of heavy industry and improved **energy conservation**. Low-energy appliances, better building insulation and more fuel-efficient cars have resulted in a 60 per cent fall in energy use by industry and a 12 per cent fall in domestic energy use.

How has the UK's energy mix changed?

The UK's **energy mix** (the range and proportions of different energy sources) has changed in the last 25 years (figure **A**). By 2020 the UK aims to meet 15 per cent of its energy requirement from renewable sources. However, in 2015 the government decided to phase out subsidies for wind and solar energy development.

How and why has the UK's energy mix changed?

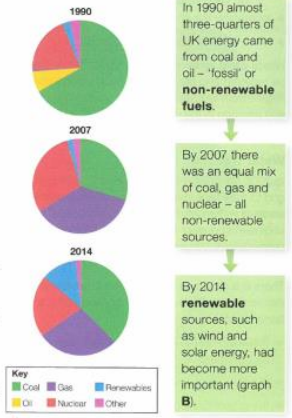
The UK is no longer self-sufficient in energy. About 75 per cent of the UK's known oil and natural gas reserves have been exhausted. By 2020 the UK is likely to be importing 75 per cent of its energy. The UK's **energy security** is affected as it becomes increasingly dependent on imported energy.

Two-thirds of UK gas reserves remain, with oil remaining in less accessible oilfields. The remote Mariner oilfield (150 km east of the Shetland Isles) will start producing in 2017, but UK oil production overall has declined by 6 per cent each year during the last decade.

The major change in the UK energy mix has been the decline of coal. Between 1990 and 2007 there was a steady decline because of concerns about greenhouse gas emissions and ageing coal-fired power stations.

However, fossil fuels are likely to remain important in the future because:

- the UK's remaining reserves of fossil fuels will provide energy for several decades
- coal imports are cheap – over three-quarters of the UK's coal now comes from abroad, mainly from Russia, Colombia and the USA
- existing UK power stations use fossil fuels – all coal-fueled power stations to be closed by 2025
- shale gas deposits will be exploited in the future.

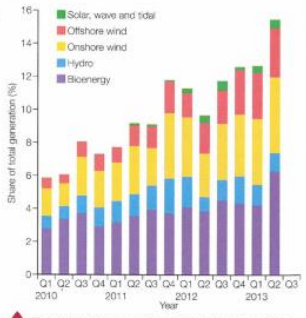


In 1990 almost three-quarters of UK energy came from coal and oil – 'fossil' or **non-renewable fuels**.

By 2007 there was an equal mix of coal, gas and nuclear – all non-renewable sources.

By 2014 **renewable** sources, such as wind and solar energy, had become more important (graph **B**).

A *The UK's changing energy mix*



B *The renewable share of total electricity generation*

What is the fracking issue?

The UK has rich reserves of natural gas trapped deep underground in shale rocks. To extract the gas, high-pressure liquids (water, sand and chemicals) are introduced to fracture the shale and release the gas. This process is called **fracking**.

Fracking has become a very controversial issue (photo **C**). People are concerned about:

- the possibility of earthquakes
- pollution of underground water sources
- the high costs of extraction.

C *An anti-fracking protest*

The impacts of energy exploitation

Energy exploitation can have both economic and environmental impacts. Table **D** focuses on two important energy sources being developed in the UK.

D *The economic and environmental impacts of nuclear and wind power development*

	Economic	Environmental
Nuclear	• Nuclear power plants are very expensive to build. The proposed new Hinkley Point plant (page 46) could cost £18 billion, with funding from China. • High costs for producing electricity. • Decommissioning old nuclear power plants is expensive. • Construction of new plants provides job opportunities and boosts the local economy.	• The safe processing and storage of the highly toxic and radioactive waste is a big problem. • Warm waste water can harm local ecosystems. • The risk of harmful radioactive leaks.
Wind farms	• High construction costs. • May have negative impacts on local economy by reducing visitor numbers. • Some wind farms attract visitors by becoming tourist attractions. • At Delabole wind farm in Cornwall, the UK's first commercial wind farm, local homeowners benefit from lower energy bills. The wind farm has also set up a Community Fund.	• Visual impact on the landscape. In the Lake District, concerns about falling visitor numbers have resulted in several plans being rejected. • Wind farms avoid harmful gas emissions and help reduce the carbon footprint. • Noise from wind turbines. • Construction of a wind farm and access roads can impact on the environment.

