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2ND EDITION

GEOGRAPHY

COURSE COMPANION

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Course Companion definition

The IB Diploma Programme Course Companions are resource materials designed to support students throughout their two-year Diploma Programme course of study in a particular subject. They will help students gain an understanding of what is expected from the study of an IB Diploma Programme subject while presenting content in a way that illustrates the purpose and aims of the IB. They reflect the philosophy and approach of the IB and encourage a deep understanding of each subject by making connections to wider issues and providing opportunities for critical thinking.

The books mirror the IB philosophy of viewing the curriculum in terms of a whole-course approach; the use of a wide range of resources, international mindedness, the IB learner profile and the IB Diploma Programme core requirements, theory of knowledge, the extended essay, and creativity, activity, service (CAS).

Each book can be used in conjunction with other materials and indeed, students of the IB are required and encouraged to draw conclusions from a variety of resources. Suggestions for additional and further reading are given in each book and suggestions for how to extend research are provided.

In addition, the Course Companions provide advice and guidance on the specific course assessment requirements and on academic honesty protocol. They are distinctive and authoritative without being prescriptive.

IB mission statement

The International Baccalaureate aims to develop inquiring, knowledgable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

To this end the IB works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.

These programmes encourage students across the world to become active, compassionate, and lifelong learners who understand that other people, with their differences, can also be right.

The IB learner Profile

The aim of all IB programmes is to develop internationally minded people who, recognizing their common humanity and shared guardianship of the planet, help to create a better and more peaceful world. IB learners strive to be:

Inquirers They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning and this love of learning will be sustained throughout their lives.

Knowledgable They explore concepts, ideas, and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.

Thinkers They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems, and make reasoned, ethical decisions.

Communicators They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.

Principled They act with integrity and honesty, with a strong sense of fairness, justice, and respect for the dignity of the individual, groups, and communities. They take responsibility for their own actions and the consequences that accompany them.

Open-minded They understand and appreciate their own cultures and personal histories, and are open to the perspectives, values, and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view, and are willing to grow from the experience.

Caring They show empathy, compassion, and respect towards the needs and feelings of others. They have a personal commitment to service, and act to make a positive difference to the lives of others and to the environment.

Risk-takers They approach unfamiliar situations and uncertainty with courage and forethought, and have the independence of spirit to explore new roles, ideas, and strategies. They are brave and articulate in defending their beliefs.

Balanced They understand the importance of intellectual, physical, and emotional balance to achieve personal well-being for themselves and others.

Reflective They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development.

A note on academic honesty

It is of vital importance to acknowledge and appropriately credit the owners of information when that information is used in your work. After all, owners of ideas (intellectual property) have property rights. To have an authentic piece of work, it must be based on your individual and original ideas with the work of others fully acknowledged. Therefore, all assignments, written or oral, completed for assessment must use your own language and expression. Where sources are used or referred to, whether in the form of direct quotation or paraphrase, such sources must be appropriately acknowledged.

How do I acknowledge the work of others?

The way that you acknowledge that you have used the ideas of other people is through the use of footnotes and bibliographies.

Footnotes (placed at the bottom of a page) or endnotes (placed at the end of a document) are to be provided when you quote or paraphrase from another document, or closely summarize the information provided in another document. You do not need to provide a footnote for information that is part of a 'body of knowledge'. That is, definitions do not need to be footnoted as they are part of the assumed knowledge.

Bibliographies should include a formal list of the resources that you used in your work. The listing should include all resources, including books, magazines, newspaper articles, Internet-based resources, CDs and works of art. 'Formal' means that you should use one of the several accepted forms of presentation. You must provide full information as to how a reader or viewer of your work can find the same information. A bibliography is compulsory in the extended essay.

What constitutes misconduct?

Misconduct is behaviour that results in, or may result in, you or any student gaining an unfair advantage in one or more assessment component. Misconduct includes plagiarism and collusion.

Plagiarism is defined as the representation of the ideas or work of another person as your own. The following are some of the ways to avoid plagiarism:

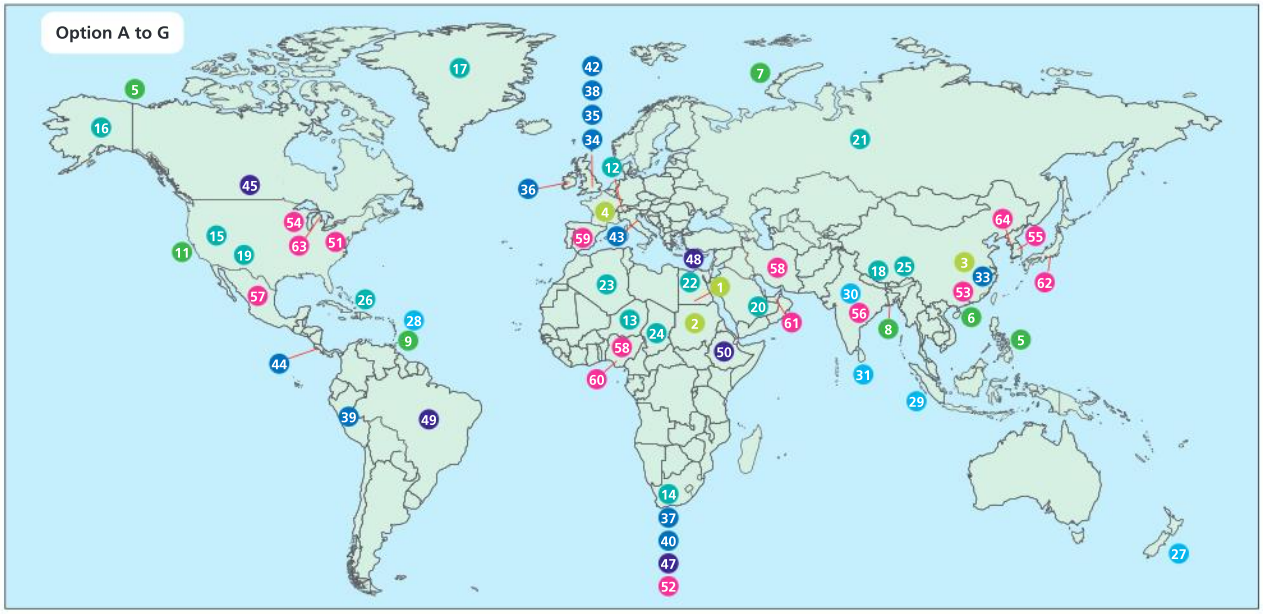
- Words and ideas of another person used to support one's arguments must be acknowledged.
- Passages that are quoted verbatim must be enclosed within quotation marks and acknowledged.
- CD-ROMs, email messages, web sites on the Internet, and any other electronic media must be treated in the same way as books and journals.
- The sources of all photographs, maps, illustrations, computer programs, data, graphs, audio-visual, and similar material must be acknowledged if they are not your own work.
- Works of art, whether music, film, dance, theatre arts, or visual arts, and where the creative use of a part of a work takes place, must be acknowledged.

Collusion is defined as supporting misconduct by another student. This includes:

- allowing your work to be copied or submitted for assessment by another student
- duplicating work for different assessment components and/or diploma requirements.

Other forms of misconduct include any action that gives you an unfair advantage or affects the results of another student. Examples include, taking unauthorized material into an examination room, misconduct during an examination, and falsifying a CAS record.

The location of case studies



Option A – Freshwater – Drainage basins

1. Egypt – Aswan Dam
2. Nile Basin
3. China – water diversion
4. Europe – river regimes

Option B – Oceans and coastal margins

5. Philippines – Typhoon Haiyan
6. South China sea – geopolitics
7. Arctic – geopolitics
8. Bangladesh – flow mitigation
9. St Lucia – coastal management
10. USA – floods
11. USA – oceanside littoral cell

Option C – Extreme environments

12. Switzerland – Gorner Glacier
13. Sahara – climate changes
14. Eastern Cape, South Africa – farming in semi-arid areas
15. Rosemont Copper, Arizona, USA
16. Alaska National Wildlife Refuge
17. Greenland – resource nationalism
18. Nepal – Tourism
19. New Mexico, USA – tourism
20. Middle East – resource security
21. Yamal Peninsula, Russia – oil megaproject
22. Sustainable farming in Egypt
23. Sahara – solar energy
24. Sahel – coping in semi-arid areas
25. Nepal landslides, 2015
26. Haiti earthquake, 2010

Option D – Geophysical hazards

27. Christchurch earthquake, 2010, 2012
28. Soufrière Hills, volcano, Montsalvat
29. Mt. Sinabung volcano, Indonesia
30. Urban Landslides, Kalimpong, West Bengal India
31. Landslides in Sri Lanka, 2016
32. Reconstructing Haiti

Option E – Leisure, tourism and sport

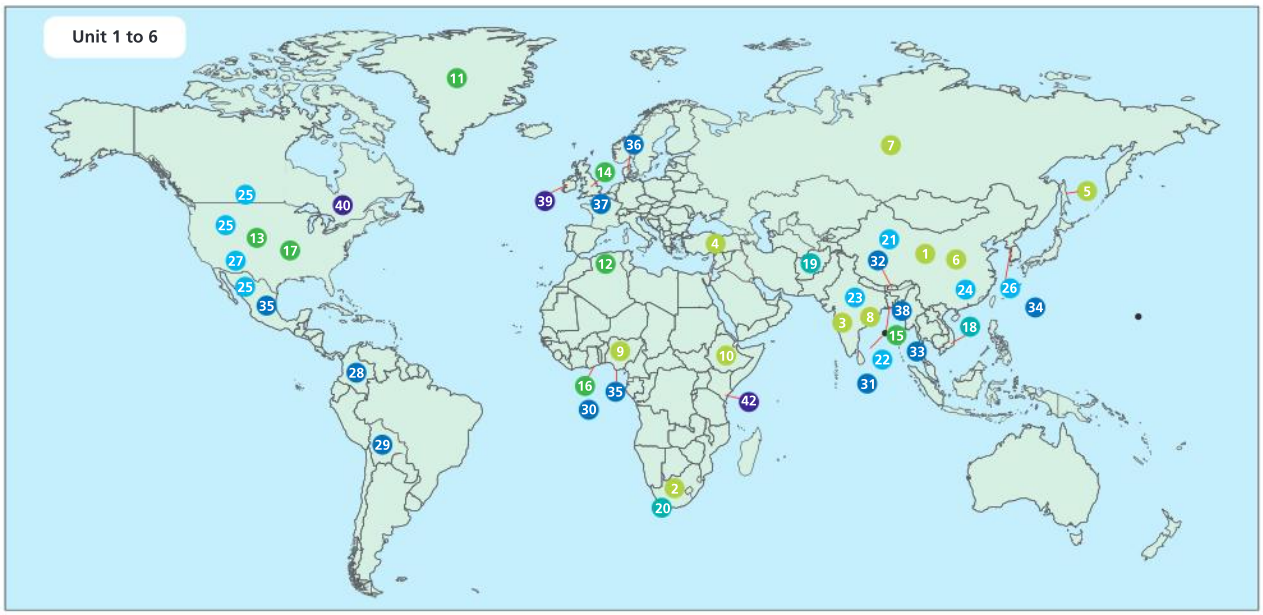
33. China's theme park
34. Participation in sport in UK
35. Oxford – tourism hotspot
36. Killarney National Park
37. National sports league in South Africa
38. Glastonbury festival
39. Machu Picchu – heritage tourism
40. Tourism as a national development strategy – South Africa
41. Tourism in the Maldives
42. London Olympic Games
43. Venice – urban tourism hotspot
44. Monteverde cloud forest, Costa Rica

Option F – The geography of food and health

45. HALE in Canada
46. Epidemiological transition in USA, China and Afghanistan
47. Food consumption in Cape Town
48. Food consumption in the Middle East
49. Changing dietary patterns in Brazil
50. Famine in Ethiopia

Option G – Urban environments

51. Land-use in New York
52. Gentrification and relocation in Cape Town, South Africa
53. Changing urban environment – Shanghai
54. Urban decline in Detroit
55. Urban microclimate, Seoul, South Korea
56. Air pollution in Delhi, India
57. Managing air pollution in Mexico City
58. Urban crime, Iran and Nigeria
59. Urban deprivation and regeneration in Barcelona
60. Protecting Lagos
61. Masdar City
62. Tokyo's ecological footprint
63. Environmental measures in Chicago
64. Songdo International Business District, South Korea



Unit 1 – Changing population

1. Population distribution in China
2. Population distribution in South Africa
3. Megacity growth – Mumbai
4. Forced migration from Syria
5. Japan's ageing population
6. China's one-child policy
7. Pro-natalist policies in Russia
8. Literacy and gender in Kerala
9. Trafficking of Nigerian women to Europe
10. Ethiopia and the demographic dividend

Unit 2 – Global climate – vulnerability and resilience

11. Negative feedback in Greenland
12. The retreat of Swiss glaciers
13. The destruction of forests in the USA
14. Climate change and the UK
15. Flooding in Bangladesh
16. Vulnerability and adaptation in Ghana
17. Corporate change mitigation in the USA

Unit 3 – Global resource consumption and security

18. Economic growth in Vietnam
19. Food, water and energy security in Hindu Kush
20. Improving food security in South Africa

Unit 4 – Power, places and networks

21. China – a rising superpower
22. Aid and Bangladesh
23. The Tata Group
24. The Apple Group
25. NAFTA
26. Incheon, South Korea
27. Migration control in the USA

Unit 5 – Human development and Diversity

28. Empowering women in Colombia
29. Mapajo Lodge, Bolivia
30. Fair trade pineapples in Ghana
31. The Rana Plaza disaster, Bangladesh
32. Cultural change in Tibet
33. Cultural change in the Andaman Islands
34. Cultural diffusion in Seoul, South Korea
35. Shell and Ogoniland, Nigeria
36. Denmark's immigration laws
37. The "Jungle" in Calais, France
38. Political change in Myanmar

Unit 6 – Global risks and resilience

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40. Acid rain in Eastern Canada
41. *Maquiladora* developments in Mexico
42. Water problems and flower farming in Kenya

Contents

Preparing for the exam

Available on: **www.oxfordsecondary.co.uk/9780198396031**

Additional case studies are available wherever you see this icon: 

OPTION A
FRESHWATER – DRAINAGE BASINS

Key terms

Drainage basin	The area drained by a river and its tributaries.
Freshwater	Freshwater includes rivers, lakes, wetlands, groundwater, glaciers and ice caps.
Hydrological cycle	A conceptual model that describes the storage and movement of water between the biosphere, atmosphere, lithosphere and the hydrosphere.
Watershed	Also known as the drainage divide, this is the imaginary line defining the boundary of a river or stream drainage basin separating it from the adjacent basin(s).
Discharge	The volume of water passing a given point over a set time.
Physical water scarcity	Lack of available water where water resource development is approaching or has exceeded unsustainable levels; it relates availability to demand and implies that arid areas are not necessarily water scarce.
Economic water scarcity	Lack of water where water is available locally, but not accessible for human, institutional or financial capital reasons.
Storm hydrograph	A graph showing how a river changes over a short period, such as a day or a couple of days.
Flood	A discharge great enough to cause a body of water to overflow its channel and submerge surrounding land.

This optional theme encompasses the physical geography of freshwater in a systems framework, including core elements of hydrology (and the factors and processes that give rise to bankfull discharge and flooding) and fluvial geomorphology (including river process and landform study).

It also covers the study of water on the land as a scarce resource requiring careful management, including freshwater bodies such as lakes and aquifers. This includes the ways in which humans respond to the challenges of managing the quantity and quality of freshwater, as well as the consequences (whether intended or unintended, positive or negative) of management within drainage basins.

The importance of integrated planning is emphasised, in addition to the geopolitical consequences of growing pressures on internationally shared water resources.

Through study of this optional theme, students will develop their understanding of processes, places, power and geographical possibilities. They will also gain understanding of other concepts including systems (the hydrological cycle), flood mitigation (attempts to tackle flooding) and water security.

Key questions

1. How do physical **processes** influence drainage basin systems and landforms?
2. How do physical and human factors both increase (exacerbate) and reduce (mitigate) flood risk for different **places**?
3. What are the varying **powers** of different stakeholders in relation to water management issues?
4. What are the future **possibilities** for management intervention in drainage basins?

1 Drainage basin hydrology and geomorphology

Conceptual understanding

Key question

How do physical **processes** influence drainage basin systems and landforms?

Key content

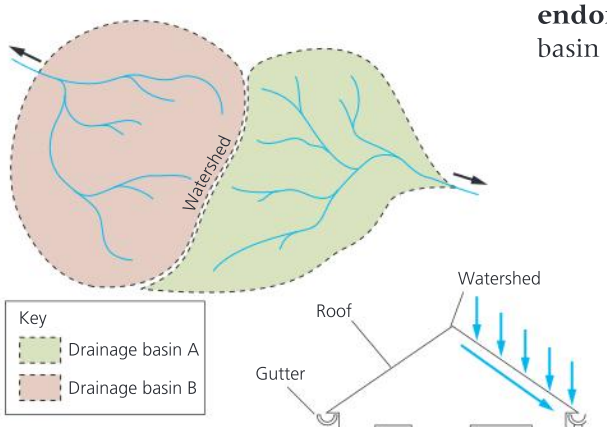
- The drainage basin as an open system, with inputs (precipitation of varying type and intensity), outputs (evaporation and transpiration), flows (infiltration, throughflow, overland flow and base flow) and stores (including vegetation, soil, aquifers and the cryosphere).
- River discharge and its relationship to stream flow (velocity) and channel shape/hydraulic radius.
- River processes of erosion, transportation and deposition, and spatial and temporal factors that influence their operation, including channel characteristics and seasonality.
- The formation of typical river landforms including waterfalls, floodplains, meanders, levees and deltas.

The drainage basin as an open system

A **drainage basin** is an area within which water supplied by precipitation is transferred to the ocean, a lake or larger stream. It includes all of the area that is drained by a river and its tributaries. Drainage basins are divided by watersheds (also known as drainage divides) – imaginary lines separating adjacent basins (Figure A.1). The watershed is rather like the top of a sloping roof, dividing water into one gutter or another.

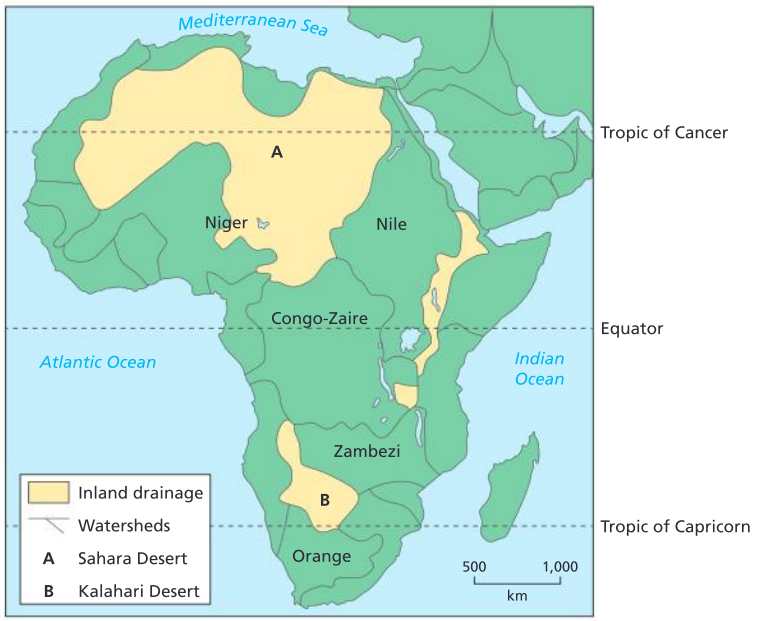
Some drainage basins are extremely large. Figure A.2 shows the major drainage basins for Africa. In contrast, very small drainage basins occur in small streams near the source of a river. Figure A.3 shows some drainage basins and watersheds for streams in the Arthur's Pass region of New Zealand.

Some rivers drain into the sea – the Nile is a good example. Others do not reach the sea but drain into an inland depression for example. These drainage basins are called **endorheic** or **closed drainage basins**. The Okavango drainage basin on Figure A.2 is an example of an endorheic basin.



The watershed is like the top of a roof – water that falls on one side of the roof flows in one direction, into one set of gutters and drains (the drainage basin, its rivers and streams). On the other side of the watershed (which is normally high ground), the water drains in a different direction.

▲ **Figure A.1:** Drainage basins and watershed



▲ **Figure A.2:** Major drainage basins in Africa

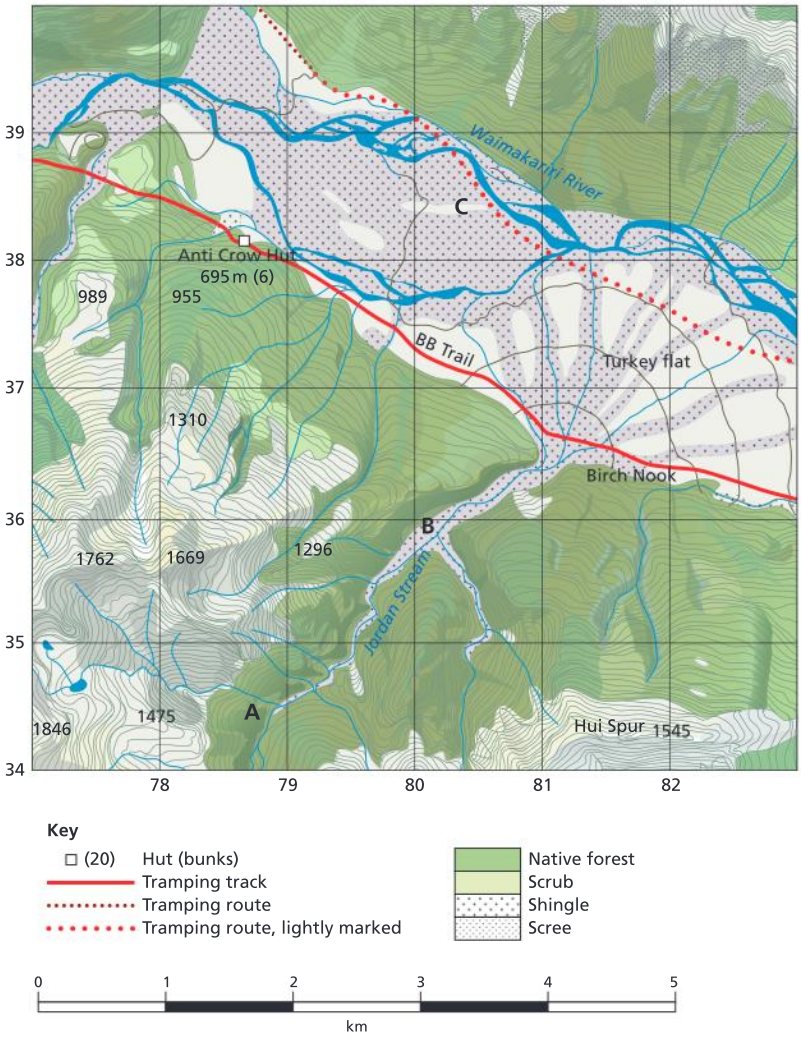


Figure A.3: A small drainage basin: Arthur's Pass, New Zealand

Activity 1

Compare the drainage basins of the rivers at A, B and C in Figure A.3.

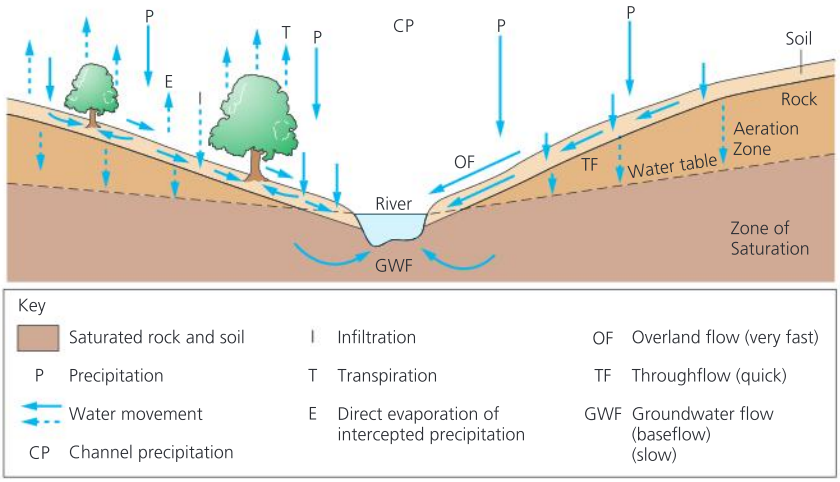
Activity 2

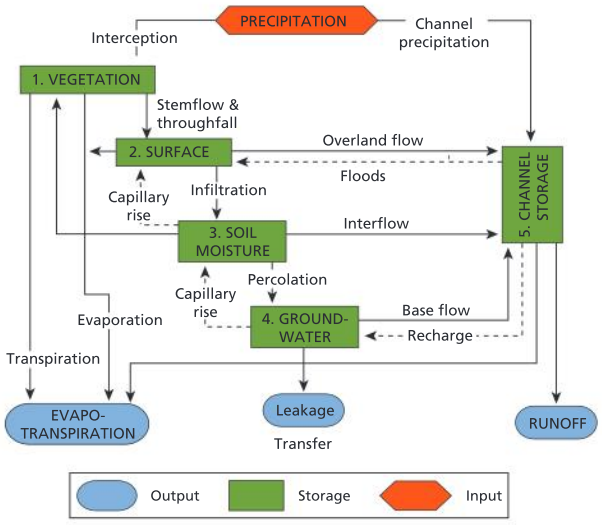
1. Identify three stores and three processes in the drainage basin system.
2. Explain why drainage basins are considered to be open systems.

The drainage basin as an open system, including the major flows and stores

The **hydrological cycle** refers to the cycle of water between the biosphere, atmosphere, lithosphere and hydrosphere. At a local scale – the drainage basin (Figure A.4) – the cycle has a single input, precipitation (PPT), and two major losses (outputs), evapotranspiration (EVT) and run-off. A third output, leakage, may also occur from the deeper subsurface to other basins. The drainage basin system is an **open system** as it allows the movement of energy and matter across its boundaries (Figure A.5). Water can be stored at a number of stages or levels within the cycle. These stores include vegetation, surface, soil moisture, groundwater and water channels. These stores are linked by a number of flows.

Figure A.4: Drainage basin hydrology





▲ **Figure A.5:** Drainage basin hydrology – a systems approach

▲ **Photo A.1:** Soil erosion leads to soil compaction and increased overland flow

Inputs

Precipitation

The main input into the drainage basin is **precipitation**. Precipitation includes all forms of rainfall, snow, frost, hail and dew. It is the conversion and transfer of moisture in the atmosphere to the land. The main characteristics of precipitation that affect local hydrology are:

- the total amount of precipitation
- intensity
- type (snow, rain and so on)
- geographic distribution and
- variability.

Other inputs could include irrigation water, water transfer schemes and the use of desalinated water.

Outputs

Evaporation

Evaporation is the process by which a liquid or a solid is changed into a gas. It is the conversion of solid and liquid precipitation (snow, ice and water) to water vapour in the atmosphere. It is most important from oceans and seas. Evaporation increases under warm, dry conditions and decreases under cold, calm conditions. Evaporation losses will be greater in arid and semi-arid climates than they will be in polar regions.

Factors affecting evaporation include meteorological influences such as temperature, humidity and wind speed. Of these, temperature is the most important factor. Other factors include the amount of water available, vegetation cover and colour of the surface (albedo or reflectivity of the surface).

Evapotranspiration

Transpiration is the process by which water vapour escapes from living plants, mainly the leaves, and enters the atmosphere. The combined effects of evaporation and transpiration are normally referred to as evapotranspiration (EVT). EVT represents the most important aspect of water loss, accounting for the loss of nearly 100 per cent of the annual precipitation in arid areas and 75 per cent in humid areas. Only over ice and snow fields, bare rock slopes, desert areas, water surfaces and bare soil will purely evaporative losses occur.

Potential evapotranspiration (P.EVT)

The distinction between actual EVT and potential evapotranspiration (P.EVT) lies in the concept of **moisture availability**. Potential evapotranspiration is the water loss that would occur if there was an unlimited supply of water in the soil for use by the vegetation. For example, the actual evapotranspiration rate in Egypt is less than 250 mm, because there is less than 250 mm of rain annually. However, given the high temperatures experienced in Egypt, if the rainfall was as high as, say, 2,000 mm, there would be sufficient heat to evaporate that water. Hence the potential evapotranspiration rate there is 2,000 mm. The factors affecting evapotranspiration include all of those that affect evaporation. In addition, some plants have adapted to help them reduce moisture loss, such as cacti.

Flows

Infiltration

Infiltration is the process by which water soaks into or is absorbed by the soil. The **infiltration capacity** is the maximum rate at which rain can be absorbed by a soil in a given condition.

Infiltration capacity decreases with time during a period of rainfall, until a more or less constant value is reached. Infiltration rates of 0–4 mm^{-1}/$hour^{-1}$ are common on clay soils whereas 3–12 mm/hour are common on sand soils. Vegetation also increases infiltration. This is because it intercepts some rainfall and slows down the speed at which it arrives at the surface. For example, on bare soils where rain-splash impact occurs, infiltration rates may reach 10 mm/hour. On similar soils covered by vegetation, rates of 50–100 mm/hour have been recorded. Infiltrated water is chemically rich as it picks up minerals and organic acids from vegetation and soil. Plant roots provide fine channels for percolation (percolines).

Infiltration is inversely related to overland run-off and is influenced by a variety of factors such as duration of rainfall, antecedent soil moisture (pre-existing levels of soil moisture), soil porosity, vegetation cover, raindrop size and slope angle.

Overland flow

Overland flow (surface run-off) is water that flows over the land's surface. It occurs in two main ways:

- when precipitation exceeds the infiltration rate
- when the soil is saturated (all the pore spaces are filled with water).

In areas of high precipitation intensity and low infiltration capacity, overland run-off is common. This is seen clearly in semi-arid areas and in cultivated fields. By contrast, where precipitation intensity is low and infiltration is high, most overland flow occurs close to streams and river channels.

Throughflow refers to water flowing through the soil in natural pipes and **percolines** (lines of concentrated water flow between soil horizons).

Base flow refers to the part of a river's **discharge** that is provided by groundwater seeping into the bed of a river. It is a relatively constant flow although it increases slightly following a wet period.

Stores

Vegetation

Interception refers to water that is caught and stored by vegetation. There are three main components:

- **interception** – water that is retained by plant surfaces and which is later evaporated away or absorbed by the plant
- **throughfall** – water that either falls through gaps in the vegetation or which drops from leaves, twigs or stems
- **stemflow** – water that trickles along twigs and branches and finally down the main trunk.

Interception loss varies with different types of vegetation. Interception is less from grasses than from deciduous woodland owing to the smaller surface area of the grass shoots. From agricultural crops, and from cereals in particular, interception increases with crop density. Coniferous trees intercept more than deciduous trees in winter, but this is reversed in summer.

Soil

Soil moisture refers to the subsurface water in the soil. **Field capacity** refers to the amount of water held in the soil after excess water drains away, that is, saturation or near saturation. **Wilting point** refers to the range of moisture content in which permanent wilting of plants occurs. The wilting point defines the approximate limits to plant growth.

Aquifers

Groundwater refers to subsurface water. Water moves slowly downwards from the soil into the bedrock – this is known as percolation. Depending on the permeability of the rock this may be very slow, or in some rocks, such as carboniferous limestone and chalk, it may be quite fast, locally. The permanently saturated zone within solid rocks and sediments is known as the phreatic zone. The upper layer of this is known as the **water table**. The water table varies seasonally. It is higher in winter following increased levels of precipitation. The zone that is seasonally wetted and seasonally dries out is known as the aeration zone. Most groundwater is found within a few hundred metres of the surface, but it has been found at depths of up to 4 km beneath the surface.

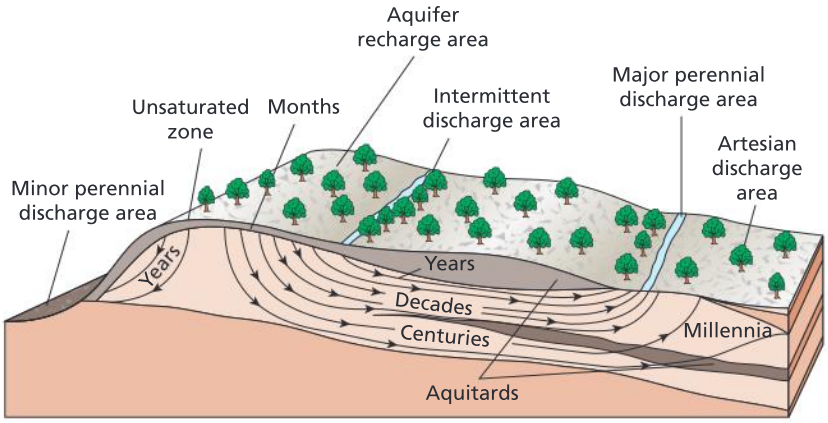
Groundwater is very important. It accounts for 96.5 per cent of all **freshwater** on the Earth. However, while some soil moisture may be recycled by evaporation into atmospheric moisture within a matter of days or weeks, groundwater may not be recycled for as long as 20,000 years. **Recharge** refers to the refilling of water in pores where the water has dried up or been extracted by human activity. Hence, in some places, where recharge is not taking place, groundwater is considered a non-renewable resource.

Aquifers (rocks that contain significant quantities of water) provide a great reservoir of water. Aquifers are permeable rocks such as sandstone and limestone. The water in aquifers moves very slowly and acts

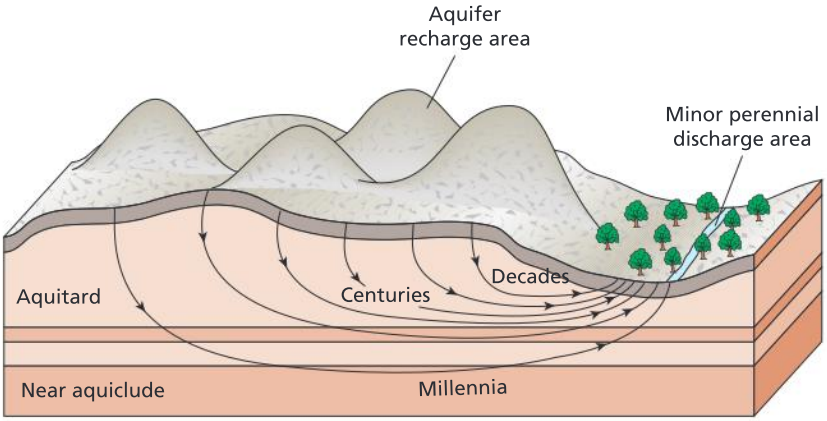
as a natural regulator in the hydrological cycle by absorbing rainfall that would otherwise reach streams rapidly. In addition, aquifers maintain stream flow during long dry periods. Where water flow reaches the surface (as shown by the discharge areas in Figure A.6) springs may be found. These may be substantial enough to become the source of a stream or river.

Groundwater recharge occurs as a result of:

- infiltration of part of the total precipitation at the ground surface
- seepage through the banks and bed of surface water bodies such as ditches, rivers, lakes and oceans
- groundwater leakage and inflow from adjacent rocks and aquifers
- artificial recharge from irrigation, reservoirs and so on.



(a) In humid regions



(b) In semi-arid regions

▲ **Figure A.6:** Groundwater sources

Cryosphere

The **cryosphere** is the snow and ice environment. Up to 66 per cent of the world's freshwater is in the form of snow and ice. (Over 97 per cent of the world's water is salt water, so there is a limited supply of freshwater available to humans.) High latitude regions and high altitude areas may have important stores of snow and ice. Some of this may melt seasonally to produce major changes in the basin hydrological cycle.

