12 Environmental management

In this chapter you will learn about:

- The relative sustainability of renewable and non-renewable energy resources and the various factors which affect the supply and demand of energy at the national scale. How different countries attempt to achieve a balance between the different sources of energy. Recent changes in the consumption of fossil fuels, nuclear power and renewables in LICs, MICs and HICs. The environmental impact of energy production, energy transport and energy use at a variety of scales.
- How energy supply is managed, including case studies of electricity production, consumption and management at the national scale.
- The causes of land, air and water pollution and the problems this pollution causes. The factors that affect the supply of, and demand for, water. The ways in which water quality varies. The ways in which rural and urban environments can be damaged and degraded and the management strategies that can be adopted to counter this degradation. **Conservation** (protection, management and improvement) of environments at risk.
- A case study of a degraded environment, illustrating the causes of degradation, the problems that the damage produces and an evaluation of the strategies adopted for its improvement.

Sustainable energy supplies

Energy use is closely related to economic development. As a country uses more energy, it becomes more productive and it gets richer. As it gets richer, it can afford to use more energy.

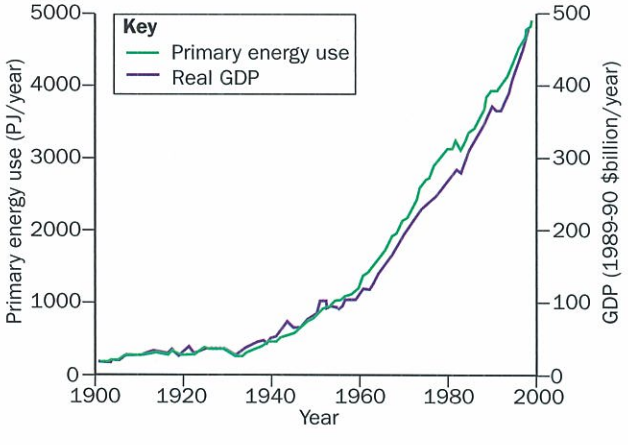

Fig. 12.1 The link between economic development and energy use over time: 1900 to 2000. As global GDP increased, so did energy use

Understanding this relationship is essential if we are to explain the changes in global energy use in the recent past and if we want to predict energy use in the future. It also helps to explain why some countries use more energy than others.

In terms of the environment, however, increasing energy use is not good news. World energy supply is heavily dependent on **fossil fuels**. Burning fossil fuels produces carbon dioxide and this 'extra' atmospheric carbon dioxide is widely blamed for **global warming**.

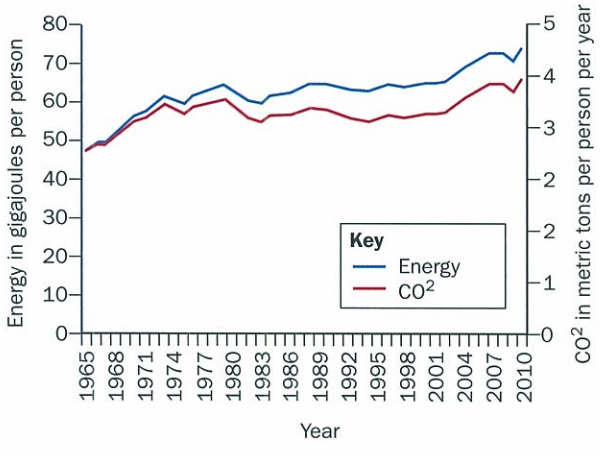

Fig. 12.2 The link between energy use and carbon dioxide production, 1965 to 2010

Figs 12.1 and 12.2 show that energy use has a positive economic impact but a negative environmental impact – energy use is not *environmentally* sustainable. Current energy use is not *economically* sustainable either because we rely so heavily on the use of fossil fuels. The supply of fossil fuels is finite and at some point they will run out. If we have no alternative energy supplies available, energy production will decrease and economic output will fall. This will have an enormous impact

on most people's quality of life, meaning that current energy use is not *socially* sustainable either. Making energy use sustainable is a key challenge for the future.

Renewable and non-renewable energy resources

A **resource** is any part of the environment that can be used to meet human needs. An **energy resource** is something that can be used to provide people with heat, light and power.

Why do we need energy?

In most countries energy is used in four main ways. The following figures are for the UK in 2010:

- Transport: 34 per cent
- Domestic use: 29 per cent
- Industry: 23 per cent
- Commerce and other uses: 14 per cent.

1. Produce four spider diagrams, one for each of the main types of energy use. They should show the ways in which energy is used, so for 'domestic use', for example, include the different ways that energy is used in the home.

Non-renewable energy resources have been built up over a very long period of time and they cannot be used without reducing the amount available. They are mostly fossil fuels (coal, oil and natural gas) but they also include uranium which is the main resource for producing nuclear energy. They are also called *finite*, *stock* or *capital* energy resources.

Renewable energy resources either have unlimited availability (e.g. solar power) or can be replenished relatively quickly (e.g. wood). They are also known as *flow* or *income* resources – they yield a continuous *flow* of energy. Renewable energy resources can be classified into two groups:

- **Non-critical** renewable energy resources have unlimited availability. They are 'everlasting' and we do not need to worry about the rate at which they are used, e.g. solar power, tidal power and wave power.
- **Critical** renewable energy resources require careful management as they can be used up at a faster rate than they are being replaced, e.g. energy produced from wood, biomass and animal wastes.

Wood is a renewable energy resource which is important in LICs. It is a critical resource because if too much wood is used in a short space of time, the natural cycle of replenishment is disrupted and the resource is used up. This often happens when the population rises rapidly and the extra people put too much pressure on the resource. If woodland is managed carefully, for example by replanting or by **coppicing**, it can be considered as a renewable resource.

RESEARCH Write definitions of the following words and phrases with reference to energy:

- reserve
- recoverable reserves
- speculative reserves
- sustainable development.

Factors affecting the supply of and demand for energy at the national scale

Energy use varies from country to country. Supply is determined by the availability of energy resources within a country, its ability to harness those energy resources and its ability to purchase energy resources from abroad. Demand is mostly influenced by the size of the country's population and its level of economic development.

Sustainability

In terms of energy use, sustainability requires that we are able to meet our current energy needs without compromising the ability of future generations to meet their energy needs. It also requires that we do not do unacceptable damage to the natural environment. The fact that many countries signed the Kyoto treaty shows that most national governments are aware of the need for a sustainable energy policy. The Kyoto treaty (or protocol) is an international treaty which commits the countries that sign it to reduce their greenhouse gas emissions. It is based on the assumptions that global warming exists and man-made CO_2 emissions have caused it. Non-renewable energy resources should be used sparingly because they will eventually run out. We should maximise our use of renewable energy and invest in new technology to develop new renewable sources. We should try to reduce the environmental impact of energy use. Moving from fossil fuels to renewable energy will ensure future supplies and will reduce environmental damage, especially the problems caused by global warming.

Levels of development

Fig. 12.3 shows that HICs use more energy than MICs and LICs. High energy use is mostly confined to the HICs, together with some 'oil-rich' states such as Venezuela and Saudi Arabia. NICs such as China, Brazil and Mexico have a medium but rapidly-growing energy use. The poorest countries in the world are in sub-Saharan Africa and the map shows that their energy use is minimal. People in HICs can afford high levels of energy use, e.g. the use of private cars, air conditioning and central heating. Commercial agriculture and manufacturing industry both use high levels of energy and this also increases energy use in NICs and HICs. These countries have the technology to exploit their domestic energy resources and can also afford to import energy resources.

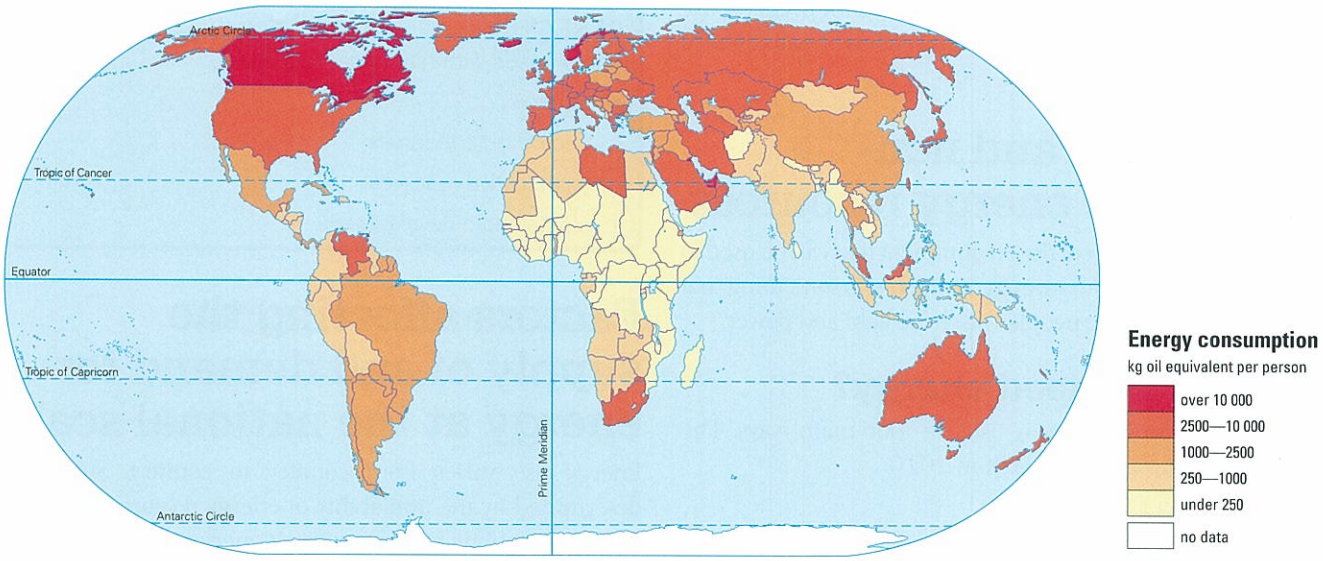

Fig. 12.3 Energy consumption per person in different countries of the world, in 2004

Resource endowment

Energy resources are not evenly distributed. Some countries have many energy resources while others have few. Russia has large reserves of oil and gas and China has huge reserves of coal. Australia and Canada both produce significant quantities of uranium. **Hydro-electric power** (HEP) is best produced in countries with a rainy climate and high relief, such as Norway. Solar power works best in a warm, sunny climate, such as southern Spain.

Climate

This affects the supply of energy. Denmark has a very windy climate and has invested in wind power. Spain has a sunny climate and uses significant amounts of solar power. Norway is very rainy and obtains most of its electricity from HEP. Climate also affects demand. Canada and the Scandinavian countries use more energy than other HICs, reflecting their need for heating and lighting during the long, cold winters.

World energy prices

World prices for energy vary and because demand for energy has been growing faster than supply, energy prices have tended to increase over time. The technology to produce oil from the **tar sands** of Canada has existed for many years but until recently the oil produced was too expensive to trade on world markets. In the past 15 years, the rise in oil prices has made it possible to produce crude oil from these vast resources in a profitable way.

Capital

Most energy resources require the investment of large amounts of money before they can be used. Finding and then developing oil fields is costly. **Power stations** are expensive to build. The infrastructure needed to transport energy from its point of production to its point of use is also expensive to develop, e.g. oil and gas pipelines and electricity transmission grids. HICs usually have the capital available for these developments but MICs and LICs may not. They may have to rely on trans-national corporations (TNCs) to make the investments, losing their freedom of action regarding national energy policy.

Technology

The technology involved in the production and use of energy changes over time. Early coalmines were small and shallow because the technology to ventilate and drain deeper mines was not available. The massive trucks and draglines used in open-cast or strip mining of coal were only developed in the mid 20th century, but using these machines was much cheaper than using miners to dig out the coal using traditional deep mining methods. In HICs where labour costs are high, coal from strip mines is much cheaper to produce than coal from deep mines.

The science behind nuclear power was only formulated in the mid 20th century and the related power station technology did not become available until the late 20th century.

Demand for energy is also affected by technological developments. The invention of the internal combustion engine using petrol and diesel led to great changes in transport technology, moving transport away from railways and onto roads. This reduced the demand for coal and increased the demand for **petroleum** which is refined to make petrol and diesel. The cheapness and the popularity of the private car in HICs is one of the main reasons why demand for oil is high and increasing. The increased domestic use of electrical gadgets, central heating and air conditioning has also had a big effect on the demand for energy. More recently, the technology associated with **fracking** has massively increased viable gas reserves and gas supply in the USA and led to a large reduction in the price of gas in that country.

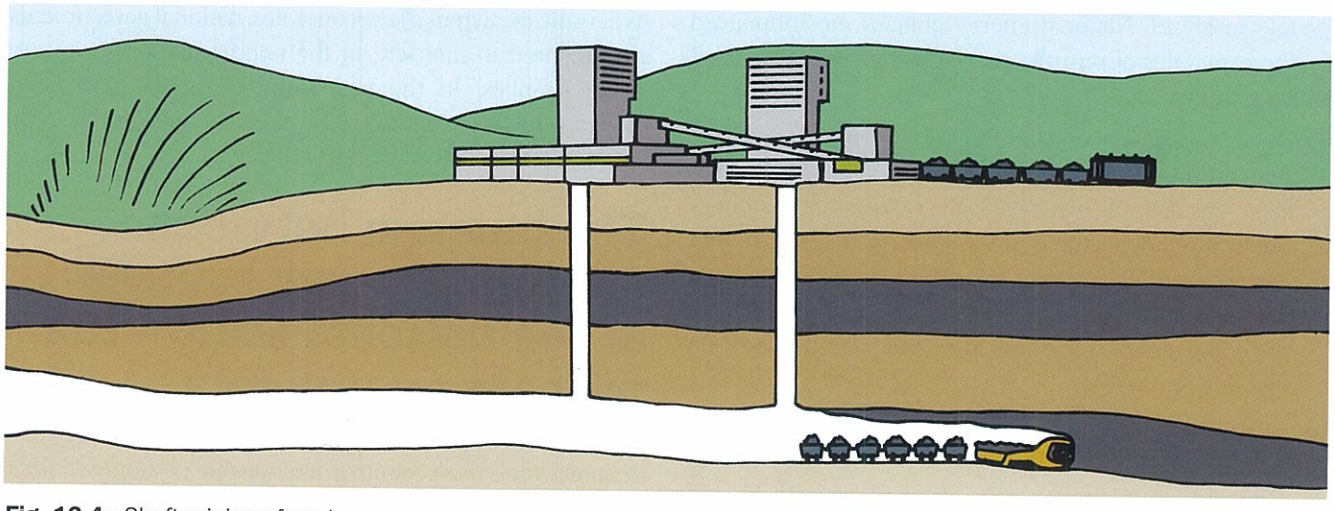

Fig. 12.4a Shaft mining of coal

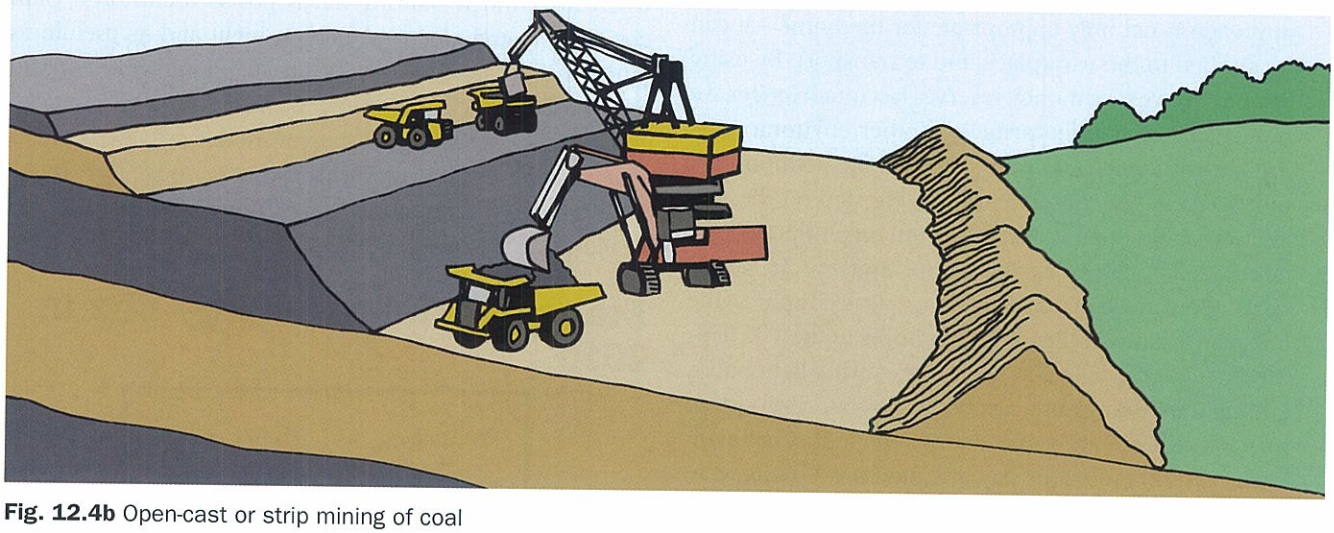

Fig. 12.4b Open-cast or strip mining of coal

Pollution

Energy production, transportation and use have the potential to pollute the natural environment. In West Virginia in the USA, whole mountains are being destroyed to get at the layers of coal within them. In northern Russia, oil well sites are covered in oil spills and other places are contaminated by leaks from the pipelines. Oil tankers running aground can leak oil into the sea, killing wildlife, destroying wildlife habitats and covering beaches in black, tarry oil. The Deepwater Horizon oilrig explosion in the Gulf of Mexico in 2010 had a massive impact on the environment and the regional economy. Burning fossil fuels to produce carbon dioxide is one of the main causes of global warming which could have a significant environmental and economic impact.