ACTIVITIES

1 **a** What percentage of the UK's energy came from oil in 1990 and 2014 (figure **A**)?
b Which energy source saw the greatest reduction between 1990 and 2014?
c Describe the UK's changing energy mix.
2 Work out the percentage electricity generation from wind energy in the second quarter of 2013 (graph **B**).
3 Suggest reasons why 'solar, wave and tidal' contribute so little to the renewable share of total electricity generation.
4 Look at table **D**. Sort the economic and environmental impacts for each energy source into advantages and disadvantages. Debate which energy source would be best for your local area.

Stretch yourself

Research the controversial issue of fracking. What are the arguments for and against exploiting shale gas? How might it affect the UK's energy mix in the future?

Practice question

Explain why the UK's energy mix will include both renewable and non-renewable sources in the future. *(6 marks)*

14:39
07/06/2019

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21 Water management

21.1 Global water supply

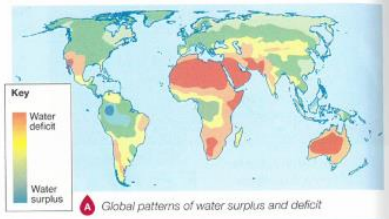
On this spread you will find out that demand for water is rising globally but supply is not spread evenly across the world

Water surplus and deficit

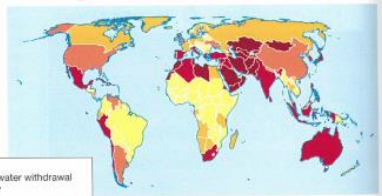
Map **A** shows global patterns of **water surplus** and **water deficit**. Regions with a water surplus have a plentiful supply of water with supply exceeding demand. These regions include North America, Europe and parts of Asia. Other regions have a water deficit, where demand exceeds supply and supplies are under pressure.

Regions with high rainfall usually have a water surplus. Areas with low rainfall, such as hot deserts, are more likely to have a water deficit.

Areas of high population density and high concentrations of industry have the highest demand for water. Without sufficient water supply these areas may experience a water deficit. Areas with low rainfall but a lower demand may have a water surplus!



A Global patterns of water surplus and deficit



B Global water stress

Water security/insecurity

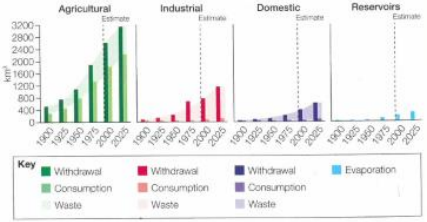
Water security means having access to enough clean water to sustain well-being, good health and economic development. Regions which do not have access to sufficient safe water supplies are described as being in a situation of **water insecurity**.

Water security is very important for improving quality of life because it:

- reduces poverty
- helps to improve education
- increases living standards.

What is water stress?

Many countries face high water stress (map **B**). This means that more than 80 per cent of available water is used every year, leaving the threat of water scarcity.



C Global water consumption since 1900

Countries begin to experience water stress when less than 1700m³ is available per person per year. Below 1000m³, water stress may damage economic development – and human health and well-being. Regions with high water stress include several Caribbean islands, Bahrain, Cyprus, Malta and the Middle East.

Why is water consumption increasing?

The steady growth of the world's population, by roughly 80 million each year, means that more water is needed. Water consumption is increasing because economic development results in greater demand (figure **C**).

There are other reasons why we are all using more water.