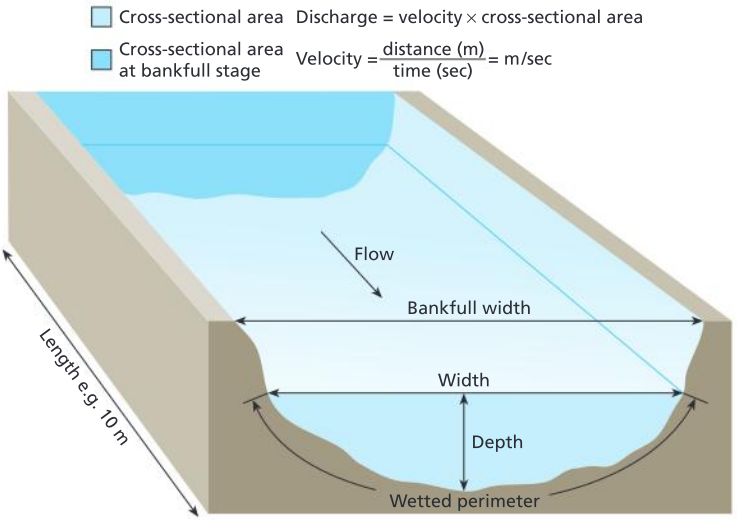
River discharge

River **discharge** is the volume of water passing a given point over a set time (Figure A.7). Discharge is found by multiplying the cross-sectional area of a river or stream by the mean velocity of the water. Steeper slopes should lead to higher velocities because of the influence of gravity. Velocity also increases as a stream moves from pools of low gradient to rapids. Discharge is normally expressed in cubic metres per second, or m^3/sec (cumecs).

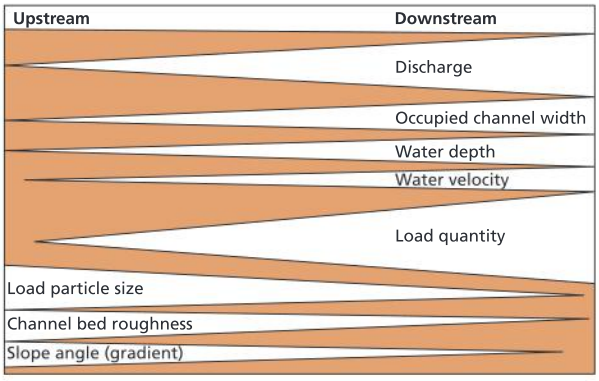
Discharge (Q) normally increases downstream, as does width, depth and velocity. By contrast, channel roughness decreases (Figure A.8). The increase in channel width downstream is normally greater than that of channel depth. Large rivers with a higher width to depth (w:d)

ATL Research and communication skills

1. Research and quantify the main flows and stores for any named drainage basin.
2. Explain how you acquire this information in the field.
3. Prepare a map showing physical background and the variables that affect flows and stores in your chosen basin.
4. Explain how human activities impact upon the basin.



▲ **Figure A.7:** Discharge in a river



▲ **Figure A.8:** The Bradshaw model of channel variables

ratio are more efficient than smaller rivers with a lower w:d ratio since less energy is spent in overcoming friction. Thus the carrying capacity increases and a lower gradient is required to transport the load. Although river gradients decrease downstream, the load carried is smaller and therefore easier to transport.

Stream flow

Water flow in rivers

Hydraulics is the study of water flow in a channel. Water flow is subject to two main forces: **gravity**, which causes downstream flow, and **frictional resistance** with the bed and bank, which opposes the flow downstream. In addition, the **volume of water** within a channel and the **shape of the channel** affect the amount of energy a stream has to do its work.

Water flow is not steady or uniform. It is **turbulent**, chaotic and eddying. Turbulence provides the upward motion in the flow which allows the lifting and support of fine particles. The conditions necessary for turbulent flow to occur are:

- complex channel shapes such as meandering channels and alternating pools and riffles
- high velocities
- cavitation in which pockets of air explode under high pressure.

By contrast, laminar flow is the movement of water in a series of sheets (or laminae). It is common in groundwater and in glaciers, but not in rivers, although it can occur in the bed in the lower course of a river. The best conditions for laminar flow are:

- shallow channels
- smooth, straight channels
- low velocities.

If laminar flow alone occurred in rivers, all of the sediment would remain on the bed.

When water velocities are low, turbulence is reduced and not readily visible to the eye (except at the banks). As water levels rise, mean velocity increases, the hydraulic radius increases, and the stream appears more turbulent. Turbulence is therefore a product of channel roughness and velocity.

Velocity

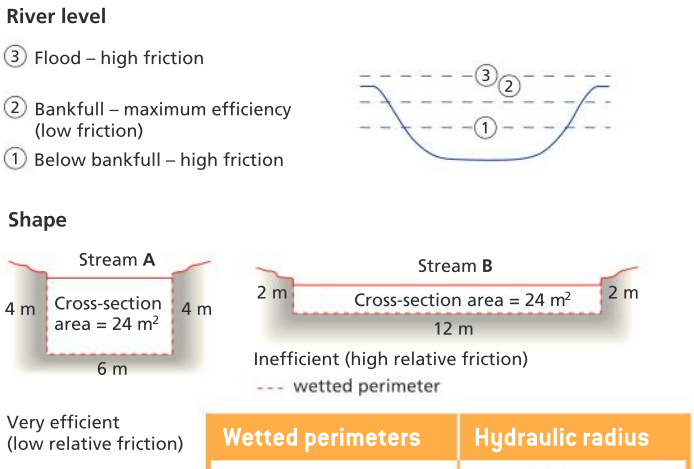
The effect of friction is to create an uneven distribution of velocity in a stream. Water closest to the bed and bank travels slowest, while water nearest the centre travels fastest. The highest velocity is thus mid-stream about a third of the way down (at the surface it is affected by surface resistance). The shape of the channel also affects velocity. In asymmetric channels maximum velocity is nearer the deep bank and slightly under the surface. This has important implications for erosion and deposition.

Velocity varies with a number of factors: volume of water; roughness of bed; gradient of stream; width, depth and shape of channel.

Channel shape

The efficiency of a stream's shape is measured by its **hydraulic radius**, the cross-sectional area divided by the wetted perimeter (Figure A.9). The higher the ratio, the more efficient the stream is and the smaller the frictional loss is. The ideal form is semicircular.

There is a close relationship between velocity, discharge and the characteristics of the channel in which the water is flowing. These include depth, width, channel roughness and hydraulic geometry. The width:depth ratio is a good measure of comparison. The shape of the channel is also determined by the material forming the channel and river forces. Solid rock allows only slow changes, whereas alluvium allows rapid changes. Silt and clay produce steep, deep, narrow valleys (the fine material being cohesive and stable), whereas sand and gravel promote wide, shallow channels.



Wetted perimeters	Hydraulic radius
Stream A:	Stream A:
4 + 4 + 6 = 14 m	$\frac{24}{14}$ = 1.71 m
Stream B:	Stream B:
2 + 2 + 12 = 16 m	$\frac{24}{16}$ = 1.5 m

▲ **Figure A.9:** Hydraulic radii

Channel roughness

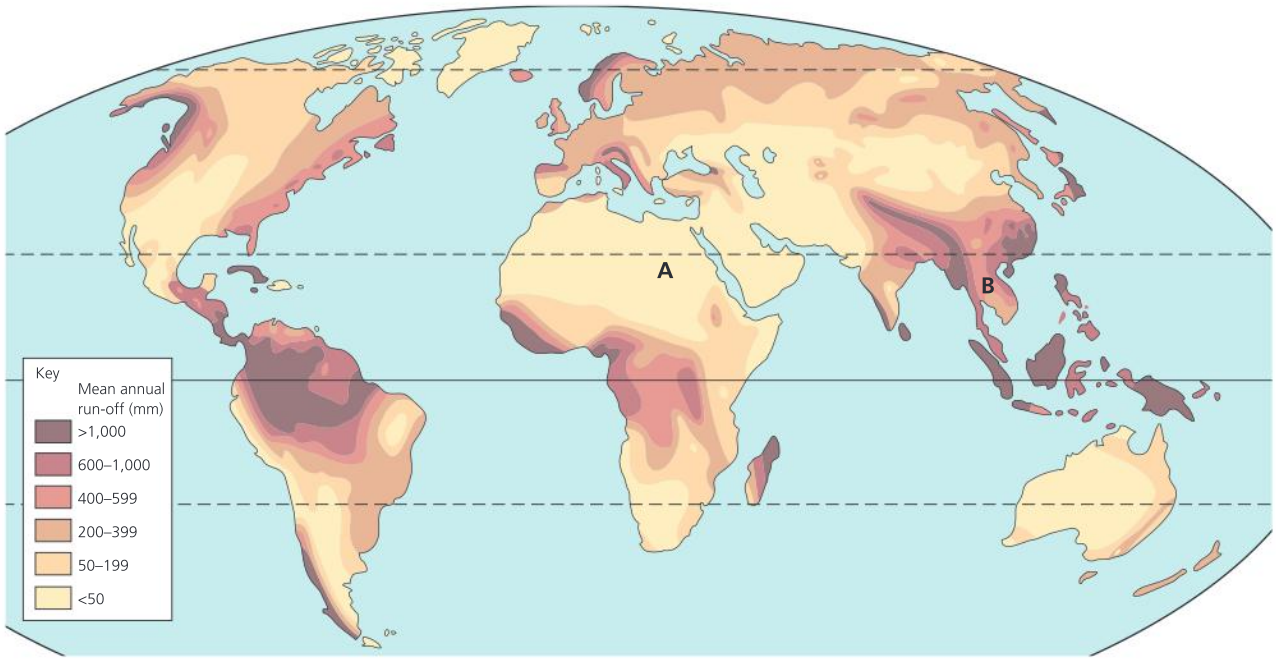
Channel roughness causes friction, which slows down the velocity of the water. Friction is caused by irregularities in the river bed, boulders, trees and vegetation, and contact between the water and the bed and bank. Manning's n is a formula that describes the relationship between channel roughness and velocity:

$$v = \frac{R^{2/3}S^{1/2}}{n}$$

where v = velocity, R = hydraulic radius, S = slope and n = roughness. The higher value of n, the rougher the bed, as shown in Table A.1.

▼ **Table A.1:** Channel roughness and velocity

Bed profile	Sand and gravel	Coarse gravel	Boulders
Uniform	0.02	0.03	0.05
Undulating	0.05	0.06	0.07
Irregular	0.08	0.09	0.10



▲ **Figure A.10:** Global variations in mean annual run-off/basin area

Activity 3

Study Figure A.10 which shows global variations in the mean annual run-off.

1. What is meant by the depth-equivalent discharge?
2. Describe the patterns shown in Figure A.10.
3. Using an atlas, suggest reasons for:
   a. the value at location A, and
   b. the value at location B.

Mean annual discharge

A useful statistic is the mean annual discharge divided by the drainage basin area. This gives a depth-equivalent discharge (that is, how much water runs off the surface for each area). The values range from over 1,000 mm for the Amazon river to 31 mm for the Colorado river. In terms of absolute discharge, the Amazon is highest at 230,000 m^3/sec. (Some 700 m upstream from its mouth it is 2.5 km wide and 60 m deep!) Second is the Zaire river at 40,000 m^3/sec, while the Mississippi is just 18,000 m^3/sec. Even in **flood**, the discharge of the Mississippi has only once reached 57,000 m^3/sec.

Processes of erosion, transportation and deposition

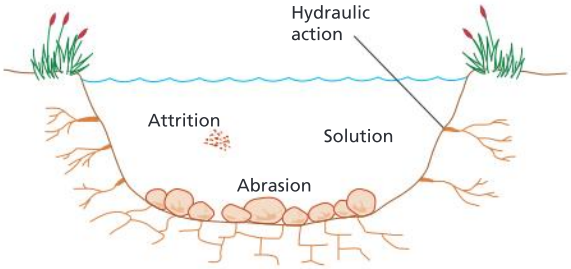
Erosion

Corrasion or **abrasion** is the wearing away of the bed and bank by the load carried by a river. Technically corrasion is the process and abrasion is the result, but the terms are used interchangeably. Corrasion is the mechanical impact produced by the debris eroding the bed and banks of the stream. In most rivers it is the principal means of erosion. The effectiveness of abrasion depends on the concentration, hardness and energy of the impacting particles and the resistance of the bedrock. Abrasion increases as velocity increases (kinetic energy is proportional to the square of velocity).

Attrition is the wearing away of the load carried by a river. It creates smaller, rounder particles.

Hydraulic action is the force of air and water on the sides of rivers and in cracks. It includes the direct force of flowing water and the force of air exploding. As fluids accelerate, pressure drops and may cause air bubbles to form. Cavitation occurs as bubbles implode and eject tiny jets of water with velocities of up to 130 m/sec. These can damage solid rock. Cavitation is an important process in rapids and waterfalls, and is generally accompanied by abrasion.

Corrosion or **solution** is the removal of chemical ions, especially calcium. The key factors controlling the rate of corrosion are bedrock, solute concentration of the stream water, discharge and velocity. Maximum rates of corrosion occur where fast-flowing streams pass over soluble rocks such as chalk and limestone.



▲ **Figure A.11:** Types of erosion

There are a number of factors affecting rates of erosion including:

- **Load** – the heavier and sharper the load, the greater the potential for erosion
- **Velocity** – the greater the velocity, the greater the potential for erosion (Figure A.13)
- **Gradient** – increased gradient increases the rate of erosion
- **Geology** – soft, unconsolidated rocks such as sand and gravel are easily eroded
- **pH** – rates of solution are increased when the water is more acidic
- **Human impact** – deforestation, dams and bridges interfere with the natural flow of a river and frequently end up increasing the rate of erosion.

Erosion by the river will provide loose material. This eroded material (plus other weathered material that has moved downslope from the upper valley sides) is carried by the river as its load.

Transport

The load is transported downstream in a number of ways (Figure A.12).

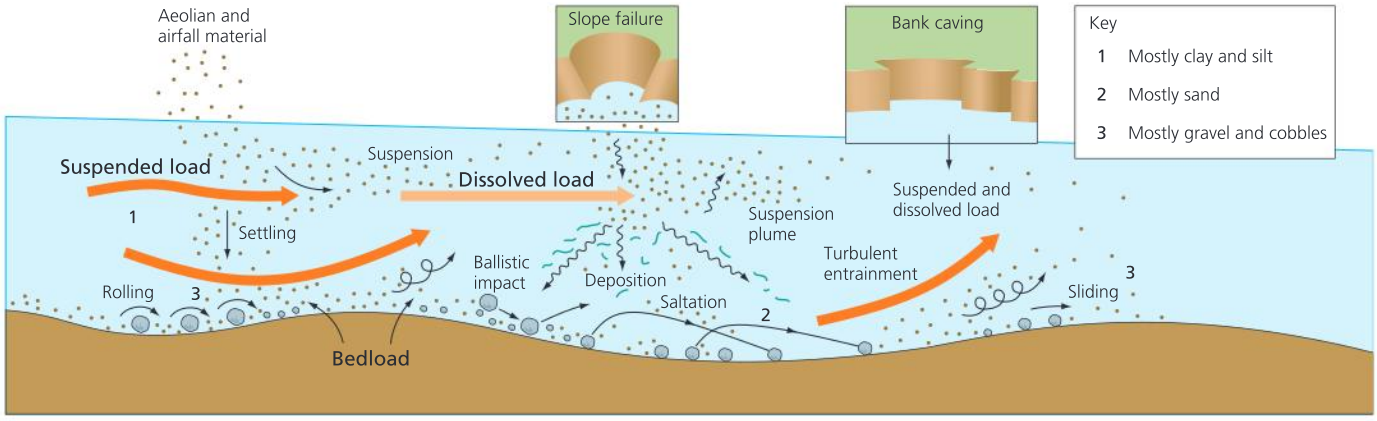
- The smallest particles (silts and clays) are carried in suspension as the suspended load.
- Larger particles (sands, gravels, very small stones) are transported in a series of "hops" as the saltated load.
- Pebbles are shunted along the bed as the bed or tracted load.
- In areas of calcareous rock, material is carried in solution as the dissolved load.
- Floatation is the process by which materials, such as leaves and occasionally bodies, are carried on the surface of ariver.

The load of a river varies with discharge and velocity. The capacity of a stream refers to the largest amount of debris that a stream can carry, while the competence refers to the diameter of the largest

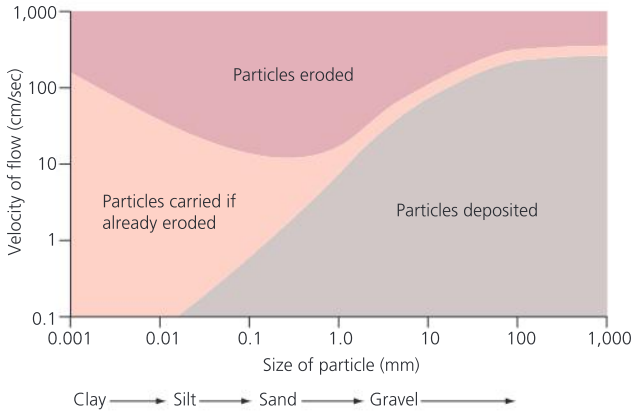
! Common mistake

✗ Some students believe that clay is easy to erode because it is so small.

✓ Clay is difficult to erode because it is so small that it tends to be very cohesive (it sticks together).



▲ **Figure A.12:** Types of transport



▲ **Figure A.13:** Hjulström curves

particle that can be carried. The critical erosion velocity is the lowest velocity at which grains of a given size can be moved. The relationship between these variables is shown by means of a Hjulström curve (Figure A.13). For example, sand can be moved more easily than silt or clay as fine-grained particles tend to be more cohesive. High velocities are required to move gravel and cobbles because of their large size. The critical velocities tend to be an area rather than a straight line on the graph.

There are three important features of Hjulström curves.

- The smallest and largest particles require high velocities to lift them. For example, particles between 0.1 mm and 1 mm require velocities of around 100 mm/sec to be entrained, compared with values of over 500 mm/sec to lift clay (0.01 m) and gravel (over 2 mm). Clay resists entrainment due to its cohesion, gravel due to its weight.
- Higher velocities are required for entrainment than for transport.
- When velocity falls below a certain level (settling or fall velocity) those particles are deposited.

Activity 4

Study Figure A.13 which shows the Hjulström curve.

1. Describe the work of the river when sediment size is 1 mm.
2. Comment on the relationship between velocity, sediment size and river process when the river is moving at 0.5 m/sec^{-1}.

Deposition

There are a number of causes of deposition such as:

- a shallowing of gradient which decreases velocity and energy
- a decrease in the volume of water in the channel
- an increase in the friction between water and channel.

River processes vary seasonally. Some rivers have a clear wet season, when the velocity is greater, depth increases and width may increase. Monsoonal rivers erode and

◀ **Photo A.2:** Erosion and deposition is highly seasonal at Myrdalsjohkull in Iceland

carry more sediment in the wet season. Some rivers, such as the river that flows from the Solheimjokull glacier in Iceland, have a very high flow in spring following the spring snow melt. Once the discharge drops, it deposits its load, forming and reshaping a braided channel. Erosion and deposition may vary due to human activity – the building of large dams increases deposition behind the dam but encourages erosion downstream as the river no longer has a load to carry.

ATL Communication skills

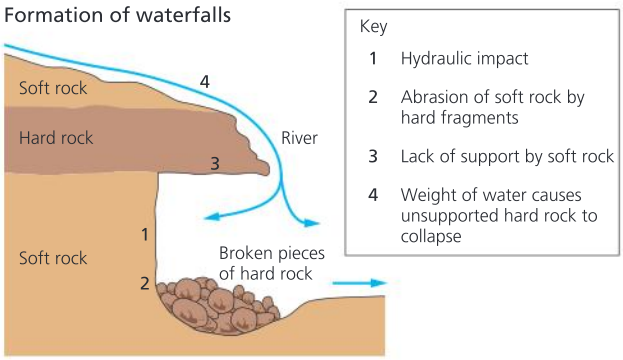
Prepare a two-minute presentation on the Hjulström curve.

The formation of typical river landforms

Waterfalls

Waterfalls frequently occur on horizontally bedded rocks. The soft rock is undercut by hydraulic action and abrasion (Figure A.14). The weight of the water and the lack of support cause the waterfall to collapse and retreat. Over thousands of years the waterfall may retreat enough to form a gorge or recession, such as at Niagara Falls. Gorges can also be formed by the collapse of a cave.

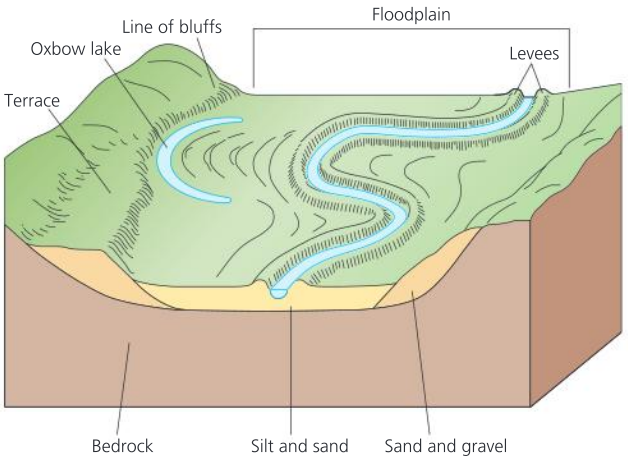
▲ **Photo A.3:** The Axara Falls at Thingvellir, Iceland



▲ **Figure A.14:** Formation of waterfalls

Flood plains

The main features of deposition are flood plains, meanders, levees, oxbow lakes and deltas. Flood plains are areas of low relief formed by deposition when a river floods (Figure A.15). The alluvium is generally a mixture of sand and gravel, eroded on the outside of the meander and built up by channel deposition as a series of bars. Flood plains vary greatly in size, and low-magnitude high-frequency floods cover only a small part of the flood plain.



▲ **Figure A.15:** Flood plains

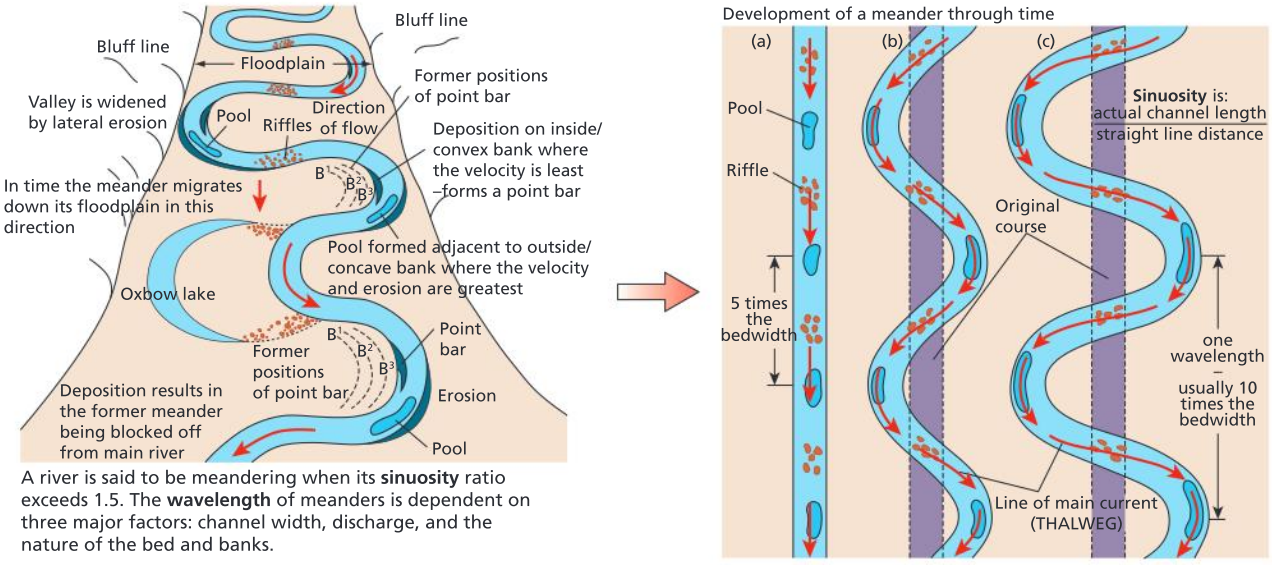
Meanders

Meandering is the normal behaviour of fluids and gases in motion. Meanders can occur on a variety of materials, from ice to solid rock. Meander development occurs in conditions where channel slope, discharge and load combine to create a situation where meandering is the only way that the stream can spread its energy over the entire length of the channel.

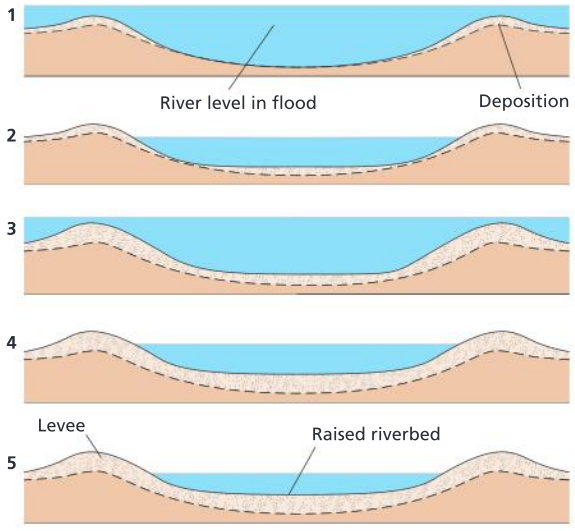
▼ **Photo A.4:** The Port Meadow flood plain in Oxford, UK

Levees

One of the most prominent deposits are levees (Figure A.17). These are formed by the deposition of coarse material near the channel, while the finer deposits are carried out



▲ **Figure A.16:** Formation of meanders



1 When the river floods, it bursts its banks. It deposits its coarsest load (gravel and sand) closer to the bank and the finer load (silt and clay) further away.

2, 3, 4. This continues over a long time, for centuries.

5 The river has built up raised banks called levees, consisting of coarse material, and a floodplain of fine material.

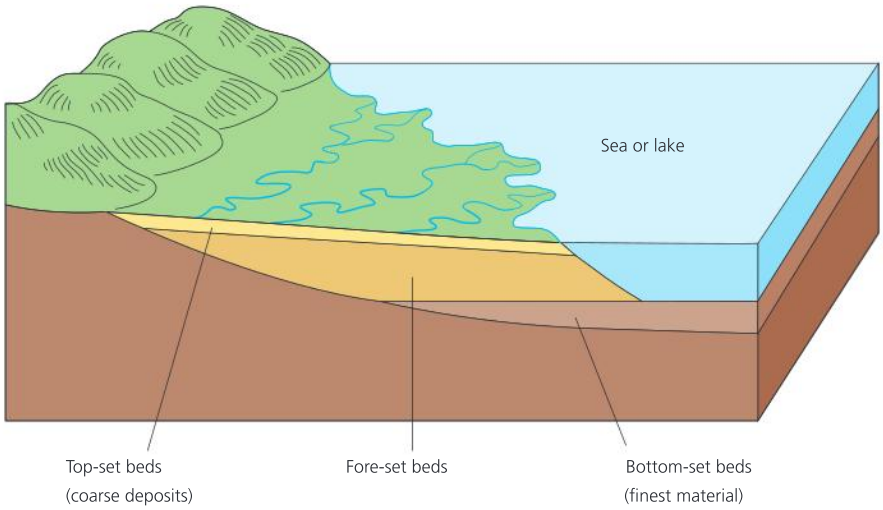
▲ **Figure A.17:** Formation of levees

into the flood plain. Levees are raised banks at the edge of a river. They are formed by repeated flooding of the river. When the river floods its speed is reduced. This is because it is slowed down by the vegetation on the flood plain. As its speed is reduced it has to deposit some of its load. It drops the coarser, heavier material first and the finer, lighter material last. This means that over centuries the levees build up from coarse material, such as sand and gravel, while the flood plain consists of fine silt and clay. The levees on the Yangtze river are up to 20 m higher than the flood plain.

Deltas

When a stream flows into a standing body of water it may form a delta (Figure A.18). For deltas to be formed a river needs to carry a large volume of sediment. Deposition is increased if the water is salty, as this causes salt particles to group together (a process termed **flocculation**) and become heavier, so they are deposited. Vegetation also increases the rate of deposition by slowing down the water, a process known as **bioconstruction**.

Deposition occurs because of the rapid drop in stream velocity. There is a regular succession of deposits. The finest deposits are removed furthest (the bottom-set beds), medium-grade deposits are deposited as steep-angled wedges (fore-set beds), and the coarsest material is deposited at the top (top-set beds). There are a wide variety of deltas depending upon whether marine, tidal or fluvial processes dominate. Similarly, there are a wide variety of shapes, including the curving shoreline of the **arcuate** type (for example the Nile) and the projecting **bird's foot type** (for example the Mississippi).



▲ **Figure A.18:** Formation of deltas

Concepts in context

In this section, we have seen how many **processes** operate in drainage basins. These include precipitation, infiltration, overland flow, evapotranspiration and interception. There are also processes of erosion, transport and deposition. The actual process that occurs depends on climate geology, relief and, increasingly, human activities.

The processes that operate in drainage basins use much energy. Some processes, such as erosion, transport or evaporation require a lot of energy. Others, such as deposition, require less energy. In the upper sections where gradients are steep, gravity may have a greater influence on rivers than in lower sections.

Check your understanding

1. Define the term "drainage basin" and "endorheic".
2. Explain why the hydrological cycle can be considered to be an open system.
3. Describe how a systems approach of the drainage basin hydrological cycles (Figure A.5) differs from that of a graphical representation (A.4).
4. What is the evidence of erosion in: (a) an upland river and (b) a lowland river?
5. Describe how the load of a river varies between upstream and downstream.
6. Define the following hydrological characteristics: (a) interception, (b) evaporation, (c) infiltration, (d) groundwater, (e) base flow.
7. Briefly explain the formation of waterfalls.
8. With the use of an annotated diagram explain the formation of levees.
9. Outline the main processes in the formation of deltas.
10. Describe the main characteristics of an aquifer.

2 Flooding and flood mitigation

Conceptual understanding

Key question

How do physical and human factors both increase (exacerbate) and reduce (mitigate) flood risk for different **places**?

Key content

- Hydrograph characteristics (lag time, peak discharge, base flow) and natural influences on hydrographs including geology and seasonality.
- How urbanization, deforestation and channel modifications affect flood risk within a drainage basin, including its distribution, frequency and magnitude.
- Flood mitigation including structural measures (dams, afforestation, channel modification and levee strengthening) and planning (personal insurance and flood preparation, and flood warning technology).
- Attempts at flood prediction, including changes in weather forecasting and uncertainty in climate modelling.

Hydrographs and variations in discharge

Hydrographs

A **storm hydrograph** or **flood hydrograph** shows how a river channel responds to the key processes of the hydrological cycle. It measures the speed at which rain falling on a drainage basin reaches the river channel. It is a graph on which river discharge during a storm or run-off event is plotted against time (Figure A.19).

Rising limb:

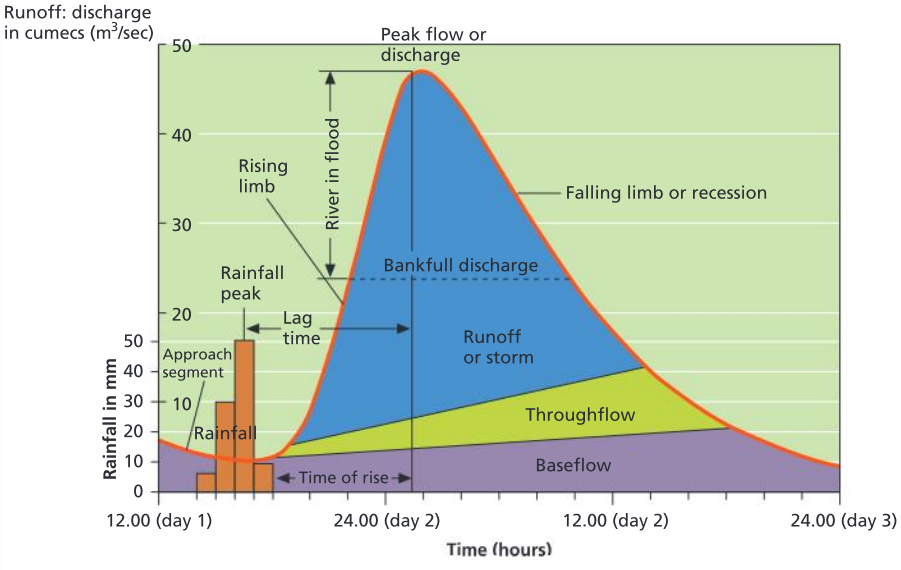
- indicates the amount of discharge and the speed at which it is increasing
- very steep in a flash flood or in small drainage basins where the response is rapid
- generally steep in urbanized catchments.

Peak flow or discharge:

- higher in larger basins
- steep catchments have lower infiltration rates
- flat catchments have high infiltration rates, so more throughflow and lower peaks.

Lag time:

- time interval between peak rainfall and peak discharge
- influenced by basin shape, steepness, stream order.



▲ **Figure A.19:** A storm hydrograph

Run-off curve:

- reveals the relationship between overland flow and throughflow
- where infiltration is low, antecedent moisture high, surface impermeable and rainfall strong, overland flow will dominate.

Base flow:

- the seepage of groundwater into the channel – very important where rocks have high pore space
- a slow movement, and the main, long-term supplier of the river's discharge.

Recessional limb:

- influenced by geological composition and behaviour of local aquifers
- larger catchments have less-steep recessional limbs, likewise flatter areas.

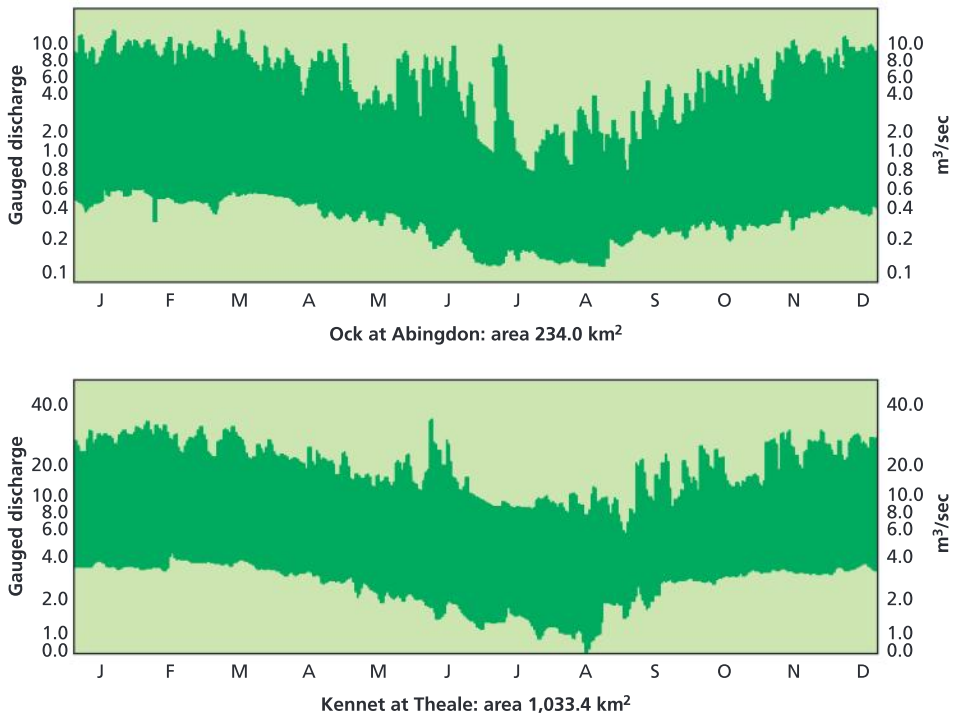
Hydrograph size (area under the graph):

- the higher the rainfall, the greater the discharge
- the larger the basin size, the greater the discharge.

The influence of geology

In general, impermeable rocks (and soils) will generate more overland flow, so a shorter time lag and a higher peak flow. This is true both for shorter flood hydrographs and for longer river regimes (Figure A.20).