During the early stages of economic development, MICs often ignore the pollution caused by energy production and use. The critical role that energy plays in economic development is seen as so important that the resulting pollution is a price worth paying for economic growth. Once the country becomes rich, however, *quality of life* becomes more important to many people and a clean environment moves up the political agenda. In the UK, the move from coal-fired power stations to gas-fired power stations in the 1990s was stimulated by economic factors (electricity generated from gas is cheaper than that generated from coal) but the environmental advantages were also important; gas power stations produce much less carbon dioxide for the same amount of electricity than coal power stations.

Energy policy

Governments can have a big impact on the nature of energy production and use by adopting **energy policies**. In a capitalist economy, energy supply should be dictated by the market and the decisions of the big energy TNCs. However, most governments know that the market in energy is imperfect so they adopt policies to secure the energy supply and to ensure that the price of energy is not too high for

people to afford. National energy policies are influenced by the principles of **supply management** and **demand management**.

- *Supply management* depends on the government ensuring that supplies are sufficient to match demand. At first sight, this does not sound like a very sustainable strategy but by influencing the sources of energy the government can ensure that more energy is supplied from sustainable and renewable sources. One way of doing this is by providing grants for companies that are prepared to invest in renewables.
- *Demand management* involves decreasing the demand to match the limited supply. The UK government estimates that 56 per cent of energy used in UK homes could be cut using currently available strategies and technologies. This is **energy conservation** – using energy more carefully and less wastefully. This approach is not only appropriate for the home – it can be applied to the workplace and to transport. By using less energy we save money, reserves last much longer, we reduce our carbon footprint, and other environmental problems such as acid rain and local air pollution are reduced. Energy conservation is a big step on the way to sustainable energy use. Governments influence the demand for energy by legislation and by tax policy. Legislation involves passing laws – an example is the law which banned filament light bulbs in the UK. This meant that people had to use energy-saving light bulbs, cutting their energy use. Tax policy has been important in making UK cars more energy-efficient. Cars with lower carbon emissions pay less road tax. Grants were also made available to people who made their homes more energy-efficient, e.g. by using loft insulation and cavity wall insulation.

2. Make a list of the ways in which your school or college could save energy.

Energy security at the national scale is defined as the uninterrupted availability of energy sources at a price that people and industry can afford. Long-term energy security deals with ensuring that future energy supply is in line with future economic developments and environmental needs. Short-term energy security is the ability of the national energy system to react promptly to sudden changes in demand.

Access to affordable energy is essential if an economy is to function and grow. The uneven global distribution of energy supplies and the variation in national energy needs has led to some countries becoming vulnerable to energy shortages. To provide solid economic growth and to maintain levels of economic performance, a country's energy must be readily available, affordable and with capacity in the system to overcome potential shortages.

As a result, even in market economies, national governments are prepared to interfere in the energy market to ensure future supplies. In the past some countries have been prepared to go to war to secure their energy supplies, e.g. Japan in 1941 and the USA in 1992.

The balance between different energy sources at the national scale – the primary energy mix

A country's **energy mix** describes the sources of energy that a country uses. Most countries are not able to supply all their energy needs from one source – and many would not want to. Fuels suitable for electricity generation may not be suitable for transport. Wind power is a good form of renewable energy when the wind is blowing but is not so useful on a calm day. Solar energy does not work at night and its usefulness diminishes on a cloudy day. As a result, most countries try to use an energy mix in their choice of primary energy resources. The amount of each of the sources used is usually shown as a percentage – this is the primary energy mix. The factors involved in determining a country's primary energy mix can be illustrated by the following examples.

France's primary energy mix in 2010

nuclear	38 per cent
oil	33 per cent
natural gas	17 per cent
renewables	7 per cent
coal	5 per cent

- France has limited coal and oil reserves and most of their supplies have to be imported. Coal-mining ended in France in 2004. Large amounts of oil have to be imported due to the demand for transport fuel.
- France imports natural gas from north Africa and the amount used has been increasing, but France still uses much less than other EU states (EU average = 24 per cent).
- Because of its limited fossil fuel reserves, France invested heavily in nuclear power after 1970 in order to secure electricity production. France is the second-biggest producer of nuclear power in the world, and the biggest in Europe.
- Most of the renewable power comes from HEP (in the Alps and on big rivers like the Rhone) and from biomass. France has the first large-scale tidal power station in the world.

3. Draw a pie chart to show France's primary energy mix in 2010.

Kenya's primary energy mix in 2007

→ biomass	74 per cent
→ oil	19 per cent
→ geothermal	5 per cent
→ HEP	2 per cent

Biomass is used in the form of fuel wood and charcoal. A large percentage of Kenyans live in rural areas where biomass is the main source of energy for cooking and heating purposes. The demand for fuelwood has increased in recent years because of the growing population but the government wants to reduce the demand for fuelwood because of the deforestation that it causes. The use of fuelwood exceeds the natural growth of forests making biomass a critical renewable energy resource in Kenya.

Oil is used in the transport sector and for electricity generation. Any increase in world oil prices is a problem for the Kenyan economy and the government would like to reduce the country's dependence on oil, but alternative vehicle fuels are difficult to find.

The use of geothermal energy has been rising since the building of the first geothermal plant in the 1980s in the tectonically-active Rift Valley region.

Hydroelectricity is used for electricity generation in Kenya but it depends on Kenya's unreliable rainfall. There are a total of 14 small hydro stations and two additional projects are planned but the number of suitable sites is quite limited.

4. The 'modal value' is a type of average – the most common number or category in a distribution. What are the modal energy sources used by France and Kenya?
5. Describe how the primary energy mix of France differs from that of Kenya. To what extent are these differences the result of differences in the economic development of the two countries?

Trends in the consumption of fossil fuels, nuclear power and renewables

Statistics show that world energy consumption has been increasing rapidly. There are, however, variations in this pattern between different parts of the world and between different sources of energy.

Until recently, HICs consumed most of the world's energy. For example, in the 1990s the USA had only 5 per cent of the world's population but it consumed 25 per cent of the world's energy. By 2007, however, MICs and NICs were consuming as much energy as the HICs and it is predicted that their energy use will continue to grow. This is partly due to the energy conservation measures introduced in many HICs but mostly due to population growth and economic development in the MICs/NICs.

The decline in the USA's use of energy shown in Fig. 12.5 is partly due to energy conservation measures but is also due to the increasing use of energy by other countries in the world (these are *percentage* figures, not *absolute* figures). The increase in China's energy consumption reflects its rapid industrial growth. It also reflects the increasing affluence of many Chinese people which means they can afford to use more energy, e.g. through purchasing a private car. India's energy use is increasing less quickly than that

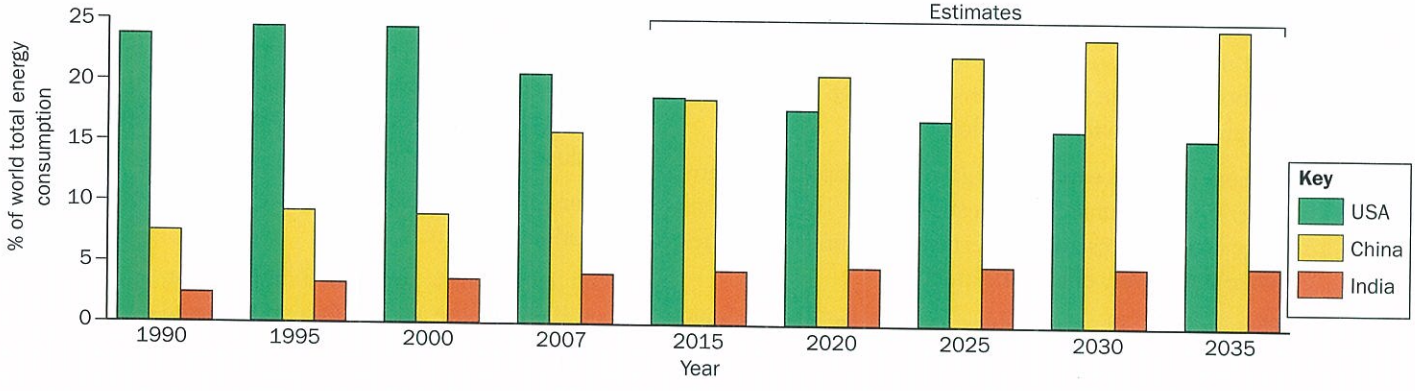

Fig. 12.5 The percentage of total world energy consumption by the USA, China and India, 1990 to 2035 (estimated). This is a comparative bar graph

of China. India's economy is growing but there are still a huge number of very poor people in India who can afford to use only small amounts of energy. China and India lead the world's economic growth and their energy consumption reflects this. Together they accounted for 10 per cent of world energy consumption in 1990 but this had doubled to 20 per cent by 2007. As their economies continue to grow, their combined energy demand will rise to 30 per cent of total world energy consumption by 2035.

There have also been considerable changes in the use of different sources of energy in recent years.

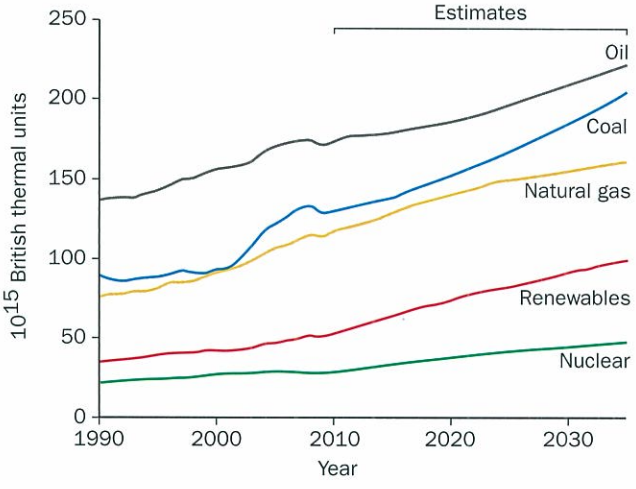

Fig. 12.6 World energy consumption by fuel type, 1990 to 2035 (estimated)

The main points to note are:

- Fossil fuels (oil, coal and gas) dominate world energy consumption and are expected to continue to do so.
- Oil is the most important of the fossil fuels because it can be moved cheaply by ship and pipeline and it is the only practical fuel for transport.
- In the late 1990s it looked as if natural gas would overtake coal as the second most important fossil fuel. This is because gas is cleaner and more energy-efficient than coal. However, during the first decade of the 21st century coal use grew, mostly due to the growth in the Chinese economy and the fact that China has huge coal reserves which are cheap for it to exploit.
- The use of coal is expected to grow more rapidly than any other energy source in the next 20 years. The world has huge coal reserves and modern strip mining techniques make it relatively cheap to extract.
- The growth of renewables is the result of new technologies, e.g. solar cells are becoming much cheaper to produce and last much longer than in the past. It also reflects the increasing concern over the effects of global warming. Most of the increase in renewables is likely to be in the HICs who can afford the expensive technology associated with schemes such as offshore wind farms. However, there is also likely to be an increase in small-scale **appropriate technology** renewable energy schemes such as micro-hydro plants in LICs.
- The use of nuclear power grew very slowly between 1990 and 2010, reflecting the growing realisation that decommissioning old nuclear stations is a very expensive business and disposing of nuclear waste is problematic. However, it is predicted to grow more rapidly in the next 20 years. Nuclear power does not produce carbon dioxide so it is seen as a way of decreasing dependence on fossil fuels and reducing the impact of global warming. There is also optimism that we will soon have the technology to dispose of the nuclear waste safely. Nuclear power stations are very expensive to build, however, and nuclear power is not likely to be important in LICs and MICs in the near future.

Trends in the consumption of fossil fuels

The main fossil fuels are coal, crude oil and natural gas. Their use has been increasing and is expected to increase in the near future.

Crude oil

It is predicted that oil use will grow more slowly than the overall increase in world energy consumption, reflecting the fact that it is a finite resource. However, oil is still expected to remain the largest source of energy.

OPEC (the Organization of Petroleum Exporting Countries) is a **cartel** - a group of 13 oil-producing countries (mostly in the Middle East) that work together to control production in order to influence prices. As world demand for oil has increased, the OPEC countries have increased production to stop the price of oil rising too rapidly.

There are several other recent trends:

- A rise in the price of oil after 2005 was mostly due to the fact that supply is fairly static but demand is rising, especially in rapidly-industrialising countries such as China. OPEC tried to restrict the price rise by increasing production, but price rises did occur. In the rich, oil-importing countries price rises have led to inflation and reduced economic growth.
- Wars in the Middle East have led to a reduction of production there.
- Oil companies, concerned by current and potential problems in the Middle East and spurred on by the high price of oil, have been drilling in more and more extreme environments, e.g. a mile below sea level in the Gulf of Mexico. This pushes the technology to its limits and when things go wrong the environmental consequences are horrendous - as with the BP 'Deepwater Horizon' disaster in 2010.

→ Oil is a commodity and is traded like other commodities. Speculators on the world's stock markets have influenced prices for their own personal gain.

The concept of **global peak oil production** is worth exploring here. The production of a finite resource such as oil is predicted by the Hubbert Curve which predicts a rising build-up phase as more oil reserves are discovered and exploited. The peak of production then occurs as demand drives production upwards. The decline in production is due to the reserves running out and this will lead to rapid rises in the price of oil. This in turn will lead to the search for alternative fuels but also a search for new oil reserves that are more expensive to exploit. As the technology is developed to exploit more of these 'difficult' reserves, the decline will become less steep and a 'tail' of production could continue for many years.

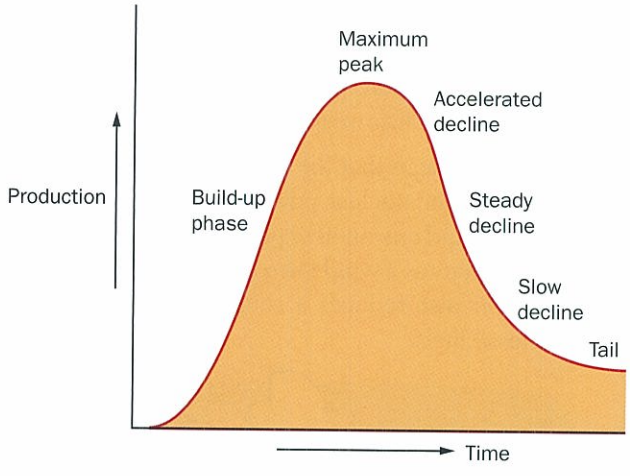

Fig. 12.7 The Hubbert Curve

Fig. 12.8 corresponds broadly to the Hubbert Curve and suggests that global peak oil production occurred about 2007. However, if these data had been consulted in 1982, with no reference to the future, the conclusion would have been drawn that the global oil peak had occurred in 1978. New technologies and new discoveries make the determination of global peak oil very difficult. Until recently, it was not cost-effective to extract oil from the tar sands of Canada. The increasing price of oil and the development of new technologies meant that this vast reserve of oil is now being exploited. Other developments of this type may extend the peak of oil production further into the future.