- Changes in lifestyle and eating habits have increased the average use of water per head.
- Global demand for food is expected to increase by 70 per cent by 2050 – water is used to irrigate crops and in food processing.
- All sources of energy require water in their production. Global energy consumption is expected to increase by 50 per cent by 2035.
- As urbanisation increases, more water is needed for drinking, sanitation and drainage.

What is water stress?

Water stress takes into account several physical factors that are related to water resources. These include:

- water scarcity
- water quality
- accessibility of water
- environmental flows (the quality, quantity and timing of water flow needed to maintain healthy ecosystems in streams, rivers, and the estuaries they feed).

Water availability

There are a number of factors affecting the availability of water supplies.

Geology – infiltration of water (as in the Sahara Desert) through permeable rock builds up important groundwater supplies. Much of London's water comes from the chalk underlying the city.

Climate – regions with high rainfall usually have surplus water. Those with drier climates have less water available.

Over-abstraction – pumping water out of the ground faster than it is replaced by rainfall. This can cause wells to dry up, sinking water tables and higher pumping costs. Lower water tables mean that rivers are not fed by springs in the dry season.

D What affects the availability of water?

Pollution – increasing amounts of waste and growing use of chemicals in farming have led to higher levels of pollution. In some LICs and NEEs water sources are often used as open sewers leading to **waterborne diseases**.

Limited infrastructure – poorer countries may lack the infrastructure for transporting water to areas of need (for example, pumping stations and pipes).

Poverty – many poorer communities lack mains water or only have access to shared water supplies.

ACTIVITIES

1 **a** Define the meaning of 'water surplus' and 'water deficit'.
b Which continent has the highest water deficit (map **A**)?
c Which are the main areas of water surplus?
d Explain the different patterns of water surplus and deficit.
2 Describe and suggest reasons for the pattern of global water stress (map **B**).
3 **a** Describe the trends in each of the four graphs in figure **C**.
b Which shows the most waste? Why?
4 'Poverty is the main factor affecting water supply.' To what extent do you agree with this statement?

Stretch yourself

Explain how access to safe water can improve people's standard of living.

Practice question

Explain how both physical and human factors can influence the availability of water. *(6 marks)*

14:39
07/06/2019

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21.2 The impact of water insecurity

On this spread you will find out about the impacts of water insecurity

What are the impacts of water insecurity?

Water insecurity can cause social, economic and environmental problems. It is experienced in some richer, more developed countries, as well as LICs.

Waterborne disease and water pollution

In countries where water supply infrastructure is limited, there may be little or no sanitation. There may be open sewers and high levels of pollution in rivers and other water sources. Contaminated drinking water can cause outbreaks of life-threatening disease such as cholera and dysentery.

With a shortage of clean water, people may have to queue for a long time to obtain a supply from standpipes (photo **A**). This wastes time and reduces levels of productivity.

A *Queuing for water at a standpipe*

Water pollution: The River Ganges, India

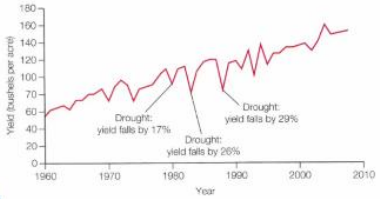
The River Ganga (Ganges) is 2520 km long and flows through northern India and Bangladesh. It is the most polluted river in the world, with both human and industrial waste.

- Over one billion litres of raw sewage enter the river each day from the cities, towns and villages along its banks.
- Hundreds of factories discharge 260 million litres of untreated wastewater from factories is discharged into the river daily.
- The major polluting industry along the Ganges is the leather industry, because toxic chemicals leak into the river.
- Run off from pesticides and fertilisers is another major source of pollution.

Poilution of the Ganges has become so serious that bathing in the river and drinking its water have become very dangerous.

Food production

Agriculture uses 70 per cent of global water supply and suffers the most from water insecurity. Drier regions of the world with unreliable rainfall are most at risk. The USA supplies 30 per cent of the world's wheat, maize and rice. Droughts and water shortages are serious issues across much of the USA (graph **B**) and can have a global impact on food production and supply.