The rivers Ock and Kennet are tributaries of the River Thames. They have a similar climate. The river regimes for the two rivers show a similar pattern of peak water flow in winter and lower flow in summer. Differences in the terrain that the two rivers pass over can, in part, account for the variation between the two regimes. The River Ock flows mainly over clay. Clay is impermeable and increases overland run-off. In contrast, the River Kennet flows mainly over tertiary rocks, sands and gravels. It drains an area over four times larger than that drained by the River Ock.



▲ **Figure A.20:** The influence on geology on flood response

Activity 5

1. Describe the main variations in the river regimes of the Glomma and the Shannon, as shown in Figure A.21.
2. Referring to Figure A.20, explain how differences in geology have affected the river regimes.

ATL Research skills

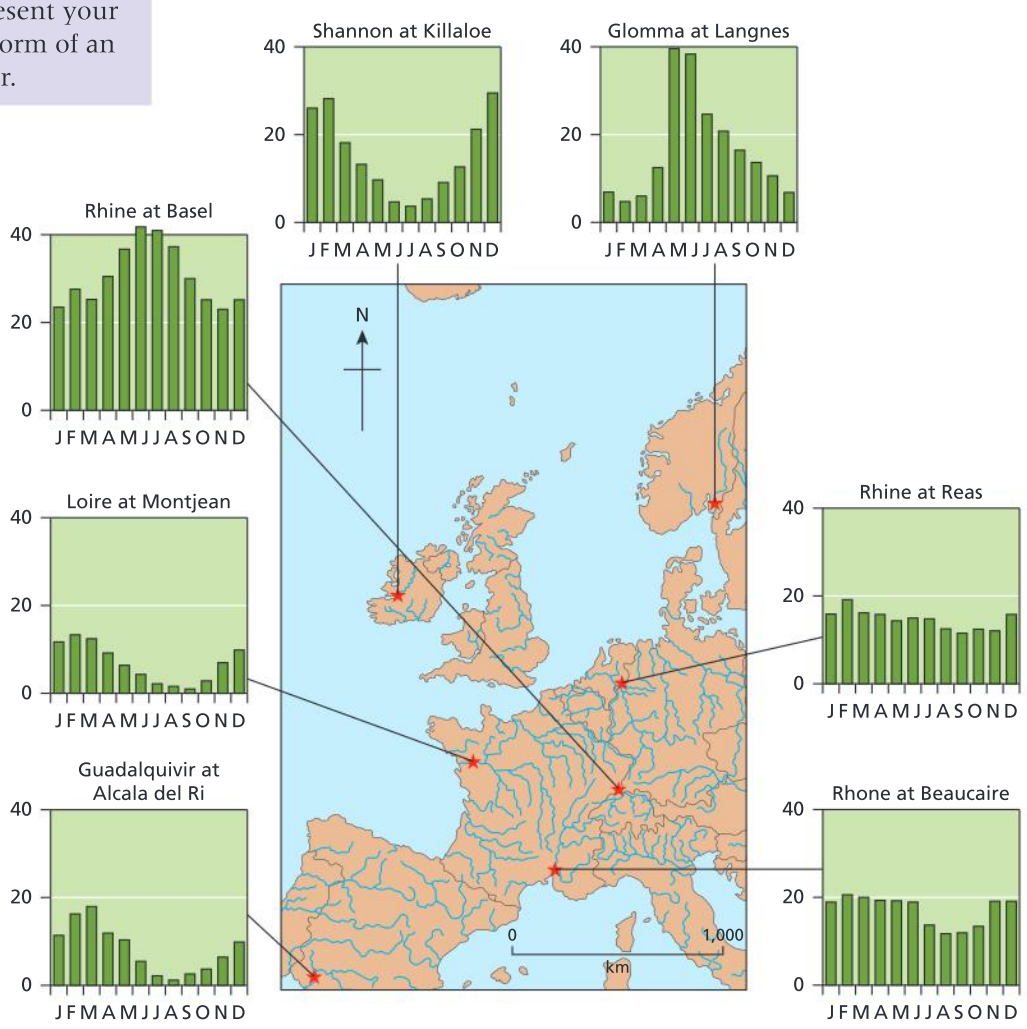
Find out about the typical river regime for a river in your home area. Suggest reasons for the pattern you identify. Present your findings in the form of an annotated poster.

River regimes – the influence of seasonality

The river regime is the seasonal variation in the flow of a river (Figure A.21). Arctic streams have maximum flow in spring, following snow melt, whereas monsoonal rivers have maximum flows following the summer floods. Variations in a river's flow depend on many factors such as:

- the amount and nature of precipitation
- seasonal variations in temperature and evapotranspiration
- changes in vegetation cover
- variations in rock types, soil types and the shape and size of the drainage basin.

Of these, seasonal changes in climate generally have the greatest impact on changes in river flow.



Note: All the graphs show specific discharge in l/second per km^2

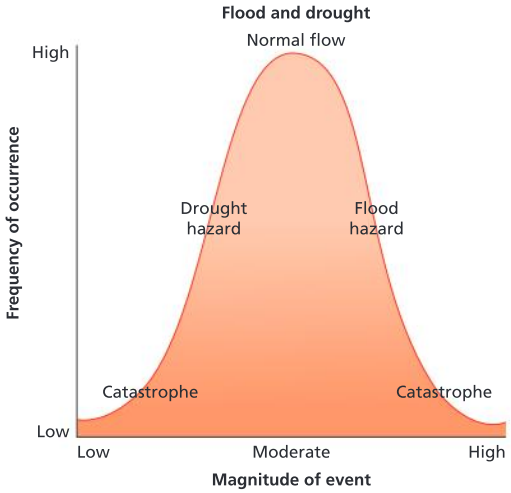
▲ **Figure A.21:** River regimes in Europe

Factors affecting flood risk

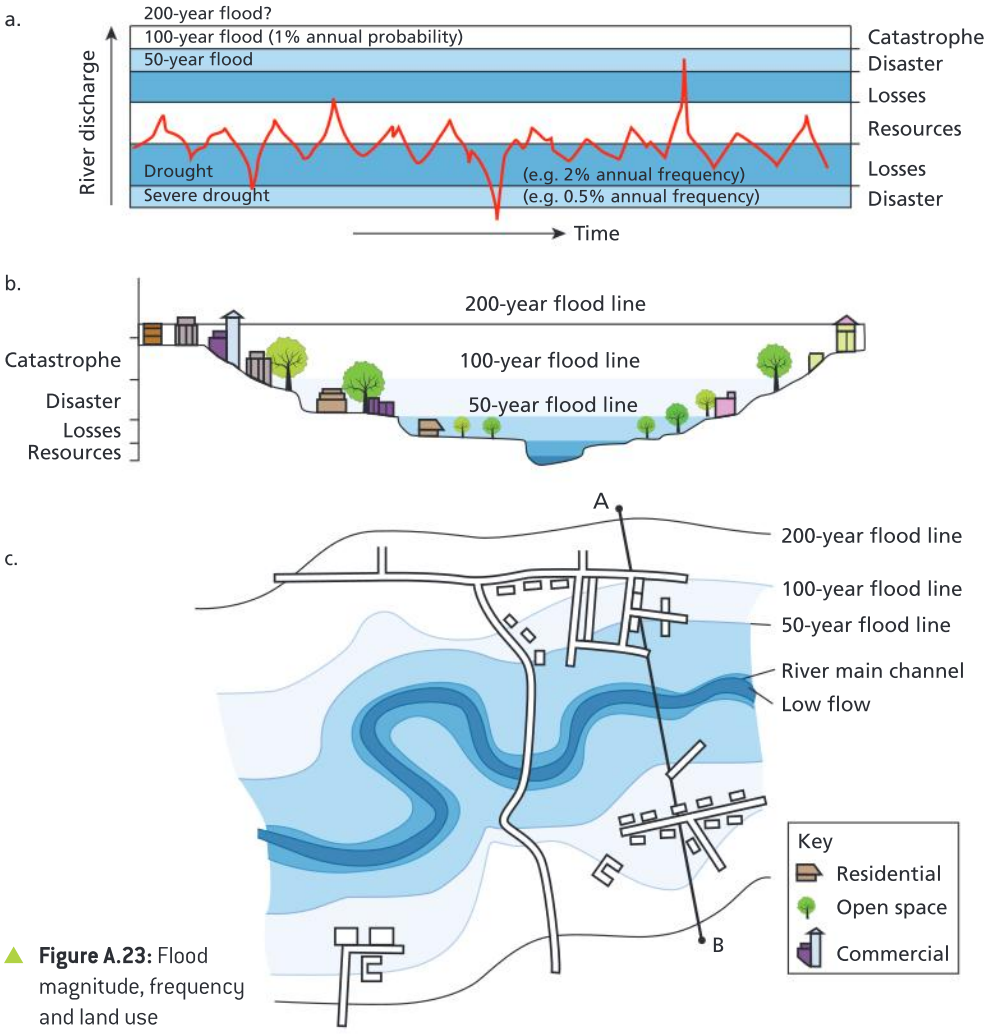
A flood occurs when a river can no longer contain all the water it is transporting in its channel. The water flows out of the channel onto a **flood plain**. Most small floods are contained on the flood plain close to the river. Larger floods, which occur less often, cover a larger part of the flood plain.

The recurrence interval is the frequency with which events of a certain size occur. Very large events happen very infrequently. Small events happen very frequently. For example, high-magnitude low-frequency events might occur once every 50 years, whereas low-magnitude high-frequency events may occur every year.

Figure A.23 shows the relationship between flood magnitude, frequency, land use and economic loss. In diagram (a) we see that most flows are contained within normal operating levels. Disasters are caused by extremes of floods (or drought) and catastrophes are caused under very extreme conditions. The distinction



▲ **Figure A.22:** River flows and recurrence intervals



▲ **Figure A.23:** Flood magnitude, frequency and land use

Activity 6

1. Describe the relationship between flood magnitude (including drought) and frequency, as show in Figure A.22.
2. Describe the relationship between flood magnitude and land use as shown in Figure A.23.

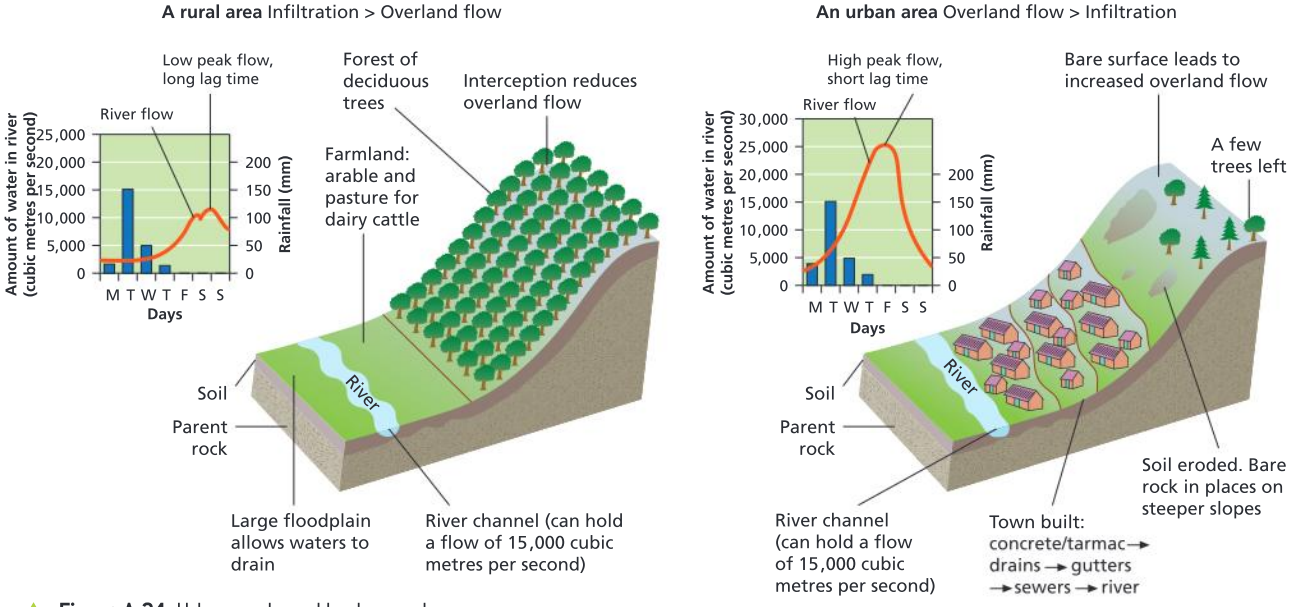
between a disaster and a catastrophe, in the case of floods, is that catastrophes have a higher magnitude but a lower frequency.

There are a number of factors that influence flood risk. These are summarized in Table A.2.

The hydrological impact of urbanization

Urban hydrographs are different from rural ones because there are more impermeable surfaces in urban areas (roofs, pavements, roads, buildings) as well as more drainage channels (gutters, drains, sewers) (Figure A.24). Urban hydrographs have:

- a shorter lag time
- a steeper rising limb
- a higher peak flow (discharge)
- a steeper recessional limb.



▲ **Figure A.24:** Urban and rural hydrographs

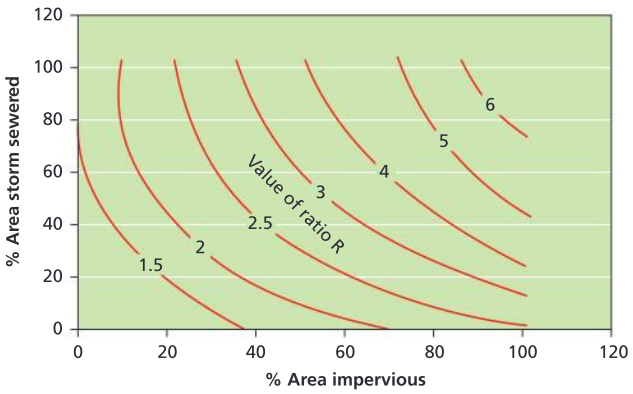
▼ **Table A.2:** Physical factors affecting flood risk

Factor	Influence on flood risk
Precipitation type and intensity	Highly intensive rainfall is likely to produce overland flow and produce a greater flood. Low-intensity rainfall is likely to infiltrate into the soil and percolate slowly into the rock thereby reducing the peak of the flood. Precipitation that falls as snow sits on the ground until it melts. Sudden, rapid melting can cause flooding and lead to high rates of overland flow, and high peak flows. Also, intense rain compacts the ground and reduces infiltration.
Temperature and evapotranspiration	Not only does temperature affect the type of precipitation, it also affects the evaporation rate (higher temperatures lead to more evaporation and so less water getting into rivers). On the other hand, warm air can hold more water so the potential for high peak flows in hot areas is increased.
Antecedent moisture	If it has been raining previously and the ground is saturated or near saturated, rainfall will quickly produce overland flow and a high peak flood.

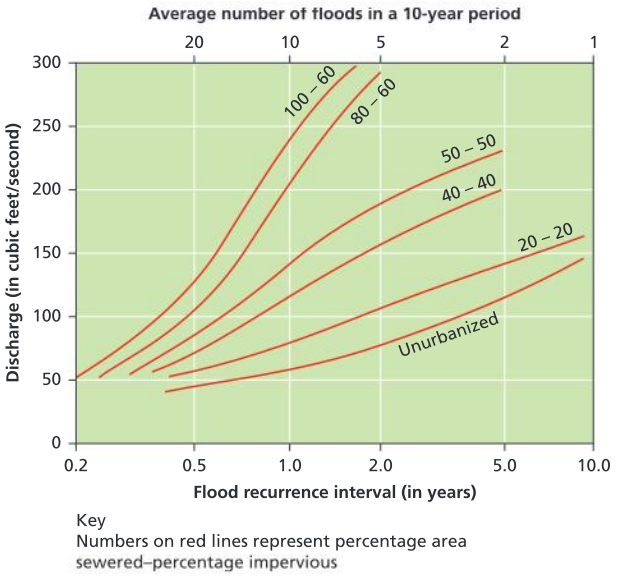
Factor	Influence on flood risk
Drainage basin size and shape	Smaller drainage basins respond more quickly to rainfall conditions. For example, the Boscastle (UK) floods of 2004 drained an area of less than 15 km^2. This meant that the peak of the flood occurred soon after the peak of the storm. In contrast, the Mississippi river is over 3,700 km long – it takes much longer for the lower part of the river to respond to an event that might occur in the upper course of the river. Circular basins respond more quickly than linear basins, where the response is more drawn out.
Drainage density	Basins with a high drainage density – such as urban basins with a network of sewers and drains – flood very quickly. Networks with a low drainage density have a longer time before it floods.
Porosity and impermeability of rocks and soils	Impermeable surfaces cause more water to flow overland. This causes greater peak flows. Urban areas contain large areas of impermeable surfaces. In contrast, rocks such as chalk and gravel are permeable and allow water to infiltrate and percolate. This reduces the peak flow. Sandy soils allow water to infiltrate whereas clay is much more impermeable and causes water to pass overland.
Slopes	Steeper slopes create more overland flow, and higher peak flows.
Vegetation type	Broad-leafed vegetation intercepts more rainfall, especially in summer, and so reduces the amount of overland flow, peak flow and increases time lag. In winter, deciduous trees lose their leaves and so intercept less rainfall.
Land use	Land uses which create impermeable surfaces or reduce vegetation cover reduce interception and increase overland flow. If more drainage channels are built (sewers, ditches, drains) the water is carried to rivers very quickly. This means that peak flows are increased and time lags reduced.

Urbanization, for example, increases the magnitude and frequency of floods in at least three ways (Figures A.25 and A.26):

- creation of highly impermeable surfaces, such as roads, roofs, pavements (Photo A.5)
- smooth surfaces served with a dense network of drains, gutters and underground sewers increase drainage density
- natural river channels are often constricted by bridge supports or riverside facilities reducing their carrying capacity.



▲ **Figure A.25:** Annual flood increments with increasing urban and sewer cover



▲ **Figure A.26:** Flood frequency curves for different levels of urbanization

▲ **Photo A.5:** Impermeable surface in an urban area, and flooding from a drain

Urbanization has a greater impact on processes in the lower part of a drainage basin than the upper course. This is because more urban areas are found in the lower parts of drainage basins. Urbanization can have conflicting impacts on hydrological processes, for example:

- increased erosion due to more water getting into rivers
- increased speed of flow and transport of materials due to enlarged channels
- less erosion due to riverbank protection schemes.

Activity 7

1. Describe how urban and rural flood hydrographs differ, as shown in Figure A.24.
2. Explain why urban and rural flood hydrographs differ.
3. Figure A.25 shows the mean annual flood increments with increasing urban cover and sewerage facilities. The ratio R shows the factor by which the flood level has increased (for instance, when R = 3, flood levels have tripled). Describe what happens to flood levels as the proportion of impervious land increases and the number of storm sewers increases.
4. Using the data in Figure A.26, describe and explain the changes that occur in the magnitudes and frequency of flood discharge as urbanization increases.

▼ **Table A.3:** Potential hydrological effects of urbanization

Urbanising influence	Potential hydrological response
Removal of trees and vegetation	Decreased evapotranspiration and interception; increased stream sedimentation.
Initial construction of houses, streets and culverts	Decreased infiltration and lowered groundwater table; increased storm flows and decreased base flows during dry periods. Sedimentation continues while bare ground is still exposed.
Complete development of residential, commercial and industrial areas	Decreased porosity, reducing time of run-off concentration, thereby increasing peak discharges and compressing the time distribution of the flow; greatly increased volume of run-off and flood damage potential.
Construction of storm drains and channel improvements	Local relief from flooding; concentration of floodwaters may aggravate flood problems downstream.

Deforestation

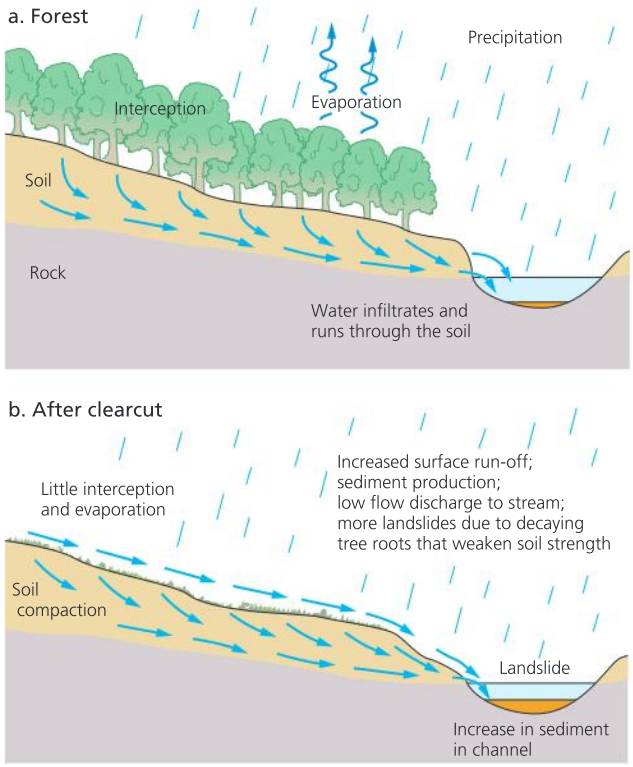
Deforestation can have an impact on flood hydrographs similar to that of urbanization. As Figure A.27 shows, the presence of vegetation increases interception, reduces overland flow and increases evapotranspiration. In contrast, deforestation reduces interception, increases overland flow and reduces evapotranspiration. This causes flood hydrographs to have shorter time lags and higher peak flows.

This increases the flood risk in deforested areas. The risk of higher magnitudes, greater frequencies and reduced recurrence intervals increases when the vegetation cover is removed.

Deforestation is also a cause of increased flood run-off and a decrease in channel capacity. This occurs due to an increase in deposition within the channel. However, the evidence is not always conclusive. In the Himalayas, for example, changes in flooding and increased deposition of silt in parts of the lower Ganges-Brahmaputra are due to the combination of high monsoon rains, steep slopes and the seismically unstable terrain. This ensures that run-off is rapid and sedimentation is high irrespective of the vegetation cover.

Deforestation is likely to occur over a much broader area than urbanization. This is because deforestation may occur for land-use changes (for example conversion to agriculture), industrial development, to make way for tourist developments and to allow urbanization to occur. Hence it is likely to have a more widespread impact on hydrological processes. These may include:

- more overland flow leading to more frequent erosion
- rivers transporting more sediment
- reduced evapotranspiration.

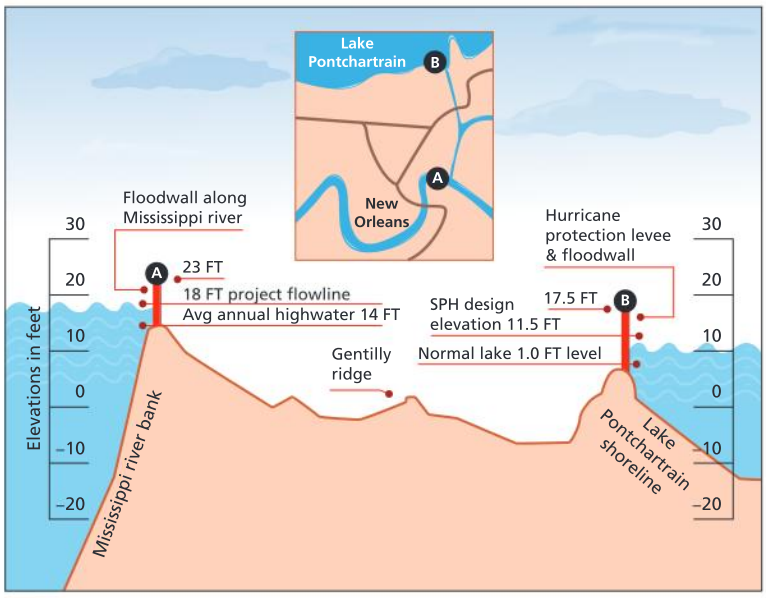


▲ **Figure A.27:** The influence of deforestation on drainage basin hydrology and flooding

Channel modifications

Channel modifications include channelization, enlargement and straightening. Channelization may create new channels. These are likely to be quite straight. This speeds up water movement and so time lags are likely to be reduced. Enlarging channels through levees (raised banks) enables rivers to carry more water. Thus the peak flow may be higher. However, the purpose of channelization and straightening is to remove water from an area, and so reduce the threat of a flood. This works up to a point. The levees on the Mississippi are able to deal with small-scale and medium-sized floods but are very vulnerable to severe floods such as those caused by Hurricane Katrina in 2005, when over 50 breaks occurred in the levees.

Channel modifications may alter processes, especially if the channel is covered (culverted). Widening and deepening of the channel should increase the amount of water that the river can hold. Straightening of the channel should speed up flow and remove the water from the area quickly. Scouring of the channel (removing sediment from its bed) should also allow the river to carry more water, thereby reducing the risk of flooding.



▲ **Figure A.28:** The breaching of levees in New Orleans during Hurricane Katrina

Flood mitigation

There are a number of ways in which the flood risk can be reduced. These include hard engineering schemes, such as the building of dams, as well as soft engineering schemes, such as afforestation.

▲ **Photo A.6:** Evretou dam, Paphos, Cyprus

Dams

The number of large dams (more than 15 m high) that are being built around the world is increasing rapidly and is reaching a level of almost two completions every day. The advantages of dams are numerous and are not just related to flood control. In simple terms, they hold back water during times of flood and release it when the flood risk has gone. The Aswan High Dam on the River Nile, Egypt, protects the lower Nile from flooding, but it also has benefits for agriculture, navigation, recreation, tourism and hydroelectric power. On the other hand, it can lead to increased loss of water due to evaporation, channel erosion downstream ("clear-water erosion"), a decline in sediments reaching the Nile Delta, and the spread of diseases such as schistosomiasis (bilharzia) and malaria.

Reservoirs store excess rainwater in the upper drainage basin. However, this may only be appropriate in small drainage networks. It has been estimated that some 66 billion cubic metres of storage is needed to make any significant impact on major floods in Bangladesh.

Afforestation

Flood abatement involves decreasing the amount of run-off, thereby reducing the flood peak in a drainage basin. There are a number of ways of reducing flood peaks. These include:

- afforestation/reforestation
- reseeding of sparsely vegetated areas to increase evaporative losses
- treatment of slopes such as contour ploughing or terracing to reduce the run-off coefficient
- comprehensive protection of vegetation from wildfires, overgrazing and clear cutting of forests
- clearance of sediment and other debris from headwater streams
- construction of small water and sediment holding areas
- preservation of natural water storage zones, such as lakes.

Afforestation should increase the amount of interception and reduce the amount of overland flow, thereby reducing the risk of floods, although the evidence does not necessarily support this. For example, in parts of the Severn catchment (in the UK) sediment loads increased four times after afforestation. Why was this? The result is explained by a combination of an increase in overland run-off, little ground vegetation, young trees, access routes for tractors, and fire breaks and wind breaks. All of these allowed a large amount of bare ground. However, only five years later the amount of erosion reduced because the trees had grown and were intercepting more rainfall. The Tennessee Valley Authority (TVA) used afforestation in the 1930s to combat soil erosion and flooding in the USA.

ATL Research skills

Find out about the aims and successes of the TVA.

ATL Thinking skills

How and why might afforestataion cause a variation in overland run-off over time?

Channel modification

Modification of river channels includes raising the banks (to hold more water), straightening the river (to speed up flow and remove the water as quickly as possible) and creating new channels (flood-relief channels) to carry water when the river is in flood (Figure A.29). Channels can also be strengthened with steel or concrete to make them less vulnerable to erosion.

Artificial **levees** are the most common form of river engineering. This is when the banks of the river are increased in height so that the river can carry more water and sediment. Levees can also be used to divert and restrict water to low-value land on the flood plain. Over 4,500 km of the Mississippi River has levees. Channel improvements such as dredging the river bed of sediment will increase the carrying capacity of the river.

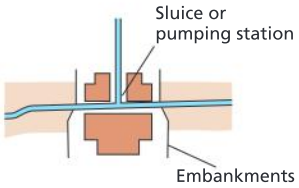
Planning

Planning for floods includes having personal insurance as well as being prepared for the floods. This may take the form of using sandbags to protect homes against the risk of flooding, sealing doors and windows, moving valuables upstairs, moving electrical generators to the top of buildings rather than having them in the basement, and designing homes so that the electrical features are at a level higher than the expected flood level.

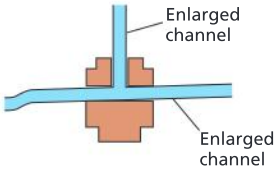
Loss-sharing adjustments include disaster aid and insurance. **Disaster aid** refers to any aid, such as money, equipment, staff and technical assistance that is given to a community following a disaster. In high-income countries (HICs) **insurance** is an important loss-sharing strategy. However not all flood-prone households have insurance and many of those who are insured may be underinsured. Many people in low-income countries are unable to obtain flood insurance, as are many residents of new homes built on flood plains in the UK.

Attempts at flood prediction and forecasting

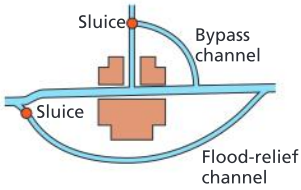
During the 1980s and 1990s flood forecasting and warning became more accurate and it is now one of the most widely used measures to reduce the problems caused by flooding. Despite advances in weather satellites and the use of radar for forecasting, over 50 per cent of all of unprotected dwellings in England and Wales have less than six hours of flood warning time. In most low-income countries (LICs) there is much less effective



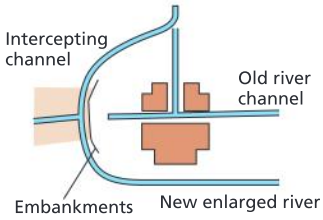
1. Flood embankments with sluice gates. The main problem with this is it may raise flood levels up- and downstream.



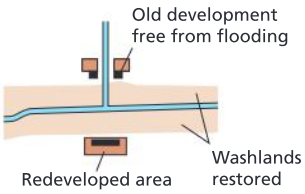
2. Channel enlargement to accommodate larger discharges. One problem with such schemes is that as the enlarged channel is only rarely used it becomes clogged with weed.



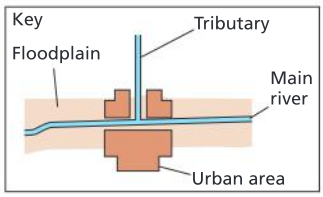
3. Flood-relief channel. This is appropriate where it is impossible to modify the original channel as it tends to be rather expensive, e.g. the flood relief channels around Oxford, UK.



4. Intercepting channels. These divert only part of the flow away, allowing flow for town and agricultural use, e.g. the Great Ouse Protection Scheme in England's Fenlands.



5. Removal of settlements. This is rarely used because of cost, although many communities, e.g. the village of Valmeyer, Illinois, USA, were forced to leave as a result of the 1993 Mississippi floods.



▲ **Figure A.29:** Flood control measures

flood forecasting. An exception is Bangladesh. Most floods in Bangladesh originate in the Himalayas, so authorities have about 72 hours warning. Flooding from monsoon rains may also be predicted by the use of satellite imagery. Making warnings available to people is easier now, as more people have access to television, smartphones and computers than in the past. However, the poorest members of societies have least access to new technology, and so they may be the least informed in terms of impending floods.

According to the United Nations Environment Programme's publication *Early warning and assessment,* there are a number of things that could be done to improve flood warnings. These include:

- improved rainfall and snow-pack estimates, better and longer forecasts of rainfall
- better gauging of rivers, collection of meteorological information and mapping of channels
- better and more-current information about human populations; and infrastructure, elevation and stream channels need to be incorporated into flood risk assessment models
- better sharing of information is needed between forecasters, national agencies, relief organizations and the general public
- more complete and timely sharing of meteorological and hydrological information is needed among countries within international drainage basins
- technology should be shared among all agencies involved in flood forecasting and risk assessment both in the basins and around the world.

However, as a result of global climate change there is increased uncertainty in forecasting. In some areas, floods are predicted to become higher and more frequent, whereas in other areas, rainfall patterns may become more erratic. On the other hand, as more people have access to ICT, they may be able to keep up to date with weather warnings.

ATL Research skills

Research flood mitigation in a river basin of your choice.

Case study

Protecting the Mississippi

For over a century the Mississippi has been mapped, protected and regulated. The river flows through 10 states and drains one-third of the USA. It contains some of the USA's most important agricultural regions. A number of methods have been used to control flooding in the river, and its effects, including:

- stone and earthen levees to raise the banks of the river
- holding dams to hold back water in times of flood
- lateral dykes to divert water away from the river
- straightening of the channel to remove water speedily.

Altogether over $10 billion has been spent on controlling the Mississippi, and annual maintenance costs are nearly $200 million. But it was not enough. In 1993 following heavy rain between April and July, many of the levees collapsed allowing the river to flood its floodplain. The damage was estimated to be over $12 billion yet only 43 people died. Over

Case study (Continued)

25,000 km² of land were flooded. The river was only performing its natural function – people and engineers had modified the channel so much that its normal function did not occur often, and so people thought they were safe from the effects of flooding. Some 50 breaks occurred during the floods caused by Hurricane Katrina in New Orleans (see Figure A.28).

According to some geographers, if the Mississippi were left to its own devices a new channel would have been created by the mid-1970s, so much so that the ports at New Orleans and Baton Rouge would be defunct. However, river protection schemes have prevented this. For example, at New Orleans 7 m levees flank the river and 3 m levees abut Lake Pontchartrain. New Orleans is 1.5 m below the average river level and 5.5 m below flood level!

Flood relief measures include:

- Bonnet Carre Waterway from New Orleans to Lake Pontchartrain and then to the Gulf of Mexico
- Atchafalaya River, which carries up to 25 per cent of the Mississippi flow
- Dredging of the Atchafalaya and Mississippi Rivers
- Morganza floodway between Mississippi and Atchafalaya.

Concepts in context

We have seen how hydrographs vary with place. **Place** is fundamental to the study of Geography. Places vary in terms of climate, geology, level of human impact, type of land use, type and intensity of physical processes. These interact in a unique way in every location to produce unique geographical characteristics for every place.

Different places interact with each other. This may be deliberate or accidental, positive or negative. As the human population increases, human impacts on the environment will intensify, and more places will be interacting with other places.

Online case study

Flood mitigation in Bangladesh

Check your understanding

1. Define the term "flood hydrograph".
2. How does a river regime differ from a flood hydrograph?
3. Examine the relationship between flood magnitude and frequency.
4. Explain the meaning of the term "land-use zoning".
5. Outline the physical factors that increase flood risk.
6. Outline the hydrological effects of urbanization.
7. How does deforestation increase the risk of flooding?
8. Outline how channel modification can affect the impact of flooding.
9. In what ways can forecasting help to reduce the impact of floods?
10. How can individual decisions affect the impact of flooding?

3 Water scarcity and water quality

Conceptual understanding

Key question

What are the varying **powers** of different actors in relation to water management issues?