Natural gas

In the 1960s, natural gas was a by-product of oil production. It was difficult to transport so most of it was flared-off in the oil fields. Now it is a major source of energy, accounting for almost 25 per cent of the world's energy consumption. There are enormous reserves of natural gas, expected to last for 70 years. Russia has a third of these reserves and another third are located in the Middle East, mostly in Iran and Qatar. Further large deposits of natural gas are still likely to be discovered.

Natural gas is the cleanest of the fossil fuels, producing almost no sulphur dioxide and only half the CO_2 of oil and coal. It is, therefore in great demand. Because of this, new technologies have been developed to extract gas from shale rocks. In the past, most gas has been extracted from porous rocks such as sandstone from which it flows up the boreholes quite readily. The pore spaces in shale are much smaller and it is more difficult for the gas to escape the grip of the rock. In the USA, borehole technology now allows a whole series of holes to be drilled into the gas-bearing shales. Mud and liquids are pumped into the rocks under pressure, cracking the rocks and allowing the gas to

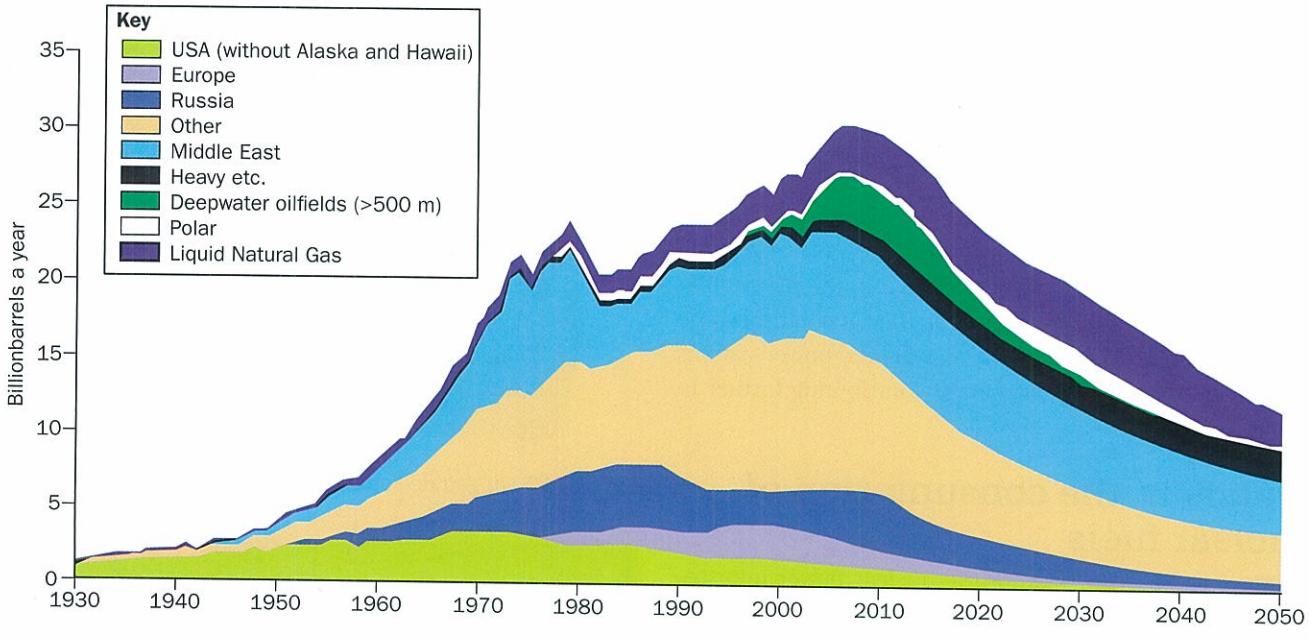

Fig. 12.8 Past and predicted global oil production

escape. Once the liquids are removed, the gas flows readily. This technology is called fracturing or, more commonly, fracking and it has led to a huge increase in gas production in the USA, with a 50 per cent reduction in gas prices. In the near future, the technology will spread, increasing world gas production. The UK government, for example, sees it as an important way to increase energy supplies but the environmental impacts of fracking may lead to protests over its introduction.

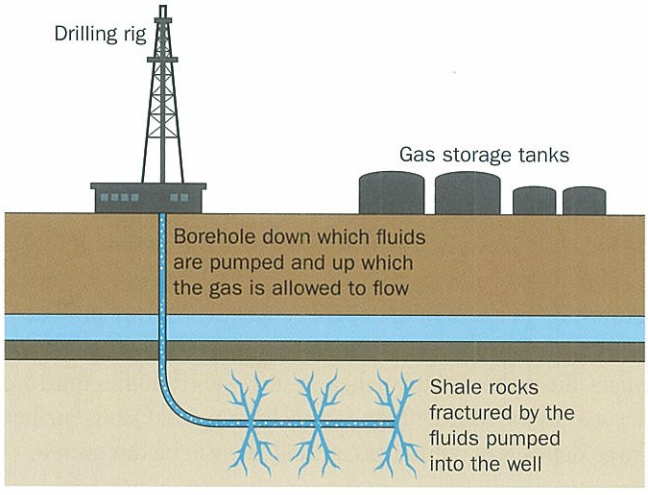

Fig. 12.9 How fracking works – a simplified diagram

Coal

Coal is the second most-used energy source after oil. The world has large reserves, enough for another 150 years, and they are spread widely - 70 countries have significant reserves of coal. However, the USA, Russia, China and Australia are the big players with about 60 per cent of the world's coal reserves. Coal is a dirty fuel (high sulphur content) and can be difficult to mine, so its use is declining in HICs. However, it is the fuel of choice in many NICs and MICs, especially China where it supplies almost two-thirds of the primary energy mix.

Coal-fired power stations are easy to build and simple to run and they can produce large amounts of electricity in one place. Currently, 40 per cent of the world's electricity is generated from coal.

The future of coal is difficult to predict but as the oil reserves decline and oil prices rise, it should become more important. If new technologies can be developed, e.g. the gasification of coal while it is still underground, then it could become easier to extract. Carbon capture at coal-fired power stations could allow it to be used without it contributing further to climate change.

Trends in the consumption of nuclear fuels

Uranium is the major fuel for the nuclear power industry. In a nuclear power station, fuel rods of uranium undergo radioactive decay, producing heat which is converted into electricity. Almost half of the world's uranium reserves are in the USA, Canada and Australia. Nuclear power stations are mostly found in HICs but NICs such as India, China, Korea and Brazil have also developed nuclear power.

Nuclear power has its problems:

- Accidents at Three Mile Island (USA), Chernobyl (Ukraine) and Fukushima (Japan) have led to significant releases of dangerous radioactive material.
- Nuclear power stations are very expensive to build which is one of the main reasons why they are only found in HICs.
- They take a long time to build so they have to be planned well in advance - they can't be used as a 'quick fix' to solve a shortfall in energy supply.
- Old nuclear power stations are difficult and expensive to decommission.
- The used fuel rods contain highly toxic nuclear waste - there is currently no safe way of disposing of it.
- Nuclear power stations produce by-products that can be used to make nuclear weapons.

These problems mean that the future of nuclear power is uncertain. However, nuclear power does not contribute to climate change and one nuclear power station can produce as much electricity as a wind farm the size of Luxembourg. Nuclear power also reduces a country's dependence on imported fossil fuels.

Fig. 12.10 *I'm getting some unusually high readings around you*

6. Describe what the cartoon shows.
7. What is the point that the cartoon is making about nuclear power?

Trends in the consumption of renewable energy sources

Hydro-electricity

HEP stations are located beside a source of flowing water and it is the flowing water that turns the turbines. Because they need a large head of water, HEP stations are associated with dams in mountainous regions where rainfall is high.

They can also be built into barrages – barriers built across large rivers that the river water has to flow through. Pumped-storage HEP schemes have a low lake and a high lake. Water falls from the high lake down to the low lake turning the turbines as it flows. Water can then be pumped from the low lake back to the high lake at times of low demand and reused when demand rises once more.

The future of HEP is uncertain. Large HEP stations can provide huge amounts of electricity but they are expensive and they take a long time to build. Although they do not burn fossil fuels and don't contribute to global warming, they can have negative environmental impacts and many of the best sites have already been used. Small-scale micro-hydro schemes have been successful in LICs but their contribution to a country's overall energy supply is tiny.

Wind power

The use of wind power has increased dramatically over the past 15 years.

There are several reasons for this increase and for the growth of wind power in the future:

- The growing realisation that the use of fossil fuels is causing global warming which will have negative consequences in the future. Combined with this is the desire of countries to reduce their carbon footprint.
- The cost of wind power is steadily falling, making it competitive with other forms of electricity generation. Generating costs are now only 10 per cent of what they were in 1994.
- Technological advances mean that modern multi-megawatt wind turbines are much bigger and much more efficient than the older turbines.
- Turbine manufacture is now big business with a large number of firms and factories involved in their manufacture. Despite this, demand still outstrips supply.
- The bigger turbines rotate more slowly and are more aesthetically pleasing.

The world's leading producers of wind power are the USA, China, India, and the HICs of western Europe. Being an island, the UK is a windy country and many of the new wind farms are offshore, where the wind blows more strongly. Despite this, the growth of wind power in the UK has been slow, partly due to the objections of local people and of environmentalists.

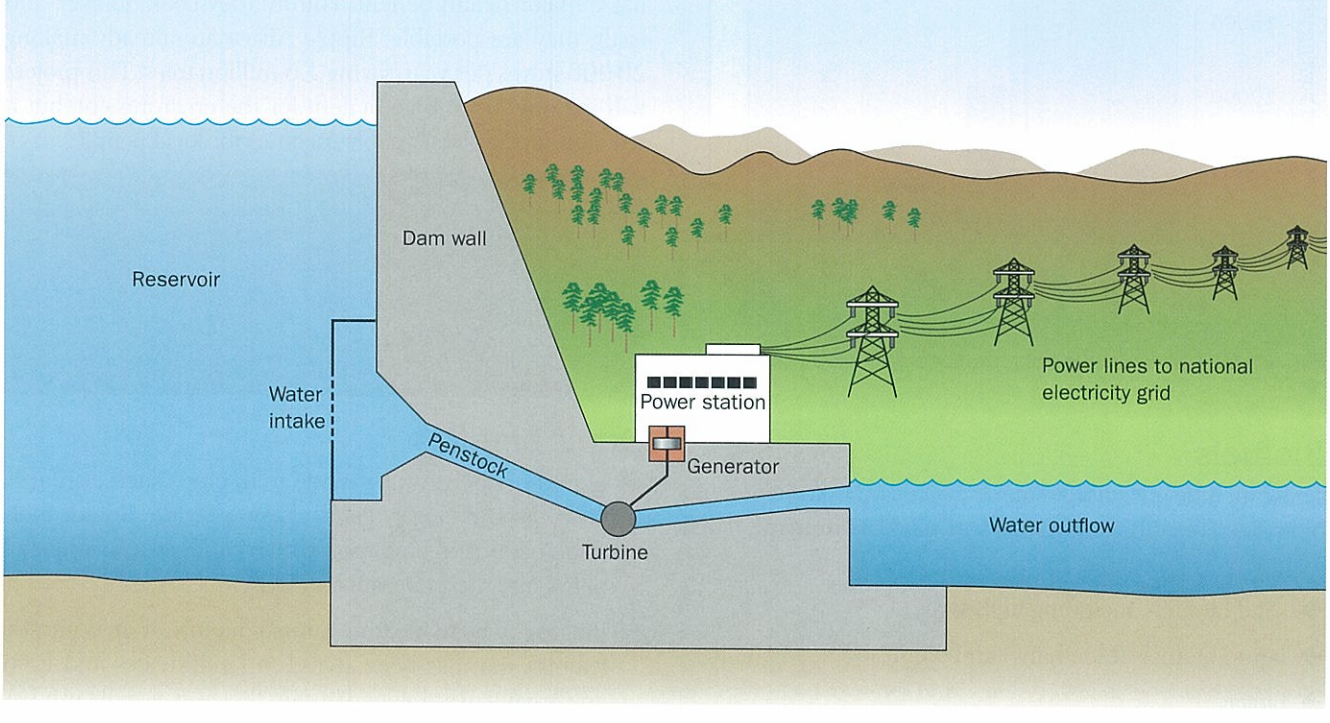

Fig. 12.11 How a typical HEP station works

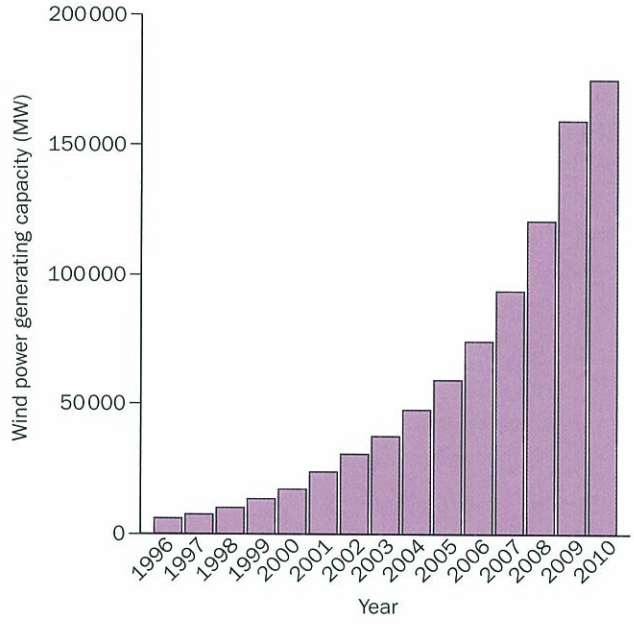

Fig. 12.12 World wind power generating capacity, 1996–2010

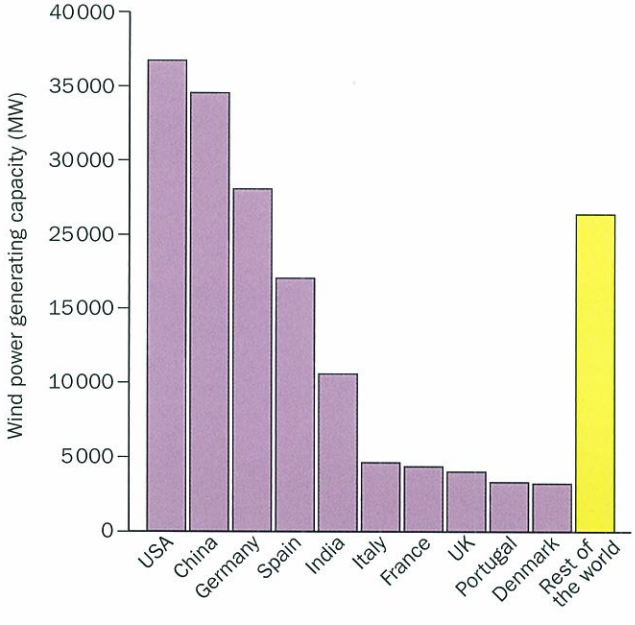

Fig. 12.13 The world's leading producers of wind power in 2010

Biofuels

These include any energy source which comes from organic biomass. They are renewable and **carbon-neutral**. They include:

- solid biofuels, including fuelwood
- liquid biofuels (bioethanol and biodiesel)
- biogas.

Fuelwood in LICs

In LICs, especially in rural areas, cooking accounts for 90 per cent of domestic energy use. Most of these households have no access to electricity or kerosene and so the fuel they use is wood, gathered from the surrounding land. It is estimated that 2.5 billion people rely on fuelwood for their cooking.

Wood is a renewable resource if gathered sustainably but its use can still have social consequences. Wood gathering is often a job for women and young girls. Girls are often withdrawn from school to engage in this activity – severely affecting their education. Burning wood in poorly ventilated homes can lead to respiratory diseases, significantly reducing life expectancy in these countries.

In some parts of the world fuelwood gathering is no longer sustainable as it is having an irreversible effect on the environment. In Burkina Faso and other countries of the Sahel, population pressure means that increasing amounts of woodland are being removed. This leads to wind erosion of the fertile topsoil during the dry season. Once the topsoil is gone, nothing will grow and the people have to move away. This is **desertification**.

One solution is to encourage people to plant trees to replace the ones they have cut down. They can also be educated into using the trees more sustainably, e.g. by coppicing them so that they will regrow their branches quickly. Kerosene stoves are an alternative but kerosene is made from oil (fossil fuel) and is expensive to buy. Ripple Africa is a NGO (non-government organisation – a charity) that makes fuel-efficient wood-burning clay stoves. The clay stoves have many advantages. Firstly, they use one-third of the wood of open fires, reducing annual household usage from 150 to 40 small trees a year. Secondly, they produce less smoke which has a major health benefit. Thirdly, they cook quicker, and lastly, they are portable. Ripple Africa are already making 20 000 stoves per year, saving 1.6 million trees. This project will not only be a huge benefit for the environment, but it will also provide sustainable incomes for local people.