B *Crop yields in the USA*

Water shortages in Egypt

Shortage of water is affecting Egypt's food security. The River Nile is Egypt's primary source of water. Climate change and the demands of countries upstream are expected to reduce its flow by 90 per cent by the end of the century. Although 80 per cent of Egypt's water supply is used in agriculture, food production is likely to decline by 30 per cent over the next 30 years. Egypt currently has to import 60 per cent of its food.

Industrial output

Growth of manufacturing industry, particularly in NEEs, is making increasing demands on water supplies.

Chinese industry

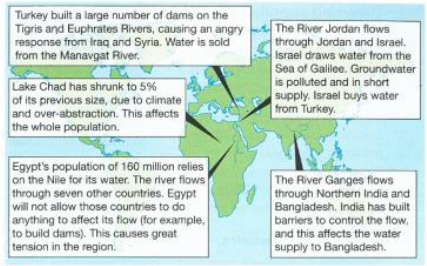
By 2030 Chinese industry will use 33 per cent of the country's available water. Water shortages cost China US$40 billion in lower industrial production. Some factories have closed temporarily due to water shortages. Also, China is depends on its coal resources to drive its economic growth. Coal mining and power stations use 20 per cent of China's water.

Water conflict

In the past, wars were fought over oil supplies – in the future, they may be fought over water. This is because water sources, such as rivers and groundwater aquifers, cross national and political borders. Many of the world's great rivers, such as the Nile and Danube, flow through several countries. Issues such as reservoir construction and pollution can impact on more than one country, and create conflict (map **C**).

Did you know?

About one fifth of the world's population live where there is not enough water to meet demand.



C *The world's potential water conflict zones*

The Rogun Dam, Tajikistan

Several rivers flow from mountainous Tajikistan to Uzbekistan in the west. In 2014 the World Bank agreed to finance the Rogun Dam Project on the Vakhsh River (map **D**). The construction of the dam has been hit by economic and political problems. Once completed, electricity generated by the dam will support industrial development in Tajikistan.

The project is very controversial in neighbouring Uzbekistan, which suffers from a water deficit. Irrigated cotton is Uzbekistan's main export and there is concern about the impact of reduced water supplies on its economy. The Nurek Dam (map **D**), built in the 1970s, already affects the flow of the river. The new dam could lead to further tensions.

D *The location of the Rogun Dam*

ACTIVITIES

1 Suggest the social and economic impacts of polluted water supplies in LICs.

2 **a** In which year was the greatest fall in yields due to drought?

b Which decade saw the worst drought?

3 What are the causes of the potential conflicts identified on map **C**?

Stretch yourself

Research more information on one of the potential conflicts in map **C**. Do you agree that future wars may be fought over water resources? Why?

Practice question

Explain how human actions can contribute to water insecurity. *(6 marks)*

21.3 How can water supply be increased?

14:39
07/06/2019

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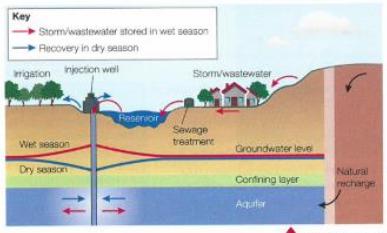
21.3 How can water supply be increased?

On this spread you will find out about strategies to increase water supply

The amount of water available is limited. To make more water available means finding new sources or moving it from areas of surplus to areas of deficit.



A *Aquifer storage and recovery*

Diverting supplies and increasing storage

Water supplies can be artificially diverted and stored for use over longer periods. For example, in some parts of the world surface water evaporates rapidly and is lost. This water can be stored in deep reservoirs or in permeable rocks (aquifers) underground.

In Oklahoma, USA, rainfall is infrequent but heavy. Surface water quickly evaporates. So it is collected and diverted into underlying alluvial soils where it can be stored (diagram **A**). Alluvial soils are loose at the surface with good water-holding capacity.