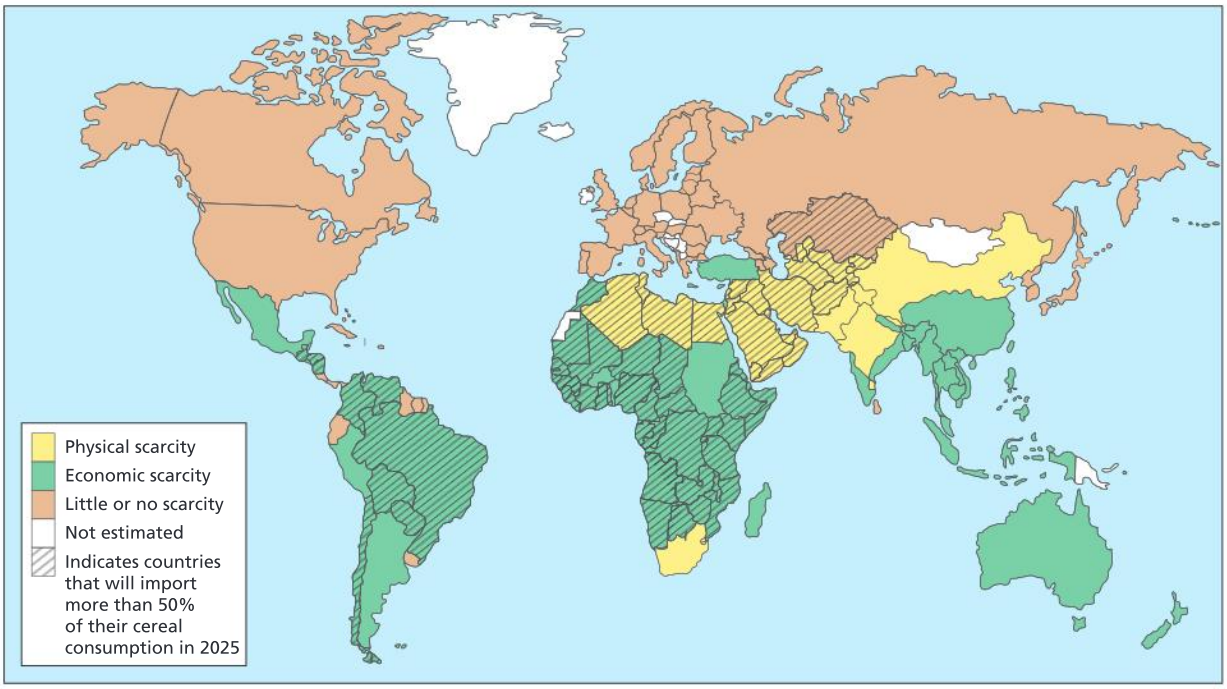
Key content

- Classifying physical and economic water scarcity, and the factors that control these including causes and impacts of droughts; and the distinction between water quantity and water quality.
- Environmental consequences of agricultural activities on water quality, to include pollution (eutrophication) and irrigation (salinization).
- Growing human pressures on rivers, lakes and aquifers, including economic growth and population migration.
- Internationally shared water resources as a source of conflict.

Physical water scarcity and economic water scarcity

The level of water scarcity in a country depends on precipitation and water availability, population growth, demand for water, affordability of

▼ **Figure A.30:** Physical and economic water scarcity



supplies and infrastructure. Where water supplies are inadequate, two types of water scarcity exist:

- **Physical water scarcity**, where water consumption exceeds 60 per cent of the useable supply. To help meet water needs some countries such as Saudi Arabia and Kuwait have to import much of their food and invest in desalinization plants.
- **Economic water scarcity**, where a country physically has sufficient water to meet its needs, but requires additional storage and transport facilities. This means having to embark on large and expensive water-development projects, as in many sub-Saharan countries.

Activity 8

Describe the distribution of areas expected to experience physical water scarcity in 2025. How does this compare with those expected to experience economic water scarcity?

Drought

Drought is an extended period of dry weather leading to conditions of extreme dryness. Absolute drought is a period of at least 15 consecutive days with less than 0.2 mm of rainfall. Partial drought is a period of at least 29 consecutive days during which the average daily rainfall does not exceed 0.2 mm.

Some drought is seasonal, whereas some can be linked to El Niño events. The severity of a drought depends upon the length of the drought and how severe the water shortage is. The impacts of drought can include reduced crop yields, increased animal mortality, an increase in illnesses in humans (linked to dehydration), an increase in forest fires, hosepipe bans, a ban on watering private gardens or washing cars.

Water quantity and water quality

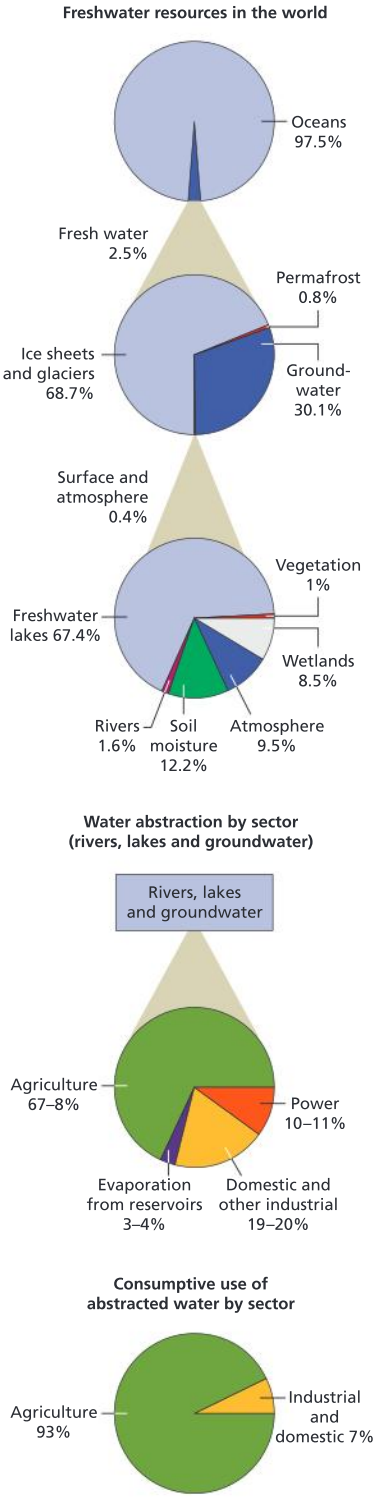
Water quantity (supply) depends on several factors in the water cycle, which include:

- rates of rainfall
- evaporation
- the use of water by plants (transpiration)
- river and groundwater flows.

Less than 1 per cent of all freshwater is available for people to use (the remainder is locked up in ice sheets and glaciers). Globally, around 12,500 cubic kilometres of water are considered available for human use on an annual basis. This amounts to about 6,600 cubic metres per person per year. If current trends continue, only 4,800 cubic metres will be available in 2025.

The world's available freshwater supply is not distributed evenly around the globe, either seasonally or from year to year.

- About three-quarters of annual rainfall occurs in areas containing less than a third of the world's population.
- Two-thirds of the world's population live in the areas receiving only a quarter of the world's annual rainfall.



▲ **Figure A.31:** Availability of freshwater supplies

Activity 9

Comment on the availability of freshwater shown in Figure A.31.

ATL Thinking skills

In some parts of the world, most water is collected by women and children. What impact is that likely to have on their physical development, level of health and tiredness. In what ways is this unjust?

Water stress

When per capita water supply is less than 1,700 cubic metres per year, an area suffers from "water stress" and is subject to frequent water shortages. Currently, in many of these areas water supply is actually less than 1,000 cubic metres per capita, which causes serious problems for food production and economic development. In 2016, 2.3 billion people lived in water-stressed areas. If current trends continue, water stress will affect 3.5 billion people – 48 per cent of the world's projected population – in 2025.

Water use

The world's population has tripled since 1922, while our water use has increased sixfold. Some rivers that once reached the sea, such as the Colorado in the USA, no longer do so. Moreover:

- half the world's wetlands have disappeared in the same period
- 20 per cent of freshwater species are endangered or extinct
- many important aquifers are being depleted
- water tables in many parts of the world are falling at an alarming rate.

World water use is projected to increase by about 50 per cent by around 2040. By 2025, 4 billion people – half the world's population at that time – will live under conditions of severe water stress, especially in Africa, the Middle East and south Asia. Disputes over scarce water resources may lead to an increase in armed conflicts. Currently, about 1.1 billion people lack access to safe water, 2.6 billion are without adequate sanitation, and more than 4 billion do not have their wastewater treated to any degree. These numbers are likely to get worse in the coming decades.

Activity 10

Describe the trends in water use, as shown in Figure A.32. Which sector has the highest level of consumption?

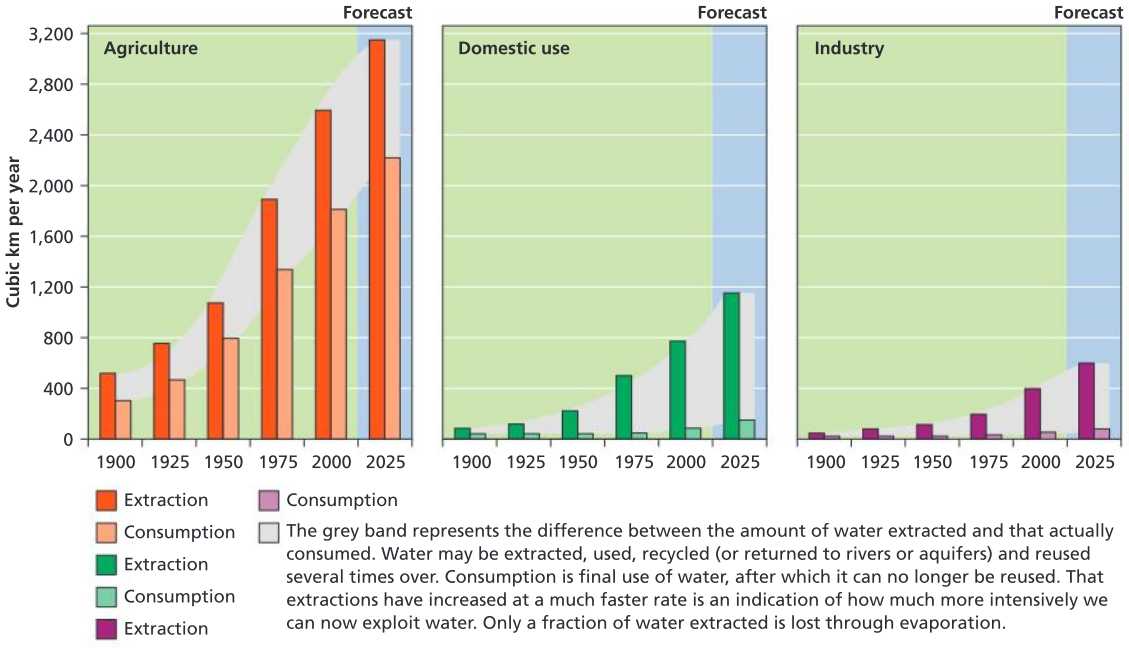
Online case study

Water footprints

Water quality

Water also needs to be of an adequate quality for consumption. However, in developing countries too many people lack access to

Figure A.32: Trends in global water use



safe and affordable water supplies and sanitation. The World Health Organization (WHO) estimates that around 4 million deaths each year are from water-related disease, particularly cholera, hepatitis, malaria and other parasitic diseases. Water quality may be affected by organic waste from sewage, fertilizers and pesticides from farming, and by heavy metals and acids from industrial processes and transport. Factors affecting access to safe drinking water include:

- water availability
- water infrastructure
- cost of water.

Urban areas are better served than rural areas, and countries in Asia, Latin America and the Caribbean are better off than African countries. In the case of Asia, China and India alone were made up of some 2.28 billion people in the year 2000, or over 60 per cent of the region's total population. Many piped water systems, however, do not meet water quality criteria, leading more people to rely on bottled water for personal use, which is bought in markets (as in major cities in Colombia, India, Mexico, Thailand, Venezuela and Yemen).

In some cases the poor actually pay more for their water than the rich. For example, in Port-au-Prince, Haiti, surveys have shown that households connected to the water system typically paid around $1.00 per cubic metre, while unconnected customers forced to purchase water from mobile vendors paid from $5.50 to a staggering $16.50 per cubic metre.

▼ **Table A.4:** National water footprints

Country	National water footprint (m^3/yr per capita)
Brazil	2,027
China	1,071
Ethiopia	1,167
India	1,089
Saudi Arabia	1,849
South Africa	1,255
Spain	2,461
UK	1,258
USA	2,842
World average	1,385

Environmental consequences of agricultural activities on water quality

Eutrophication

Eutrophication leads to increased amounts of nitrogen and/or phosphorus that are carried in streams, lakes and groundwater, causing nutrient enrichment (Figure A.33). This leads to an increase in algal blooms as plants respond to the increased nutrient availability. This is an example of positive feedback. However, the increase in algae and plankton shade the water below, cutting off the light supply for submerged plants. The prolific growth of algae, especially in the autumn as a result of increased levels of nutrients in the water and higher temperatures, results in **anoxia** (oxygen starvation in the water). On a larger scale they may lead to the formation of "dead zones" in coastal areas close to river mouths.

There are three main reasons why the high concentrations of nitrogen in rivers and groundwater are a problem. First, nitrogen compounds can cause undesirable effects in the aquatic ecosystems, especially excessive growth of algae. Second, the loss of fertilizer is an economic loss to the farmer. Third, high nitrate concentrations in drinking water may affect human health; for example, methaemoglobinemia (blue baby syndrome) may develop.

▲ **Photo A.7:** Eutrophication – algal bloom caused by excessively high nitrate levels in freshwater

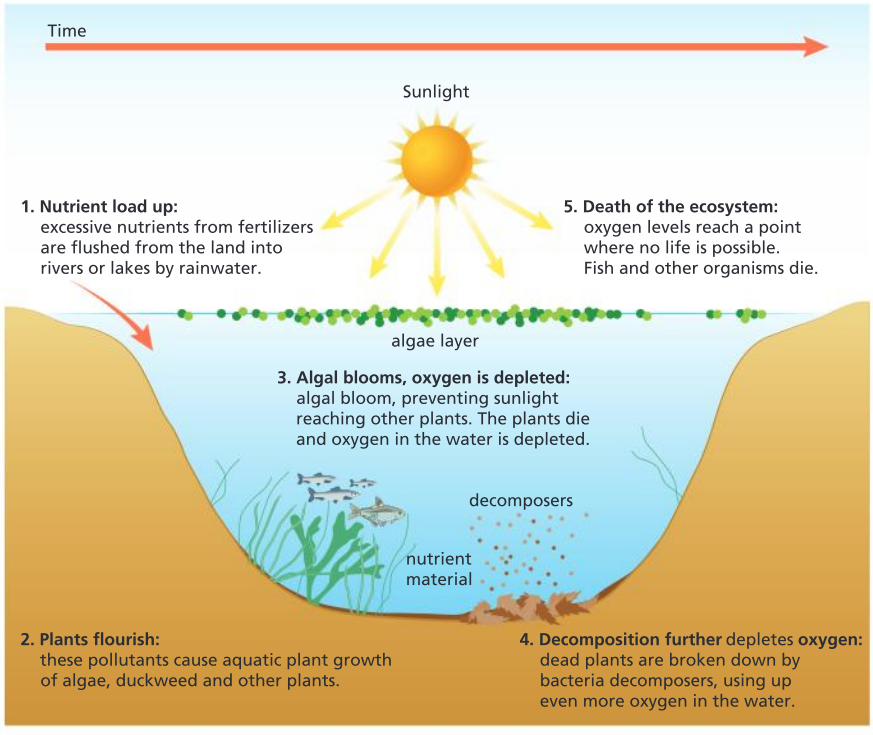


Figure A.33: The process of eutrophication

Table A.5: Global variations in eutrophication

Percentage of lakes and reservoirs suffering eutrophication	
Asia and the Pacific	54%
Europe	53%
Africa	28%
North America	48%
South America	41%

Source: UNEP/ILEC surveys

Photo A.8: The use of bales of barley straw to reduce the effects of eutrophication

Dealing with eutrophication

There are three main ways of dealing with eutrophication. These include:

- altering the human activities that produce pollution; for example, by using alternative types of fertilizer and detergent
- regulating and reducing pollutants at the point of emission; for example, in sewage treatment plants that remove nitrates and phosphates from waste
- restoring water quality by pumping mud from eutrophic lakes.

Possible measures to reduce nitrate loss are as follows (based on the northern hemisphere).

- Avoiding the use of nitrogen fertilizers between mid-September and mid-February when soils are wet and therefore it is more likely that fertilizer will wash through the soil.
- Preferring autumn-sown crops – their roots conserve nitrogen in the soil and use up nitrogen left from the previous year.
- Sowing autumn-sown crops as early as possible, and maintaining crop cover through autumn and winter to conserve nitrogen.
- Avoiding applying nitrogen to fields next to a stream or lake.
- Avoiding applying nitrogen just before heavy rain is forecast.
- Using less nitrogen fertilizer after a dry year because less would have been washed away in the previous year. (This is difficult to assess precisely.)
- Avoiding ploughing up grass as this releases nitrogen.

- Using bales of barley straw to prevent the growth of green algae. It uses nitrogen as it decays, with up to 13 per cent less nitrogen lost; it also locks up phosphorus.

Stakeholders

There are many people who benefit from increased crop yields and food production and there are many who suffer from eutrophication. Who should bear the cost of cleaning up eutrophication? The stakeholders include:

- the farmers who apply the fertilizer and have increased farm yields
- the chemical companies that profit from the sale of fertilizers
- the government that may begin to achieve food security
- the customers who receive more reliable food supplies and benefit from lower prices
- the water companies that provide the water to consumers.

Ultimately, the cost of cleaning up eutrophic water is likely to be passed on by the water companies to the consumers.

Activity 11

1. Choose an appropriate method to show the data in Table A.5. Comment on your results.
2. Describe the human causes of eutrophication.
3. Outline the ways in which it is possible to manage eutrophication.

TOK

Is it fair that consumers should pay for the clean-up of polluted water? What should the role and responsibility of the other stakeholders be?

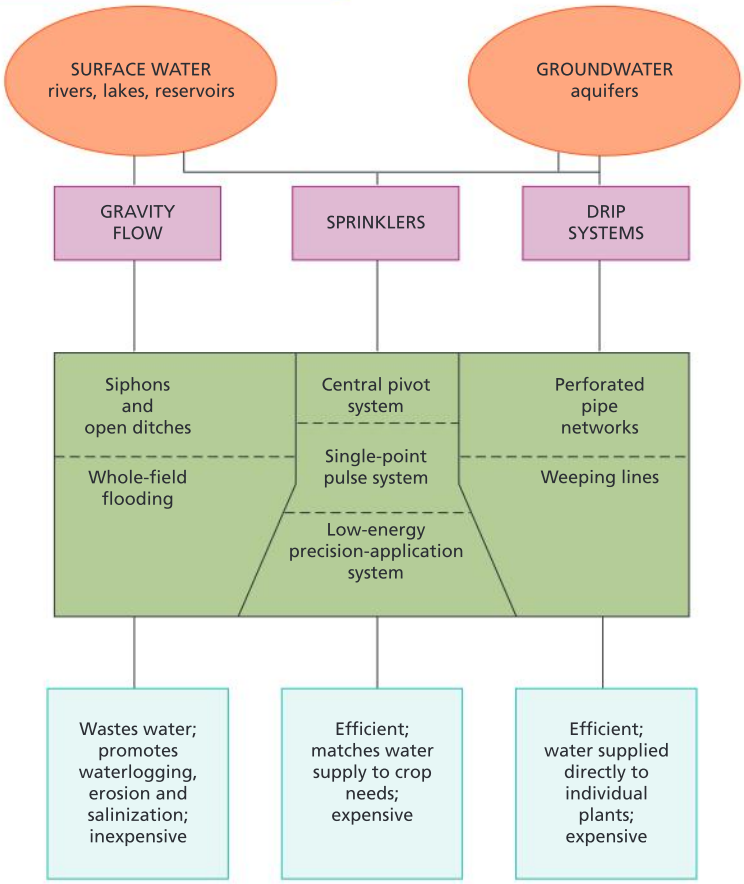
Extension work

Visit www.chesapeakebay.net and investigate the environmental issues in the bay, the potential solutions, and how progress towards restoring Chesapeake Bay by 2025 is progressing.

The potential effects of irrigation

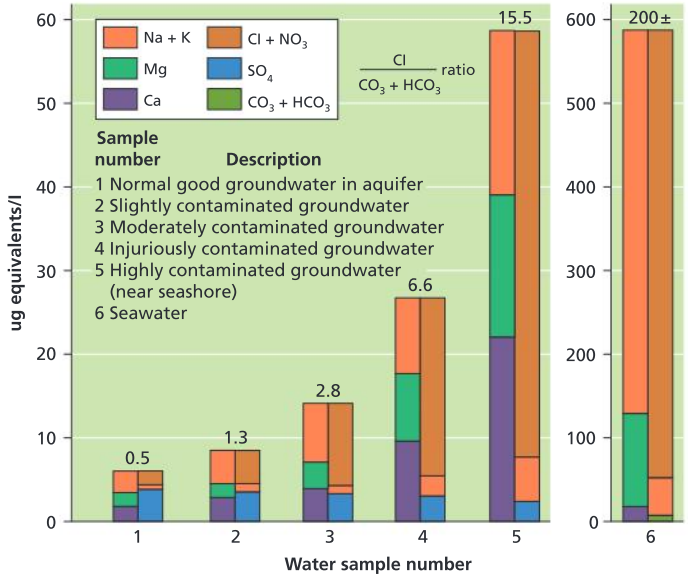
People have irrigated crops since ancient times: there is evidence of **irrigation** in Egypt going back nearly 6,000 years. Water for irrigation can be taken from surface stores, such as lakes, dams, reservoirs and rivers, or from groundwater. Types of irrigation range from total flooding, as in the case of paddy fields, to drip irrigation, where precise amounts are measured out to each individual plant (Figure A.34). Irrigation may lead to unwanted consequences, for example in relation to groundwater quality (Figure A.35) and **salinization** (Figure A.36).

Figure A.34: Types of irrigation



Impacts of irrigation

Irrigation occurs in developed as well as developing countries. For example, large parts of the USA and Australia are irrigated. The advent of diesel and electric motors in the mid-20th century led for the first time to systems that could pump



▲ **Figure A.35:** Changes in groundwater quality with distance from an aquifer

groundwater out of aquifers faster than it was recharged. This has led in some regions to loss of aquifer capacity, decreased water quality and other problems. In Texas, USA, irrigation has reduced the water table by as much as 50 metres. By contrast, in the fertile Indus Plain in Pakistan, irrigation has raised the water table by as much as six metres since 1922 and caused widespread salinization.

Irrigation can reduce the Earth's albedo (reflectivity) by as much as 10 per cent. This is because a reflective sandy surface may be replaced by one with dark green crops. Irrigation can also cause changes in precipitation. Large-scale irrigation in semi-arid areas, such as the High Plains of Texas, has been linked with increased rainfall, hailstorms and tornadoes. Under natural conditions semi-arid areas have sparse vegetation and dry soils in summer. However, when irrigated these areas have moist soils in summer and complete vegetation cover. Evapotranspiration rates increase, resulting in greater amounts of summer rainfall across Kansas, Nebraska, Colorado and the Texas Panhandle. In addition, hailstorms and tornadoes are more common over irrigated areas compared with non-irrigated areas.

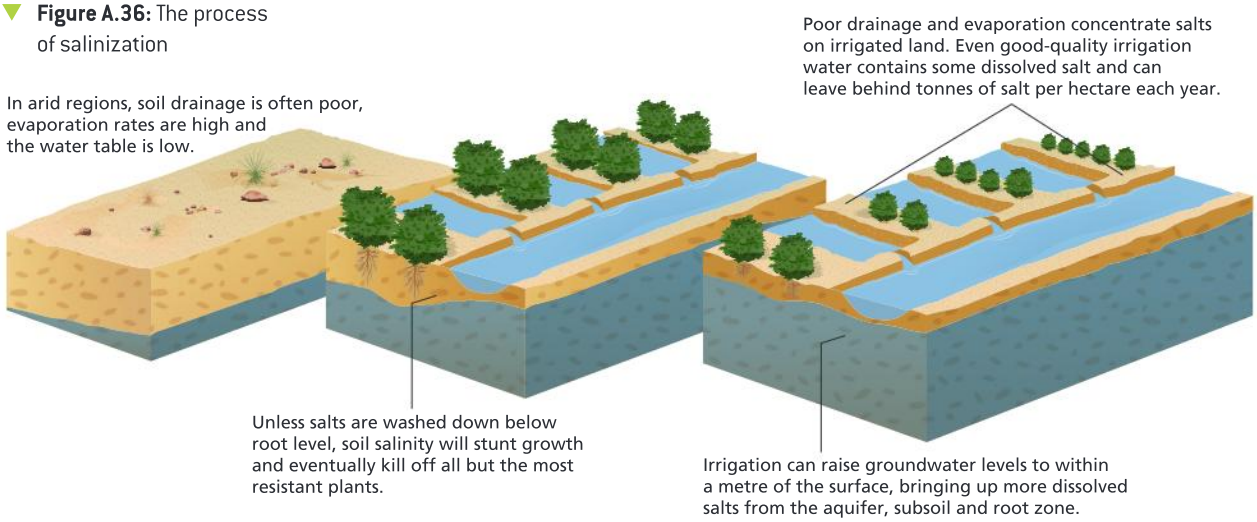
Salinization

Irrigation frequently leads to an increase in the amount of salt in the soil, known as salinization. This occurs when groundwater levels are close to the surface. In clay soils this may be within three metres of the surface, whereas on sandy and silty soils it is less. Capillary forces bring water to the surface where it may be evaporated, leaving behind any soluble salts that it is carrying.

Some irrigation, especially paddy rice, requires huge amounts of water. As water evaporates in the hot sun, the salinity levels of the remaining water increase. This also occurs behind large dams.

Chemical changes are also important. In Salinas, California, salinization is characterized by an increase in dissolved salts and an increase in the ratio of chlorides to bicarbonates.

▼ **Figure A.36:** The process of salinization



Growing human pressures on rivers, lakes and aquifers including economic growth and population migration

As populations continue to grow, there will be increasing pressure on water resources. Population growth is uneven and so there will be increased pressure in certain locations. Urban areas experiencing rapid economic growth are likely to experience the greatest increases in water stress.

The quantity of water currently used for all purposes exceeds 3,700 cubic kilometres per year. Agriculture is the largest user, consuming almost two-thirds of all water drawn from rivers, lakes and groundwater. Since 1960 water use for crop irrigation has risen by 60–70 per cent. Industry uses about 20 per cent of available water, and the municipal sector uses about 10 per cent. Population growth, urbanization and industrialization have increased the use of water in these sectors. As world population and industrial output have increased, water use has accelerated, and this is projected to continue. By 2025 global availability of freshwater may drop to an estimated 5,100 cubic metres per person per year, a decrease of 25 per cent on the 2000 figure.

Growing pressure on rivers has meant that a number of rivers no longer reach the sea, for example the Colorado river. In addition, of those that do, they may be heavily polluted, such as the Ganges, Yangtze and Hwang He rivers, making them unsafe for domestic consumption. The Rio Nuevo (New River) that flows from Baja California into California is now contaminated with agricultural, industrial and municipal waste. It is the most polluted river of its size in the USA. The pollutants cause regular algal blooms. The river feeds the inland Salton Sea in California, which has become increasingly saline over time. It is now saltier than seawater and there have been major fish deaths due to increasing temperatures, salinity and bacteria present in the river.

Overuse of the Ogallala aquifer in the USA has resulted in a decline of 9 per cent since 1950, and 2 per cent between 2000 and 2009. It is believed that it would take 6,000 years to recharge at current rainfall levels. Another vast aquifer is the Nubian Sandstone Aquifer System under the Sahara Desert. This is more than 2 million km^2 in area and offers great potential for the region.

Lakes and rivers are also vulnerable to pollution. Between 2014 and 2016 the Flint river in Michigan, USA, was polluted with chemicals related to industrial activity. Authorities from the city of Flint began using river water in their drinking-water supply, and it resulted in lead poisoning for a large number of residents.

Rapid economic growth in China has resulted in widespread declining water quality. Over 70 per cent of the country's rivers have such high levels of pollution that the water cannot safely be used as drinking water. Some 300 million people do not have access to clean water. Industrial and agricultural discharges into the Hwang He river have made the water unsafe even for agricultural uses. The use of fertilizers in agriculture is believed to be the cause of algal blooms in the Tai Lake.

The Middle East and North Africa (MENA) region contains over 6 per cent of the world's population but has only 1.4 per cent of its freshwater.

Activity 12

1. Explain how irrigation can both:
   a. raise groundwater levels, and
   b. lower groundwater levels.
2. Study Figure A.35, which shows changes in the quality of groundwater with distance from the centre of an aquifer in California.
   a. Describe the differences in water quality between "normal" groundwater in the aquifer (site 1) with that nearest the coast (site 5).
   b. How does the relative composition of (i) Cl and NO_3 and (ii) CO_3 and HCO_3 vary with distance from the centre of the aquifer? Suggest reasons for these changes.
3. Explain the causes of salinization, as shown in Figure A.36. Visit the website to view a case study about the effects of agriculture on the Aral Sea.

As the population increases, pressure on the water resources is likely to intensify. Twelve of the world's 15 water-scarce countries are in the MENA region. Nevertheless, careful use of the Nubian Sandstone Aquifer System and irrigation channels such as the Great Man-made River Project would enable the MENA region to access more freshwater resources.

Integrated planning is important to manage rivers for different users. Sometimes this may include different countries, or it may be different users within the same country. Failure to plan may result in unequal access to resources, and may lead to conflict, including geopolitical conflict, that is, between countries.

Internationally shared water resources as a source of conflict

Case study

The Grand Ethiopian Renaissance Dam

Ethiopia is currently building Africa's largest dam, the Grand Ethiopian Renaissance Dam (GERD), on the Blue Nile (Figure A.37). When it is finished, it will be 170 m tall and 1.8 km wide. Its reservoir will be able to hold more than the volume of the entire Blue Nile. It is designed to produce 6,000 megawatts of electricity, more than double Ethiopia's current output which leaves three out of four people in the dark.

This opportunity for Ethiopia could spell disaster for Egypt. The Nile provides nearly all of Egypt's water. Egypt claims two-thirds of that flow based on a treaty it signed with Sudan in 1959. However, this is no longer enough to satisfy the growing population (1.8 per cent growth in 2015) and agricultural sector. Annual water supply per person has fallen by well over half since 1970. The United Nations (UN) has warned of a looming crisis.

The stakeholders include the governments of Egypt, Ethiopia and Sudan, as well as the United Nations and the people who will make use of the water.

Egyptian leaders have been very forceful in the protection of their water supply. This has soured relations with the other countries that share the Nile Basin. However, most of them have agreed to cooperate with each other, dismissing another old treaty which, Egypt claims, gives it a veto over upstream projects.

In March 2015 the leaders of Egypt, Ethiopia and Sudan signed a declaration that approved construction of the dam as long as there is no "significant harm" to downstream countries. Two French firms were commissioned to study the dam's potential impact. Some Egyptians believe that Ethiopia is stalling so that the dam becomes a fait accompli. Already half-finished, experts worry that it may be too late to correct any problems.

There is uncertainty over the dam's ultimate use. Ethiopia insists that it will produce only power and that the water pushing its turbines (less some evaporation during storage) will ultimately flow downstream. Egyptians fear it will also be used for irrigation, reducing downstream supply.

A more reasonable concern is over the dam's large reservoir. If filled too quickly, it would for a time significantly reduce Egypt's water supply and affect the electricity-generating capacity of its own Aswan Dam. But the Ethiopian government faces pressure to see a quick return on its investment. The project, which is mostly self-funded, will cost around $4.8 billion. Some experts say filling the reservoir could take seven years.

Sudan has long sided with Egypt in opposition to the dam, which is some 20 km from its border. But as the potential benefits to Sudan have become clear, it has backed Ethiopia. Sudan will receive some of the power produced by the dam. By stabilizing the Nile's flow, it will also allow Sudan to prevent flooding, consume more water and increase agricultural output. Currently much

Case study (continued)

of the country's allocation of water under the 1959 treaty is actually consumed by Egyptians.

How much water Sudan uses in the future, and other variables such as changes in rainfall and water quality, should determine how the dam is operated. That will require more cooperation and a willingness to compromise. Disagreement between Egypt and Sudan over such things as the definition of "significant harm" bodes ill.

The Grand Ethiopian Renaissance Dam is merely the latest test of countries' willingness to share water. Ethiopia plans to build other dams on the river, which could further affect downstream supply. Sudan has promised foreign investors an abundance of water for irrigation. Egypt faces an uncertain future over its water supplies.

▲ **Figure A.37:** The location of the Grand Ethiopian Renaissance Dam on the Blue Nile

Large-scale water developments carry a dual threat – conflict with neighbouring countries, but also internal conflict due to the displacement of large communities. Egypt views the building of the GERD as a threat to its national security. Egypt has tended to use military threats in Nile disputes but is unlikely to be able to follow the threat through. Greater cooperation between Egypt and other Nile Basin countries is likely to be the most feasible way forward for Egypt.

A UN-backed plan suggests using the Nubian Sandstone Aquifer, below the eastern part of the Sahara Desert. Egypt, Sudan, Chad and Libya have agreed the plan. The UN suggests there could be 400 years worth of water there.

TOK

Visit the following website to investigate water disputes in the Middle East: http://journal.georgetown.edu/stemming-the-rising-tide-the-future-of-water-conflicts-in-the-middle-east-and-north-africa/.

Suggest why future "water wars" are very likely.

ATL Research skills

Use the First Chinese Water Census at http://www.mwr.gov.cn/2013pcgb/merge1.pdf for an update on water quantity and quality in China. (The information in English is in the second half of the census.)

Visit http://www.theguardian.com/environment/gallery/2011/sep/09/china-south-north-water-diversion-project-in-pictures for a photo essay on the impact of the diversion project on resettlement.

Activity 13

Develop a case study to show an international conflict over water, based on your own choice.

Online case study

Managing water resources in Tunisia

Case study

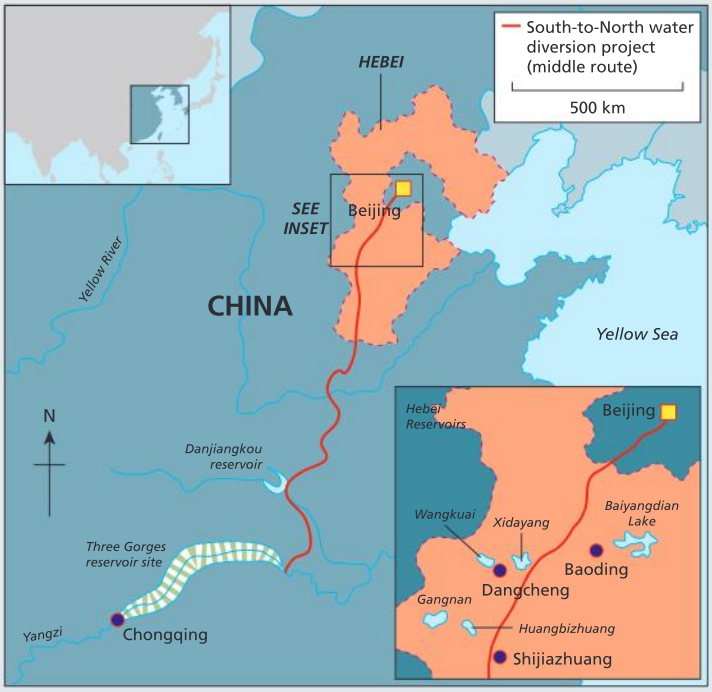
Water diversion in China

China's controversial South–North Water Diversion Project channels water from the south of Hebei province to Beijing in the north. The south–north diversion project cost £48 billion and consists of 2,400 km of canals and tunnels designed to divert 44.8 billion cubic metres of water from the wetter south to the north (Figure A.38). Some 350,000 people were relocated due to the building of reservoirs and canals.

Case study (continued)

Some complain that the scheme has exacerbated poverty in Hebei, forcing water-hungry and polluting industries to close and some farmers to forsake rice growing for less water-intensive but also less profitable maize. Also, over half of China's 50,000 rivers have disappeared and about 70 per cent of the remaining ones are polluted.

The extent of Beijing's predicament is not in doubt. In June 2008 Beijing's reservoirs were down to a tenth of their capacity. Beijing draws two-thirds of its water supply from underground and the water table is dropping by a metre a year, threatening geological disaster. Beijing has been trying to reduce demand by increasing water tariffs. Beijing's industries are now recycling 15 per cent of their water consumption compared with 85 per cent in developed countries.