8. How is the use of fuelwood likely to change in the future? You should consider:

- population growth
- economic development
- technological change.

Other biofuels

- Liquid biofuels can be made from crops such as maize, oilseeds and sugar cane. They provide liquid fuels (bioethanol and biodiesel) which can be used instead of petrol and diesel in cars and lorries.
- Biogas can be made from animal manure, from domestic rubbish that has been stored in landfill sites and from any organic waste in a digester. Biogas is usually used as a domestic fuel but can be used to generate electricity.
- Biomass is any bulky crop that can be burnt in a conventional thermal power station and also includes the burning of domestic rubbish in waste-to-power incinerators.

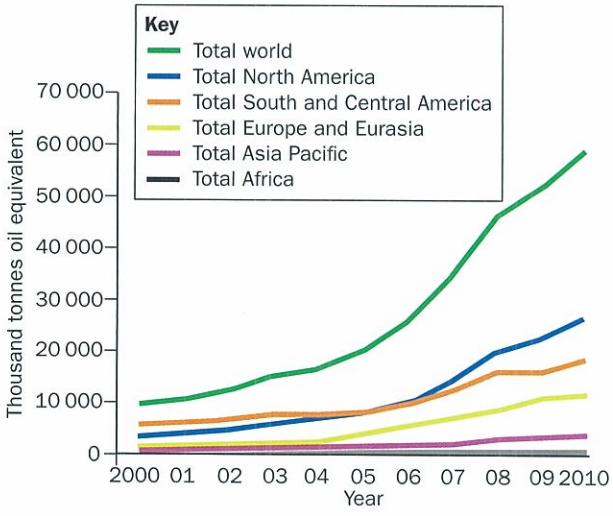

Fig. 12.14 Global production of biofuels

Fig. 12.14 shows that the global production of biofuels has been rising rapidly. This is one reason why the global use of renewable energy has been increasing (see Fig. 12.6 on page 404). The use of biofuels is predicted to increase in future, especially in NICs and HICs where there is money to invest in the technology required. The main reasons for this growth are as follows:

- Prices are stable.
- Supplies are more secure than imported fuels.
- They are carbon-neutral because they are part of the natural **carbon cycle**. They burn to produce CO_2 but it is not *new* CO_2 - it was absorbed from the atmosphere as the plants grew so is simply being returned to the atmosphere from where it came a few weeks earlier.
- In HICs, food supplies are secure and land is available to produce biofuels.
- Burning domestic rubbish for the production of energy is preferred to dumping it in landfill sites, especially in HICs.

The main disadvantage of biofuels is that they are grown on land that was previously used to grow food. This leads to a reduction in food supply and an increase in food prices. This is a major reason why the use of biofuels in LICs and MICs is unlikely to grow in the near future.

The environmental impact of energy production, transport and use

All forms of energy production, transport, and use can have an impact on the environment. On the whole, renewable sources of energy are cleaner and less harmful than non-renewables, but renewables do have their own problems.

Environmental impacts of renewable energy sources

- Fuelwood - gathering fuelwood can lead to deforestation, habitat loss, desertification and soil erosion.
- Wind farms - some people think they are noisy, spoil the view and object to the death of birds that fly into them.
- HEP stations - if they are built in rainforest areas and the forest is not cleared first, the rotting un-cleared vegetation can produce huge amounts of greenhouse gas. All HEP stations have the potential to affect fish migration and fish-breeding patterns.
- For all renewable energy sources, making the equipment needed, e.g. solar panels, takes energy and releases CO_2 into the atmosphere.

Environmental impacts of non-renewable energy sources:

- Coal-mining involves disturbing or removing large areas of land and can lead to habitat loss, the release of dust, noise, contamination of surface water and the building of large waste heaps.
- Transporting oil can lead to oil spills which can kill the local wildlife and reduce the visual attractiveness of beaches.
- Burning oil and coal can lead to acid rain which damages forests and threatens freshwater wildlife.
- Burning all three fossil fuels (coal, oil, and natural gas) contributes to global warming and climate change.
- Burning coal and oil-based vehicle fuels can cause local air pollution including dust, smog and photochemical smog (which includes ground-level ozone).
- Fracking to extract gas from shale can lead to the contamination of groundwater supplies.
- Nuclear power production can lead to the escape of radioactive material. This can lead to genetic deformities and the death of people and wildlife.

The environmental impacts of energy production – nuclear power generation

In nuclear power stations, heat energy is released by the radioactive decay (nuclear fission) of uranium and the heat is used to generate electricity. Accidents which release radioactive material into the environment can have devastating consequences. Humans, animals and plants can be killed or made very ill. Large areas of land around the accident site can be contaminated and remain unusable for years.

The 1986 explosion at the Chernobyl nuclear plant in the former USSR was a *local-scale* disaster that seriously affected

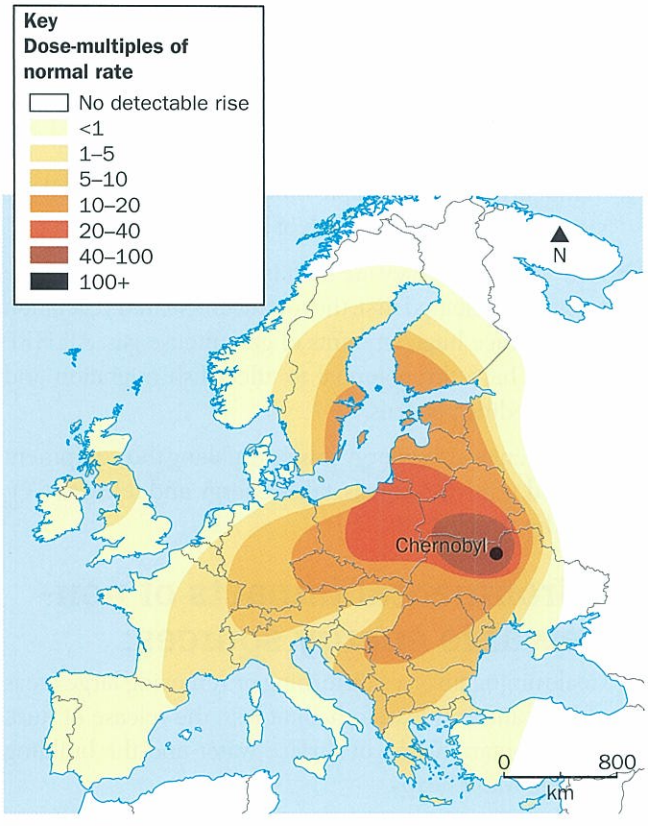

Fig. 12.15 The local, regional and continental-scale impacts of the Chernobyl nuclear accident

the area close to the power station and a *regional-scale* problem that affected many countries in Northern Europe. The accident caused 56 deaths in the local area at the time of the accident (local-scale impact) and the radiation that was released may have contributed to thousands more deaths in the regions around the power plant over the long term (regional-scale impact). Many people are still very ill with radiation-linked illnesses, especially thyroid cancers and leukaemia.

- Local-scale impacts were severe but only affected the area around Chernobyl, which is now an exclusion zone.
- Regional-scale impacts have caused long-term illness in Ukraine, Belarus and Poland.
- Continental-scale impacts were relatively short-lived but affected farm animals as far away as the British Isles.

The environmental impacts of energy transport

Crude oil provides a range of vehicle fuels and it is used as a valuable raw material in the petro-chemical industry, producing plastics and other useful substances. Crude oil is also a very dirty substance; thick, black and tarry, it sticks to anything that comes into contact with it. Crude oil is transported from the oil fields to the refineries, either in giant ships called oil tankers or by pipelines. Most of the time this does not cause any problems but when there is a spillage of crude oil the environmental consequences can be disastrous.

Oil tankers are extremely large ships, carrying over 250 000 tons of oil. Major oil spills are caused when an oil tanker runs aground and its cargo spills out onto the sea. In March 1989, the *Exxon Valdez* oil tanker ran aground in Prince William Sound on the coast of Alaska. An oil slick, 10 cm thick, contaminated 1700 km of the coastline, making this a *regional-scale* disaster. The environmental impact was considerable. The clean-up operation lasted for over 10 years and cost the company Exxon more than £1 billion.

Oil pipelines also carry huge amounts of crude oil, mostly overland. When a pipeline bursts, the spilled oil has a *local-scale* impact, polluting water sources and killing plants and wildlife.

Electricity transmission lines are seen by many people as a cause of visual pollution. The building of new wind farms in mid-Wales after 2010 meant that electricity transmission pylons needed to be built through the beautiful, rural area of north Shropshire. This was a *local-scale* issue and many of the local people tried to stop the pylons being built on the grounds that it would spoil their views.

The environmental impacts of energy production and use at the local and regional scale – acid rain

During the 1970s and 1980s people in Scandinavia became aware that forests and the aquatic wildlife were being damaged. The problem was due to acid rain, which has a pH similar to that of vinegar. This is caused by burning fossil fuels, producing sulphur dioxide and nitrogen oxides which dissolve in clouds to produce acid rain. Scandinavia was suffering because of pollutants produced in the UK. This acid rain is known as 'wet deposition' and is a *regional-scale* impact. In the UK the gases themselves were corroding buildings – this is known as 'dry deposition' and is a *local-scale* impact.

The main pollutants were sulphur dioxide and the oxides of nitrogen:

- Coal contains sulphur. Burning coal in power stations releases large amounts of sulphur dioxide.
- When cars burn petrol they produce a range of exhaust gases, including the oxides of nitrogen.

The impacts were varied:

- The acids attack statues, gravestones and buildings, especially if they are made from limestone.
- Close to the source of the pollutants, the gases are often breathed in by people, causing respiratory problems.
- The acid rain damages trees, especially coniferous trees.
- Aluminium is leached out of the soil. This is washed into streams, rivers and lakes where it proves to be toxic for aquatic life.

The EU introduced legislation in 1988 to tackle the problem. By 1999 the levels of acid rain in Scandinavia had fallen by 30 per cent. Things have continued to improve since then. What was done?

- **Catalytic converters** were made compulsory, cutting down the nitrogen oxides that car exhausts produced.
- Many old coal-fired power stations were replaced with new gas-fired power stations. Gas is a much cleaner fuel than coal and produces very little sulphur dioxide.
- The remaining coal fired power stations used 'sulphur scrubbers' on their chimneys to remove the sulphur dioxide before it was released into the atmosphere.
- The increasing use of renewable energy sources and nuclear power has also helped to reduce the problem.

The environmental impacts of energy use at the global scale – global warming

Some people argue that the greatest problem that the planet faces is global warming - human-induced climate change produced by an enhanced greenhouse effect. In HICs, and to an increasing extent in NICs, energy use is increasing. Most of this energy is derived from fossil fuels, producing the extra greenhouse gas.

The problem was recognised at the Earth Summit in Rio in 1992, and many nations have now agreed to reduce their emissions. This will not be easy but the consequences of climate change could include sea level rise, increased atmospheric hazards and a reduction in global food supplies.

Greenhouse gases trap heat radiated by the Earth, stopping it escaping into space and so heating the atmosphere. This greenhouse effect is natural but it has been enhanced in recent decades by human activity, especially the burning of fossil fuels. The main greenhouse gases are:

- carbon dioxide - produced when we burn fossil fuels (coal, natural gas and oil)
- methane - produced by rotting rubbish in landfill sites, by rice fields and by cows' digestive systems.

This enhanced greenhouse effect has produced global warming - an increase of average global temperature, which is impacting on global ecosystems. More gales and storms are likely. Rainfall patterns will change; more droughts and floods are likely, again impacting further on ecosystems. Ice caps could melt and sea levels rise. Land could be flooded by the sea. This would have a severe effect on the coastal environment. The sea will get warmer and expand, making sea level rise even more.

It is happening all over the world - it is a *global-scale* problem - but the effects will be different in different places. LICs and some MICs will be affected more severely than HICs because they have not got the money, the infrastructure or the resources to prepare for and cope with the consequences of climate change.

Managing the problem is difficult. A lot of damage has already been done because we've been burning fossil fuels since the start of the Industrial Revolution. However, many countries signed the Kyoto Agreement suggesting that there is a desire to reduce the future effects of global warming. Strategies include:

- developing energy conservation
- using cars less and using more energy-efficient cars
- using public transport or walking whenever possible
- using more nuclear and hydro-electric power stations and developing sustainable energy sources such as wind power and bio-diesel
- planting trees and stopping deforestation
- having international agreements and cooperation. It is a global problem and HICs must help the other countries.

Some people feel that it is already too late and we should prepare to live with the consequences of human-induced climate change rather than try to address the causes.

9. 'The global impact of energy use is more serious than the local impacts.' To what extent do you agree with this statement?
10. 'Solving the problem of climate change is much more difficult than solving the problem of acid rain.' Discuss.

RESEARCH

- What is the greenhouse effect? Find and copy a diagram which shows how it works.
- Find out how human-induced climate change is likely to affect the country that you live in.

The management of energy supply

The supply and use of energy within one country can be managed in a variety of ways. The role of the country's government is often very important as energy is seen as a strategic resource, vital to the country's economy and to the quality of life of its people. Demand management and supply management are both used and these strategies often involve large companies, organisations and individuals as well as the government. The long term aim of energy management is to achieve energy security ensuring that affordable energy is available now and in the future.

Case study: One country's overall electrical energy strategy: Norway

Norway is a rich HIC in northern Europe. Annual total energy consumption is very high at 6.2 tons of oil equivalent per person (the EU average is 3.8 tonnes). Per person electricity consumption is the highest in the world. Why is this the case?

- Norway is a rich country with a GDP per person of $55 000 and one of the highest HDI (human development index) figures in the world (0.944). Norwegians can afford to spend a lot of money on energy.
- Norway is a cold country with long, dark winters. This means that a lot of energy has to be used for heating and lighting.

Norway has large reserves of oil and gas, most of which are exported. Instead of using these reserves domestically, it uses its vast HEP potential: 99 per cent of Norwegian electricity is generated from hydro-electric plants (Norway is wet and mountainous with many high-level lakes). Overall, only 39 per cent of total energy consumption comes from fossil fuels and 61 per cent from renewables, mostly HEP.

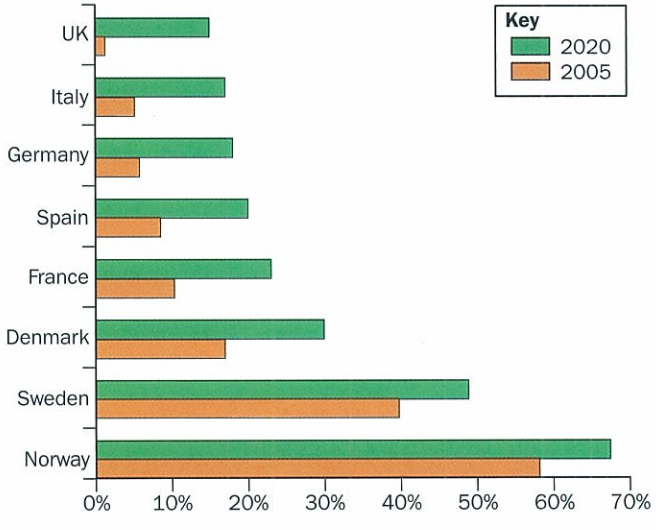

Fig. 12.16 Percentage of energy obtained from renewable resources, 2005 and 2020 (estimated) for selected European countries

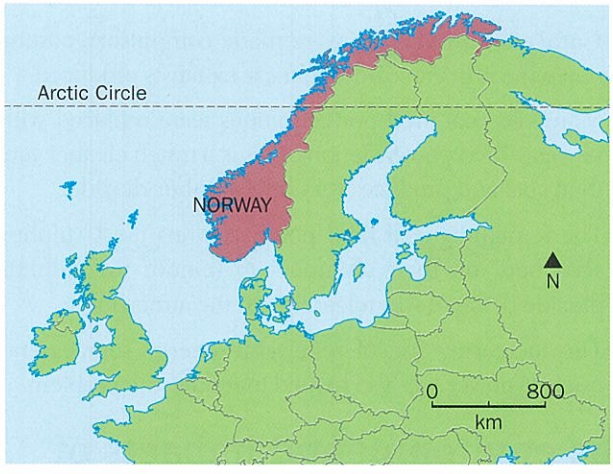

Fig. 12.17 Norway's location in Europe

Most of Norway's electricity is supplied by HEP

- With many high-altitude lakes and high rainfall, Norway can generate 99 per cent of its electricity and 50 per cent of total energy supplies from HEP.
- This makes Norway the largest producer of HEP in Europe and the sixth largest in the world.
- Because many of the lakes are natural, they have less environmental impact than artificially created reservoirs.
- HEP is renewable by nature and is therefore already sustainable.