Dams and reservoirs

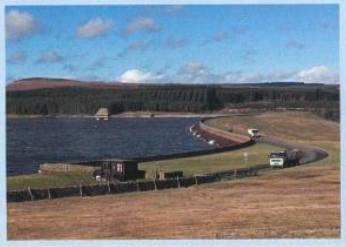
Dams control water flow in rivers by storing water in reservoirs. Rainfall can be collected and stored when it is plentiful and then released gradually during drier periods. The control of water flow enables it to be transported and used for irrigation. It helps to prevent flooding.

Dams range widely in size. There are huge, multi-purpose dams like the Three Gorges Dam in China. Small earth or cement dams a few metres high are common in sub-Saharan Africa. Large dams are expensive to construct and maintain. They can lead to the displacement of large numbers of people. Also, they may reduce the flow of water downstream. In hot and arid regions, reservoirs with a large surface area can lose a lot of water through evaporation.

Kielder Water, Northumberland

Kielder Water is the UK's largest reservoir in terms of its storage capacity (photo **B**). The dam, 1.2 km long and 50 m high, was built in the late 1970s at North Tyne Valley near Falstone. The valley is relatively narrow, reducing the cost of building. The 10 km-long reservoir took two years to fill.

The reservoir regulates flow in the North Tyne, making up for water abstracted (taken) further downstream. Water is also used to generate electricity.



B *Kielder Water*

Water transfers

Water transfer schemes aim to redistribute water from areas of water surplus to areas of water deficit. They often involve elaborate systems of canals and pipelines to take water from one river basin to another. In the UK the Kielder transfer scheme carries water south to the rivers Wear and Tees.

China's south–north water transfer scheme

China is spending over US$79 billion on an ambitious project to transfer water from the Yangtze River in the south to the Yellow River Basin in the arid north (map **C**). The water will be transferred through three canal systems. The eastern and central routes were completed in 2015. The western route is due for completion by 2020.

The controversial western route involves building several dams and hundreds of tunnels through the Bayankela Mountains. The entire project could take 50 years. However, it is still uncertain whether the scheme will actually be completed.

C *China's water transfer project*

Desalination

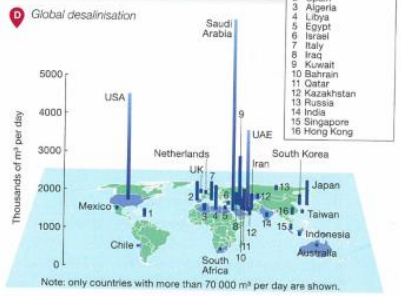
Desalination involves removing salt from seawater to produce fresh water. This is a very expensive process. It is used only where there is a serious shortage of water with few alternatives to increase water supply. Both Saudi Arabia and UAE have developed desalination plants.

There are several issues linked with the process of desalination, such as:

- environmental impacts on ecosystems when salt waste is dumped back into the sea
- the vast amount of energy required, adding to carbon emissions
- the high cost of transporting the desalinated water to inland areas.

Future technological improvements may reduce costs and make this process more economically viable for NEEs or even LICs.

D *Global desalinisation*



Note: only countries with more than 70 000 m³ per day are shown.

ACTIVITIES

1. Copy diagram **A** and add labels to describe how water can be collected and stored underground for future use.
2. What are the advantages and disadvantages of creating reservoirs such as Kielder Water (photo **B**)?
3. Explain how China's climate has influenced the Chinese plan to transfer water (map **C**).
4. Describe the distribution of the countries where large amounts of water are desalinised (diagram **D**).

Stretch yourself

Imagine you're a journalist sent to investigate the western route of China's south–north water transfer scheme. Investigate the advantages and disadvantages of this route. Write a front-page report for tomorrow's paper.