▲ **Figure A.38:** The south–north water diversion scheme in China

Concepts in context

Water scarcity and water quality are influenced by many processes, some natural and some human induced. These include climate, climate change, land-use changes, demand for water, population increase, war and economic development. Water scarcity and water quality are major issues in many parts of the world – potentially they could lead to the spread of disease, reduced crop yields and reduced quality of life.

Countries that are more **powerful** may seize water resources or develop water resources, whereas poorer countries may be forced to cope with reduced access to water. We have also seen how poor people often have to pay more for their water than richer people. There is unequal access to freshwater around the world.

Check your understanding

1. Define physical water scarcity.
2. Explain what is meant by economic water scarcity.
3. Explain what is meant by the term "water stress".
4. Explain why many poor people pay more for their water than richer people.
5. Explain what is meant by virtual water.
6. On which river is the Grand Ethiopian Renaissance Dam?
7. Outline the process of salinization.
8. Explain the process of eutrophication.
9. In which environments is salinization most frequent?
10. Suggest different ways in which Egypt's water supply may be reduced in future decades.

4 Water management futures

Costs and benefits of a dam as a multi-purpose water scheme

The impacts of the Aswan Dam (a megadam) on the River Nile

The number of large dams (more than 15 m high) being built around the world is increasing rapidly and is reaching a level of almost two completions every day. Examples of such megadams include the Akosombo (Ghana), Tucurui (Brazil), Hoover (USA), Kariba (Zimbabwe) and the Grand Ethiopian Renaissance Dam (page 36–37).

The advantages of dams are numerous. In the case of the Aswan High Dam on the River Nile, Egypt, they include:

- flood and drought control: dams allow good crops in dry years as, for example, in Egypt in 1972 and 1973
- irrigation: 60 per cent of the water from the Aswan Dam is used for irrigation and up to 3.4 million hectares (4,000 square kilometres) of the desert are irrigated
- hydroelectric power: this accounts for 7,000 million kilowatt hours each year
- improved navigation
- recreation and tourism.

It is estimated that the value of the Aswan High Dam to the Egyptian economy is about $500 million each year.

On the other hand, there are numerous costs. For example, in the case of the Aswan High Dam:

- water losses: the dam provides less than half the amount of water expected
- salinization: crop yields have been reduced on up to a third of the area irrigated by water from the dam due to salinization
- groundwater changes: seepage leads to increased groundwater levels and may cause secondary salinization
- displacement of population: up to 100,000 Nubian people have been removed from their ancestral homes
- drowning of archaeological sites: the tombs of Rameses II and Nefertari at Abu Simbel had to be moved to safer locations, and the increase in the humidity of the area has led to increased weathering of ancient monuments
- seismic stress: the earthquake of November 1981 is believed to have been caused by the Aswan Dam; as water levels in the dam decrease, so too does seismic activity

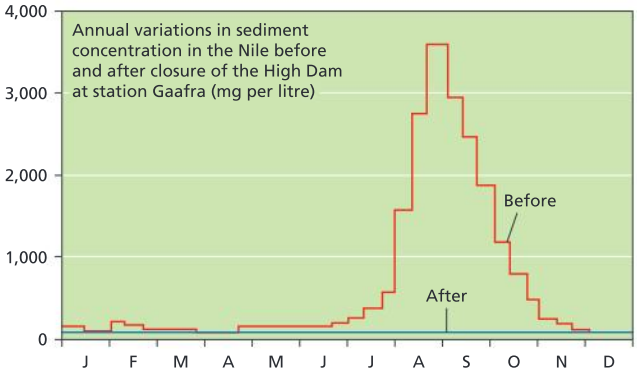
Conceptual understanding

Key question

What are the future possibilities for management intervention in drainage basins?

Key content

- Increased dam building for multipurpose water schemes, and the costs and benefits they bring.
- The growing importance of integrated drainage basin management (IDBM) plans, and the costs and benefits they bring.
- Growing pressures on major wetlands and efforts to protect them, including Ramsar wetland restoration schemes/projects.
- The importance of strengthening participation of local communities to improve water management in different economic development contexts, including sustainable water use and efficiency, and ensuring access to clean, safe and affordable water.



▲ **Figure A.39:** Changes in sedimentation along the Nile Valley

- deposition within the lake: infilling is taking place at a rate of about 100 million tonnes each year
- channel erosion (clear water erosion) beneath the channel: lowering the channel by 25 mm over 18 years, a modest amount
- erosion of the Nile delta: this is taking place at a rate of about 25 mm a year
- loss of nutrients: it is estimated that it costs $100 million a year to buy commercial fertilizers to make up for the nutrients that get trapped behind the dam
- decreased fish catches: sardine yields are down 95 per cent and 3,000 jobs in Egyptian fisheries have been lost.

▼ **Table A.6:** The logistics, benefits, costs and prospects of the Aswan Dam

Logistics	Benefits	Side effects	General assessment and prospects
Land development was a necessity to cope with the huge imbalance between the country's population growth and agricultural production. Agriculture is basic to the Egyptian economy.	It controls high floods and is a source of water during the dry season, saving Egypt from the costs of the damage from both high and low floods.	Water loss through evaporation and seepage is likely to affect the water supply needed for development plans; studies show that the water loss is within the predicted volume.	The Aswan High Dam is hard engineering work; more importantly, it is fulfilling a vital need for 40 million people.
Egypt had no option but to increase the water supply to meet the needs of land development policies.	Land reclamation allowed for an increase in the cultivated area, and increased the crop production of the existing land through conversion from annual to perennial irrigation.	Loss of the Nile silt requires costly use of fertilizers; it has also caused riverbed degradation and coastal erosion of the northern delta.	All dams have problems; some are recognized while others are unforeseen at the time of planning.
Building a dam and forming a water reservoir in an Egyptian territory minimizes the risks of water control politics on the part of riparian countries.	Nile navigation improved, and changed from seasonal to year round.	Soil salinity is increasing and land in most areas is becoming waterlogged due to delays in implementing drainage schemes.	A lesson learned from the Aswan project is that dams may be built with missionary zeal but little careful planning and monitoring of side effects.
Egypt perceived the Aswan High Dam as a multi-purpose project, basic to national development plans.	Electric power generated by the dam now supplies 50% of Egypt's consumption, but the dam was not built primarily for power generation but for water conservation.	Increased contact with water through irrigation extension schemes was expected to increase schistosomiasis (bilharzia) rates; evidence exists that rates have not increased due to use of protected water supplies.	As a result of the new semi-capitalist policies and also the technical and monetary aid that Egypt received from several western countries, it is expected that several of the dam's problems will be efficiently controlled and monitored.

Logistics	Benefits	Side effects	General assessment and prospects
	The new lake has economic benefits, including land cultivation and settlement, fishing and tourist industries.	The Nile water quality has been deteriorating, but it does not yet constitute a health hazard.	Dam-related studies have recognized problems and provided possible solutions. The dam will meet expectations providing that research findings are utilized.
			The development potential and economic returns of this water project are expected to be rewarding in the long run, if the project's developments are systematically studied and monitored.

Ethiopia is building a huge new dam on the River Nile, the Grand Ethiopian Renaissance Dam (known as GERD). It will be Africa's largest hydroelectric scheme when it is completed. It will cost almost $5 billion and is located close to the border with Sudan. In 2014 builders diverted the course of the Blue Nile so that construction of GERD could take place. Egypt fears that the new dam will restrict the flow of the Nile, Egypt's main source of freshwater.

Integrated drainage basin management

In the past, river engineering has frequently used embankments to reduce the impact of flooding. It is increasingly recognized that flood-plain embankments, while usually effective at reducing flood risk, may result in a variety of adverse consequences to the functioning of the river and its associated drainage basin. Land and water management is increasingly focused on the drainage basin. Nevertheless, integrated basin management has operated in the USA since the 1930s with the creation of the Tennessee Valley Authority (TVA), which adopted a holistic approach to river management.

Components of integrated drainage basin management include water supply, water quality, river channels, flood control, and the management of the basin in relation to agricultural, industrial, recreational, energy and ecosystem needs. Recent channel management has tended to work *with* the river rather than against it, but it has often focused on a small part of the river.

In the USA, the Mississippi drainage basin produces $54 billion of agricultural products and 92 per cent of the country's farm exports. Over half the goods and services consumed by US people are produced with water from the Mississippi drainage basin. Nevertheless, there are threats to the Mississippi and its tributaries.

Activity 14

Table A.7 provides information about the Aswan Dam. Identify the need for the dam, its costs and benefits, and evaluate its overall prospects.

Extension work

Visit the International Rivers Network at https://www.internationalrivers.org/resources/we-all-live-downstream-2700 and watch the video slideshow called "We all live downstream".

Photo A.9: Reservoir development, Antigua

Activity 15

Evaluate the effectiveness of large dams.

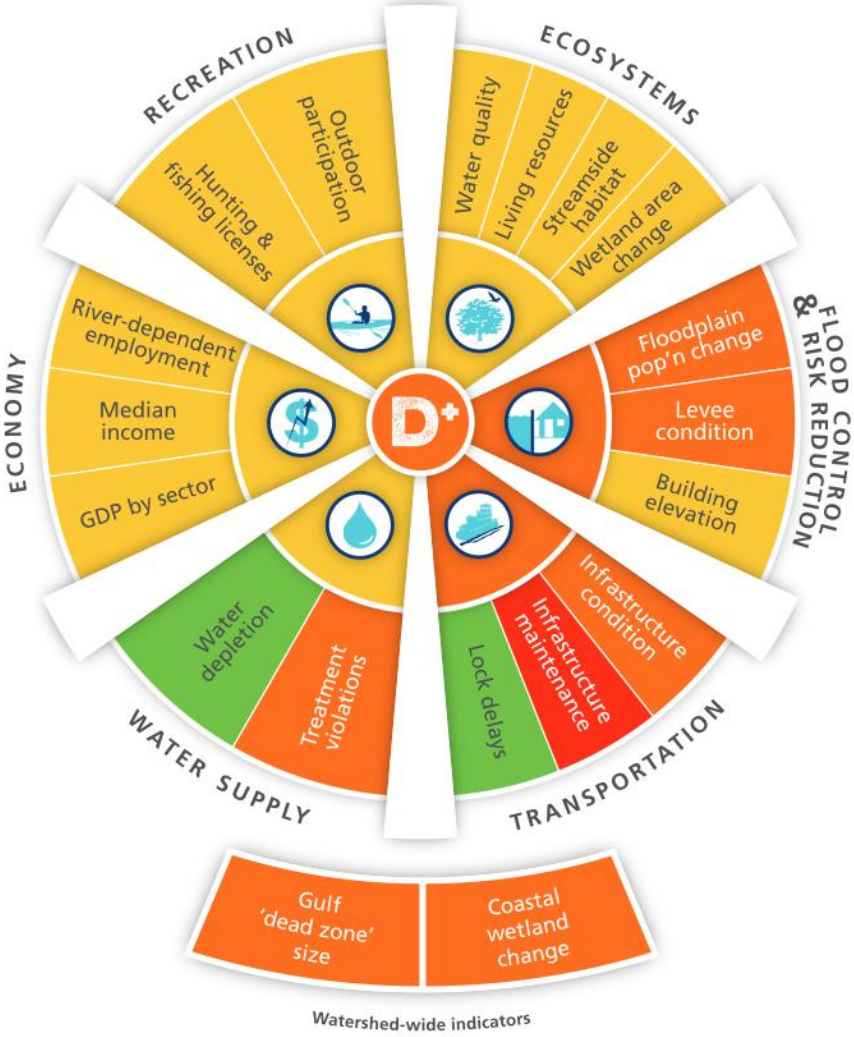
ATL Communications and social skills

Divide into two groups, A and B. Plan for a debate on the advantages and disadvantages of large dams. A is in favour of large dams, B is against them.

- Rising demand for water caused by population increase and increases in consumption have placed great stress on water resources.
- Floods on the Mississippi and its tributaries threaten people and economic activities.
- Global demand for crops such as cotton, corn and soya beans will increase pressure on water resources.
- Much of the water infrastructure is aging and needs replacing.

The America's Great Watershed Initiative (AGWI) is a project to increase water availability, improve its quality and safeguard its use for future generations. It involves government, academics, businesses and civil societies to help find solutions for the challenges of managing the Mississippi drainage basin. The AGWI Report Card (Figure A.40) measures six key areas of concern: ecosystems, flood control and risk reduction, transportation, water supply, economy and recreation.

One goal is to support and enhance healthy and productive ecosystems, as these provide abundant fish, wildlife and vegetation, which in turn provide many ecosystem services. The quality of ecosystems is very varied across the Mississippi drainage basin. The industrialized eastern part of the basin and the Lower Mississippi river are the greatest threats to natural areas. Poor water quality is the result of high nutrient run-off from agriculture and industry and is a major cause of hypoxia in fish in the Gulf of Mexico.



▲ **Figure A.40:** AGWI Report Card

The AGWI also attempts to reduce flooding and flood risk. The threat from flooding increases dramatically when basins lose their natural capacity to store water and when communities or businesses are located in the flood plain. The risk of flooding in the basin is increasing as developments on the flood plain increase. Nevertheless, investment in flood control reduced the losses from the 2011 Mississippi floods.

The Mississippi is also one of the USA's most important commercial routes. The rivers carries most of the country's farm exports and over 60 per cent of the USA's grain products for global consumption. However, many of the locks and dams are in relatively poor condition, and there has been a lack of investment in infrastructure. As facilities deteriorate, delays will become longer, and some carriers may seek alternative forms of transport/alternative routes.

Demand for groundwater and surface water will increase as the population increases and standards of living improve. The growing demand, along with an aging infrastructure, will increase the pressure on water resources. Water from the basin provides drinking water for millions of people, and helps to produce some 25 per cent of the nation's hydroelectric power. Water is also used for irrigation and industrial production. Demand for water is increasing but the supplies are becoming less reliable or in some cases contaminated.

Another aim of the AGWI is to enrich the quality of life for people and recreation-based economies by maintaining and enhancing riverine, lake and wetland-associated recreation. Every year, millions of people fish, boat, hike, jog or cycle along rivers. This is a multi-billion dollar recreational economy that is vital to many small communities and businesses.

Coastal wetlands in Louisiana enjoy a varied biodiversity, provide important storm protection from hurricanes and sea surges, and are a nursery for the commercial seafood industry. However, Louisiana's wetlands account for about 40 per cent of the USA's wetlands but 80 per cent of the lost wetlands. Some 75 square kilometres of Lousiana's 12,000 square kilometres of wetlands are lost annually. However, some wetlands are growing. On the whole, construction of dams on the Mississippi river and its tributaries, and raising the levels of the levees, has reduced the amount of sediment that reaches coastal wetlands.

Wetlands

A **wetland** is defined as "land with soils that are permanently flooded". There are a wide variety of wetland habitats. These account for about 6 per cent of the world's habitats and provide an important resource for those who live on them. However, wetlands have not always been viewed favourably, and for much of the 20th century they have been destroyed, altered, drained and removed to make way for agriculture, settlements, transport and industrial developments. Wetlands are under increasing pressure as a result of global warming. Nevertheless, examples of sustainable management of wetlands show that it is possible at a local level and at a regional/international level to manage wetlands sustainably.

The Ramsar Convention, an international treaty to conserve wetlands, defines wetlands as "areas of **marsh**, fen, **peatland** or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt." Thus, according to the Ramsar classification, there are marine, coastal, inland and man-made types of wetland, subdivided into 30 categories of natural wetland and nine human-made ones, such as reservoirs, barrages and gravel pits. Wetlands now represent only 6 per cent of the Earth's surface, of which 30 per cent are **bogs**, 26 per cent are **fens**, 20 per cent are **swamps**, 15 per cent are flood plains and 2 per cent are lakes. It is estimated that in 1900 there was twice as much wetland area as there was in 2000.

Wetlands provide many important social, economic and environmental benefits. These include water storage, groundwater recharge, storm protection, flood mitigation, shoreline stabilization, erosion control, and retention of carbon, nutrients, sediments and pollutants. Wetlands also

Table A.7: Ecosystem services provided by drainage basins

Provisioning services
Water (quantity and quality) for consumptive use (for drinking, domestic use, and agriculture and industrial use).
Water for non-consumptive use (for generating power and transport/navigation).
Aquatic organisms for food and medicines.
Supporting services
Role in nutrient cycling (role in maintenance of flood-plain fertility), primary production.
Predator/prey relationships and ecosystem resilience.
Regulatory services
Maintenance of water quality (natural filtration and water treatment).
Buffering of flood flows, erosion control through water–land interactions and flood control infrastructure.
Cultural services
Recreation (river rafting, kayaking, hiking and fishing as a sport).
Tourism (river viewing).
Existence values (personal satisfaction from free-flowing rivers).

ATL Research skills

Visit the website to view a case study on integrated drainage basin management for the Murray-Darling basin in Australia.

▲ **Photo A.10:** Wetlands

produce goods that have a significant economic value such as clean water, opportunities for tourism, fisheries, timber, peat and wildlife resources.

Wetland functions can generally be grouped into three main types: regulation, provision of habitats, and production. Wetlands are important regulators of water quantity and water quality. Flood-plain wetlands, for example, store water when rivers over-top their banks, reducing flood risk downstream. Wetlands also regulate water quality. Reed beds and other wetland plants, for example, are known as important regulators since they remove toxins and excessive nutrients from the water.

Wetlands are characterized by a large number of ecological niches and are very diverse. Many components of wetland ecosystems also provide resources for direct human consumption including water for drinking, fish, reeds for thatched roofs, timber for construction, peat and fuel wood. Recreational uses include fishing, sport hunting, birdwatching, photography and water sports.

Wetlands are highly dependent on water levels, and so changes in climatic conditions that affect water availability, such as long-term increases in temperature, sea-level rise and changes in precipitation, will have a big influence on the nature and function of specific wetlands. The ability of wetland ecosystems to adapt will be highly dependent on the rate and extent of these changes. Nevertheless, there is uncertainty about the increase in frequency and intensity of extreme events, such as storms, droughts and floods. For example, the range of change in climatic conditions from pre-industrial levels for North America are believed to be +/−20 per cent for precipitation, +/−10 per cent for evaporation and +/−50 per cent for run-off.

The Ramsar Convention

The Convention on Wetlands of International Importance especially as Waterfowl Habitat (usually referred to as the Ramsar Convention after the place of its ratification in Iran in 1971) is one of the most important instruments for conserving wetlands. This treaty laid the basis for international cooperation in conserving wetlands and more than 60 countries have signed up to the Convention.

The convention requires the signatories to:

- designate wetlands of international importance for inclusion in a list of so-called Ramsar sites
- maintain the ecological character of their listed Ramsar sites
- organize their planning so as to achieve the wise use of all of the wetlands on their territory
- designate wetlands as nature reserves.

There are more than 500 wetland sites on the Ramsar list, covering in excess of 30 million hectares of wetland habitat. To be considered a wetland of international importance, a site must:

- support a significant population of waterfowl, threatened species, or peculiar fauna or flora

- be a regionally representative example of a type of wetland
- be physically and administratively capable of benefiting from protection and management measures.

A distinguishing characteristic of the Ramsar Convention on Wetlands is the adoption of the concept of "wise use" as a part of the idea of nature conservation. The wise use of wetlands is their sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem. In this context, **sustainable utilization** is defined as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations".

Wetlands are one of the most productive ecosystems in the world, and the total economic value (TEV) of wetlands has often been underestimated. This TEV includes:

- direct use values of products such as fish and fuel wood, and services such as recreation and transport
- indirect use values such as flood control and storm protection provided by mangroves
- option values, which could be discovered in the future
- intrinsic values, the value of the wetland "of its own right" with its attributes.

A study of the large Hadejia-Nguru wetland in arid northern Nigeria found that water in the wetland yielded a profit in fish, firewood, cattle grazing lands and natural crop irrigation that was 30 times greater than the yield of water being diverted from the wetland into a costly irrigation project. A recent attempt to put a dollar value on the ecological services provided by different ecosystems worldwide put wetlands top at almost $15,000 per hectare per year, seven times more than that of the tropical rainforest. Much of this value comes from flood prevention.

Natural causes of wetland loss include sea-level rise, drought, hurricanes and other storms, and erosion. However, the main cause has been human interference, either direct or indirect. The reclamation of wetlands and dam construction cause the greatest loss of wetland habitat. Other causes include the conversion for aquaculture, mining of wetlands for peat, coal, gravel, phosphate and other materials, and groundwater abstraction. In other cases it has been down to human conflict.

Table A.8: The value of wetlands

Functions
Flood control
Sediment accretion and deposition
Groundwater recharge
Groundwater discharge
Water purification
Storage of organic matter
Food-chain support/cycling
Water transport
Tourism/recreation
Products
Fisheries
Game
Forage
Timber
Water
Attributes
Biological diversity
Culture and heritage

ATL Research skills

Visit the Ramsar website at http://www.ramsar.org/ and investigate sites that are closest to you or in places you have visited or are interested in.

Visit the website at http://www.ces.fau.edu/riverwoods/kissimmee.php to learn about the restoration of the Kissimmee River.

Community-level responses to water management

According to WaterAid there are 748 million people in the world without access to safe water. This is roughly one in ten of the world's population. Nearly half of the people who gained access to water between 1990 and 2008 live in India and China. Since 1981 WaterAid has provided 21 million people with safe water. There are various approaches to water management.

Water saving

There are many ways of saving water. Smaller-capacity baths hold less water. Taking a shower rather than a bath saves water. Water-efficient

showerheads produce water flows that feel far greater than they actually are. Taps with a low flow rate can be fitted to bathroom and kitchen sinks. Taps with push-down mechanisms that automatically turn off after a short time use less water than traditional screw taps. To help identify products that are water efficient, manufacturers have a Water Efficiency Products Labelling Scheme.

Turning off taps when not in use and fixing dripping taps are important ways of saving water. A running tap can waste more than six litres of water a minute. A dripping tap can waste more than 5,500 litres of water a year, so taps should be turned off properly and washers changed promptly when taps start to drip. Dishwashers and washing machines should only be used when they are full, and always on the most efficient water and energy settings.

Customer pricing

In many areas people pay for the amount of water they use. However, in some locations people do not pay the full cost of the water. This is especially true in some farming regions, where water may be heavily subsidized. This may encourage wasteful practices and lead to the decline of aquifers and other water sources.

Domestic water consumption can be measured through the use of meters. This enables water companies to charge customers for the amount of water they use. However, in some cases this has proved controversial. For example, a person who has medical care at home (for example kidney dialysis) may help to reduce a hospital's use of water and skilled staff, but they would face an increased water bill for the water they use.

In 2014 the Water Services Regulation Authority (Ofwat) in the UK announced that it was changing the rules for pricing water in England and Wales. It wants all consumers to be able to choose the water company that supplies them, and to allow new water suppliers to enter the market. It believes this would provide greater competition, lower prices and innovation in the water sector.

New technologies

These include nanotechnology infiltration, membrane chemistry, seawater desalination, smart monitoring, intelligent irrigation, waste-water processing and mobile recycling facilities.

Nanotechnology infiltration removes microbes, bacteria and other matter by using silver ions that destroy contaminants. **Membrane chemistry** enables water to be filtered and purified. The pores of membranes used in ultrafiltration are 3,000 times finer than a human hair. Recent breakthroughs have been credited with forcing down the cost of desalinated water around the world, from $1 per cubic metre to between $0.80 and $0.50 over five years. New ceramic membranes are helping to make treatment more affordable.

Seawater desalination is still extremely expensive, with reverse osmosis technology consuming a vast amount of energy: around 4 kilowatt hours of energy for every cubic metre of water. Britain's first-ever mainland desalination plant was opened at the Thames

Gateway Water Treatment Works in 2010. One solution being explored in Singapore, which opened its first seawater desalination plant in 2005, is **biomimicry** – mimicking the biological processes by which mangrove plants and fish extract seawater using minimal energy. If science can find a way of effectively mimicking these biological processes, innovative engineering solutions can potentially be derived for seawater desalination.

In developing countries alone, it is estimated that 45 million cubic metres of water is lost every day in distribution networks. Leaks are not only costly for companies, they increase pressure on stretched water resources. **Smart monitoring** technologies help companies to ensure the quality of their water supply networks. Electronic instruments, such as pressure and acoustic sensors, connected wirelessly to centralized and cloud-based monitoring systems will allow companies to detect and pinpoint leaks much quicker.

Approximately 70 per cent of the world's freshwater is used by the agricultural industry. Applying a more intelligent approach to water management by deploying **precision irrigation systems** could bring benefits to farmers in developed countries.

Many people living in urban areas, even in advanced economies, still do not have their sewage adequately treated, and wastewater is often discharged, untreated, into rivers and estuaries or used as irrigation water. New technologies promise to transform wastewater into a resource for energy generation and a source of drinking water. Sludge digesters, for example, are now removing nutrients to be used as fertilizers and are, in turn, reducing by up to 50 per cent the energy required for treatment.

An unexpected by-product from the explosion of the global hydraulic fracturing industry has been demand for **highly mobile water treatment and recycling facilities**. As these technologies develop and learn to treat high volumes of water, it will lead to cheaper, more potable treatment systems.

Zoning

Zoning relates to zones, or areas, that are protected from development in order to safeguard water quality. This has been a feature of some dry areas in the USA for decades. The aim is to allow aquifers to recharge. Zoning may also maintain water quality and reduce the risk of subsidence due to over-abstraction. The 1991 Nitrates Directive is one of the earliest pieces of European Union (EU) legislation aimed at controlling pollution and improving water quality. **Nitrate vulnerable zones** were identified, such as fields next to rivers and streams. Farmers were advised not to apply nitrogen fertilizers to these fields as there was a high chance the nitrogen would be washed into the streams, thereby increasing the risk of eutrophication. The policy has been successful. Between 2004 and 2007, nitrate concentrations in surface water remained stable or reduced at 70 per cent of monitored sites. Quality at 66 per cent of groundwater monitoring points is stable or improving.

Water purification

Water purification is the removal of impurities from water so that it is fit for purpose. Impurities may include chemicals, suspended solids, biological contaminants and gases. Physical methods of purification include filtration, sedimentation and distillation; there are also chemical processes such as chlorination and flocculation. According to the World Health Organization, over 1 billion people lack access to a drinking supply that is of an acceptable quality. Sand has been used as a filter for water since 1804. It is still the most common type of filter. The first successful use of chlorine to disinfect water supply was when John Snow used it in 1854 to treat the water supply in Soho, London, that had spread cholera. This is still the most common type of disinfect[a]nt as it rapidly kills many harmful microorganisms. Desalination of seawater is another example of water being purified and made fit for human and livestock consumption.

Rainwater harvesting

Water **harvesting** refers to making use of available water before it drains away or evaporates. Efficient use or storage of water can be achieved in many ways, for example:

- irrigation of individual plants rather than whole fields
- covering expanses of water with plastic or chemicals to reduce evaporation
- storage of water underground in gravel-filled reservoirs (again to reduce evaporation losses).

Substantial areas of valley bottomlands are suited for irrigation with low-cost pumps. Flood recession farming involves the planting of crops after a flood recedes.

Water harvesting aims to capture and channel a greater share of rainfall into the soil, and conserve moisture in the root zone where crops can use it.

In many drainage basins, constructing dams across stream headwaters can trap large amounts of run-off, which can either be channelled directly to a field, stored in a tank or small reservoir for later use, or allowed to percolate through the soil to recharge the groundwater. Check dams are small-scale dams that are designed to trap water and sediment during a flood. They are cheap to construct (generally less than £250) and typically last for about five years. Some are built entirely from local debris, while others may be built from manufactured bricks.

Gansu province in China and north-east Brazil have the largest rooftop rainwater harvesting projects. In Bermuda, it is a legal requirement that all new construction includes sufficient rainwater harvesting for its residents. In contrast, in Colorado, USA, water harvesting was restricted

▲ **Photo A.11:** Water butt

Activity 16

Explain how a water butt and a check dam can capture water.

by law until 2009 – it was believed to reduce the availability of water to those who had rights to take water from the drainage basin.

▲ **Photo A.12:** Check dam, Eastern Cape, South Africa

Concepts in context

There are many **possibilities** for management strategies to reduce water scarcity. These vary from multi-government organizations, such as the World Bank, to small-scale community plans or individual plans, for example for a borehole or a water butt. Some schemes may be international in scale whereas others are very local. It is possible to restore environments that have been harmed through human activities. River restoration is possible but expensive. Some large dams are very expensive and may lead to unforeseen consequences, for example the spread of diseases and increased water losses due to evaporation.

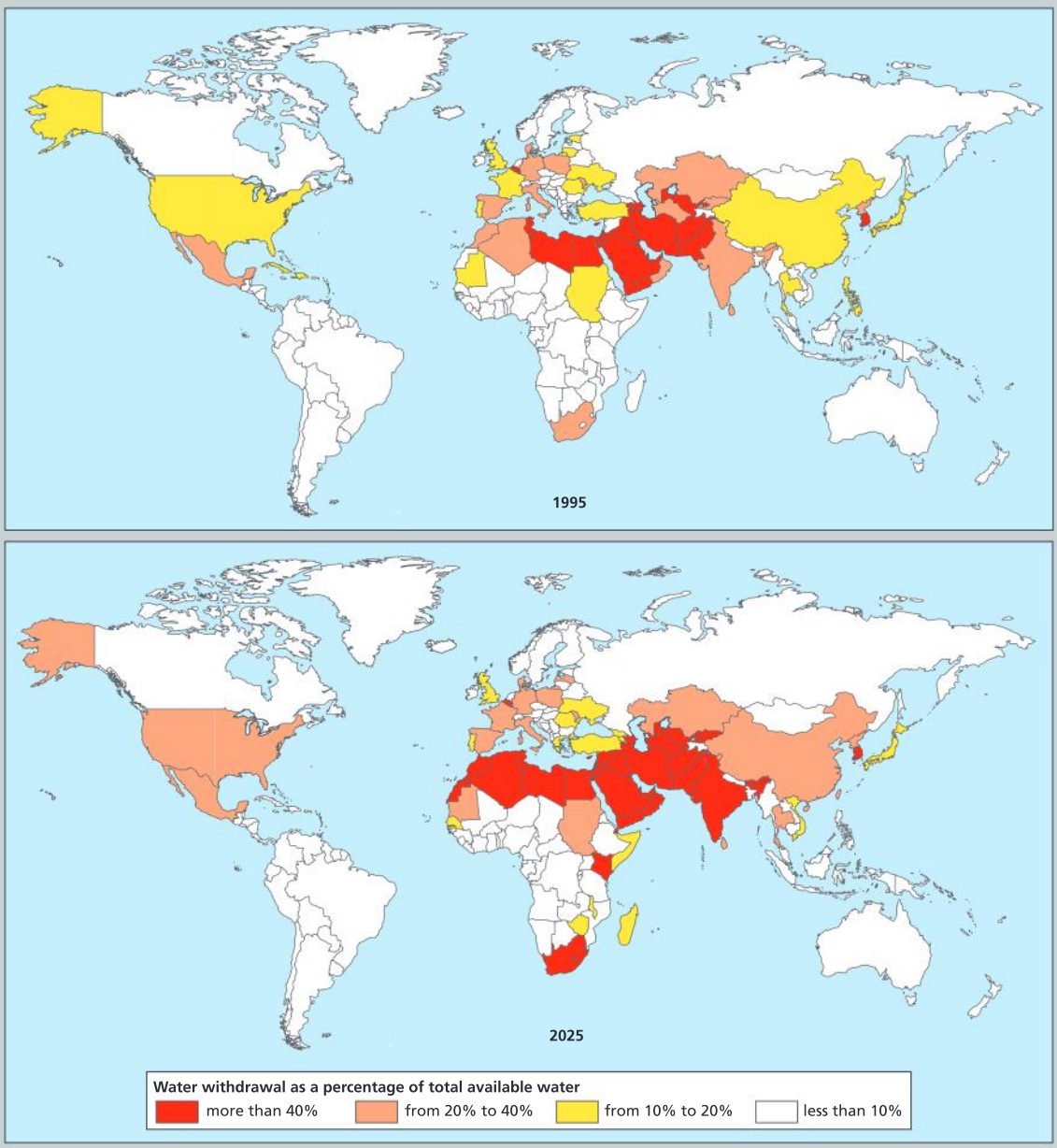
Check your understanding

1. Outline ways in which it is possible to save water.
2. How can pricing help reduce water loss?
3. Define the term "rainwater harvesting".
4. Briefly explain how two new technologies may promote greater access to freshwater.
5. Explain why many wetlands have disappeared.
6. Outline the advantages of wetlands.
7. Identify an integrated drainage basin scheme.
8. Identify one large dam scheme.
9. Outline the advantages of large dams.
10. Briefly explain the disadvantages of large dams.

Synthesis and evaluation

- The material in this chapter has shown how natural processes and human activities in one part of the drainage basin may affect other parts. For example, deforestation in the upper part of a basin may lead to increased discharge in the lower part of the basin.
- Water management can take place at a variety of scales. Large-scale drainage basin management may cover a wide area, such as the Tennessee Valley Authority, whereas individuals may collect water in water butts.
- There are different perspectives on water development schemes – ranging from international organizations such as the United Nations and the World Bank, to national governments and end users such as farmers and other consumers.
- Water cycling and water systems flows can be represented graphically by means of annotated sketches and systems/flow diagrams.

The maps show water withdrawals in 1995 and 2025 as a percentage of total available water.



(a) **(i)** State the water withdrawal, as a percentage of total available water, in China and in India in 1995 and 2025. (2 marks)

(ii) Describe the pattern of water withdrawal in 1995. (3 marks)

(iii) Outline two changes to withdrawals of over 40 per cent between 1995 and 2005. (2 marks)

(iv) Explain why access to freshwater is important to humans. (3 marks)

(b) **Either**

Examine the view that the cost of dams outweighs their potential benefits. (10 marks)

Or

Examine the role of human activities in increasing flood risk. (10 marks)

OPTION B
OCEANS AND COASTAL MARGINS

Key terms

Coastal margins	All areas from the deep oceans to inland areas that are affected by coastal processes (for example land–sea breezes) and that affect the coastline (for example sources of sediment).
ENSO – El Niño Southern Oscillation	A reversal of the normal atmospheric circulation in the southern Pacific Ocean, bringing warm water and low pressure to the eastern Pacific, and cool water and high pressure to the western Pacific. It occurs once every 2–10 years.
La Niña	An intensification of normal atmospheric processes, for example increased flooding in normally humid areas and increased drought in areas that are relatively dry.
Eustatic and isostatic sea-level changes	Eustatic changes are worldwide changes in sea level caused by the growth and decay of ice caps, thereby locking up and later releasing water from ice. Isostatic changes are localized changes in the relative level of the land and sea, caused by the depression of the Earth's crust, such as due to the weight of an ice sheet. Following deglaciation, the crust beneath the weight begins to rise again, and relative sea level therefore falls.
Advancing and retreating coastlines	Coastlines that are growing/getting larger either due to deposition or a fall in sea level are called advancing coasts. Retreating coasts are those that are getting smaller/disappearing either due to erosion or to a rise in sea level.
Global commons	Resources that are outside the reach of any one nation, for example oceans, the atmosphere and Antarctica. Global commons may be exploited or degraded and so need to be managed carefully.

Oceans cover over 70 per cent of the Earth's surface and are of great importance to humans in a number of ways. This optional theme provides an introduction to the physical characteristics and processes of the oceans with particular reference to the atmosphere–ocean link, concentrating on the important role that oceans play in influencing climatic conditions. Issues arising from the oceans as resource bases are also considered.

This theme will help develop an understanding of the concepts of place, processes, power and geographical possibilities. There will also be more specialist concepts including systems (ocean conveyor belts and coastal landform systems), territories (exclusive economic zones) and the Global commons.

Key questions

1. How do physical **processes** link the Earth's atmospheric and ocean systems?
2. How are coastal **places** shaped by their interaction with the ocean?
3. How **powerful** are different stakeholders in relation to coastal margin management?
4. What are the future **possibilities** for managing the oceans as a Global commons?

1 Ocean–atmosphere interactions

Conceptual understanding

Key question

How do physical **processes** link the Earth's atmospheric and ocean systems?