Norway is investing in renewable energy for the future

- One of Norway's energy aims is to reduce its dependence on HEP by using a wider range of renewable resources.
- This is needed to cope with any future rise in energy demand because almost all the potential HEP sites have been exploited.
- US$3 billion were invested in developing renewable energy and energy-efficiency in 2006. One of the main aims is to triple wind power capacity.
- Research into solar power aims to increase the percentage of the sun's energy that can be converted into electricity from 17 per cent to 50 per cent via research into making solar panels more efficient. Norwegian winters are very dark but in the summer the days are very long: with 24 hours of sunlight (clouds permitting) around the summer solstice.

- The government also provides funding for companies to research and develop biofuels to use for transport instead of petrol and diesel, for example producing biodiesel from waste from Norway's salmon industry.
- As a wealthy nation, Norway is able to invest in research in order to develop a sustainable energy future.

Control of energy demand

- The most effective way to control energy demand in Norway is by influencing the price through taxation. When the government increases the tax on energy, people have an incentive to use less.
- The Norwegian government also encourages energy conservation by ensuring all new buildings are energy-efficient, e.g. triple glazing. Advertising campaigns are used to encourage people to conserve energy, for example turning off electronic gadgets when they are not in use.
- Norway has a public agency that advises on energy-efficiency: Enova SF, run by the Ministry of Petroleum and Energy. House owners and business owners can contact the Enova call centre for advice about energy saving.
- An industrial energy-efficiency network (Bransjenettverket) was established in 1989 by the Ministry of Petroleum and Energy to encourage energy-efficiency in Norwegian industry. Companies can obtain grants to analyse the potential for energy savings and compare their performance against other companies. Approximately 900 companies have received information and financial support for lowering their energy consumption.

How successful and sustainable is Norway's energy strategy?

- Norway has a sustainable electricity supply within the country. This means that the country doesn't have to worry about energy security in the short term.
- It can concentrate on developing a long-term sustainable energy supply.
- Some aspects of the overall energy policy are already sustainable, e.g. using HEP stations to generate electricity, but others are not, e.g. relying on oil for transport. Encouraging the use of electric cars or biofuels could improve this.
- Norway's sustainable energy (HEP) is a non-critical renewable resource which guarantees future electricity supplies.
- Policies such as investing in energy-efficiency and renewables and putting high taxes on oil also promote sustainability.
- Norway can manage energy demand by controlling the price through taxation and by encouraging households and industries to adopt energy conservation measures such as triple glazing.
- The political stability and wealth of the country allow it to pursue a long-term sustainable energy future. Norway has a stable government and corruption is not a problem. TNCs and other countries are prepared to invest in Norway.
- Norway is a rich country with a great deal of choice about its energy resources.
- Norway has achieved energy security and is adopting strategies to ensure that it has energy security in the foreseeable future.

Case study: Producing electricity in Norway: the Ulla-Førre hydropower complex

Ulla-Førre is Norway's largest HEP complex with a total capacity of 2057 megawatts and a mean annual production of 4.5 terawatt hours. (One unit of domestic electricity consumption is the kilowatt hour and a terawatt hour is equivalent to one billion kilowatt hours.) The HEP complex consists of three generating stations which all utilise water from the Blasjø reservoir. The main power station, Kvilldal, with a capacity of 1240 MW, is Norway's largest power station. Kvilldal was opened in 1982 and is operated by Statkraft SF, the largest power company in Norway and 100 per cent owned by the state.

The Ulla-Førre complex is located in Rogaland in south-west Norway, 100 km north-east of the major port city of Stavanger.

Locational factors

Southern Norway has a high annual rainfall, over 2000 mm per year, and no dry season. There are, on average, between 15 and 20 rainy days every month so there is no shortage of water. Evaporation rates on the cold, high plateau where most of the water is stored are very low. Water is a non-critical renewable resource in this part of the world.

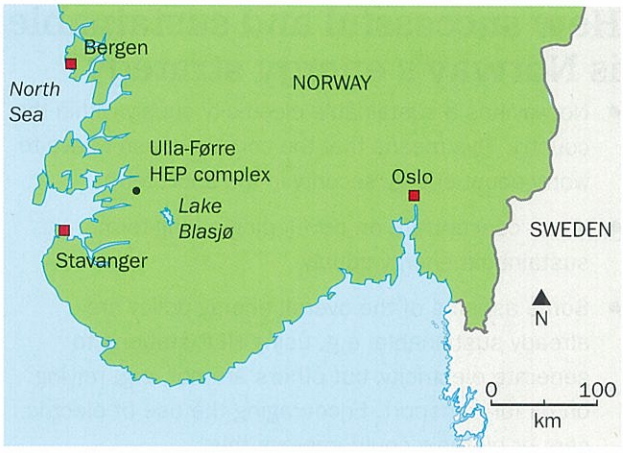

Fig. 12.18 The location of the Ulla-Førre HEP complex

This is also an area of high relief with mountains rising rapidly from the coastline. There are many high lakes on the *fjell*, a plateau at about 1000 m above sea level and the construction of the Storvass Dam allowed several of these lakes to be raised and combined into one large reservoir, Lake Blasjø. The deep, narrow valleys can also be dammed to form lower-lying reservoirs such as the Suldalsvatn reservoir in the valley of the Suldalslagen River.

The power complex is within 250 km of Oslo, 125 km of Bergen and 100 km of Stavanger. This means that electricity transmission to the three main cities of southern Norway is relatively easy and little power is lost over these short distances.

Operation

The operation of the Ulla-Førre HEP complex depends on a series of pipes, tunnels and pumps that move water between the two main reservoirs and the three generating stations.

The main water supply is from the Blasjø Reservoir which collects rainwater falling on the high fjell plateau. Water is also collected from 39 rivers and brooks and stored in the Suldalsvatn Reservoir. When required, the Saurdal and Hylen power stations can pump water from the lower levels into the high level Lake Blasjø to ensure that supplies of water are always available. The Blasjø Reservoir can hold 3.1 billion tons of water. Because Blasjø is at 1000 m above sea level and the three generating stations are much closer to sea level, this provides a large 'head of water', allowing large amounts of electricity to be generated. Kvilldal power station has four large Francis turbines which can operate continuously if required.

Combining the three power stations into a larger complex gives considerable flexibility of operation. Because Saurdal is a pumped-storage HEP station, the complex can meet peaks of demand when water is drained from Blasjø Reservoir faster than its natural replenishment rate but it can then pump water back up to Lake Blasjø using off-peak electricity generated when demand for power is low. This allows the complex to cope with short-term fluctuations in demand.

How successful is the Ulla-Førre HEP complex?

Overall, the Ulla-Førre complex and the massive Kvilldal HEP station have proved to be very successful:

- Large amounts of electricity can be supplied to the cities of southern Norway.
- The electricity is produced without using fossil fuels so the generating complex does not contribute to global warming.
- In southern Norway water is a non-critical renewable resource because of the high rainfall and because of the ability of the complex to reuse water if required. This makes the system highly sustainable and able to cope with long-term variations in demand.
- Because the Blasjø Reservoir was created on the uninhabited plateau at 1000 m above sea level, it did not flood any villages or towns. No one had to be relocated.
    - It was expensive to build but operating costs are very low, making the electricity cheap.
    - Linking three power stations into one large complex allowed the flexibility to respond to variations in demand.
    - Salmon migrations have been allowed to continue, which is good for the natural environment and for the local tourist industry.

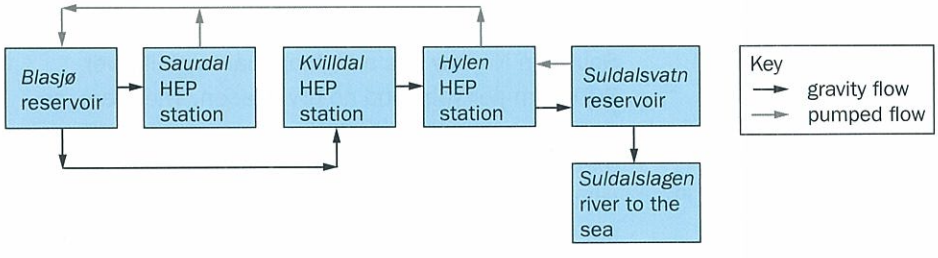

Fig. 12.19 Water movements through the Ulla-Førre HEP complex

Environmental degradation

Pollution of the land, air, and water

Pollution is defined as 'the introduction of substances into the natural environment that cause adverse change and which damage the natural environment'. Pollutants can be introduced into the environment by human activity or can be natural.

This definition refers to 'substances' but light and noise can also be regarded as pollutants, especially in big cities.

Very often, it is the concentration of the pollutant that is critical – farmyard manure is a beneficial fertiliser when used sparingly but if there is too much of it, it can be a poisonous pollutant.

Pollution is often classed as **point source** or **non-point source pollution**:

- Point source pollution occurs when the pollutant is issued at one point, e.g. a pipe pouring untreated sewage into a river.
- Non-point source pollution emanates from an area, e.g. exhaust emissions from all the vehicles in a city.

Another way of classifying pollution is as **incidental pollution** and **sustained pollution**:

- Incidental pollution is a one-off event, e.g. the Chernobyl radiation leak or the Exxon Valdez oil spill (see page 404).
- Sustained pollution is long-term pollution caused by on-going human activities, e.g. the release of carbon dioxide into the atmosphere from the burning of fossil fuels.

Although the impacts of the two examples of incidental pollution given above were severe and long-lasting, the impacts of sustained pollution are usually much worse in the long run.

Most pollution is caused by human activity and it is often a major factor in the degradation of the environment. Pollution caused by human activity can also be a cause of poor human health. Figures released in 2014 by the World Health Organization suggested that air pollution alone kills about 7 million people a year and is linked to one in eight deaths worldwide.

Pollution of the land

Waste products and by-products are often simply dumped onto the ground or buried in landfill sites. Sources of land pollution include the following.

Mining and quarrying

Waste tips from coalmines scar the landscape in many former mining areas. They are visually unsightly, they are often difficult to landscape and vegetation will not grow on them. Quarries and strip mines produce dust and noise while they are operating and can lead to severe degradation of the environment, especially in fragile rainforest areas.

Industry

Many industries produce solid waste which is dumped onto the land. Other industries produce toxic by-products which are simply allowed to drain away into the land around the factory. This can make the reclamation of the land very expensive when the factory closes and the site is used for something else, e.g. housing.

Energy production

Leaks from oil pipelines can contaminate the land over which the pipelines pass. Ash from coal-fired power stations is often dumped into large holes in the ground. The ash is loose and sterile.

Dumping of domestic waste

In traditional societies, domestic waste tends to be burned and the ashes, together with the rubbish that won't burn, are often dumped outside, on a midden. This is unsightly but small-scale. In developed urban societies, people are more affluent and have more to throw away. Domestic waste collection is usually organised by the local authority and the waste is often buried outside the urban area in landfill sites – holes in the ground which are filled with rubbish. The rubbish in these landfill sites contains organic food waste which breaks down to produce methane. The methane escapes and contributes to air pollution. Rainwater draining through the landfill site picks up toxic chemicals produced by the decay of the domestic waste and these chemicals move down into the groundwater aquifers, causing water pollution.

Air pollution

Air pollution is a major problem locally, regionally and globally. Causes of air pollution include the following:

Energy production

The production and use of energy can pollute the air in a number of ways:

- burning fuelwood in the home
- dust from the strip mining of coal
- acid rain
- carbon dioxide from fossil fuels.

Agriculture

Storing and spreading farmyard manure can cause a bad smell which can affect nearby settlements. Burning straw after the grain harvest produces smoke and soot.

Deforestation

Clearing trees from a forested area is often achieved by cutting them down and then burning them. The ash from the burnt vegetation helps to fertilise the soil. On a small-scale the smoke quickly dissipates and does not have a serious impact. However, when this is done on a large scale, and in many places at the same time, it can cause a problem that extends across several countries. Burning the rainforest in south-east Asia has led to serious air pollution across the whole region. This happens every year but the 1997 South-east Asian Haze was a large-scale air quality disaster which caused **smog** and health problems. The cost of the 1997 South-east Asian Haze is estimated at $US 9 billion due mainly to the closure of schools, the increased need for healthcare and the disruption of air travel and business activities.

Industry

Heavy industry often produces a range of atmospheric pollutants. Iron and steel, chemicals, petro-chemicals and oil refining are some of the worst offenders and because the factories operate for a long period of time, they produce sustained pollution.

Industrial accidents can contaminate large areas with extremely toxic materials. These accidents are examples of incidental pollution. An explosion at the Union Carbide chemical factory in Bhopal, India, in 1984 released methyl isocyanate gas into the surrounding city. People were blinded and choked by the gas and the long-term death toll is around 20 000 people. Many more were permanently disabled.

Traffic

The number of vehicles in big cities is growing all the time and the exhaust fumes they produce are also increasing. Traffic congestion makes things worse s the vehicles still produce fumes when they are caught in traffic jams. The pollution is often worst in MICs where vehicles are poorly maintained. A wide range of pollutants is released by road vehicles as can be seen in the following table.

Pollutant	Source	Problems caused
Carbon monoxide (CO)	Exhaust fumes from vehicles that are not burning their fuel efficiently.	Reduces the supply of oxygen to the heart.
Carbon dioxide (CO_2)	Exhaust fumes from efficient vehicle engines.	Global warming.
Oxides of nitrogen (NO_x)	Petrol engine exhausts where no catalytic converter has been fitted.	Irritates the throat and lungs. Leads to ozone formation and contributes to acid rain.
Ground-level ozone (O_3)	Chemicals in vehicle exhausts, especially oxides of nitrogen, react with sunlight to produce ground-level ozone.	Photochemical smog (a brown haze) leading to irritation of the eyes, nose, throat and lungs. Especially dangerous for people with existing respiratory problems, e.g. asthma.
Particulates	Produced by diesel engine exhausts where no filter has been fitted.	This is black smoke and soot which leads to smog and respiratory problems. The particles can cause cancer if breathed into the lungs over a sustained period.
Hydrocarbons, including benzene	Petrol engine exhausts where no catalytic converter has been fitted.	They contribute to the formation of ground-level ozone (see above). Benzene can cause cancer.
Lead	Old petrol vehicles which burn leaded petrol – mostly a problem in MICs.	Lead causes brain damage, especially in children. Damages the kidney, liver and nervous system.

Table 12.1 Air pollution problems caused by traffic exhaust fumes

Water pollution

Water, like air, is a fluid and polluted water can spread over long distances. Polluted rivers take their pollution to the sea and ocean currents can spread the pollution around the globe. Materials made from plastic are dumped into the north Pacific Ocean by ships and are washed into the ocean by rivers flowing from all the densely-populated countries around the north Pacific. Plastic is a long-lived material and it floats. The currents of the north Pacific move in a circular fashion and they have concentrated the plastic into an area known as the 'North Pacific Garbage Patch'. Its long-term impact on the marine ecosystem is unknown but it is probably one of the major forms of pollution on the planet.