Practice question

Explain the costs and benefits involved in strategies to increase water supply. *(6 marks)*

14:39
07/06/2019

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1.4 The Lesotho Highland Water Project

On this spread you will find out about a large-scale water transfer scheme in Lesotho

Example

Lesotho is a highland country in southern Africa surrounded by the country of South Africa (map **A**). It has few resources, high levels of poverty, and is unable to feed its growing population. Most farms are for subsistence and productivity is low. Lesotho is heavily dependent economically on South Africa.

Despite experiencing food insecurity, Lesotho has a water surplus. The mountains receive high rainfall (graph **B**) and the demand for water is low.

A Location map of Lesotho

B The climate of Lesotho

What is the Lesotho Highland Water Project?

The Lesotho Highland Water Project is a huge water transfer scheme aimed to help solve the water shortage in South Africa. On completion, 40 per cent of the water from the Segu (Orange) River in Lesotho will be transferred to the River Vaal in South Africa. It is a massive scheme involving the construction of dams, reservoirs and pipelines as well as roads, bridges and other infrastructure developments (map **C**). It will take 30 years to complete.

The main features of the scheme include:

- The Katse and Mohale Dams (completed in 1998 and 2002) store water that is transferred through a tunnel to the Mohale Reservoir.
- Water is then transferred to South Africa via a 32 km tunnel enabling HEP to be produced at the Muela plant.
- The Polihali Dam will hold 2.2 billion m^3 of water with a 38 km transfer tunnel.
- The Tsoelike Dam will be built at the confluence of the Tsoelike and Senqu rivers. It will have a storage capacity of 2223 million m^3 and a pumping station.
- The Ntoahae Dam and pumping station will be built 40 km downstream from Tsoelike Dam on the Senqu River.

By 2020 there will be 200 km of tunnels and 2000 million m^3 of water will be transferred to South Africa each year.

C Map of the project

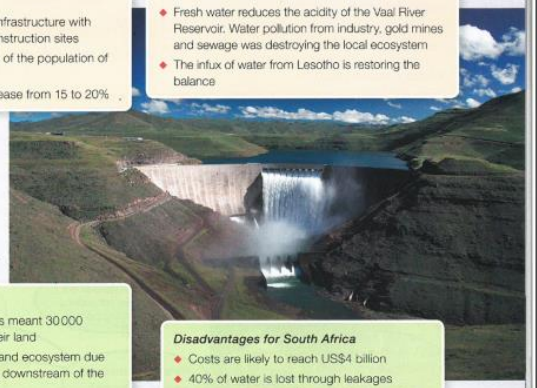
What are the advantages and disadvantages of the scheme?

Advantages for Lesotho

- Provides 75% of its GDP
- Income from the scheme helps development and to improve standard of living
- Supplies the country with all its hydro-electric power (HEP) requirements
- Improvements to transport infrastructure with access roads built to the construction sites
- Water supply will reach 90% of the population of the capital, Maseru
- Sanitation coverage will increase from 15 to 20%

Advantages for South Africa

- Provides water to an area with an uneven rainfall pattern and regular droughts
- Provides safe water for the 10% of the population without access to a safe water supply
- Fresh water reduces the acidity of the Vaal River Reservoir. Water pollution from industry, gold mines and sewage was destroying the local ecosystem
- The infux of water from Lesotho is restoring the balance



D The Katse Dam

Disadvantages for Lesotho

- Building of the first two dams meant 30 000 people had to move from their land
- Destruction of a unique wetland ecosystem due to control of regular flooding downstream of the dams
- Corruption has prevented money and investment reaching those affected by the construction
- Construction of the Polihali Dam will displace 17 villages and reduce agricultural land for 71 villages

Disadvantages for South Africa

- Costs are likely to reach US$4 billion
- 40% of water is lost through leakages
- Increased water tariffs to pay for the scheme are too high for the poorest people
- Corruption has plagued the whole project

ACTIVITIES

1 Describe the location of Lesotho (map **A**).

2 **a** How can you work out from graph **B** that Lesotho is in the southern hemisphere?

b Describe the seasonal distribution of rainfall.

c During which months would you expect there to be a water surplus?