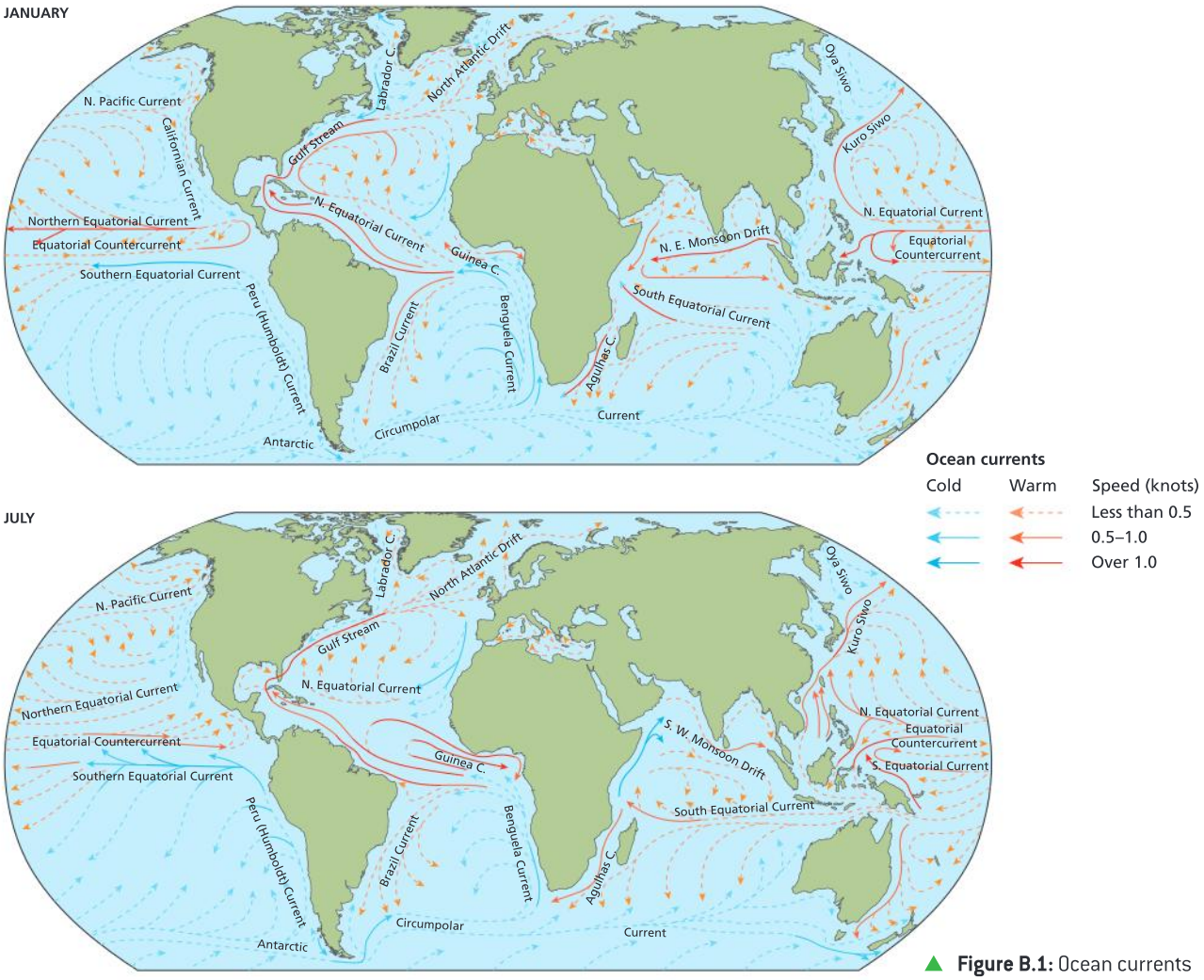
Key content

- The operation of ocean currents, including their distribution, nutrient and energy transfers and the importance of oceanic conveyor belts
- Atmosphere–oceanic interactions associated with ENSO cycles (El Niño and La Niña) and their climatic, environmental and economic effects
- The formation, distribution and physical impacts of hurricanes on coastal margins, including storm surges
- The changing role of oceans as a store and source of carbon dioxide (CO_2) and the impacts of ocean acidification on coral reefs

Ocean currents

Surface ocean currents are caused by the influence of prevailing winds blowing steadily across the sea (Figure B.1). The dominant pattern of surface ocean currents (known as **gyres**) is roughly circular flow. The pattern of these currents is clockwise in the northern hemisphere and anticlockwise in the southern hemisphere. The main exception is the circumpolar current that flows around Antarctica from west to east. There is no equivalent current in the northern hemisphere because of the distribution of land and sea. Within the circulation of the gyres water piles up into a dome. The effect of the rotation of the earth is to cause water in the oceans to push westward; this piles up water on the western edge of ocean basins rather like water slopping in a bucket. The return flow often occurs as narrow fast-flowing currents such as the Gulf Stream. The Gulf Stream in particular transports heat northwards and then eastwards across the North Atlantic. The Gulf Stream is the main reason why the British Isles have mild winters and relatively cool summers.

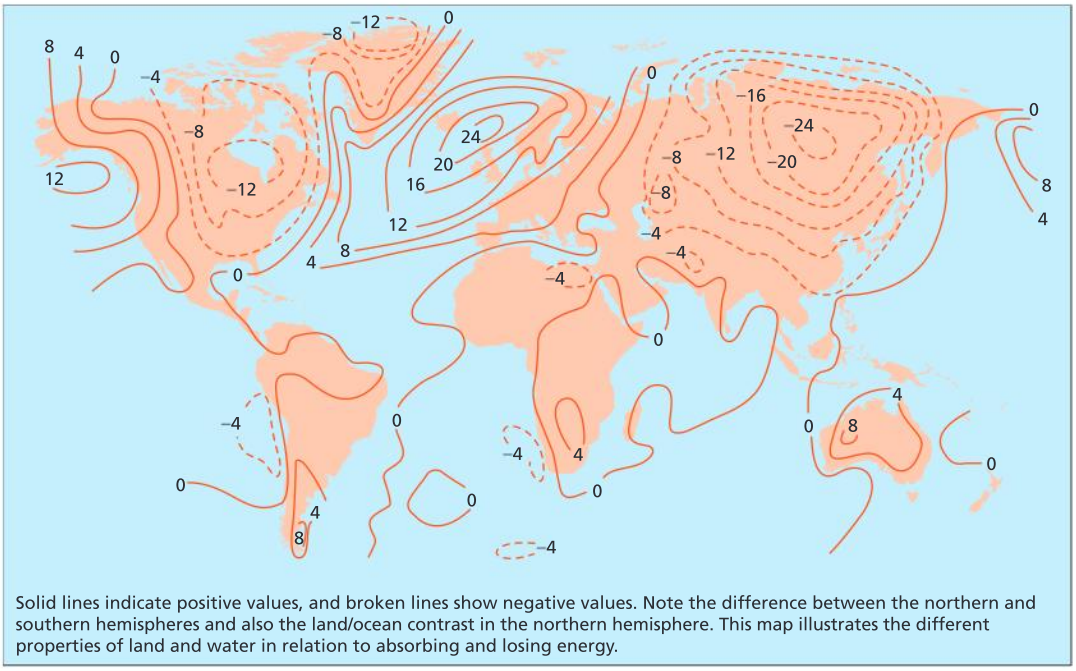
Warm ocean currents move water away from the equator. In contrast, cold ocean currents move water away from cold regions towards the equator. The major currents move huge masses of water over long distances. The warm Gulf Stream, for instance, transports 55 million cubic metres per second. Without it, the temperate lands of north-western Europe would be more like the sub-Arctic. The cold Peru Current and the Benguela Current of south-west Africa bring in nutrient-rich waters dragged to the surface by offshore winds. Ocean currents are important for the transfer of energy and nutrients.



▲ **Figure B.1:** Ocean currents

The effect of ocean currents on temperatures depends upon whether they are cold or warm. Warm currents from equatorial regions raise the temperature of polar areas (with the aid of prevailing westerly winds). However, the effect is only noticeable in winter. For example, the North Atlantic Drift raises the winter temperatures of north-west Europe. Some areas are more than 24 °C warmer than the average for their line of latitude (Figure B.2). By contrast, there are other areas that are made colder by ocean currents. Cold currents such as the Labrador Current off the north-east coast of North America may reduce summer temperatures, but only if the wind blows from the sea to the land.

Many eastern oceans experience upwelling currents, where the ocean currents move cold water, rich in nutrients, from the ocean floor to the surface. Such upwelling currents are found off the coast of Peru, California and south-west Africa. These nutrient-rich waters support important fisheries. The best-known upwelling current, off the coast of Peru, disappears periodically during El Niño events (see pages 56–58).

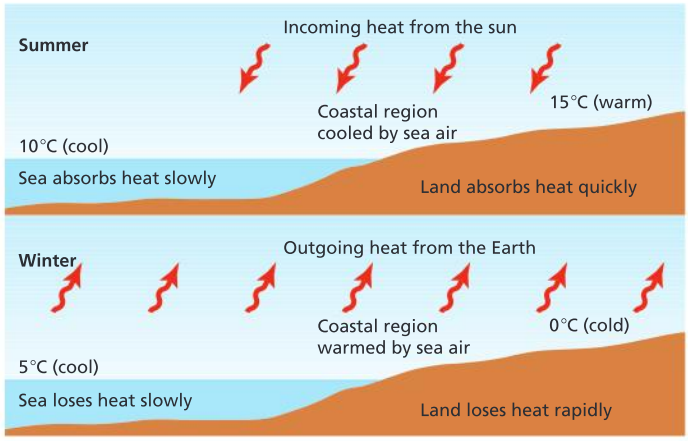


Solid lines indicate positive values, and broken lines show negative values. Note the difference between the northern and southern hemispheres and also the land/ocean contrast in the northern hemisphere. This map illustrates the different properties of land and water in relation to absorbing and losing energy.

▲ **Figure B.2:** Global temperature anomalies

Specific heat capacity

The specific heat capacity is the amount of energy it takes to raise the temperature of a body. It takes more energy to heat up water than it does to heat land. However, it takes longer for water to lose heat. Hence, land is hotter than the sea by day, but colder than the sea by night (Figure B.3). Places that are close to the sea are cool by day, but mild by night. With increasing distance from the sea this effect is reduced.



▲ **Figure B.3:** The effect of the sea on temperatures in coastal margins

In the Pacific Ocean two main atmospheric states exist. The first is warm surface water in the west with cold surface water in the east; the other is warm surface water in the east with cold surface water in the west. In both cases, the warm surface causes low pressure. As air blows from high pressure to low pressure there is a movement of water from the colder area to the warmer area. These winds push warm surface water into the warm region, exposing colder deep water behind them, and so the process repeats.

In addition, there is the **ocean conveyor belt**. This deep, grand-scale circulation of the ocean's waters effectively transfers heat from the tropics to colder regions, such as northern Europe.

The ocean conveyor belt

In addition to the transfer of energy by wind and by ocean currents, there is also a transfer of energy by deep sea currents. Oceanic

convection occurs from polar regions where cold salty water sinks into the depths and makes its way towards the equator. The densest water is found in the Antarctic area. Here seawater freezes to form ice at a temperature of around −2°C. The ice is freshwater, hence the seawater left behind is much saltier and therefore denser. This cold dense water sweeps round Antarctica at a depth of about 4 km. It then spreads into the deep basins of the Atlantic, the Pacific and the Indian Ocean. Surface currents bring warm water to the North Atlantic from the Indian and Pacific Oceans. These waters give up their heat to cold winds which blow from Canada across the North Atlantic. This water then sinks and starts the reverse convection of the deep ocean current.

Because the **ocean conveyor belt** operates in this way, the North Atlantic is warmer than the North Pacific, so there is proportionally more evaporation in the North Atlantic. The water left behind has more salt in it due to the evaporation, and therefore it is much denser, which causes it to sink. Eventually the water is transported into the Pacific where it mixes with more water and its density is reduced.

Temperature, salinity and pressure affect the density of seawater. Large water masses of different densities are important in the layering of the ocean water (denser water sinks). As temperature increases, water becomes less dense. As salinity increases, water becomes denser. As pressure increases, water becomes denser. A cold, highly saline, deep mass of water is very dense, whereas a warm, less saline, surface water mass is less dense. When large water masses with different densities meet, the denser water mass slips under the less dense mass. These responses to density are the reason for some of the deep ocean circulation models.

Activity 1

1. Describe the temperature anomalies shown in Figure B.2:
   a. across the equator
   b. about 60° North.
2. How do you account for these anomalies?

ATL Research and communication skills

Use a search engine or other resource to investigate the importance of oceanic conveyor belts in contrasting parts of the world. Give a two-minute presentation outlining the importance of ocean conveyor belts.

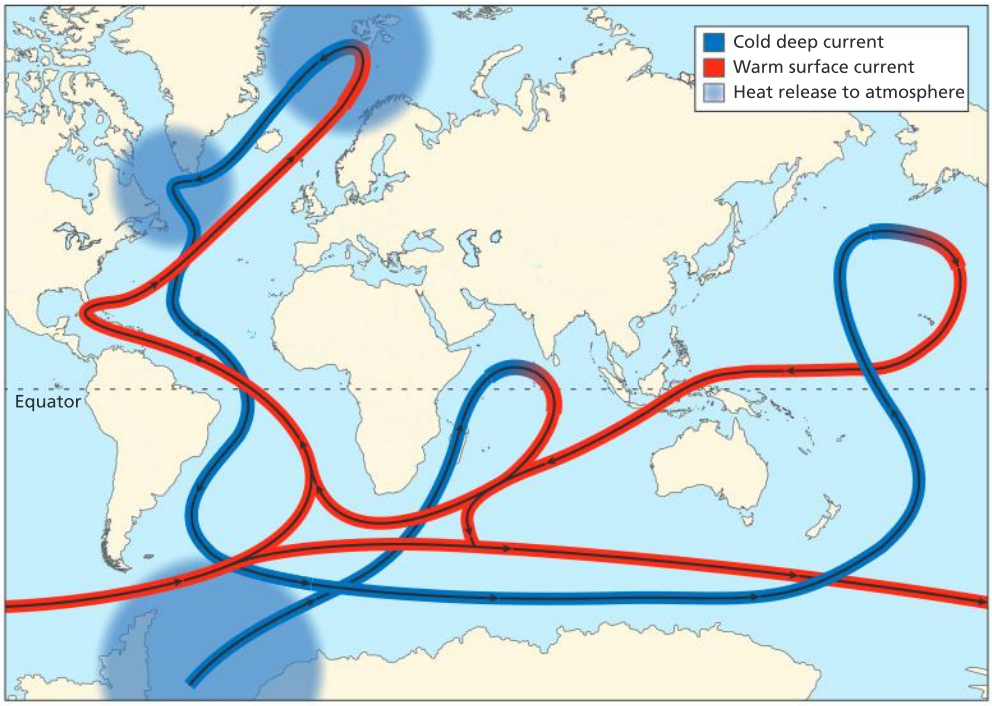
Activity 2

Describe the movement of cold and warm water in the ocean conveyor belt, as shown by Figure B.4.

Driven by changes in temperature and salinity, large ocean currents are in constant motion, moving heat from the equator to the upper latitudes and then moving cold back toward the equator.

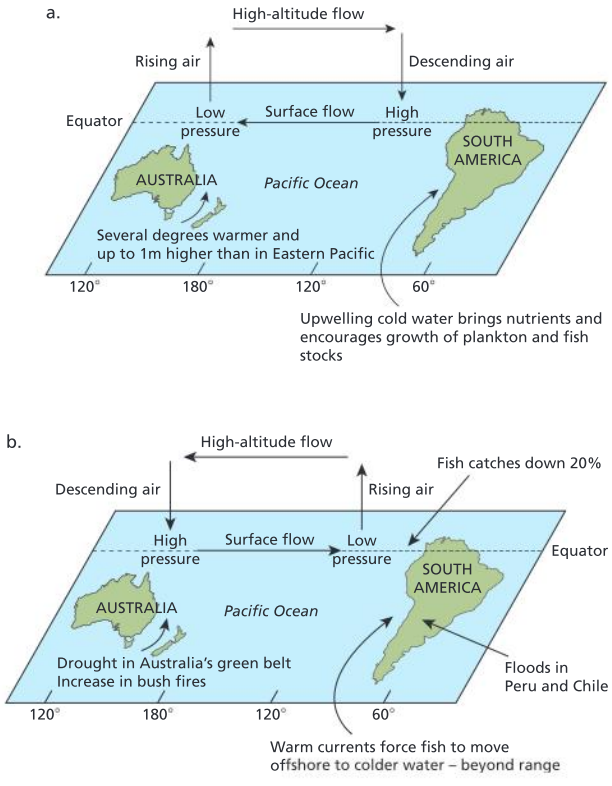
Known as 'thermohaline circulation,' this phenomenon includes the Gulf Stream, which moderates northern Europe's climate.

Some scientists speculate that global warming could weaken this circulation and leave some regions relatively cooler.



▲ **Figure B.4:** The ocean conveyor belt

El Niño and La Niña



▲ **Figure B.5:** Normal conditions shown in (a) and El Niño conditions in the South Pacific Ocean (b)
Source: NOAA

El Niño – the "Christ Child" – is a warming of the eastern Pacific that occurs at intervals between two and 10 years, and lasts for up to two years. Originally, El Niño referred to a warm current that appeared off the coast of Peru, but we now know that this current is part of a much larger system.

Normal conditions in the Pacific Ocean

The Walker circulation is the east–west circulation that occurs in low latitudes. Near South America winds blow offshore, causing upwelling of the cold, rich waters. By contrast, warm surface water is pushed into the western Pacific. Normally sea surface temperatures (SSTs) in the western Pacific are over 28 °C, causing an area of low pressure and producing high rainfall. By contrast, over coastal South America SSTs are lower, high pressure exists, and conditions are dry.

El Niño conditions in the Pacific Ocean

During El Niño episodes the pattern is reversed. Water temperatures in the eastern Pacific rise as warm water from the western Pacific flows into the eastern Pacific. During **ENSO** (El Niño Southern Oscillation) events, SSTs of over 28 °C extend much further across the Pacific. Low pressure develops over the eastern Pacific, high pressure over the west. Consequently, heavy rainfall occurs over coastal South America, whereas Indonesia and the western Pacific experience warm, dry conditions. Some of these conditions can be disastrous. The 1997–98 El Niño event is believed to have killed more than 21,000 people and caused an estimated $36 billion worth of damage.

In July 2015 the US National Oceanic and Atmospheric Administration (NOAA) reported changes in sea and air temperatures and declared the return of El Niño. During July sea surface temperatures were 1°C higher than expected in the central equatorial Pacific and 2°C higher in the eastern Pacific. This pushed SSTs over the 26.5°C needed for hurricane formation, and on 12 July six tropical cyclones began to form – more than on any single day in the previous 40 years.

In general, the USA benefits from El Niño events. Increased Pacific storm activity is matched by decreased Atlantic storm activity, and so the US East Coast experiences fewer hurricanes. Farms in the US Midwest generally experience higher yields due to milder temperatures. The US economy is believed to have benefited by as much as $15 billion in the 1997–98 El Niño event.

Other countries may not benefit if an El Niño intensifies. Indonesia could experience a prolonged drought, affecting coffee production, oil palm production and its hydroelectric production. Forest fires

would be more likely in the dry conditions, and could release up to 2 billion tonnes of carbon into the atmosphere. This is the equivalent of 5 per cent of total human-related greenhouse gas emissions for the year. Scientists warn of reductions in the Indian soya bean harvest, wheat in Australia and rice in China. A 2014 study concluded that between 1984 and 2004, almost one-quarter of the world's crops were affected by El Niño events.

El Niño events can also bring disease. In 1997 and 1998 heavy rains in East Africa created stagnant pools that allowed mosquitoes to breed. In addition, the floods damaged roads thus making it more difficult to distribute medicines, bed nets and insecticides.

A further complication is that a strong El Niño event can release a lot of stored heat. Some scientists believe that the apparent plateau of rising temperatures associated with the enhanced greenhouse effect is the result of relatively quiet El Niño events since 1997–98. Since 1999, global temperatures have increased at a rate of just 0.04°C a decade compared with 0.18°C during the 1990s.

The 2015–16 El Niño event was said to be the cause of water and food shortages for 100 million people. Some 40 million people in rural areas and nearly 10 million people in urban areas in southern Africa were affected. The area experienced its driest year for 35 years. Up to 1 million children in East Africa and Southern Africa were in need of treatment for malnutrition. Millions of people in Asia were affected by heatwaves and water shortages. In Zimbabwe the price of maize increased by over 50 per cent compared with 2015. The heavy rains in South America were considered to be one reason why the Zika virus was able to spread easily (there was more stagnant water for mosquitoes to breed in) while Central America had one of its most severe droughts in history.

It is difficult, if not impossible, to predict the likely strength of the El Niño event and therefore its impacts. Given the global scale, it is even more difficult to suggest what may or may not happen. This makes it much harder to prepare for such events.

La Niña

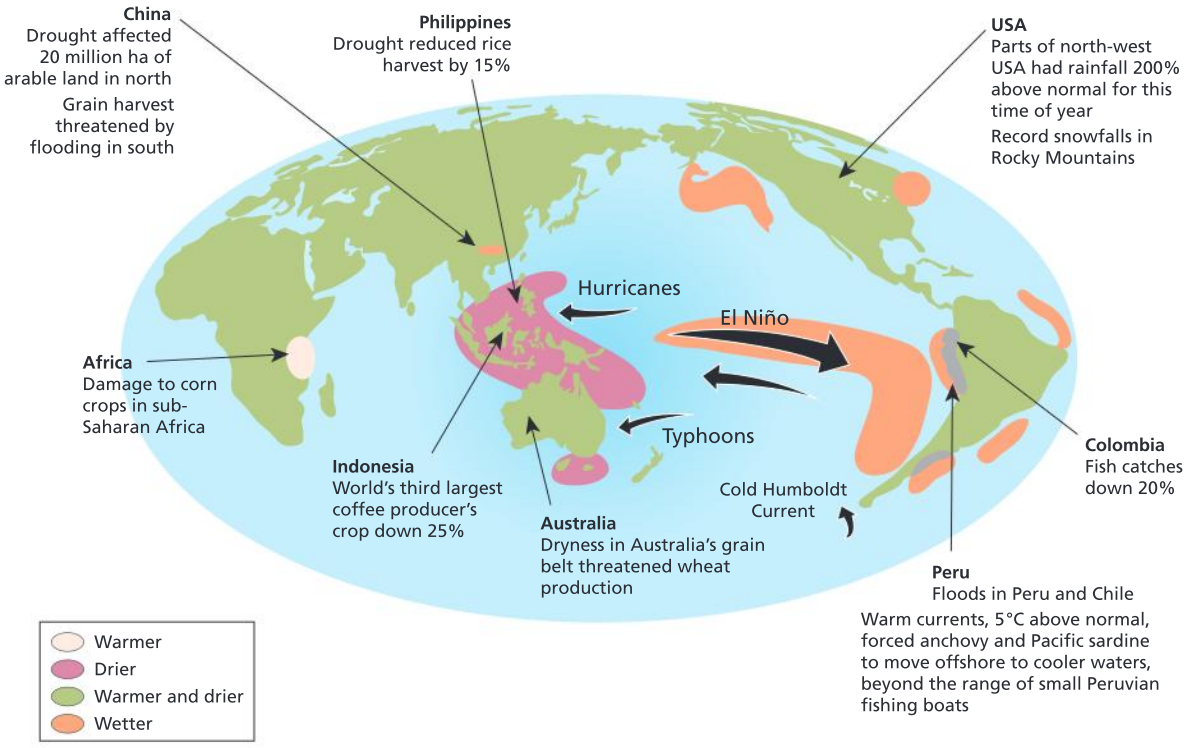
La Niña is an intermittent cold current that flows from the east across the equatorial Pacific Ocean. It is an intensification of normal conditions whereby strong easterly winds push cold upwelling water off the coast of South America into the western Pacific. Its impact extends beyond the Pacific and has been linked with unusual rainfall patterns in the Sahel (just to the south of the Sahara desert) and in India, and with unusual temperature patterns in Canada.

Managing the impacts of El Niño and La Niña

Managing the impacts of these events is difficult for many reasons. In the past, El Niño events could not be predicted with much accuracy. Now there are sensors across the Pacific that predict El Niño months in advance. They have enabled Peru to stock up with food resources and to relocate people away from vulnerable areas. Nevertheless, they affect large parts of the globe, not just the Pacific. Some of the countries

Activity 3

1. Compare the conditions in the south Pacific Ocean **a)** under normal conditions and **b)** during El Niño conditions.
2. What were the impacts of the 1997–98 El Niño event?



▲ **Figure B.6:** The effects of the 1997–98 El Niño event

affected do not have the resources to cope, and there are indirect impacts on other parts of the world through trade and aid.

Hurricanes/tropical cyclones

"Cyclone" is the term used in the South Pacific and Indian Ocean. These are called "hurricanes" in the Atlantic and north-east Pacific; and "typhoon" is the term used in the north-west Pacific (Figure B.7).

Tropical cyclones are low-pressure systems that bring heavy rainfall, strong winds and high waves, and cause other hazards such as flooding and mudslides. Hurricanes also deliver enormous quantities of water to the areas they affect. This is due to their origin over moist tropical seas. High-intensity rainfall of up to 500 millimetres in 24 hours invariably cause flooding. The path of a hurricane is erratic; hence it is not always possible to give more than 12 hours' notice. This is insufficient for proper evacuation measures to be implemented.

Hurricanes develop as intense low-pressure systems over tropical oceans. Winds spiral rapidly around a calm central area known as the eye. The diameter of the whole hurricane may be as much as 800 km, although the very strong winds that cause most of the damage are found in a narrower belt, up to 300 km wide. In a mature hurricane, pressure may fall to as low as 880 millibars. This very low pressure, and the strong contrast in pressure between the eye and outer part of the hurricane lead to strong gale-force winds.

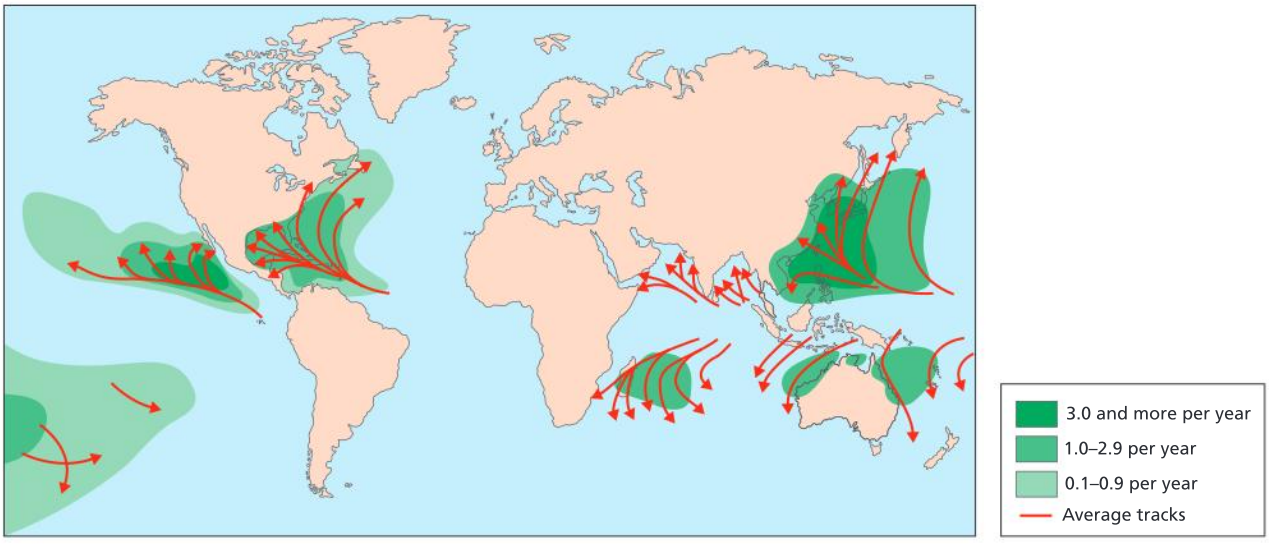
Hurricanes move excess heat from low latitudes to higher latitudes. They normally develop in the westward-flowing air just north of the equator

! Common mistake

✗ Some students confuse tropical cyclones with tornadoes.

✓ Tropical cyclones are very wide weather systems that develop over oceans. In contrast, tornadoes are very narrow weather systems that normally develop over land. Some tornadoes may form over water to produce water spouts.

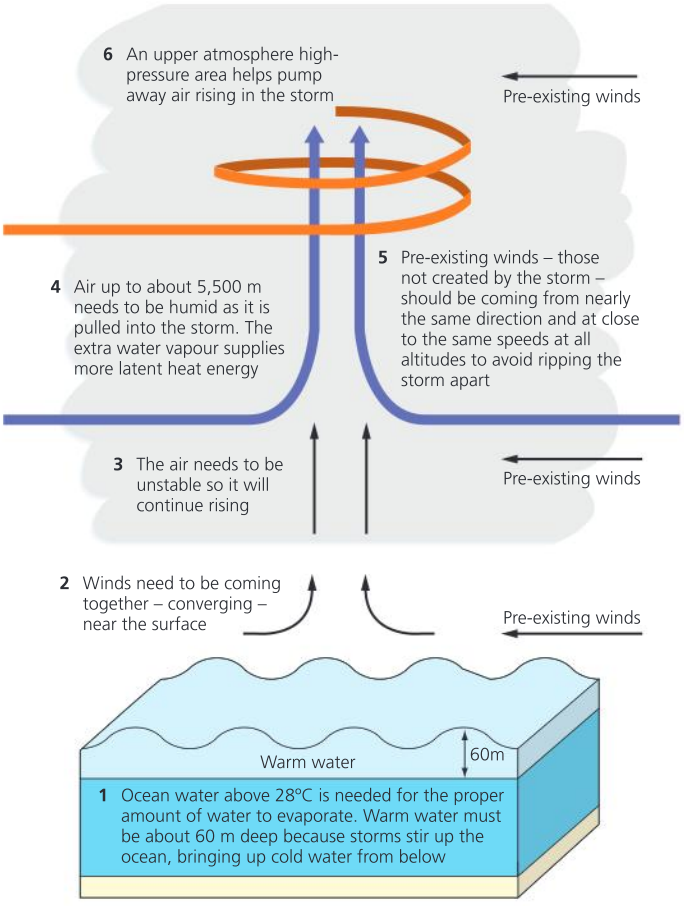
▼ **Figure B.7:** The distribution of hurricanes



(known as an easterly wave). They begin life as small-scale tropical depressions, localized areas of low pressure that cause warm air to rise. These trigger thunderstorms that persist for at least 24 hours and may develop into tropical storms, which have greater wind speeds of up to 118 km per hour (74 mph). However, only about 10 per cent of tropical disturbances ever become hurricanes.

For hurricanes to form, a number of conditions are needed (Figure B.8).

- Sea temperatures must be over 27°C to a depth of 60 metres (warm water gives off large quantities of heat when it is condensed; this is the heat that drives the hurricane).
- The low-pressure area has to be far enough away from the equator so that the Coriolis force (the force caused by the rotation of the earth) creates rotation in the rising air mass; if it is too close to the equator there is insufficient rotation and a hurricane will not develop.
- Conditions must be unstable: some tropical low-pressure systems develop into hurricanes, but not all of them, and scientists are unsure why some do but others do not.



▲ **Figure B.8:** Factors affecting the development of hurricanes

Impacts of hurricanes

The Saffir-Simpson scale, developed by the National Oceanic and Atmospheric Administration, assigns hurricanes to one of five categories of potential disaster. The categories are based on wind intensity. The

classification is used for hurricanes forming in the Atlantic and northern Pacific; other areas use different scales.

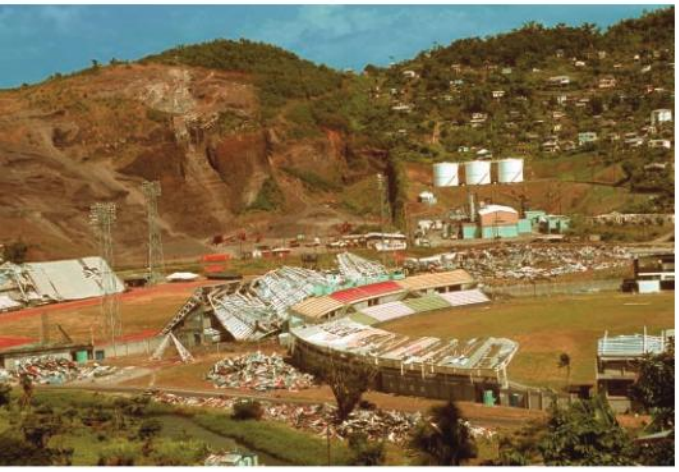
▼ **Table B.1:** The Saffir-Simpson scale

Type	Hurricane category	Damage	Pressure (mb)	Wind speed (km/h)	Storm surge (metres above normal)
Depression	–	–	–	<56	–
Tropical storm	–	–	–	57–118	–
Hurricane	1	Minimal	>980	119–53	1.2–1.5
Hurricane	2	Moderate	965–79	154–77	1.6–2.5
Hurricane	3	Extensive	945–64	178–209	2.6–3.6
Hurricane	4	Extreme	920–44	210–49	3.7–5.5
Hurricane	5	Catastrophic	<920	>250	>5.5

- The unpredictability of hurricane paths makes the effective management of hurricanes difficult. It was fortunate for Jamaica that Hurricane Ivan (2004) suddenly changed course away from the most densely populated parts of the island, where it had been expected to hit. In contrast, it was unfortunate for Florida's Punta Gorda when Hurricane Charley (2004) moved away from its predicted path.
- The strongest storms do not always cause the greatest damage. Only six lives were lost to Hurricane Frances in 2004, but 2,000 were taken by Jeanne when it was still categorized as just a "tropical storm" and had not yet reached full hurricane strength.
- The distribution of the population increases the risk associated with hurricanes. Much of the population lives in coastal settlements and is exposed to increased sea levels and the risk of flooding.
- Hazard mitigation depends on the effectiveness of the human response to natural events. This includes urban planning laws, emergency planning, evacuation measures and relief operations, such as rehousing schemes and the distribution of food aid and clean water.
- LICs (low-income countries) continue to lose lives to natural hazards as a result of inadequate planning and preparation. By contrast, insurance costs continue to be greatest in high-income countries, such as the USA or Australia, where multi-million dollar waterfront homes proliferate.

Activity 4

1. Describe the distribution of hurricanes as shown in Figure B.7.
2. Outline the main changes that occur as hurricane intensity increases (Table B.1).
3. Suggest reasons why the impacts of hurricanes vary from place to place.



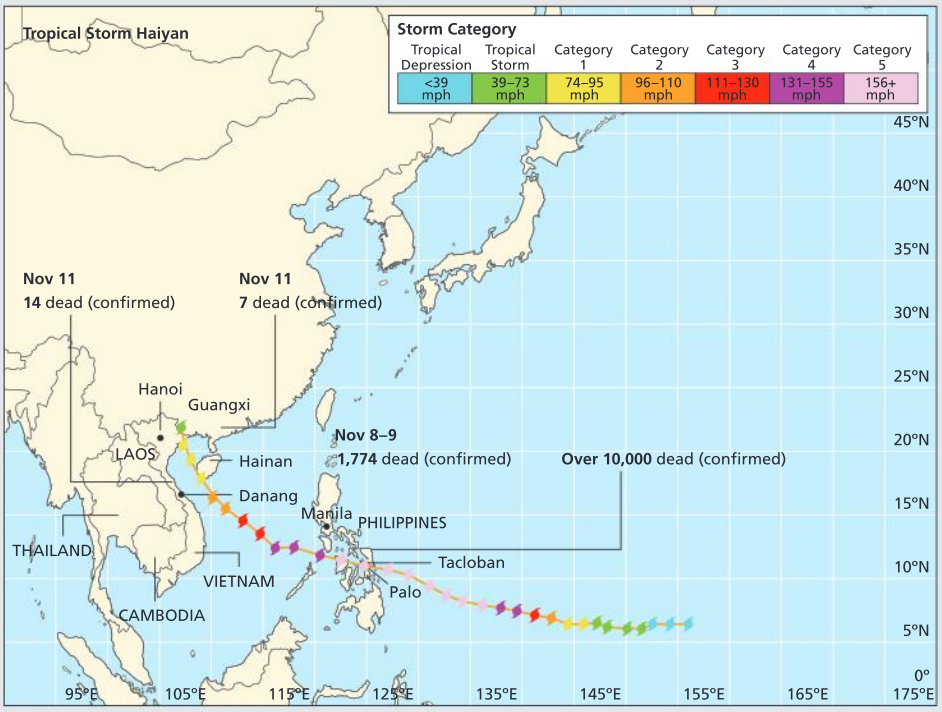
▲ **Photo B.1:** Damage in Grenada following Hurricane Ivan

Typhoon Haiyan: how does it compare to other tropical cyclones?