11. Suggest why the similar pattern of ocean currents in the south Pacific Ocean has not yet produced a 'garbage patch'.

Some of the main sources of water pollution include the following:

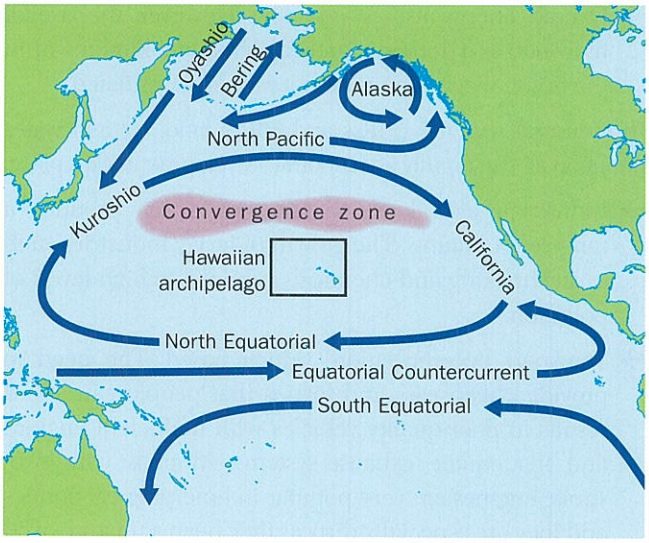

Fig. 12.20 The North Pacific Garbage Patch. The plastics have concentrated in the convergence zone shown on the map, which is between Japan and California

Fig. 12.21 Domestic rubbish in the River Ganges at Varanasi, India

Agriculture

Water pollution by agriculture is related to the increasing use of chemicals in farming. These chemicals are washed down through the soil (leaching) and often end up in rivers and streams. The increase in nitrates from fertilisers leads to the growth of algae. When the algae die, they rot and use up all the oxygen in the water (eutrophication), killing the fish and other organisms living in the rivers.

Industry

Liquid wastes from industry are often simply dumped into the sea or into nearby rivers. Papermaking has one of the worst records. The chemicals used to turn wood into wood pulp are extremely toxic and can kill most wildlife if released into local rivers without being treated and made safe first. Rivers may also be polluted with organo-chlorine compounds, used to bleach the wood pulp.

Energy production and transport

The main impacts are:

- pollution from oil spills
- air pollution from energy production contributes to acid rain which, when falling on lakes and rivers, can pollute them too
- hot water from thermal power stations is often dumped back into nearby rivers. Hot water is clean but contains very low levels of oxygen, suffocating fish
- low-level radioactive waste from nuclear power production.

Domestic rubbish

Domestic rubbish is often dumped into the nearest river. Old bicycles and shopping trolleys are common sights in rivers in HIC cities but the problem is much worse in MICs and NICs where there may not be an efficient rubbish collection system.

What are the solutions?

Solutions have to be linked to sustainability. We need to use fewer resources, make things in a cleaner way and throw away less of what we use. The problem is that many people are divorced from the chain of production that provides them with what they buy and they are ignorant of what happens to things that they throw away.

The first step, therefore, is to raise awareness. Environmental pressure groups such as Greenpeace and Friends of the Earth have been doing this for many years and their efforts have educated many people and changed their attitudes and even their behaviour. However, this has been most successful in HICs where people can afford to make informed choices about the environment. Poor people are more focused on their immediate survival than with environmental protection.

The second step is to turn this raised awareness into political action. There has to be a political will to clean up the environment and again, this is more common in HICs. Governments in MICs have to focus on the needs of a rapidly-expanding population and the policies that will stimulate economic development. Reducing environmental pollution is something that may not get to the top of their list of priorities.

When the political will does exist, pollution can be tackled by legislation, education, and taxation.

- Legislation means passing laws which outlaw pollution. The government then have to set up some sort of monitoring and inspection system which will highlight the continuing incidents of pollution and then ensure that the culprits are taken to court and punished in some way – usually by fines.
- Education involves advertising in the national media, persuading people that pollution is bad and showing them what they can do to reduce it.

- Taxation is often the hardest way of tackling pollution because people usually resent taxes and 'green taxes' are usually seen as unnecessary. Taxes on vehicle fuels aim to reduce vehicle use and the air pollution that they cause. Taxes on plastic carrier bags are designed to reduce domestic waste. In the UK the landfill tax has made local councils organise recycling in order to cut down on the amount of rubbish being thrown away. A suggestion to tax householders on the amount of rubbish that they produce – known as 'pay as you throw' – has not been received well by a population used to having their rubbish taken away 'for free'.

RESEARCH What are the ways in which the government in your country tries to reduce pollution? How successful are they?

The link between pollution and economic development

The amount of pollution in a country is linked to its level of economic development. This is shown by the Environmental Kuznets curve.

Large-scale pollution is usually not a major problem in pre-industrial societies in LICs:

- Agriculture tends to be organised on a subsistence basis and there is little money available to buy chemical fertilisers and pesticides which are the main agents of agricultural pollution. Over-use of the land can lead to environmental degradation, e.g. soil erosion, but this is not linked to pollution.
- Industry is poorly developed and tends to be small-scale craft industry which produces few pollutants. Mining and quarrying can be a source of land degradation and pollution in countries where primary raw materials are being extracted.
- Transport tends to be based on the muscle power of people and animals. The use of fossil-fuel-powered vehicles is not great.
- There is very little domestic rubbish in these poor societies where people can't afford to throw away anything that might still be useful.

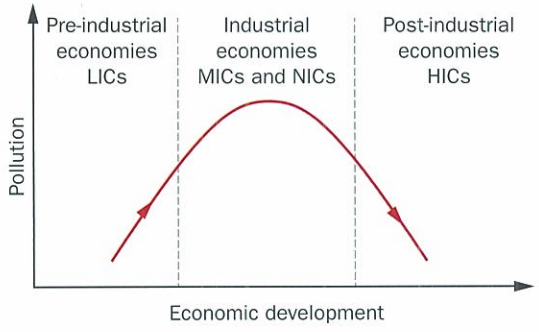

Fig. 12.22 The Environmental Kuznets curve

- Overall energy use is very low. However, the use of fuelwood as a domestic fuel can lead to pollution within the house when rooms are not properly ventilated.

In industrial societies (MICs and NICs) land, air and water pollution all rise rapidly as economic development takes place:

- Industrialisation leads to factories which produce a range of pollutants. The growth of heavy industries such as steelmaking and chemicals can lead to high levels of pollution.
- Transport becomes more vehicle-based. The need to provide cheap cars and lorries that people can afford results in poor-quality vehicles with inefficient engines and inadequate exhaust systems. Mopeds with two-stroke engines are very popular in emerging economies and they are especially dirty as they burn a mixture of oil and petrol.
- Urbanisation means that the cities grow rapidly. Sewage disposal is often inadequate (often based on local rivers and lakes) and people burn cheap, dirty fuels such as coal.
- As agriculture becomes more commercial, the use of agricultural chemicals increases, polluting rivers and streams.
- The government promotes economic development so that the basic needs of the growing population can be met. To do this they encourage TNCs to set up factories. TNCs are attracted by the absence of anti-pollution laws, amongst other factors.
- As well as leading to environmental degradation, the increased levels of pollution cause major health problems.

In post-industrial economies (HICs) pollution decreases.

- Quality of life becomes as important as standard of living and there is pressure from the population for a reduction in pollution.
- Environmental pressure groups are set up and these organisations mobilise public opinion. 'Green' political parties are set up and take part in the political process.

Fig. 12.23 Mopeds are very popular in emerging economies. This is Hanoi in Vietnam

- Most HICs are affluent democracies where governments need to take more notice of their people's wishes and where they pay less regard to the demands of TNCs. Anti-pollution laws are introduced and enforced. Initially, these are designed to improve public health, e.g. laws regarding sewage disposal and clean air, but later on laws are introduced to protect wildlife and ecosystems.
- Globalisation means that much of the old, heavy, polluting industry closes down as production is moved to emerging economies where wage rates are lower.
- The increased use of the private car means that air pollution from transport is still a problem in many HICs. However, the introduction of new technologies such as particulate filters and catalytic converters on vehicle exhausts mean that this source of pollution is being reduced.
- Although HICs have been able to reduce pollution locally within their own country, there is still a problem with pollution at the global scale. Increased energy use based on fossil fuels means that carbon dioxide is produced in very large quantities by HICs. Carbon dioxide has very little impact locally but its global impact through climate change could be immense.

Water – demand, supply and quality

We all need water to live – it is possibly the most essential of all natural resources. A reliable water supply is also an essential prerequisite for sustained economic development. 40 per cent of the world's population live in places where lack of water is a constant threat and the global demand for water is doubling every 20 years. Even when sufficient water is available, it may be polluted and unfit to drink. Lack of access to clean, safe drinking water is estimated to kill over 4000 children a day, mostly in LICs, mainly because of waterborne diseases such as diarrhoea.

12. Why is a reliable water supply an essential prerequisite for sustained economic development?

The two main sources of water are surface water and groundwater. A much less important source of water is desalination – producing fresh water from seawater.

Surface water

Surface water is obtained from rivers and lakes. Surface water can be stored in a reservoir by building a dam across a river.

Groundwater

Underground layers of porous rock that contain water are called aquifers. Wells and boreholes are used to access the aquifer and pumps can be used to raise the water to the surface.

Water demand

Water is in demand for three main uses:

- Agriculture: in many parts of the world, rainfall is low and farmers need to irrigate their fields so that crops can grow.
- Industrial use: industry can use huge amounts of water for manufacturing, e.g. papermaking, or for cooling, e.g. power stations.
- Domestic use: in HICs people use large amounts of water each day for drinking, washing, flushing toilets, watering gardens and even washing cars. In LICs people use much less water, mostly for drinking.

Drinking water has to be purified at a water treatment works and then piped to where it is needed. Dirty water has to be cleaned at a sewage treatment works before it can be put back in the river. On big rivers the water may be used several times before it reaches the sea.

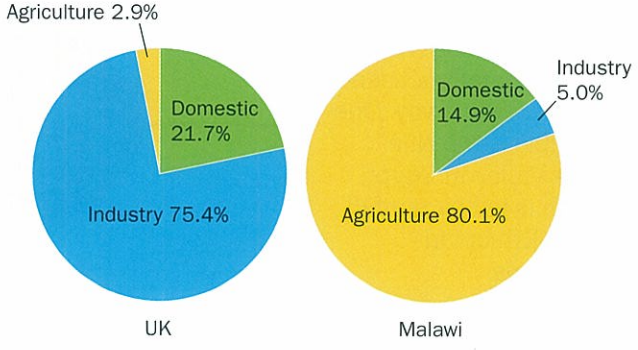

Fig. 12.24 Contrasts in water use between two selected countries

13. Suggest how climate and different levels of economic development can explain the differences shown in Fig. 12.25.

Water shortages can occur anywhere. Water is a renewable resource but when water use exceeds supply, long-term water shortages can result. This can have an impact on people and on the potential for economic development. This leads to competition for the use of the available water resources and water has to be carefully managed.

Water surplus and water deficit

Some parts of the world have a water surplus (more water than they currently need) while other areas have a water deficit (not enough water for their needs). To counter this, water is often transferred from surplus areas to deficit areas, sometimes over large distances. Dams and reservoirs may have to be built and river levels controlled. It is important that the use of water is sustainable – water use should not exceed water supply. If too much water is used, river levels can fall and wetland areas can dry out. This can have a bad effect on wildlife because habitats are reduced or destroyed. When river levels fall, pollution becomes more concentrated and wildlife suffers as a result.

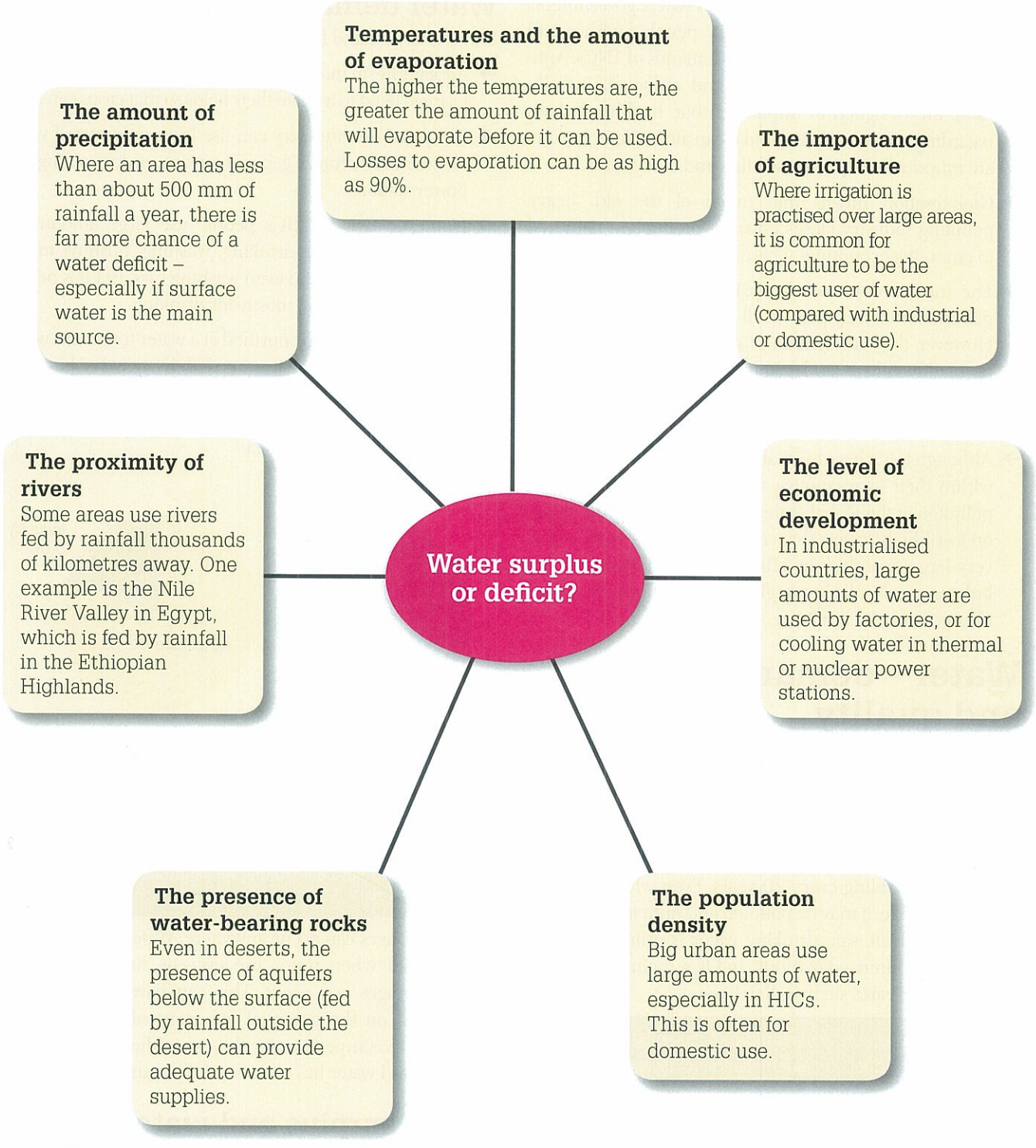

Fig. 12.25 Factors which determine whether there will be a water surplus or a water deficit

Water quality

Water for domestic use, especially drinking water, needs to be clean and free of diseases. This usually involves some sort of water treatment as natural water is rarely clean enough to drink. Building the water treatment works and the pipes to deliver the clean water to people's homes is usually seen as a job for the government or for government agencies. Fortunately, the infrastructure needed to deliver a clean water supply is relatively cheap and most countries can ensure the delivery of clean water to their people quite soon after they start to develop economically. Despite this, there is still a significant proportion of the global population who cannot rely on clean water.

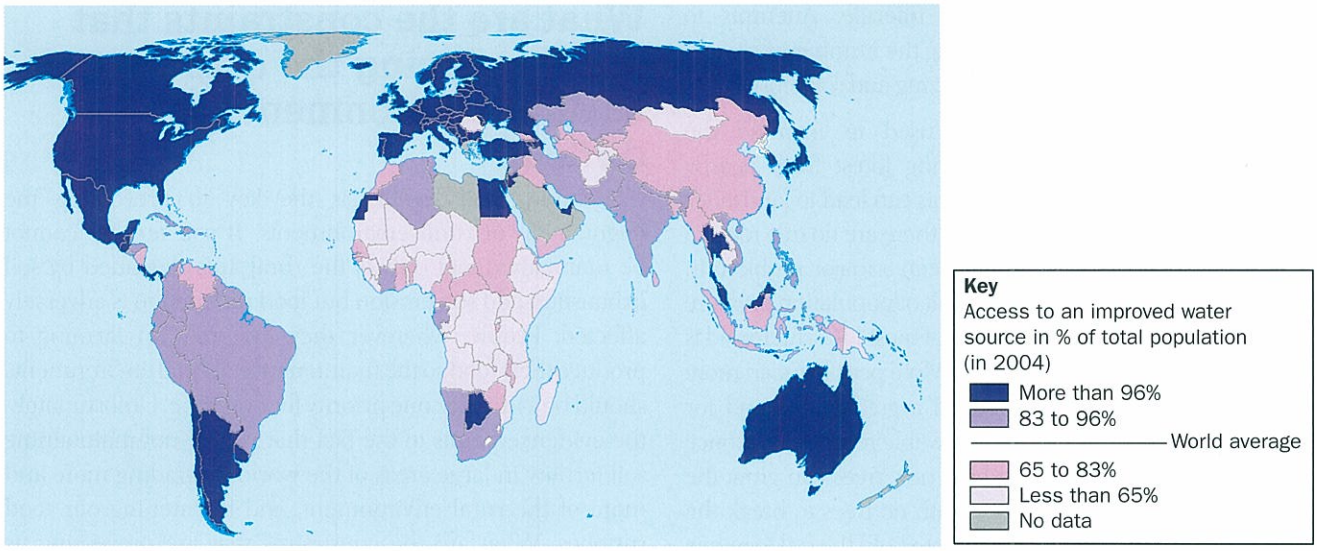

Fig. 12.26 Access to clean water

14. Describe the distribution of countries where less than 65 per cent of the population have access to an improved water source.