3 Using photo **D**, draw an annotated field sketch of the Katse Dam.

4 Discuss in pairs the advantages and disadvantages of this scheme. Who are the winners and losers?

Stretch yourself

Use the internet to research the impact of the scheme on the people of Lesotho.

Maths skills

Use climate graph **B** to estimate the total annual rainfall for Lesotho.

Practice question

Evaluate whether the Lesotho Highland Water Project is worth the enormous costs involved. *(6 marks)*

14:40
07/06/2019

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21.5 Sustainable water supplies

On this spread you will find out about strategies for a sustainable water supply

What is sustainable water supply?

Population growth and economic development will lead to greater demand for water in the future. In 2005 the United Nations began a 10-year 'Water for Life' campaign worldwide. The aim was to ensure that water resources are managed in a sustainable way in the long term.

Sustainable approaches to water supply focus on the careful management of water resources and the need to reduce waste and excessive demand.

Did you know?
Turning the tap off while you brush your teeth saves 6 litres of water per minute!

Water conservation

Conserving water is about reducing waste and unnecessary use. This can include strategies such as:

- reducing leakages (25–30 per cent of global water supply is lost through leakage)
- monitoring illegal and unmetered connections
- water tariffs, with charges increasing sharply after a certain level of usage
- improving public awareness of the importance of saving water
- water meters to encourage people to use water wisely
- preventing **pollution**.

A *How to use water sustainably*

Groundwater management

Groundwater stored in underground aquifers has to be managed to maintain the quantity and **quality** of the water. To ensure supplies are sustainable, water abstraction (loss) must be balanced by recharge (gain). If groundwater levels fall, water can become contaminated, making expensive water treatment necessary.

In many LICs individual families or groups own wells. National laws are ineffective and often ignored. So effective community-based management is needed.

B *Repairs to a well in Sierra Leone*

Recycling

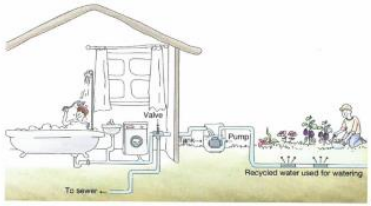
Water recycling involves re-using treated domestic or industrial wastewater for useful purposes like irrigation and industrial processes. For example:

- Large quantities of recycled water are used for cooling in electricity-generating and steel-making plants. In some Australian power stations recycled water replaces enough fresh water to fill an Olympic-sized swimming pool.
- In Kolkata, India, sewage water is re-used for fish farming and agriculture. Sewage is pumped into shallow lagoons where sunlight helps algae to photosynthesise. This oxygenates the water so that it can be re-used.
- Some nuclear power plants, like the Palo Verde nuclear generating station in Arizona, USA, use recycled water for cooling (photo **C**).

Using grey water

Grey water is taken from bathroom sinks, baths, showers and washing machines. It may contain traces of dirt, food, grease, hair and some cleaning products. If used within 24 hours it contains valuable fertiliser for plants. Water from toilets is considered to be 'black' water and cannot be used in the same way.

Grey water is mainly used for irrigation and watering gardens (diagram **D**). In Jordan 70 per cent of the water used for irrigation and gardens is grey water.



Participatory Groundwater Management (PGM), India

In rural India, 50 per cent of water for irrigation and 85 per cent of drinking water is groundwater. Communities are encouraged to conserve water from their wells through the PGM scheme. Without careful management, the future of some rural communities is at risk. The PGM scheme involves:

- training local people to record rainfall and to monitor groundwater levels and water abstraction (photo **B**)
- helping farmers to plan when and how much water to use for irrigation
- encouraging farmers to plant crops to fit in with annual periods when water is available.

Through PGM, rural communities have used scientific monitoring to balance water supply and demand using sustainable practices.