Typhoon Haiyan, described as the strongest tropical cyclone to make landfall in recorded history, hit the Philippines with winds of 314 km/h and gusts of up to 378 km/h, the fourth-strongest typhoon ever recorded (Table B.2) but the strongest to reach landfall.

Case study

Typhoon Haiyan



▲ **Figure B.9:** The track of Typhoon Haiyan

At least 10,000 people were killed in the central Philippine province of Leyte after Typhoon Haiyan, one of the strongest storms ever to make landfall, struck the Philippines in November 2013. Winds up to 315 km/h (195 mph) were recorded during the super-typhoon which tore roofs off buildings, knocked out electricity pylons and turned roads into rivers full of debris.

About 70–80 per cent of the buildings in the path of Haiyan in Leyte province were destroyed. Tacloban, the provincial capital of Leyte, had a population of over 200,000. The storm surge caused seawaters to rise by above 6 m when the typhoon hit. Power was cut and there was no mobile phone signal, so communication was possible only by radio.

With many provinces left without power or telecommunications, and airports in the hardest-hit areas, such as Tacloban, closed, it was impossible to know the full extent of the storm's damage – or to provide badly needed aid. Government figures showed that more than 4 million had been directly affected. The World Food Programme mobilized some $2 million (£1.25 million) in aid and aimed to deliver 40 tonnes of fortified biscuits to victims within days. The economic cost was estimated to be about $15 billion. Many countries pledged aid to the Philippines, including the UK ($131 million), Japan $53 million), Canada ($40 million) and the USA ($37 million).

Satellite images showed normally green patches of vegetation ripped up into brown squares of debris in Tacloban, where a local TV channel broadcast images of huge storm surges, flattened buildings and families wading through flooded streets with their possessions held above the water. Those living in the hardest-hit areas, such as the eastern Visayas, were among the poorest in the Philippines. Many had little or no savings – so the typhoon put an already vulnerable population at even greater risk of future food and job insecurity.

On Bohol island, where a 7.3 magnitude earthquake killed some 200 people in October 2013, residents were successfully evacuated ahead of the storm. However, because the island's main power supply comes from neighbouring Leyte, residents were without electricity or water. In Tacloban, the sheer force of the storm was too much for some evacuation centres, such as stadiums and churches, and they collapsed.

The Philippines experiences about 20 typhoons every year. In 2012 Typhoon Bopha killed more than 1,100 people and caused over $1 billion-worth of damage.

Table B.2: The strongest tropical cyclones in world history

Super typhoon	Year	Wind speed (km/hr)	Pressure (mb)	Landfall
Nancy	1961	346	882	Made landfall as a Category 2 in Japan, killing 191 people
Violet	1961	322	886	Made landfall in Japan as a tropical storm, killing 2 people
Ida	1958	200	877	Made landfall as a Category 1 in Japan, killing 1269 people
Haiyan	2013	314	895	Made landfall in the Philippines at peak strength, Category 5
Kit	1966	314	880	Did not make landfall
Sally	1961	314	895	Made landfall as a Category 4 in the Philippines

NB: Some of the data from the 1950s and the 1960s may have overestimated wind speeds.

ATL Communication skills

Use the data in Table B.2 to produce a scatter graph. Use the Spearman's Rank Correlation Coefficient to test whether there is a relationship between the strength of a hurricane and the number of deaths. Report your findings to your class using either a poster or a presentation.

ATL Research skills

Visit www.nhc.noaa.gov for the National Hurricane Center (USA). Enter Haiyan (or any other hurricane) in the search box for more information as well as satellite images, maps and photographs.

The role of oceans as a source and store of carbon dioxide

Oceans are the largest CO_2 sink on Earth; more than 25 per cent of the carbon dioxide that humans release into the air is absorbed into the sea. Over geological time, more than 90 per cent of the world's carbon has settled in the ocean. Biological processes, such as photosynthesis, turns carbon dioxide into organic material. Gradually, organic carbon settles into the deep ocean. The upper ocean therefore has a lower concentrations of carbon than the deep ocean. If carbon on the ocean floor was lifted to the surface (as in a thermohaline circulation) the ocean could become a source of CO_2 rather than a sink.

During cold glacial phases atmospheric CO_2 levels may have decreased to around 180 ppmv (parts per million by volume), and it is thought that much of this was stored in the oceans. In contrast, in the warm interglacials, CO_2 is released from the oceans, and atmospheric CO_2 levels may have been around 280 ppmv. Current CO_2 levels are around 400 ppm, indicating a substantial warming.

The major reservoirs of carbon dioxide are fossil fuels ($10{,}000 \times 10^{12}$ kg of carbon), the atmosphere (750×10^{12} kg of carbon) and the oceans ($38{,}000 \times 10^{12}$ kg of carbon). Oceans play a key role in the carbon cycle. Photosynthesis by plankton generates organic compounds of carbon dioxide. Some of this material passes through the food chain and sinks to the ocean floor where it decomposes into sediments. Eventually it is destroyed at subduction zones where ocean crusts are subducted beneath the continental plates. Carbon dioxide is later released during volcanic activity. The transfer of carbon dioxide from ocean to atmosphere happens over a very long timescale.

Up to half of the carbon dioxide released by burning fossil fuels since the early 1880s has been absorbed by oceans. Absorbed CO_2 in seawater forms carbonic acid, which lowers the water's pH and makes it more acidic.

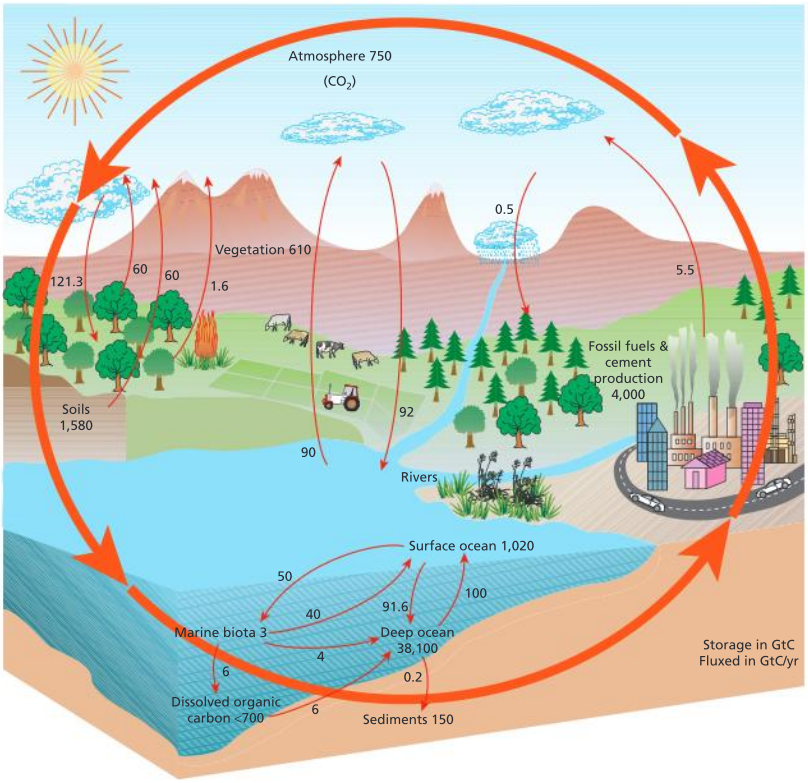
Activity 5

1. Describe the main stores of carbon in the carbon cycle.
2. Identify the main flows of carbon in the carbon cycle.

Ocean acidification

The pH of seawater

Acidity is measured on the pH scale. Freshwater has a pH reading of 7. Surface seawater had a reading of 8.2 a century ago, but now this has dropped to 8.1 because of the amount of carbon dioxide that has been absorbed by oceans. Although this may seem like a relatively small change, the pH scale is logarithmic, and so a 0.1 difference actually represents an increase in acidity of 30 per cent. By 2100, the pH of surface seawater could have dropped to 7.8, which represents an increase in acidity of about 150 per cent.



▲ **Figure B.10:** The global carbon cycle

The oceans are thought to have absorbed about 50 per cent of the extra CO_2 put into the atmosphere in the industrial age. This has lowered its pH by 0.1. Seawater is mildly alkaline with a "natural" pH of about 8.2. However, the IPCC (Intergovernmental Panel on Climate Change) forecasts that ocean pH will fall by between 0.14 and 0.35 units during the 21st century, adding to the present decrease of 0.1 units since pre-industrial times.

The cause of ocean acidification is believed to be anthropogenic (man-made) sources – such as carbon emissions from industrial plants, power stations, cars and planes. Many species are now threatened with extinction, fisheries face eradication, and coral reefs that protect coastal areas are starting to erode.

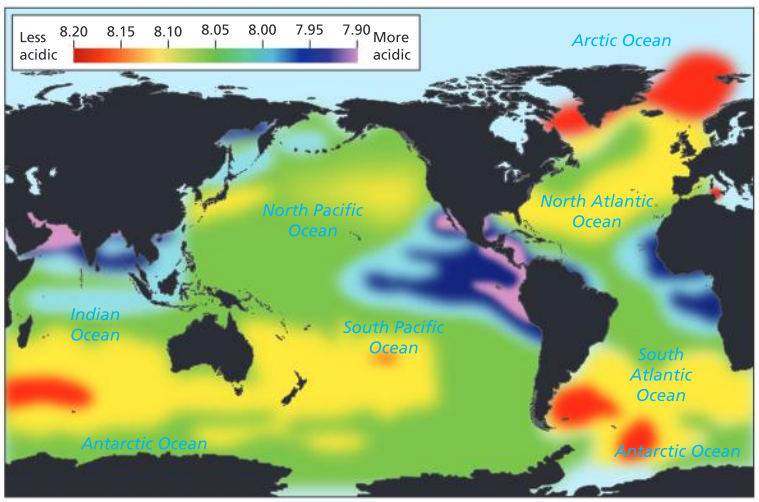
ATL Research skills

Visit http://news.bbc.co.uk/1/hi/uk/7053903.stm to see whether the world's oceans are now absorbing more or less CO_2.

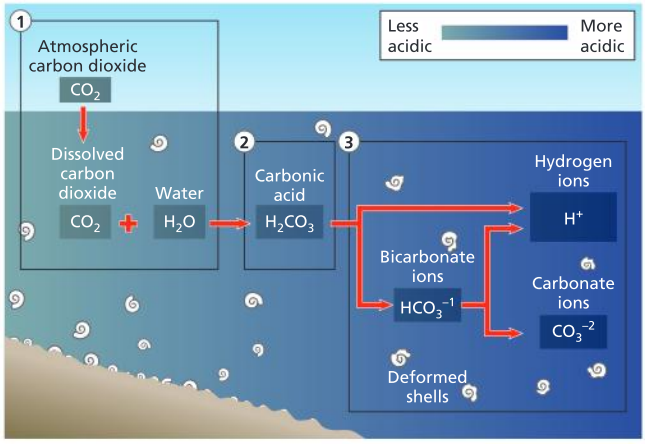
Some of the carbon that mankind emits remains in the atmosphere and causes it to heat up, driving global warming. However, about 30 per cent of carbon dioxide is absorbed by the oceans where it turns to carbonic acid.

More acidic oceans are beginning to kill off coral reefs and shellfish beds and threaten stocks of fish. Increasing ocean acidification will reduce calcification in corals and other calcifying organisms, resulting in slower growth and weaker skeletons.

Scientists estimate that oceans absorb around a million tonnes of carbon dioxide every hour. As a result, they are now 30 per cent more acidic than they were last century. This increased acidity disrupts reproductive activity and adversely affects calcium carbonate, which forms the shells and



▲ **Figure B.11:** Variations in pH levels in the world's oceans



Up to half of the carbon dioxide (CO_2) released by burning fossil fuels since the early 1800s has been absorbed by the world's oceans. Absorbed CO_2 in seawater (H_2O) forms carbonic acid (H_2CO_3), lowering the water's pH level and making it more acidic.
This raises the hydrogen ion concentration in the water, and limits organisms' access to carbonate ions, which are needed to form hard parts.

▲ **Figure B.12:** Ocean acidification

skeletons of many sea creatures. The growth rate of some species of coral has declined by 14 per cent on the Great Barrier Reef since 1990, either due to temperature stress or ocean acidification or both. Other reef areas report similar results.

Early warning signs that have been noticed include:

- the failure of commercial oyster and other shellfish beds on the Pacific coasts of the USA and Canada
- coral reefs – already bleached by rising global temperatures – have suffered disintegration in many regions
- at the poles and high latitudes, tiny shellfish called pteropods – the basis of the food chain for fish, whales and seabirds – have suffered a noticeable reduction in their numbers.

Ocean acidification is thought to be involved in all three of these changes. By 2050 over 90 per cent of coral will be affected by local and global threats.

ATL Research skills

Visit http://climateinterpreter.org/content/effects-ocean-acidification-coral-reefs for a series of articles, news and videos on ocean acidification and coral reefs.

- How is acidification affecting coral reefs?
- How widespread is it?
- What can be done to manage the problem?

Activity 6

1. Study Figure B.12. Explain how ocean acidification is changing the carbon cycle.
2. Compare the location of areas that are becoming more acidic with those that are becoming less acidic, as shown in Figure B.11.

Concepts in context

We have seen how there are many natural **processes** operating in oceans (currents; weather processes such as El Niño; hurricanes; ocean–atmospheric interactions; and the carbon cycle for example). However, many of these processes such as the carbon cycle are being affected by human activities, which in turn has an impact on atmospheric processes and ocean acidification. There is a fine balance in natural systems, and it may appear that human activities are upsetting the equilibrium.

Check your understanding

1. Outline the main causes of ocean currents.
2. Explain the main causes of ocean acidification.
3. Outline the main impacts of ocean acidification on coral reefs.
4. Explain the influence of ocean currents on energy transfers.
5. Explain how ocean currents transfer nutrients.
6. Distinguish between El Niño and La Niña.
7. Outline the main economic impacts of El Niño events.
8. Outline the main factors needed for the development of a tropical cyclone.
9. Identify the main hazards associated with tropical cyclones/hurricanes.
10. Explain how oceans may be a source and a sink of carbon.

2 Interactions between oceans and coastal places

Conceptual understanding

Key question

How are coastal places shaped by their interactions with oceans?

Key content

- Physical influences on coastal landscapes, including waves, tides, sediment supply, lithology, vegetation, subaerial processes and wave processes (littoral drift, hydraulic action and abrasion)
- The characteristics and formation of coastal landforms as a result of erosion and deposition, including wave-cut platforms, cliffs, stacks, spits and beaches
- The formation and identification of advancing and retreating coastlines, including isostatic and eustatic landforms (relict cliffs, raised beaches, fjords)
- The role of coastal processes, wind and vegetation in coastal sand dune development

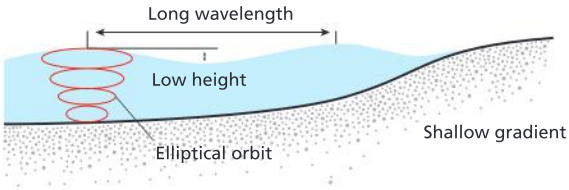
▲ **Photo B.2:** Skellig Michael, off the County Kerry coast, south-west Ireland

Coastal environments

Coastal environments are influenced by many factors, and shaped by physical and human processes. As a result there is a great variety in coastal landscapes. For example, landscapes vary on account of the following:

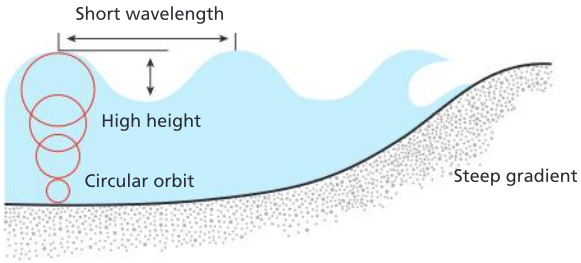
- **Lithology properties** (rock) – hard rocks such as granite and basalt give rugged landscapes, for example the Giant's Causeway in Northern Ireland or the Skellig Rocks off the south-west coast of Ireland (Photo B.2), whereas soft rocks such as sands and gravels produce low, flat landscapes, for example around Cape Cod off the north-east coast of America (Photo B.3).
- **Geological structure** – concordant (Pacific) coastlines occur where the geological strata lie parallel to the coastline, for example the Dalmatian coastline of Croatia or the Pacific coastline of the USA, whereas discordant (Atlantic-type) coastlines occur where the geological strata are at right angles to the shoreline, for example the south-west coastline of Ireland.
- **Processes** – erosional landscapes, for example the east coast of England, contain many rapidly retreating cliffs, whereas areas of rapid deposition, for example the Netherlands, contain many sand dunes and coastal flats.
- **Sea-level changes** interact with erosional and depositional processes to produce **advancing coastlines** (those growing due to deposition and/or a relative fall in sea level) or **retreating coastlines** (those being eroded and/or drowned by a relative rise in sea level).

▲ **Photo B.3:** Cape Cod, Massachusetts, USA



- Depositional waves
- Also called "spilling" waves
- Long wavelength, low height
- Low frequency (6–8 per minute)
- High period (one every 8–10 seconds)
- Swash greater than backwash
- Low gradient
- Low energy

▲ **Figure B.13:** Constructive or swell waves



- Erosional waves
- Also called "surging" or "plunging" waves
- Short wavelength, high height
- High frequency (10–12 per minute)
- Low period (one every 5–6 seconds)
- Backwash greater than swash
- Steep gradient
- High energy

▲ **Figure B.14:** Destructive or storm waves

Activity 7

Compare the main characteristics of constructive and destructive waves.

- **Human impacts** are increasingly common – some coasts, for example Cape Cod (Photo B.3), are being extensively modified, whereas others are more natural, for example Skellig Michael (Photo B.2).
- **Ecosystem type** such as mangrove, coral, sand dune, salt marsh and rocky shore add further variety to the coastline.

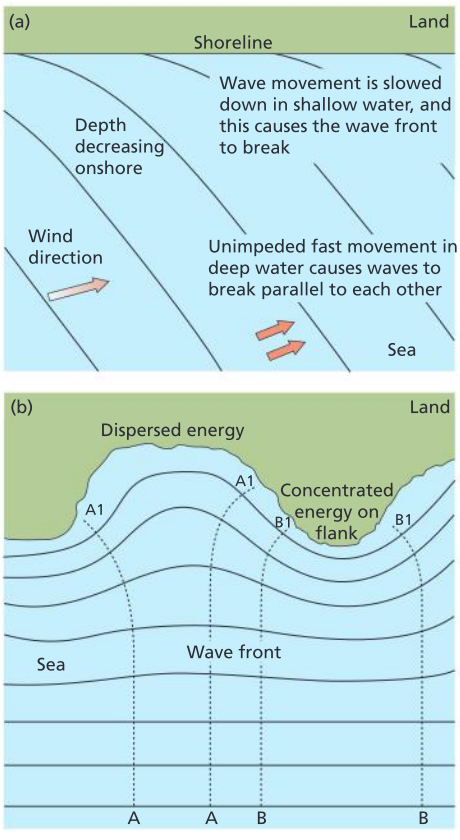
Waves

Most waves are generated by wind blowing over the sea surface, although some waves are caused by tides and earthquakes (for example tsunamis). Tsunamis have reached heights of up to 15 m and can travel at speeds of up to 600 km/h. Wave energy is controlled by:

- wind strength and duration
- fetch or distance of open water, and
- depth of the sea bed.

Waves in open water can reach heights of up to 15 m and are capable of travelling huge distances as swell waves. These are characterized by very long wavelengths and a reduced height (Figure B.13). By contrast, storm waves are generated by local winds and travel only a short distance (Figure B.14). They are also known as destructive waves.

As the wave breaks, its energy is transferred to the shore. The movement of water up the beach is known as the **swash**. The effectiveness of this is controlled by wave energy, size of beach material and beach gradient. The **backwash** is the movement of water down the beach under the force of gravity.



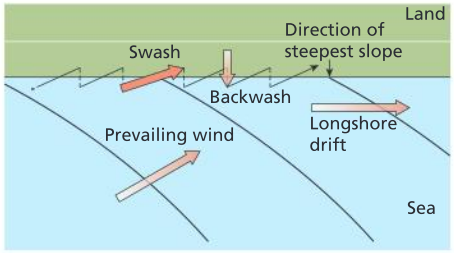
▲ **Figure B.15:** Wave refraction

Wave refraction

Wave refraction occurs when waves approach an irregular coastline or are at an oblique angle. Refraction reduces wave velocity and, if complete, causes wave fronts to break parallel to the shore (Figure B.15, a). Wave refraction concentrates energy onto the sides of headlands and dissipates energy in bays (Figure B.15, b).

Longshore drift

Refraction is rarely complete and consequently longshore drift occurs. For drifting to occur the swash carries material up the beach in a direction parallel to the prevailing wind, whereas the backwash operates at right angles to the shore due to the steepness of the beach slope (Figure B.16). The result is a net transfer of sediment along a beach. Drifting is not always straightforward. Secondary drifting may be caused by less-regular secondary waves, and refraction around an island may cause drifting to occur in converging directions.



▲ **Figure B.16:** Longshore drift

Tides

Tides are regular movements in the sea's surface caused by the gravitational pull of the moon and sun on the oceans. Tides are influenced by the size and shape of ocean basins, the characteristics of the shoreline, the Coriolis force and meteorological conditions. In general:

- tides are greatest in bays and along funnel-shaped coastlines
- in the northern hemisphere water is deflected to the right of its path
- during low-pressure weather systems, water levels rise 10 cm for every decrease of 10 millibars.

The difference between high and low tide is called the tidal range. This varies from almost nothing in enclosed seas such as the Mediterranean to almost 15 m in the Bay of Fundy, Canada. The tidal range has important influences on coastal processes.

- It controls the vertical range of erosion and deposition.
- Weathering and biological activity is affected by the time between tides.
- Velocity is influenced by the tidal range and has an important scouring effect.

Sediment supply

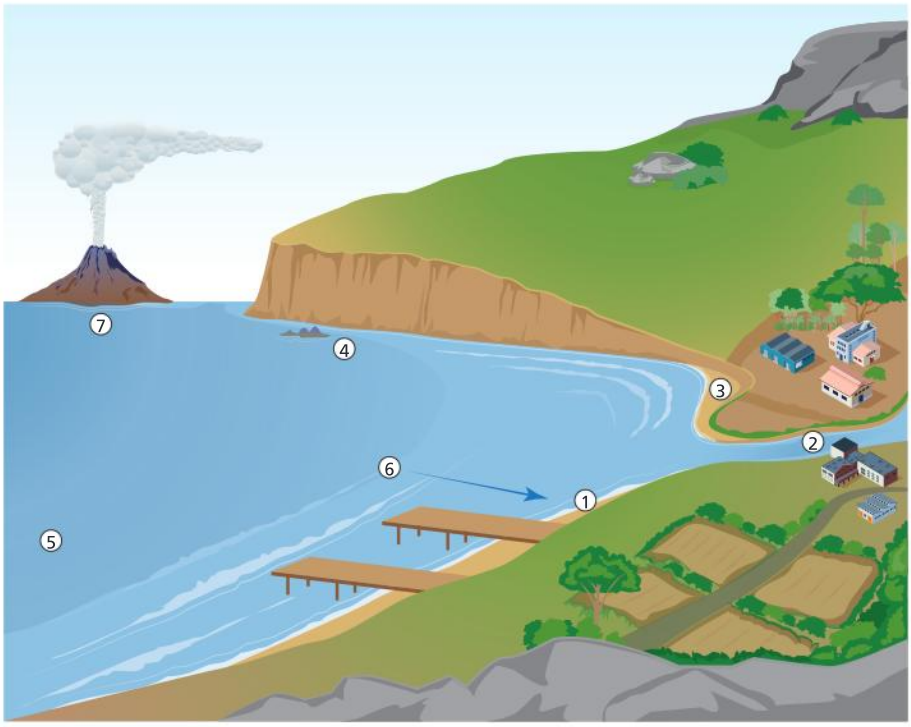
There are many sources of sediment (Figure B.17).

The coastal sediment system, or **littoral cell system**, is a simplified model that examines coastal processes and patterns in a given area (Figure B.18). It operates at a variety of scales from a single bay, for example Swanage Bay, UK, to a regional scale, for example the south California coast. Each littoral cell is a self-contained cell, in which inputs and outputs are balanced.

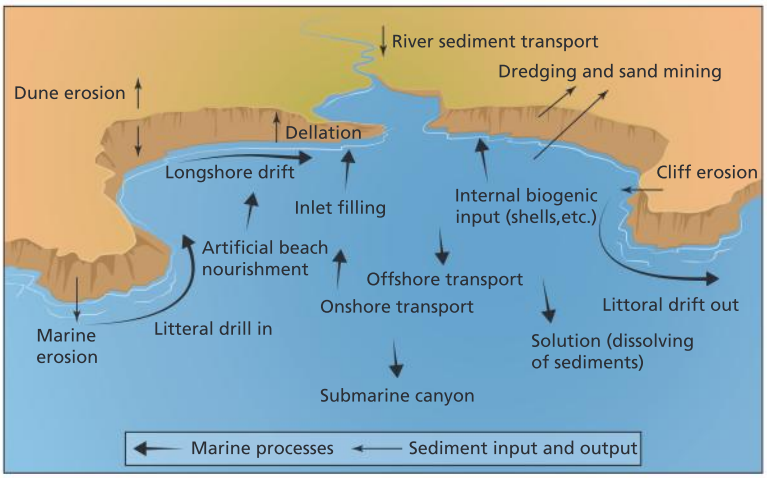
The concept of dynamic equilibrium is important to littoral cells. This concept states that any system (or in this case littoral cell) is the result of the inputs and processes that operate within the cell. Change one of the inputs (for example an increase in sediment on the shoreline following cliff collapse) and there is a knock-on effect on the processers (such as longshore drift, or transport, or beach protection) and a resulting change in the landforms (such as stabilization of cliffs or beach enlargement down drift). The balance has changed, hence **dynamic equilibrium**.

Online case study

Oceanside littoral cell



▲ **Figure B.17:** The main sources of sediment in coastal areas



▲ **Figure B.18:** A small-scale littoral cell

Lithology

Lithology refers to the characteristics of rocks such as resistance, bedding, jointing and permeability. The well-developed jointing and bedding of certain harder limestones, for example, creates a geometric cliff profile with a steep, angular cliff face and a flat top (bedding plane). Wave erosion opens up these lines of weakness, causing complete blocks to fall away and the creation of angular overhangs and cave shapes. In other well-jointed and bedded rocks, a whole variety of features is created by wave erosion, such as caves, geos, arches, stacks and stumps.

Many cliffs are composed of more than one rock type. These are known as composite cliffs. The exact shape and form of the cliff will depend on factors such as strength and structure of rock, relative hardness and the nature of the waves involved. If impermeable rock overlies permeable rock there is limited percolation and so the cliff is more stable. If permeable rock overlies impermeable rock, water may soak into the cliff, and slope failure is more likely where water builds up at the junction of the two rock types.

Subaerial and wave processes

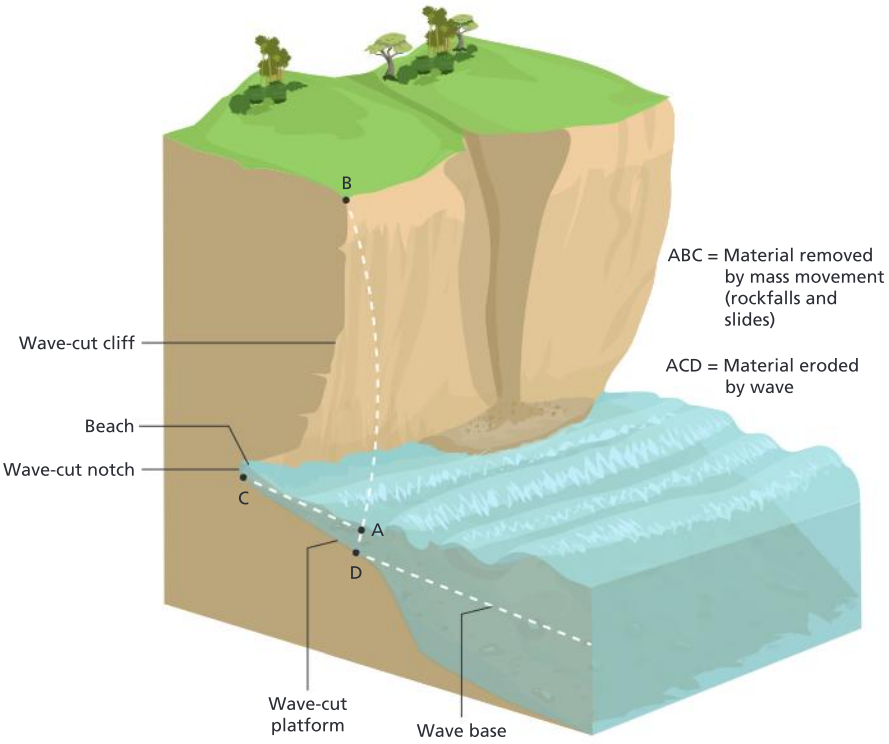
There are many subaerial and marine processes that operate on coastlines (Table B.3 and Figure B.19). They may operate together to produce

landforms, each process contributing in a different way (Figure B.19).

There are a number of types of weathering that occur in coastal zones.

- **Salt weathering** is the process by which sodium and magnesium compounds expand in joints and cracks, thereby weakening rock structures.
- **Freeze thaw weathering** is the process whereby water freezes, expands and degrades jointed rocks.
- **Water layer weathering** relates to the tidal cycle of wetting and drying (**hydration**).
- **Biological weathering** is carried out by molluscs, sponges and urchins and is very important in low-energy coasts.

Mass movements are also a common type of cliff degradation.



▲ **Figure B.19:** The contribution of marine processes and subaerial processes to a cliff and wave-cut platform

▼ **Table B.3:** Summary of the main processes on rocky shores leading to erosion

Process	Description	Conditions conducive to the process
Mechanical wave erosion		
Erosion	Loose material is removed by waves	Energetic wave conditions and microtidal range
Abrasion	Rock surfaces are scoured by wave-induced flow with a mixture of water and sediment	"Soft" rocks, energetic wave conditions, a thin layer of sediment and microtidal range
Hydraulic action	Wave-induced pressure variations within the rock cause and widen rock cracks	"Weak" rocks, energetic wave conditions and microtidal range
Weathering		
Physical weathering	Frost action and cycles of wetting/drying cause and widen rock cracks	Sedimentary rocks in cool regions
Salt weathering	Volumetric growth of salt crystals in rocks widens cracks	Sedimentary rocks in hot and dry regions
Chemical weathering	A number of chemical processes remove rock materials. These processes include hydrolysis, oxidation, hydration and solution	Sedimentary rocks in hot and wet regions
Water-layer levelling	Physical, salt and chemical weathering work together along the edges of rock pools	Sedimentary rocks in areas with high evaporation
Bio-erosion		
Biochemical	Chemical weathering by products of metabolism	Limestone in tropical regions
Biophysical	Physical removal of rock by grazing and boring animals	Limestone in tropical regions

Process	Description	Conditions conducive to the process
Mass movements		
Rockfalls and toppling	Rocks fall straight down the face of the cliff	Well-jointed rocks, undercutting of cliff by waves
Slides	Deep-seated failures	Deeply weathered rock, undercutting of cliff by rock
Flows	Flow of loose material down a slope	Unconsolidated material, undercutting of cliffs by waves

Coasts are eroded by waves in a number of ways (Figure B.20).

- **Abrasion** is the wearing away of the shoreline by material carried by the waves.
- **Hydraulic impact** or **quarrying** is the force of water and air on rocks (up to 30,000 kg/m^2 in severe storms).
- **Solution** is the wearing away of base-rich rocks, especially limestone by an acidic water. Organic acids aid the process.
- **Attrition** is the rounding and reduction of particles – so it does not actually erode the coastline, but erodes the sediment.

▲ **Photo B.4:** Saltmarsh vegetation rapidly increases deposition

Vegetation

Vegetation in coastal areas has many important functions. It may increase deposition, such as in salt marshes and mangrove forests and on sand dunes. It may protect land forms by reducing wind speed (and potentially erosion or the destructive impact of tropical cyclones), or it may increase the rate of biological weathering.

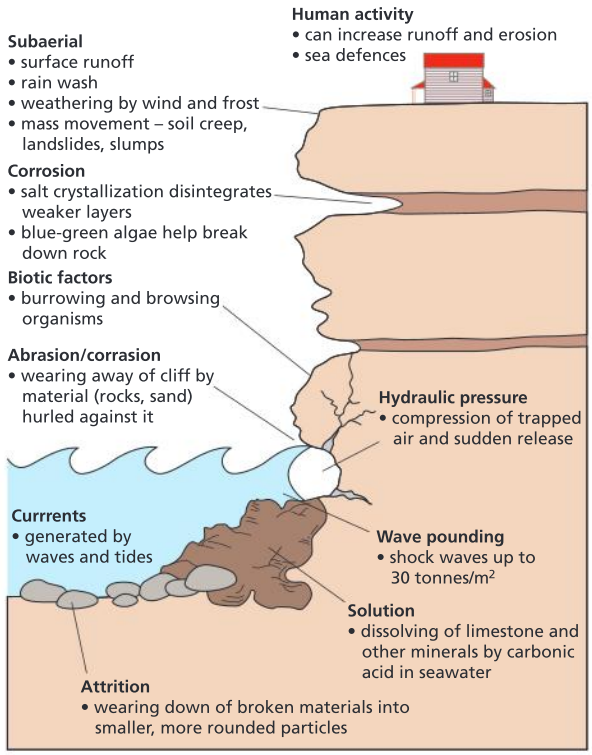
Features of erosion

Bays may be eroded in beds of weaker rock. The harder rocks form headlands that protrude, and the weaker rocks are eroded to form bays. Wave refraction in the bay spreads wave energy around the bay, but it focuses wave energy on the flanks of the headlands. Bayhead beaches are formed when constructive waves deposit sand between two headlands, such as at Maracas Bay and Tyrico Bay in northern Trinidad.

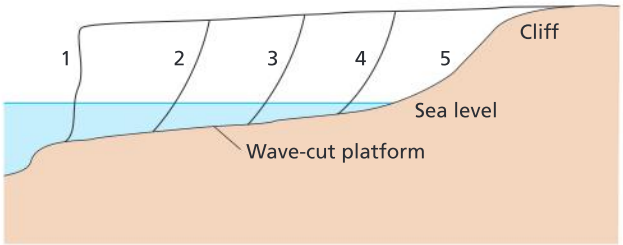
Rapid erosion occurs on rocks where there is a weakness. Faults in the rock may be eroded to form sea caves. If two sea caves meet, an arch is formed. If the roof of the arch collapses, a stack is formed, and if this is eroded a stump is formed (Figure B.21). These features are largely determined by the location of weaknesses in the rock and variations in wave energy caused by refraction on the flanks of the headland.