The degradation of rural environments

The main factors in the degradation of rural environments are over-population, poor farming practices and deforestation. These three factors are closely linked to each other and to the demands imposed on rural areas by the economic development of the country as a whole.

→ Overpopulation in rural areas is a result of economic development leading to a drop in the death rate and the movement of the country into stage 2 of the demographic transition model (DTM, page 110). Because the benefits of economic development are usually felt first in urban areas, rising rural population puts great pressure on the land. As the size of the family increases, the ability of the family's land to support everyone is reduced. Rural–urban migration could provide a safety valve but it is difficult for people to leave isolated and remote rural areas. Underemployment, malnutrition and even starvation are often the result if the land can't be made to produce higher yields of food. Attempts to make the land produce more food often lead to degradation of the land because of the poor farming techniques that are used.

→ Poor farming practices are often the result of population pressure causing people to overuse their land. The extra people can be seen as a resource because there are more hands to help with cultivating, weeding and harvesting. However, because the farming methods are inefficient, these attempts to produce more food crops will often stress the soil, leading to declining soil fertility. Many traditional farming techniques rely on a period of fallow when the land is allowed to rest and essential nutrients are replaced by natural processes. In the attempt to increase crop production, crops are grown continuously on the land with no fallow period. This takes extra nutrients from the soil and if there is no source of fertiliser, soil fertility and crop yields both decline. Sometimes the soil structure is destroyed by over-cropping and the soil is eroded, by either wind or water. Irrigation is often seen as a way of increasing crop production by extending the growing season but if some of the irrigation water is not allowed to drain away into a nearby river, salt builds up as the irrigation water is evaporated and the resulting

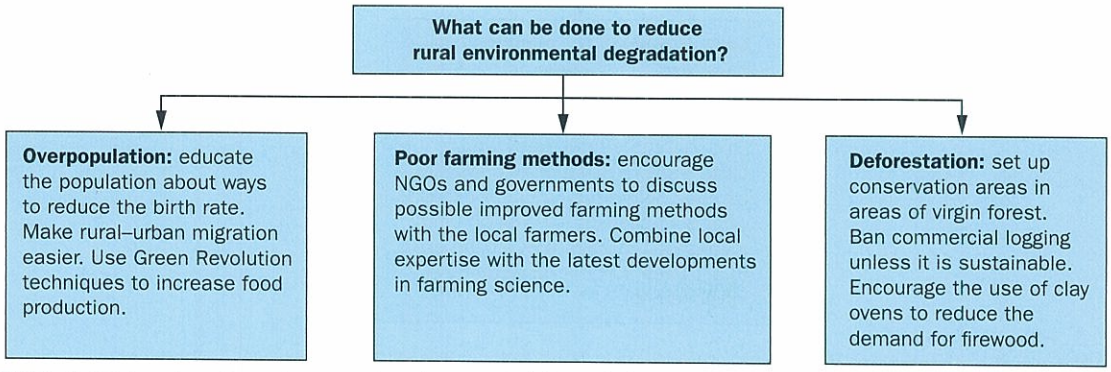

Fig. 12.27 What can be done to reduce rural environmental degradation?

salinisation renders the soil infertile. Attempts to increase food supply by increasing the number of grazing animals will often lead to overgrazing and soil erosion.

→ Deforestation is a technique used to increase the area under cultivation by clearing forest from nearby 'wilderness' areas. In hilly areas this can lead to landslides and other forms of soil erosion as there are no tree roots to hold the soil together. This has been a major problem in Nepal. Deforestation is also a result of population pressure in another way. In the rural areas of most LICs, fuelwood is the only source of domestic fuel. More people mean more households, with more fires and a greater demand for fuelwood. Wood is a critical renewable resource and once its use exceeds the rate at which new trees can grow, the whole area becomes treeless. With no trees to break the force of the wind and no tree roots to hold the soil together, soil erosion is the result.

What are the constraints that make reducing the degradation of rural environments so difficult?

Maintaining soil fertility is the key to preventing the degradation of rural environments. If soil fertility cannot be maintained, not only is the rural area degraded by soil exhaustion and soil erosion but food production is adversely affected. People, wherever they live, rely on farming to produce their food so the maintenance of rural environments should be a number one priority for everyone. Unfortunately, the evidence points to the fact that we are not maintaining soil fertility in large areas of the world, degrading more and more of the rural environment, and threatening our food supplies. What are the constraints that are preventing us from making progress with this important issue?

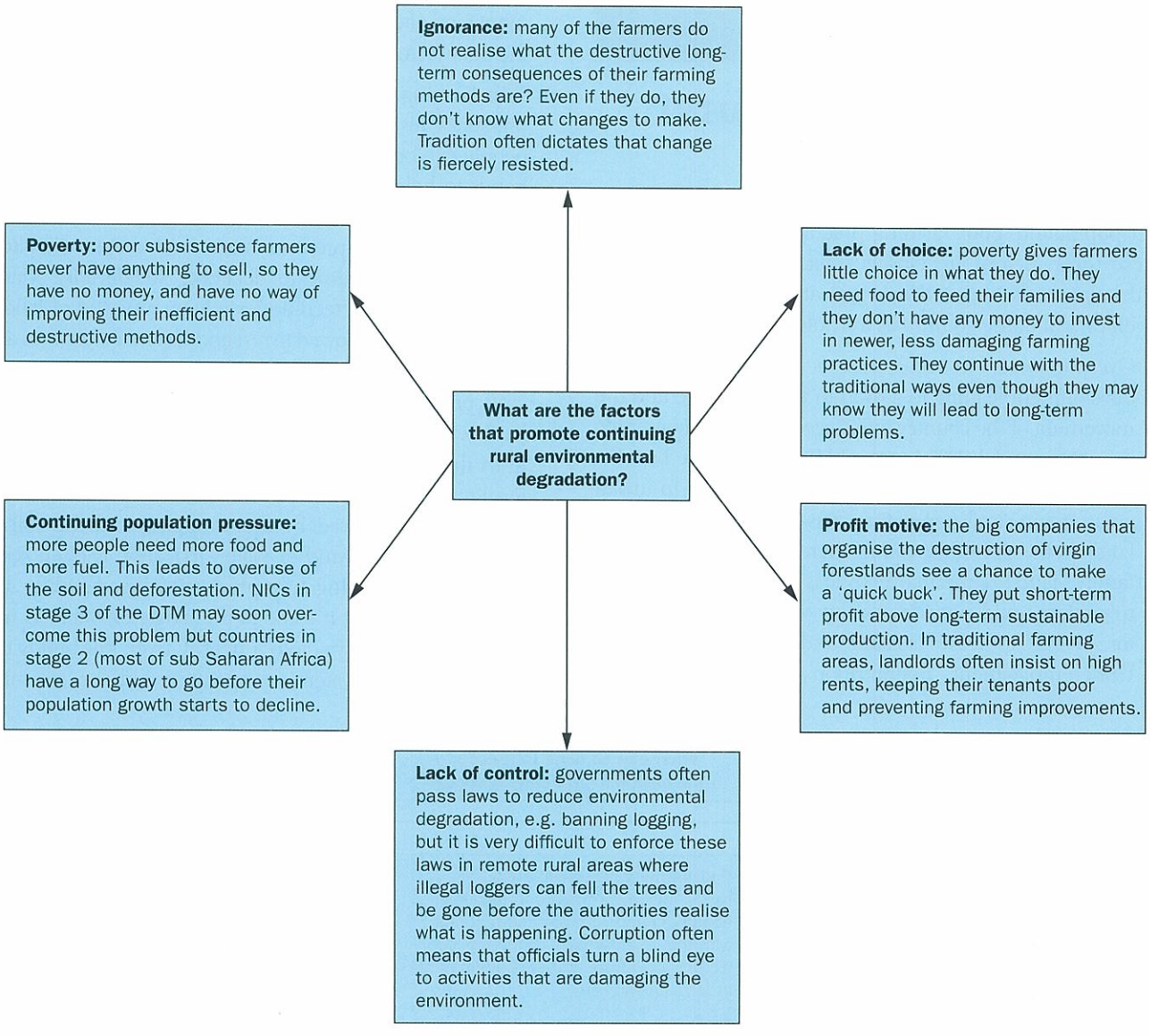

Fig. 12.28 What are the constraints that make reducing the degradation of rural environments so difficult?

The degradation of urban environments

The main factors in the degradation of urban environments are urbanisation, industrial development and inadequate waste management. In HICs, the degradation of urban environments is also related to inadequate infrastructure, social segregation, deindustrialisation and ageing and derelict buildings.

Because cities are open, dynamic systems they are subject to change, responding to the economic, environmental and social factors that affect them. Cities are useful places because they provide a range of functions which relate to their economic and social purpose. As people's needs change, city functions have to adapt. This leads to decline in some areas of the city and expansion in others. Regeneration is an attempt to improve the declining areas.

Traditionally, cities have grown outwards with new developments at their edge. However, the inner areas of HIC cities have declined as they have grown older. It is in the older industrial and residential areas where developers have been reluctant to spend money to regenerate run-down areas.

Factors causing the degradation of the urban environment in MIC cities

- *Urbanisation*: city growth has been very rapid in most MICs and NICs over the last 50 years, mostly as a result of rural-urban migration. The speed of city growth has meant that many of the developments have been unplanned and quite haphazard, especially the informal housing areas called **shanty towns** that have developed on the edges of these cities. The houses are made of whatever materials the people can find and they are generally very unsightly, causing visual pollution. Without electricity, people use wood or coal for fuel, causing air pollution.
- *Industrial development*: one of the reasons that people move to the cities is to get jobs. These jobs are often provided by the new factories that develop in the MIC cities. These factories contribute to economic growth but, in order to attract the TNCs that build the factories, the local environmental laws are not very strict. This means that air and water pollution are often a problem, degrading the urban environment around the factories.
- *Inadequate waste management*: as MIC cities have experienced rapid growth, waste disposal systems have struggled to keep up with the growth in the built-up area. Because the shanty towns are built by the people who live in them, there is no proper sewage disposal system or rubbish collection and the area very quickly becomes a very polluted, dirty and unhygienic environment. Because they are often built on marshy floodplain areas, rubbish and raw sewage gets into the rivers, causing water pollution.

Overall, the rapid growth of cities in MICs has led to large-scale environmental degradation and a very poor quality of life for many of the inhabitants of the cities, especially those living in the poorer suburbs.

What can be done to combat environmental degradation in MIC and NIC cities?

The main constraint is lack of money. As economic development proceeds, more money becomes available and, in time, the urban environment will be improved. However, the worst conditions in the shanty towns need to be dealt with as a matter of urgency. What has been done?

- City administrations have started up 'self-help' schemes where they provided the local people with the materials to improve their built environment themselves.
- City administrations have also installed clean water supplies, electricity and sanitation infrastructure in some shanty town areas, or in new areas where shanty town dwellers are encouraged (or compelled) to move.
- By improving public transport, city administrations can reduce congestion and air pollution.

Factors causing the degradation of the urban environment in HIC cities

- *Ageing and derelict buildings*: Most HIC cities experienced rapid growth in the past when the country industrialised. These cities have continued to grow outwards over time and the buildings nearest the centre have grown progressively older. It is in the **inner-city** zone where buildings have degenerated. As a building gets older, its structure starts to crumble. Walls crack and flake and roofs begin to leak. As the inner city areas are home to the poorest people, their landlords do not have much financial incentive to fix the properties. Eventually the housing becomes unfit for human habitation and it is abandoned and becomes derelict. Property developers have been reluctant to spend money re-generating these run down areas.
- *Inadequate infrastructure*: the **doughnut effect** is the movement of urban activities from the central areas of the city to the edge of the city where new ring roads provide excellent accessibility. Shops, offices and other urban functions have migrated to the edge. This movement was partly driven by the fact that the road transport infrastructure in the central area of the city was becoming inadequate. As traffic increased, the congested roads of the central areas could not cope. Traffic jams and air pollution were the result and this contributed to the blight of these inner-city areas which were already suffering from dereliction. It was easier and

cheaper to build new roads on the edge of town and the new developments followed. Property developers were not interested in spending money revitalising the derelict and congested inner-city areas where the urban environment was in a downward spiral.

- *Deindustrialisation*: as the processes of globalisation caused the manufacturing jobs to move from HICs to MICs/NICs, the factories in HIC cities began to close down. The oldest factories in the inner-city areas were most at risk and their closure led to dereliction and unemployment, further adding to the degradation of these old urban environments.
- *Social segregation*: the richer people moved out of the old inner-city zones into the modern suburbs on the urban fringe or even into new housing areas built in rural areas around the city. Only the poorest members of society were left in the inner city. They had no money to improve their homes and they paid very little tax so the local authorities had no funding to make improvements. The environmental degradation continued.
- *Waste management*: as people become richer they produce more rubbish. For many years this was collected by the council and buried in landfill sites, often on the edge of the city. These sites were smelly and unsightly and degraded the environment of the area around them. The trucks carrying the waste contributed to air pollution and traffic congestion in the city. Once full, the landfill sites leached chemicals into the groundwater, potentially polluting the city's water supply.

What can be done to combat environmental degradation in HIC cities?

Once again the main constraint is lack of money. Even in HICs, governments and councils do not have an unlimited supply of cash. Local authority renovation schemes have often failed to be successful because they were built cheaply and soon degenerated. The private sector needs to be involved in renovating rundown urban areas but the private sector will only get involved if a profit can be made.

In HICs, urban regeneration schemes have included the following:

- *Cooperation between government and the private sector* – a well known example is the London Docklands Development Corporation (see next case study), which was set up in the 1980s. The government relaxed the planning laws and ignored the wishes of local people. They acquired the land, cleared it and put in new infrastructure. They then encouraged private investors to build high profit buildings, such as office blocks and upmarket accommodation. A very large area of derelict urban space was successfully regenerated.
- *Sustainable communities* – carbon-neutral, small-scale urban developments were encouraged at the start of the 21st century. As well as environmental sustainability (e.g. being carbon neutral), sustainable communities aim to be economically sustainable, by providing local job opportunities, and socially sustainable, by ensuring local people have adequate educational provision and decent healthcare. They aim to tackle multiple deprivation and social exclusion.
- *Improved waste management* partly as a result of the **Agenda 21** initiative, city authorities have introduced recycling and composting schemes to cut down on the amount of domestic waste that has to be disposed of in landfill. Waste that cannot be recycled or composted is burnt in waste-to-energy incinerators, producing electricity.

The protection of environments at risk

The first step in protecting environments at risk is to recognise that they are at risk. The factors leading to environmental degradation need to be recognised and strategies need to be devised to combat them, reducing the risk to the environment. There are many ways that environments can be protected and even returned to their former state. Because most environments at risk (or ones that have already been degraded) have a human population, these strategies need to consider economic and social factors as well as purely environmental considerations.

If the strategies for the protection of environments at risk are to be sustainable in the long term they need to consider needs, measures and outcomes:

- *Needs* – what is the current situation and what needs to be done to protect the environment, or to prevent its further degradation, or to return it to its previous state? What are the long-term aims of the plan?
- *Measures* – what are the different policies and strategies that could be adopted to achieve the aims of the plan? Each possible way forward needs to be evaluated in terms of its economic and social cost and in terms of its impact on the environment. The strategies adopted should not destroy the livelihoods of the local people.