C *Palo Verde nuclear generating station*

D *Re-using grey water*

ACTIVITIES

1. Explain whether you think your household makes sustainable use of water (diagram **A**).
2. Why is the involvement of local communities so important in the sustainable management of groundwater in rural areas?
3. What is the difference between 'grey' water and 'black' water?

Stretch yourself

Investigate why it is not only in areas of low rainfall where sustainable use of water is needed.

Practice question

Use examples to explain why both demand and supply affect the sustainable use of water. *(6 marks)*

14:40
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1.6 The Wakel River Basin project

On this spread you find out about a local scheme to increase sustainable water supply

Example

Rajasthan is a region in north west India (map **A**). It is the driest and poorest part of India, and largely covered by the Thar Desert (see page xx). Summer temperatures can reach 53°C. Rainfall is less than 250 mm per year with 96 per cent between June and September. There is little surface water, as rain quickly soaks away or evaporates.

A *Location map of Rajasthan*

What are the issues with water supply?

Water management in the region has been poor. Over-use of water for irrigation has led to waterlogging and salinisation. Over-abstraction from unregulated pumps has resulted in falling water tables in aquifers and some wells have dried up. With access to wells controlled by households or villages, there has been little coordination of water management.

The Wakel River Basin Project

The Wakel river basin is located in the south of Rajasthan. The United States Agency for International Development has funded a project called The Global Water for Sustainability Program (2004–14). This NGO (non-government organisation) has been working with local people in the Wakel river basin to improve their water security and overcome the problems of water shortages. Local people needed to be actively involved in the decision-making process to make the water management successful.

The two main aims of the scheme are to:

- increase water supply and storage using appropriate local solutions
- raise awareness in local communities of the need for effective water management.

Did you know?
Each taanka can hold 20 000 litres – enough to supply a family for several months.

Increasing water supply

The project has encouraged greater use of rainwater harvesting techniques to collect and store water. This benefits villages and individual families. The methods used include the following.

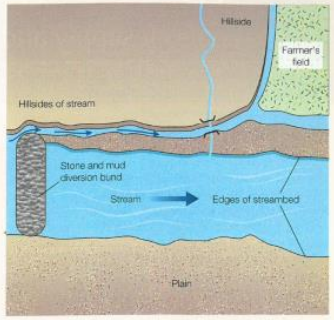
- *Taankas* – underground storage systems about 3 m in diameter and 3–4 m deep (photo **B**). They collect surface water from roofs.
- *Johed* – small earth dams to capture rainwater. These have helped to raise water tables by up to 6 m. Five rivers that used to dry up following the monsoon now flow throughout the year.
- *Pats* – irrigation channels that transfer water to the fields.

B *Collecting water from a concrete taanka*

How does the *pat* system work?

In the *pat* system, a small dam called a bund diverts water from the stream towards the fields. Bunds are made of stones, and lined with leaves to make them waterproof.

Villagers take turns to irrigate their fields using water controlled in this way. The irrigation channels need regular maintenance to avoid them breaking or silting up. This is done by the villager whose turn it is to receive the water.



C *The pat irrigation system*

Increasing public awareness

Education is used to increase awareness of the need for communities to work together to conserve water (photo **D**). By conserving water, water security is increased and problems such as soil erosion, desertification and groundwater pollution are reduced.

D *A cycle campaign to spread the message about the importance of water conservation*

ACTIVITIES

1 Summarise the physical and human factors causing water insecurity in the region.

2 a What are the key design features of a *taanka* (photo **B**)?

b How does this form of water harvesting benefit local communities?

3 a Copy diagram **C** and add labels to describe how the *pat* system works.

b How does this system demonstrate the importance of communities working together to reduce water security?

Stretch yourself

Give reasons for working at a local rather than a national level when developing an effective sustainable water scheme.

Practice question

Evaluate the success of a local scheme for increasing sustainable water supplies. *(4 marks)*

14:40
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