Case study: Urban decline and regeneration: the London Docklands

The London Docklands is the name of an area of east London in the UK. The docks were once part of the Port of London – the world's largest port in its day. The surrounding areas were cheap residential areas, housing the dockers and the people who worked in the related port industries. By the 1960s, **containerisation** and the increasing size of ships had led to the decline of the London docks and the associated port industries – trade moved downriver to the deepwater harbours such as Tilbury. By 1980, all of London's docks were closed, leaving 8 square miles of derelict land in east London.

Why was regeneration needed?

When the docks closed, 12 000 jobs were lost and the dockers did not have the transferable skills to allow them to find other jobs in the area. Unemployment led to poverty and serious social problems. There were large areas of derelict buildings that required complete redevelopment. The infrastructure of the area was poor with inadequate transport links to the rest of London.

Who would invest?

The land was owned by many different groups, from local councils to private individuals and companies. Piecemeal investment in a multitude of small areas did not seem attractive. The lack of new housing meant builders of private housing had no idea what the return on new houses would be and did not want to take the risk of investing large sums building them. The poor infrastructure meant private companies were deterred from investing – infrastructure projects are usually the responsibility of national or local government. Who was going to save the Docklands?

How did the re-generation begin?

To solve the problem, in 1981 the UK government started the London Docklands Development Corporation (LDDC) to redevelop the area. The LDDC could acquire land for development by agreement or by **compulsory purchase**. They had the funds and the powers to create a new infrastructure and to foster the development of public services such as housing, schools and hospitals. In 1982 the LDDC also designated an enterprise zone in which businesses were exempt from property taxes and had other incentives such as simplified planning regulations and capital grants. This made private investment in the area an attractive proposition. In fact most of the redevelopment was organised and funded by private companies who realised that rich profits could be made.

Was it a success?

Unemployment was reduced by a combination of training projects, improvements in transport to-and-from the rest of London and the creation of new local jobs. Regenerating the Docklands cost £3.9 billion of public money, mostly spent on improving the transport infrastructure. Private sector investment was £8.7 billion by 1998 and still continues to this day. The Canary Wharf area has become a vibrant financial and banking area. The LDDC has generated a range of economic, environmental and social improvements, including 80 000 new jobs and 24 000 new housing units. The Docklands Light Railway, the London City airport and 144 km of new roads have improved the transport infrastructure. 25 million square feet of industrial/commercial floor space has been built. 1884 acres of derelict land have been reclaimed. Five new health centres and 25 new schools or colleges have been created. The Canary Wharf area is seen as a symbol of Britain's wealth and prestige and most commentators regard the project as a success.

However, there have been some criticisms. Many of the new housing units were very expensive. The original dockland inhabitants could not afford them and felt they were being pushed aside. Many of the older dockers were not able to benefit from retraining (although their children have) and they remained unemployed and poor.

- *Outcomes* – the level of success of the chosen strategies must be evaluated at each stage of their implementation. Where necessary, strategies should be modified if they are failing to produce the desired effects. They may also need to be modified to cope with unforeseen circumstances.

Most of the schemes involve conservation in some form or another. Conservation is defined as the preservation, management and enhancement of the natural environment.

In rural areas this usually involves setting up a National Park or other large conservation area where laws are introduced to protect and enhance the environment. In the USA, National Parks are mostly wilderness areas where human impact has been minimal and the aim of the park is to maintain the pristine wilderness while still allowing people to visit it. In Kenya, the National Parks are similarly designed to protect wildlife and the natural environment but these are areas where people have traditionally made a living by hunting, herding and farming. This has led to conflicts between the park rangers and the local population, for example, over poaching for elephant ivory. In the UK the National Parks were set up in scenic rural areas where farming was already well established. There was no real effort to return these areas to their original, natural state but simply to preserve and enhance the environment that had developed over time. The two main aims of the UK National Parks were *conservation* and *recreation*, aims that are not always compatible.

In towns and cities, conservation tends to be more small-scale in nature, tackling problems in localities within the urban area. In the UK, urban ecological conservation areas have been set up in order to:

- encourage existing wildlife back into the urban area
- maintain bio-diversity and reintroduce locally extinct species
- provide green spaces for the people of the urban area to use for relaxation and recreation
- make cheap use of derelict land that would be more expensive to set up as a park or public gardens.

Work done includes:

- planting trees and other native species
- setting up nest boxes and bat boxes
- dredging and extending ponds
- returning urban floodplains back to their natural wetland state.

Organisations behind this work include:

- town and city councils
- local community groups
- Natural England and the Environment Agency – government-funded environmental organisations
- the National Trust and other private charity organisations including the National Urban Forestry Unit.

Different **stakeholders** have different priorities:

- Local councils have planning needs and must balance the desire to make use of derelict land with the cost to local taxpayers.
- Conservation groups are mostly concerned with protecting plants and animals and enhancing their environment.
- Local people are often interested in leisure activities like dog-walking, fishing and playing sport.

When it is decided to set up an ecological conservation area, a lot needs to be done. Ownership of the land has to be determined and resolved. A management plan has to be devised and costed. The needs and desires of the various user-groups and stakeholders have to be considered and reconciled. Funding has to be obtained. Despite this, many successful schemes have been approved and created.

15. Suggest how conflicts may arise over the use of open space in urban areas.

RESEARCH Make your own case studies on the following:

- The Central Amazon Conservation Complex – a regional-scale project to prevent degradation of the rainforest.
- A small-scale urban conservation project.

The management of a degraded environment

This section comprises a case study which looks at the issues surrounding environmental degradation in a rapidly-developing part of China.

Key concepts

The key concepts listed in the syllabus are set out below. For each one a summary of how it applies to this chapter is included.

Space: the global distribution of energy use is an example of this concept. Where do people use a lot of energy and where is very little used?

Scale: environmental degradation can take place at a variety of spatial scales. A landslide resulting from deforestation in the Nepalese Himalayas would be a local-scale example. Water pollution due to industrial development in the Pearl River delta in China is an example at the regional scale. The spread of radioactive pollution from Chernobyl could be considered a continental-scale example because most of Europe was affected. Climate change resulting from global warming is an environmental problem at the global scale (as its name suggests). Timescale is also important. The effects of the Chernobyl radioactive cloud were relatively shortlived in western Europe but the effects are still being felt in the countries closer to the source of the pollution. The local area very close to the Chernobyl plant could be contaminated for many years into the future.

Place: the distinctive characteristics of southern Norway make it an ideal location for HEP stations. The physical characteristics of the high fjell (cool, rainy, and with high relief) combined with the human characteristics (sparse population therefore ideal for reservoir construction) make this place one of the main HEP-producing areas in the world.

Environment: energy production, transport and use can have a major impact on the natural environment. The importance of energy in stimulating economic development and the growing realisation that we should also protect our environment have combined to ensure that people are now looking at ways of producing energy in a much more sustainable way. At some point in the near future we should have the technologies that will allow us to leave the remaining fossil fuels in the ground but still have energy security. By studying environmental degradation in rural areas we have come to realise the importance of maintaining soil fertility so that we can ensure food security in the future.

Interdependence: some countries have more energy reserves than they need while others don't have enough energy sources to maintain their economic growth. This has led to the global trade in energy resources, especially fossil fuels. Some countries (e.g. OPEC countries) are prepared to cooperate to maintain their control of this trade while other countries resort to armed conflict to ensure their energy supplies. The environmental impact of the trade in energy resources can be significant, especially when things go wrong. The strong links between energy use and economic development help to explain why some countries are richer than others.

Diversity: each country's primary energy mix reflects the unique conditions prevailing in that country now and in the past. Chad uses fuelwood because it is cheap and Chad is a poor country. France uses large amounts of nuclear power because they can afford the technology and they have few reserves of fossil fuels. Norway depends on HEP because its physical environment is ideally suited to its production. The UK uses a lot of natural gas because it has large gas fields and natural gas is a clean fuel – UK governments are usually committed to reducing pollution. The combination of physical resources, economic wealth and political priorities ensure that national energy use is extremely diverse.

Change: environmental degradation is an example of change over time. It is important to understand the reasons for environmental degradation in one place so that similar problems can be predicted elsewhere and possibly avoided. Understanding how present day pollution can lead to future problems is essential if we are to avoid those future problems. The impact of energy use on the atmosphere is leading to climate change. We had been burning fossil fuels for two hundred years before scientists noticed the change in CO_2 concentrations and linked this to changes in global temperatures. Running computer programmes to see how these changes would affect the future allowed us to predict future problems and hopefully devise ways of avoiding them. The alternative is to accept the climate change, accept the rise in sea level and develop ways of living with these changes.

Exam-style questions

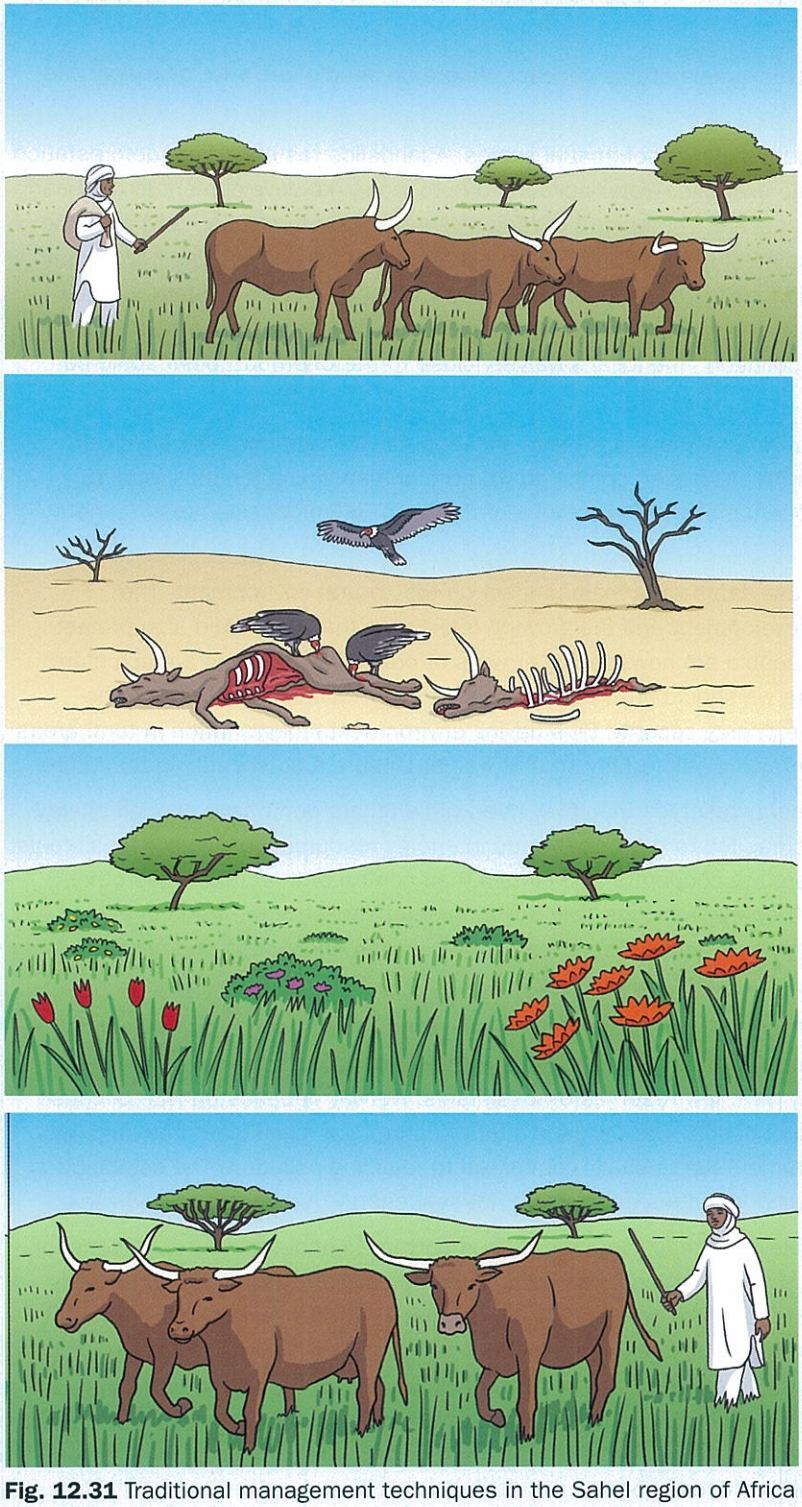

Fig. 12.31 Traditional management techniques in the Sahel region of Africa

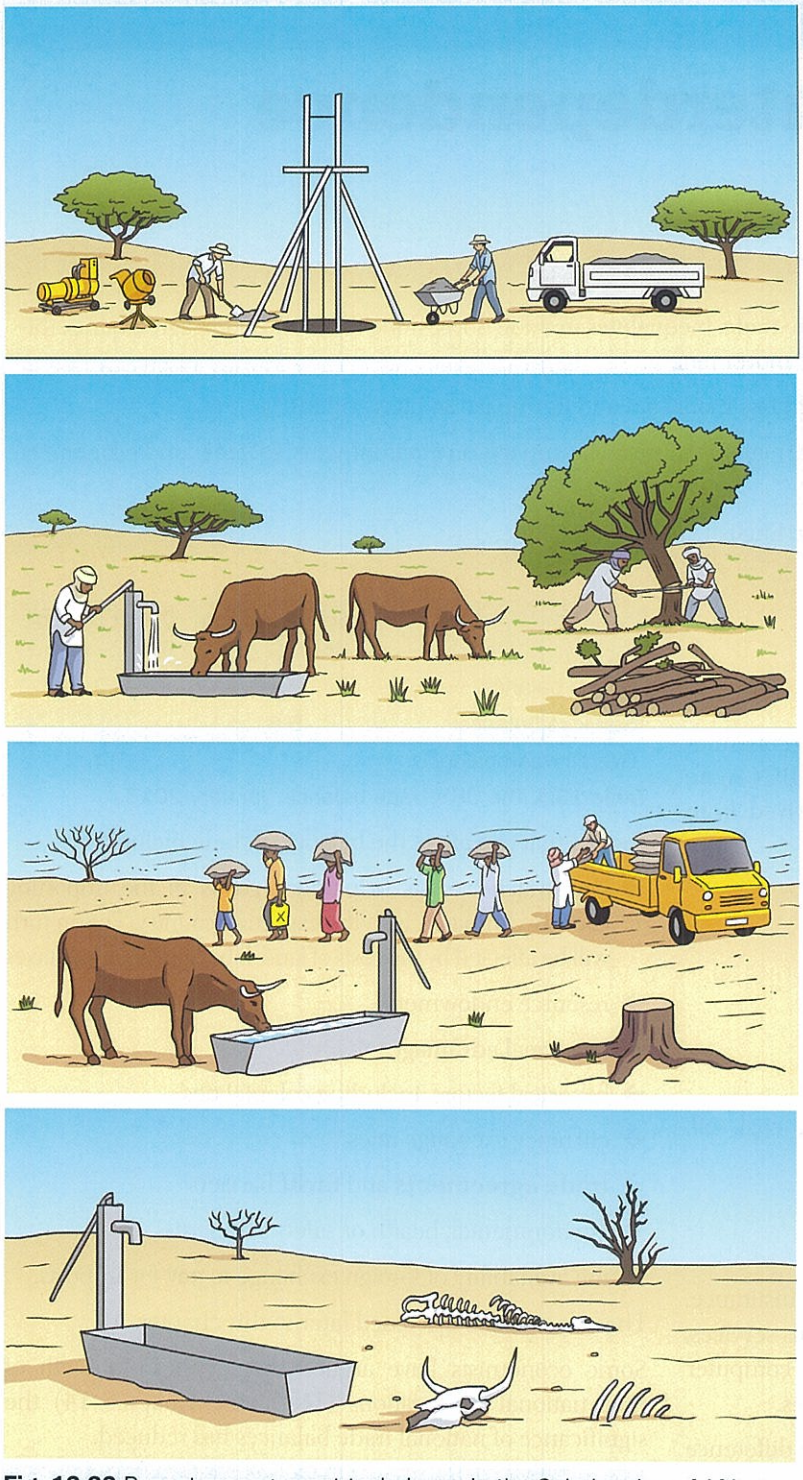

Fig. 12.32 Recent management techniques in the Sahel region of Africa

1

(a) Compare the sustainability of the traditional and the recent management techniques shown in Fig. 12.31 and Fig. 12.32. [4]

(b) Suggest why it will be difficult to improve the degraded environment shown in the fourth picture in Fig. 12.32? [6]

2 For one country that you have studied, assess the success of the strategies that have been used to ensure that the supply of electrical energy is secure and sustainable. [20]