Wave-cut (shore) platforms

Wave-cut platforms (also called shore platforms) include intertidal platforms, high-tide platforms and low-tide platforms. Wave-cut



▲ **Figure B.20:** Erosion and subaerial processes



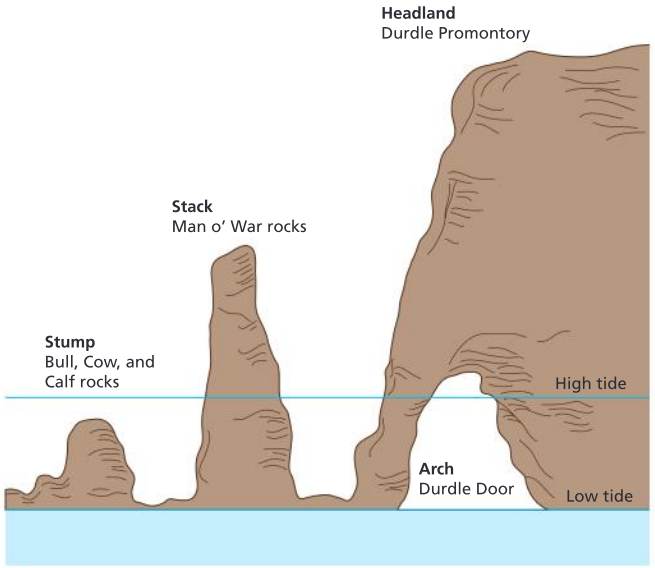
▲ **Figure B.22:** Shore platforms through cliff recession

platforms are most frequently found in high-energy environments and are typically less than 500 m wide with an angle of about 1°. A model of cliff- and shore-platform evolution (Figure B.22) shows how steep cliffs (1) are replaced by a lengthening platform and lower-angle cliffs (5), subjected to subaerial processes rather than marine forces. Alternatively, platforms might have been formed by frost action, salt weathering or biological action during periods of lower sea levels and different climates.

Cliffs

The profile of a cliff depends upon a number of factors including:

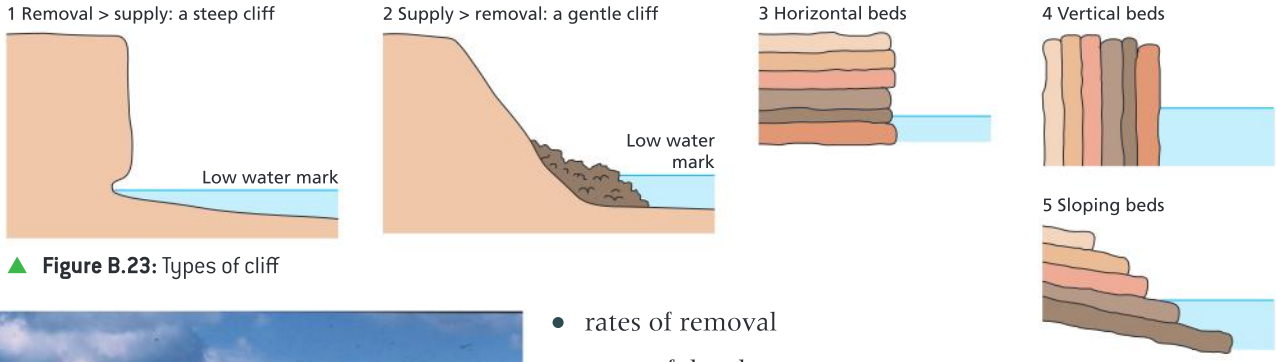
- geological structure
- subaerial and marine processes
- amount of undercutting



▲ **Figure B.21:** Features of coastal erosion: arch, stack and stump

▲ **Photo B.5:** Headlands, bay, stack and stump, Praia de Rocha, Portugal

▲ **Photo B.6:** Arch, Praia de Rocha



▲ **Figure B.23:** Types of cliff

▲ **Photo B.7:** Wave-cut platform

- rates of removal
- stage of development.

Rocks of low resistance are easily eroded and are unable to support an overhang. Jointing may determine the location of weaknesses in the rock, just as the angle of dip may control the shape of the cliff (Figure B.23). Past processes are also important. In areas affected by periglaciation bevelled cliffs are found.

Stacks

Wave refraction concentrates wave energy on the flanks of headlands. If there are lines of weakness, these may be eroded to form a geo (a widened crack or inlet). Geos may be eroded and enlarged to form caves, and if the caves on either side of a headland merge, an arch is formed. Further erosion and weathering of the arch may cause the roof of the arch to collapse, leaving an upstanding stack (Figure B.24). The eventual erosion of the stack produces a stump. Good examples of arches and stacks can be found at Etretat in northern France and at Dyrhólaey, southern Iceland.

Activity 8

Describe the coastal features shown in Photos B.6 and B.7.

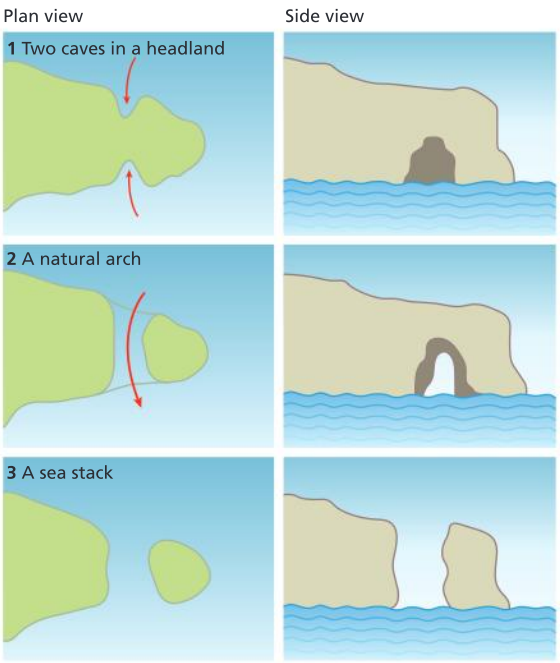
Features of deposition

Deposition creates a number of features, including spits and beaches (Figure B.25). Essential requirements include:

- a large supply of material (beach deposits, offshore deposits, river sediments, material eroded from cliffs and headlands)
- longshore drift
- an irregular, indented coastline, for example river mouths
- low-energy coastlines
- bioconstruction, namely the work of plants.

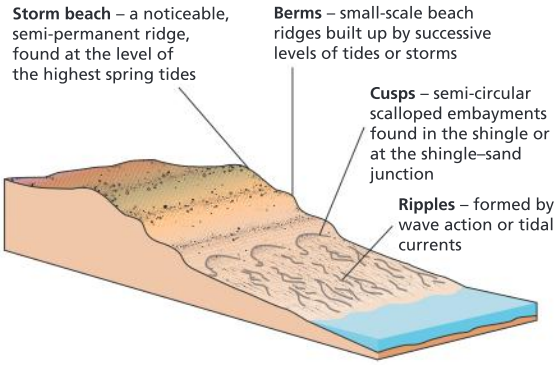
Beaches in mid and high latitudes are mostly pebble, whereas those in the tropics are mostly sand. This is due to the contribution of rivers as suppliers of sediment in the tropics.

Beach form is affected by the size, shape and composition of materials, tidal range and wave characteristics. As storm waves are more frequent in winter and swell waves more important in summer, many beaches differ in their winter and summer profile. The relationship between wave steepness and beach angle is a two-way affair. Steep destructive waves reduce beach angle whereas gentle constructive waves increase it. In turn, low gradients produce shallow water which in turn increases



1 Wave refraction concentrates erosion on the sides of headlands. Weaknesses such as joints or cracks in the rock are exploited, forming caves.
2 Caves enlarge and are eroded further back into the headland until eventually the caves from each side meet and an arch is formed.
3 Continued erosion, weathering and mass movements enlarge the arch and cause the roof of the arch to collapse, forming a high standing stack.

▲ **Figure B.24:** The formation of stacks



▲ **Figure B.25:** Beach profile

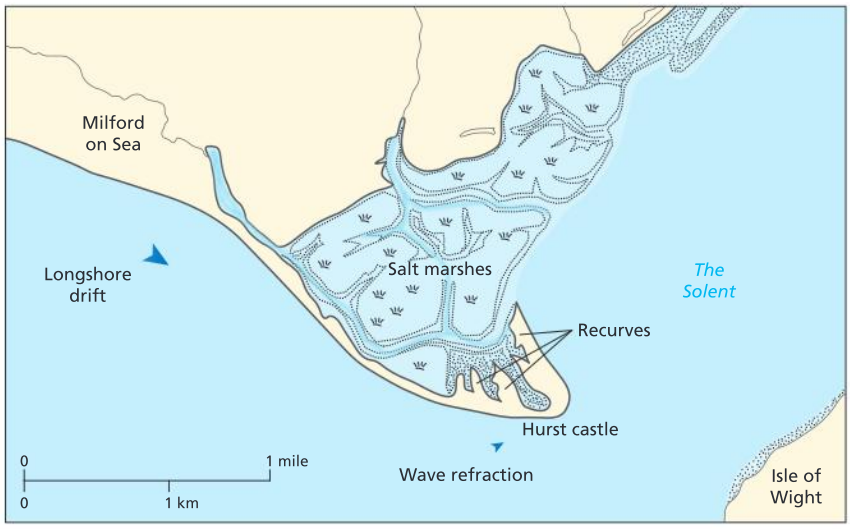
▼ **Table B.4:** Beach profiles and particle size

Material	Diameter (mm)	Beach angle
Cobbles	32	24
Pebbles	4	17
Coarse sand	2	7
Medium sand	0.2	5
Fine sand	0.02	3
Very fine sand	0.002	1

wave steepness. Hence, plunging waves are associated with gentle beaches whereas surging waves are associated with steeper beaches.

Sediment size affects beach profile through its percolation rate (Table B.4). Shingle and pebbles allow rapid infiltration and percolation, hence the impact of swash and backwash will be reduced. As the backwash is reduced it will not impede the next swash. If the swash is stronger than the backwash then deposition may occur. By contrast, sand produces a beach that has a shallower angle and allows less percolation. Backwash is likely to be more important on a sand beach than on a gravel beach. The pattern is made more complex because sediment size varies up a beach. Largest particles, the products of cliff recession, are found at the rear of a beach. Large, rounded material on the upper beach is probably supplied only during the highest spring tides and is unaffected by average conditions. On the lower beach wave action is more frequent and attrition is common, consequently particle size is smaller.

The source of beach material varies considerably and includes material eroded from cliffs and headlands, offshore supplies such as at Chesil Beach, river sediments, and periglacial and beach deposits. In Arctic areas **solifluction** is an important contributor. Globally, rivers are a greater source of coastal sediment (beaches) than erosion by the sea.



▲ **Figure B.26:** Formation of a spit; Hurst castle spit, Hampshire, UK

Spits

A spit is a beach of sand or shingle linked at one end to land. It is found on indented coastlines or at river mouths. For example, along a coast where headlands and bays are common and near mouths (estuaries and rias), wave energy is reduced. Excellent examples include Cape Cod (Photo B.3). Spits generally have a thin, attached end (the **proximal end**) and a larger, **distal end** with smaller recurves (Figure B.26).

Spits often become curved as waves undergo refraction. Cross-currents or occasional storm waves may assist this hooked formation. A good example is the sand spit in Walvis Bay, Namibia. The main body of the spit is curved, but it has additional smaller hooks, or **recurves**. Longshore drift moves sediment northwards along the coast. However, the coastline is very irregular and there is a sudden change in the trend of the coastline. Consequently, refraction occurs, causing the waves to bend around eastwards.

On the seaward side, the slope to deeper water is very steep. Within the curve of the spit, the water is shallow and a considerable area of mudflat and salt marsh is exposed at low water. These salt marshes are continuing to grow as mud is being trapped by the marsh vegetation.

▲ **Photo B.8:** Spit

Case study

The Palisadoes, Jamaica

The Palisadoes is one of the largest deposited coastal features in the Caribbean. Located just south of Kingston, Jamaica, the 13 km long feature has been formed and re-formed many times during its history. Scientists believe that it may be 4,000 years old.

Longshore drift occurs from east to west on the south coast of Jamaica. The sediment comes from rivers, cliff erosion and offshore sediments.

The Palisadoes is located at a sharp bend in the coastline. Longshore drift carries sediment westwards, and extends the length of the spit. As it grew longer, it linked up with a number of cays (small islands) turning the spit into a tombolo.

The region is affected by tropical storms and hurricanes. These can seriously damage the coast. For example, in 2004 Hurricane Ivan eroded up to a metre off the 2 m high sand dunes.

Beaches and sand dunes

The largest sand dunes are found in mid-latitude storm wave environments (Photo B.9).

Their formation is favoured by:

- a large supply of sand on the beach
- high onshore wind speeds
- low precipitation
- low humidity.

A large tidal range will expose more sand, especially if the beach gradient is low. Large, fresh supplies of sand are provided by steep, actively eroding rivers.

▲ **Photo B.9:** Sand dunes

Two types of dune are commonly described: free and impeded dunes. Free dunes are formed in the absence of vegetation and occur largely along desert margins. Impeded dunes are common in humid areas where vegetation is essential for trapping sand. A large tidal range, strong prevailing wind and large supply of sediment are important in the development of extensive dune systems.

TOK

How do we know that levels of land and sea vary?

Advancing and retreating coastlines

The level of the land also varies in relation to the sea. Land may rise as a result of tectonic uplift or following the removal of an ice sheet. The localized change in the level of the land relative to the level of the sea is known as **isostatic change** or **isostasy**. Parts of Scandinavia and Canada are continuing to rise at rates of up to 20 mm/year.

A simple sequence of sea level change can be described as follows.

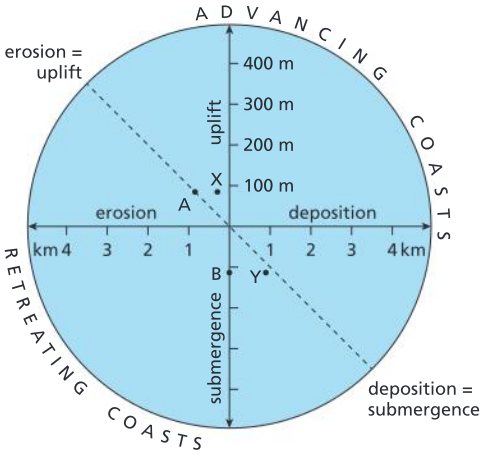
- Temperatures decrease, glaciers and ice sheets advance and sea levels fall eustatically.
- Ice thickness increases and the land is lowered isostatically.
- Temperatures rise, ice melts and sea levels rise eustatically.
- Continued melting releases pressure on the land and the land rises isostatically.

As a result of global warming (the enhanced greenhouse effect) sea levels are rising, and this is impacting low-lying communities in particular.

According to Valentin's classification (1952):

- retreating coasts include submerged coasts and coasts where the rate of erosion exceeds the rate of emergence/deposition
- advancing coasts include emerged coastlines and coasts where deposition is rapid (Figure B.27).

Figure B.27 shows Valentin's classification of advancing and retreating coasts. These are partly the result of sea-level changes, and partly the balance of erosion and deposition. On the diagram, points A and X both experienced uplift of around 100 m. However, erosion has taken place at A, reducing the effect of uplift. Similarly, B and Y have experienced about 100 m of submergence. However, Y has experienced deposition,



▲ **Figure B.28:** Advancing and retreating coasts

▲ **Photo B.10:** Fjord, western Norway

so the overall change in its position relative to sea level is negligible.

Features of emerged coastlines include:

- raised beaches, such as the Portland Raised Beach, UK (Photo B.11)
- coastal plains
- relict cliffs, such as those along the Fall Line in eastern USA
- raised mudflats, for example the Carselands of the River Forth.

Submerged coastlines include:

- rias, such as the River Fal in the UK – drowned river valleys caused by rising sea levels or due to the land sinking
- fjords (Photo B.10), such as Milford Sound, New Zealand, and the Oslo Fjord, Norway – caused by drowning of U-shaped valleys (see page 118 for the formation of U-shaped valleys)
- fjards or drowned glacial lowlands.

Activity 9

1. Describe the characteristics of the fjord shown in Photo B.10.
2. Distinguish between advancing and retreating coastlines.
3. Explain how **a)** stacks and **b)** spits are formed.
4. Examine the relationship between coastal process, subaerial processes, lithology and landform in two contrasting coastal environments.

The role of coastal processes, wind and vegetation in sand dune development

Initially, sand is moved by the wind. However, wind speed varies with height above a surface. The belt of no wind is only 1 mm above the surface. As most grains protrude above this height, they are moved by **saltation**. The strength of the wind and the nature of the surface are important. Irregularities cause increased wind speed and eddying, and more material is moved. On the leeward side of irregularities, wind speed is lower, transport decreases and deposition increases.

For dunes to become stable, vegetation is required. Plant succession and vegetation succession can be interpreted by the fact that the oldest dunes are furthest from the sea and the youngest ones are closest to the shore. On the shore, conditions are windy, arid and salty. The soil contains few nutrients and is mostly sand – hence the dunes nearest the shore are referred to as "yellow dunes". Few plants can survive, although sea couch and marram can tolerate these conditions.

Once the vegetation is established, it reduces wind speed close to ground level. The belt of no wind may increase to a height of 10 mm. As grasses such as sea couch and marram need to be buried by fresh sand in order to grow, they keep pace with deposition. As the marram grows, it traps more sand. As it is covered it grows more, and so on.

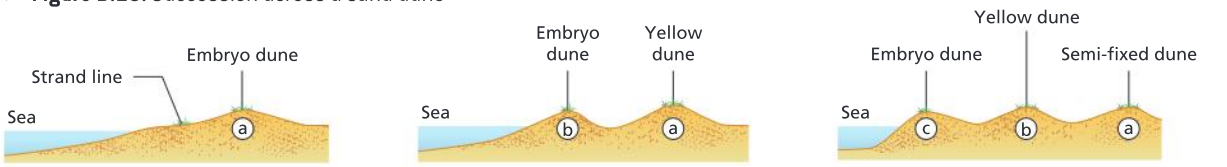
Once established, the dunes should continue to grow as long as there is a supply of sand. However, once another younger dune, a fore dune, becomes established, the supply of sand – and so the growth of the dune – is reduced. As the dune gets higher, the supply of fresh sand is reduced to dunes further back. Thus marram dies out. In addition, as wind speeds are reduced,

evapotranspiration losses are less and the soil is moister. The decaying marram adds some nutrients to the soil, which in turn becomes more acidic.

In the slacks, the low points between the dunes, conditions are noticeably moister, and marsh vegetation may occur. Towards the rear of the dune system "grey" dunes are formed – grey due to the presence of humus in the soil. The **climax vegetation** found here depends largely on the nature of the sand. If there is a high proportion of shells (providing calcium), grasslands are found. By contrast, acid dunes are found on old dunes where the calcium has been leached out, and on dunes based on outwash sands and gravels. Here, acid-loving plants such as heather and ling dominate. Pine trees favour acid soils, whereas oak can be found on more neutral soils. Thus the vegetation at the rear of the sand-dune complex is quite variable.

▲ **Photo B.11:** Raised Beach

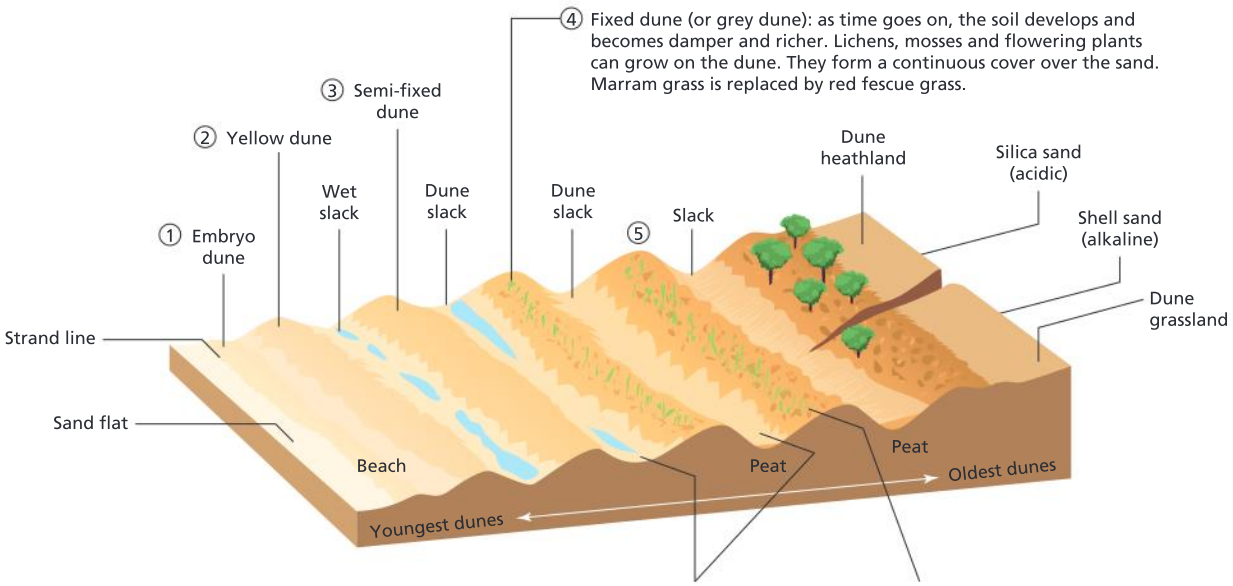
▼ **Figure B.28:** Succession across a sand dune



As the tide goes out, the sand dries out and is blown up the beach. At the top of the beach is a line of seaweed and litter called the strand line.
A small embryo dune forms in the shelter behind the strand line. This dune can be easily destroyed unless colonized by plants.

Sea couch grass colonizes and helps bind the sand. Once the dune grows to over 1 m high, marram grass replaces the sea couch. A yellow dune forms at 10–20 m high with the long-rooted marram forming a good sand trap.

Once the yellow dune is over 10 m high, less sand builds up behind it and marram grass dies to form a thin humus layer. As soil begins to form, other plants are able to grow on the dune including dandelions. This kind of dune is called a semi-fixed dune. As the original dune (a) has developed, new embryo and yellow dunes have formed.



As the dune system gets older and larger, water can collect towards the back of a dune. These damp hollows are known as dune slacks. Marsh plants and small willow trees can grow here.

Climax willow vegetation succeeds grasses and flowering plants as small trees mature.

Concepts in context

This section has examined the importance of **process**, including erosional, depositional, transportational, gravity-influenced (mass movements) and weathering. Processes do not take place in a vacuum but are affected by local conditions including climate, geology, plants, animals and, increasingly, human activities (that is, they are affected by **place**). Many places are shaped by their interaction with coastal processes, and in turn they influence the evolution of that coastal place. Every coastline is unique and is the result of the interaction of many factors and the processes that they produce.

Check your understanding

1. Distinguish between constructive and destructive waves.
2. Briefly explain the process of longshore drift.
3. Outline how littoral cells function.
4. Distinguish between subaerial and marine processes on a cliff.
5. Explain how wave-cut (shore) platforms are formed.
6. Outline the conditions required for beach formation.
7. Explain the process of sand dune development.
8. Distinguish between isostatic and eustatic changes in sea level.
9. Identify two ways in which raised beaches can be formed.
10. Distinguish between "yellow dunes" and "grey dunes" in sand dune succession.

3 Managing coastal margins

Conceptual understanding

Key question

How powerful are different stakeholders in relation to coastal margin management?

Key content

- Coastal erosion and flooding management strategies, including cliff stabilization, sea walls, managed retreat and population preparedness.
- Conflicting pressures on coastlines, including commercial land use (tourism, industry and housing) and conservation measures.
- Management of coral reefs and mangrove swamps, including different stakeholder perspectives on their use and value.
- Sovereignty rights of nations in relation to territorial limits along coastal margins and exclusive economic zones.

Coastal erosion and flooding management strategies

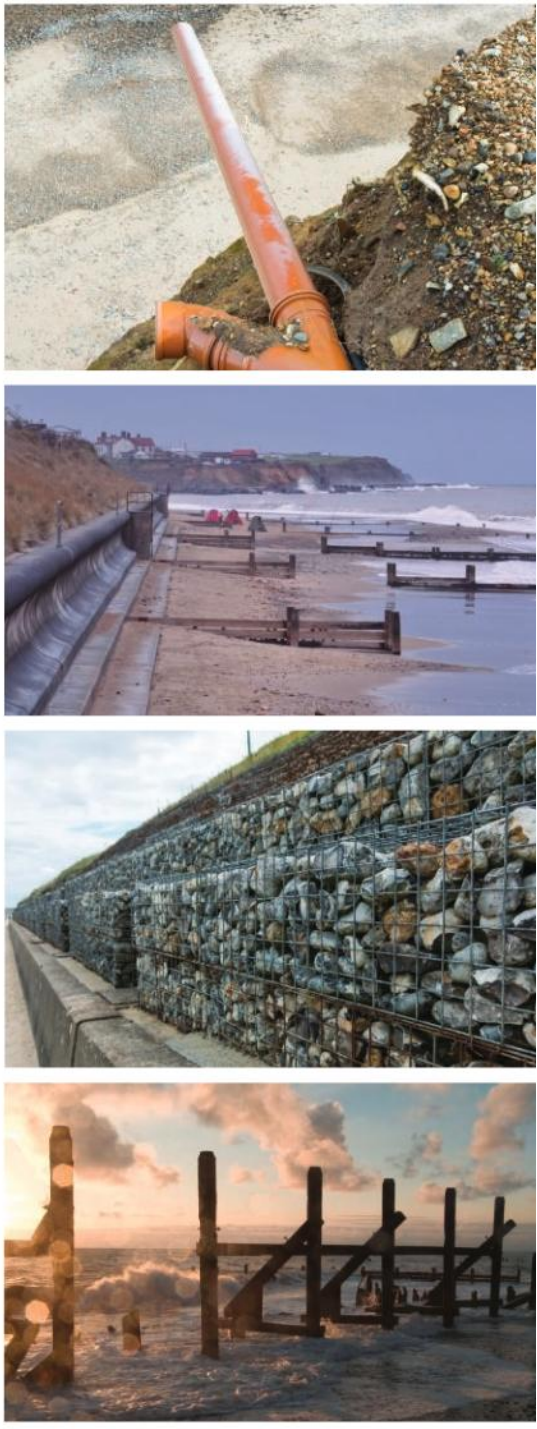
Cliff failure

Human pressures on coastal environments create the need for a variety of coastal management strategies. Coastal defences help to prevent coastal erosion and flooding by the sea. Coastal management strategies may be long term or short term, sustainable or unsustainable. Successful management requires a detailed understanding of the processes operating on a particular coastline. Pressures are likely to rise owing to an increase in population; greater numbers of people living in coastal areas; rising temperatures; and the growth of activities such as industry and trade, energy developments, fishing, tourism and recreation.

Defence options include:

- do nothing; that is, let the cliff erode/let the area flood
- maintain existing levels of defence
- improve the level of defence provided
- managed retreat; that is, protect some areas but allow other areas to be eroded.

Cliff defences can be divided into cliff base and cliff face. Cliff-base schemes include sea walls, gabions, rock armour, offshore breakwaters and revetments, as shown in Photo B.12. They attempt to absorb the energy of the waves and so protect the cliff base from erosion. Cliff-face measures



▲ **Photo B.12:** Coastal management at Brunei and Norfolk . Top to bottom: Cliff drain, Norfolk, UK; Sea walls and groynes, Norfolk, UK; Gabion and sea walls, Pantai Berakas, Brunei; Revetments, Norfolk, UK.

ATL Thinking skills

What types of coastlines/areas are most likely to experience managed retreat/"do nothing" forms of coastal protection? How might these change over time?

include cliff drainage, regrading (making the cliff less steep and so less vulnerable to failure) and vegetation schemes, which help to hold the soil together, hold in moisture and reduce overland runoff.

Whether the cliff will be protected depends on its value and the value of properties and activities locally. For example, there is a major energy development at the gas terminal at Bacton in Norfolk, UK, which is protected by gabions and concrete blocks, whereas cliffs (and housing) further down the coast at Happisburgh have been abandoned to coastal erosion.

Cost-benefit analysis of coastal defence

Superstorm Sandy, which hit New York in October 2012, brought a 14 foot storm surge; New York's defences were built to withstand a 12 foot storm surge. The surge caused $20 billion worth of damage. New defences, costing $19 billion, may protect New York.

Table B.5: Cost-benefit analysis of coastal defence

Costs	Benefits
• Cost of building • Maintenance/repair • Increased erosion downdrift due to beach starvation or reduced LSD (longshore drift) • Reduced access to beach during works • Reduced recreational value • Reduced accessibility • Smaller beach due to scour • Disruption of ecosystems and habitats • Visually unattractive • Works disrupt natural processes	• Protected buildings, roads and infrastructure (gas, water, sewage, electricity services) • Land prices rise • Peace of mind for residents • Employment on coastal defence works

Table B.6: Costs and benefits of coastal protection strategies

Type of management	Aims/methods	Strengths	Weaknesses
Hard engineering	To control natural processes		
Cliff-base management	To stop cliff or beach erosion		
Sea walls	Large-scale concrete curved walls designed to deflect wave energy	Easily made; good in areas of high density	Expensive. Lifespan about 30–40 years. Foundations may be undermined
Revetments	Porous design to absorb wave energy	Easily made; cheaper than sea walls	Lifespan limited
Gabions	Rocks held in wire cages to absorb wave energy	Cheaper than sea-walls and revetments	Small scale
Groynes	To prevent longshore drift	Relatively low cost; easily repaired	Cause erosion on downdrift side; interrupt sediment flow
Rock armour	Large rocks at base of cliff to absorb wave energy	Cheap	Unattractive; small scale; may be removed in heavy storms
Offshore breakwaters	To reduce wave power offshore	Cheap to build	Disrupt local ecology
Rock strongpoints	To reduce longshore drift	Relatively low cost; easily repaired	Disrupt longshore drift; erosion downdrift

Type of management	Aims/methods	Strengths	Weaknesses
Cliff-face strategies	To reduce the impacts of subaerial processes		
Cliff drainage	Removal of water from rocks in the cliff	Cost effective	Drains may become new lines of weakness; dry cliffs may produce rockfalls
Vegetating	To increase interception and reduce overland run-off	Relatively cheap	May increase moisture content of soil and lead to landslides
Cliff regrading	Lowering of slope angle to make cliff safer	Useful on clay (most other measures are not)	Uses large amounts of land – impractical in heavily populated areas
Soft engineering	Working with nature		
Offshore reefs	Waste materials, for example old tyres weighted down, to reduce speed of incoming waves	Low technology and relatively cost effective	Long-term impacts unknown
Beach nourishment	Sand pumped from seabed to replace eroded sand	Looks natural	Expensive; short-term solution
Managed retreat	Coastline allowed to retreat in certain places	Cost effective; maintains a natural coastline	Unpopular; political implications
"Do nothing"	Accept that nature will win	Cost effective	Unpopular; political implications
Red-lining	Planning permission withdrawn; new line of defences set back from existing coastline	Cost effective	Unpopular; political implications

Activity 10

1. Study Photo B.13, which shows a groyne/rock strong point. Longshore drift is taking place from the bottom right of the photo towards the top left. Using a sketch diagram, suggest the likely changes to the distribution of sediment 50 years after the construction of the groyne. Suggest reasons to support your answer.
2. For a coastal area or inland sea you have studied, describe how the coastline is being protected, and comment on the effectiveness of the measures used.

▼ **Photo B.13:** Groyne/rock strong point

ATL Research skills

Use the USGS Coastal Change site to increase your knowledge and understanding of coastal protection schemes (as well as many other features of coastal processes and landforms). See http://pubs.usgs.gov/circ/c1075/change.html#fig1.

ATL Communications and social skills

Divide into two groups and prepare for a debate on the following topic: "The benefits of coastal defences always outweighs the costs".

Each group has a maximum of three minutes to present their case.

Case study

Protecting the Palisadoes spit

Regular storm surges and coastal flooding over the years have led to the massive erosion of the Palisadoes peninsula's natural dune.

To manage the problem, the Jamaican Government partnered with the China Harbour Engineering Company (CHEC) to repair and protect the extensively degraded shoreline of the Palisadoes peninsula. At a cost of over $65 million, CHEC constructed rock revetment walls on the Caribbean side of the peninsula and on the harbour.

The road was raised from its previous level of 0.6–1.0 m to 2.4–3.2 m above sea level.

Additional drainage facilities were placed along the roadway – this is needed to remove excess water from rainfall and from overtopping by waves. A 10 m wide boardwalk was constructed on the harbour side of the peninsula. The rehabilitative and protective works along the peninsula have been designed for a 100-year return period, that is, the shoreline is expected to withstand storm surges only anticipated to reoccur, on average, once in every 100 years.

In October 2012 Kingston was affected by Hurricane Sandy. This caused massive storm surges. Following Hurricane Sandy, experts claimed that businesses along the Kingston Harbour could have suffered significant damage during the passage of the hurricane, and that the protection scheme had proved very effective.

Coastal flooding may be caused by hurricanes (storm surges and high wind speeds) and tsunamis. The most common form of protection is a sea wall. However, sea walls will protect only up to a certain height. The 2011 Fukushima-Daiichi tsunami generated surges of over 11 m which over topped the 10 m high sea walls.

Case study

The Thames Barrier

The Thames Barrier (Photo B.14) was completed in 1982, at a cost of £500 million, with the aim of protecting London from flooding that might otherwise result from exceptionally high surges and tides. Flood risk levels in central London have been rising for a number of reasons: a rise in the sea level, the gradual subsidence in the south-east, and local subsidence due to water abstraction and clay shrinkage. An early-warning system operates which can predict several hours in advance exceptional levels from surge, tide and river flows, giving time for the Barrier to be closed. When it was built, it was believed the Barrier would be used 2–3 times each year. Currently, it is used 6–7 times each year, and in 2014 it was closed more than 50 times. It is expected to remain operational until between 2060 and 2070.

▲ **Photo B.14:** The Thames Barrier

Conflicting pressures on coastlines: the Soufrière Marine Management Area (SMMA)

Soufrière is located on the central west coast of the Caribbean island of St Lucia. It is bordered by a narrow submarine shelf which supports the island's most diverse and productive reefs. Traditionally, agriculture and fishing have provided two main sources of employment and income. However, due to the increased focus on development of the tourism industry, fishermen (the traditional users of the area) found themselves competing on a daily basis with a variety of tourism-related users.

Past efforts at managing conflicting stakeholders or users generally took a top-down approach in that rules and regulations were established with little or no public awareness, education and/or consultation. In St Lucia, a small island with limited financial capacity, the required enforcement capabilities were often severely lacking. The establishment of the Soufrière Marine Management Area (SMMA) in 1995 led to the success of its stewardship approach to management of resources within the area.

The Soufrière Marine Management Association is a self-sustained not-for-profit NGO authorized by the Government of St Lucia to manage the SMMA. Mandated to conserve and protect the natural marine environment, the association also ensures sustainable use and development of the area, particularly within the fishing and tourism sectors.

The SMMA consists of 11 km of coastline and is divided into five different zones (Figure B.29): marine reserves, fishing priority areas, yacht mooring areas, recreational areas and multiple-use areas. These areas were designed to cater to the multitude of uses in the area, reduce conflict among users and protect critical marine resources. From the experience of the SMMA, management authorities have learned that community participation at all stages of the process is vital for the success of resource management.

The importance of beaches for coastal stability has long been recognized. Many beaches along the east coast have become prime target sites for illegal sand-mining activities since they are often located in remote areas, making surveillance activities difficult. On the east coast nearly 15 per cent of beaches were being mined for sand, compared with 6.5 per cent of beaches along the west coast.

Other problems, which affect beaches in general, include solid waste from both land- and water-based sources, and construction of infrastructure on the beach or in the nearshore area, which in turn affects the natural dynamics of the beach. In addition to destructive human practices, natural disasters also adversely impact beaches. Hurricanes are a major natural force controlling beach change.

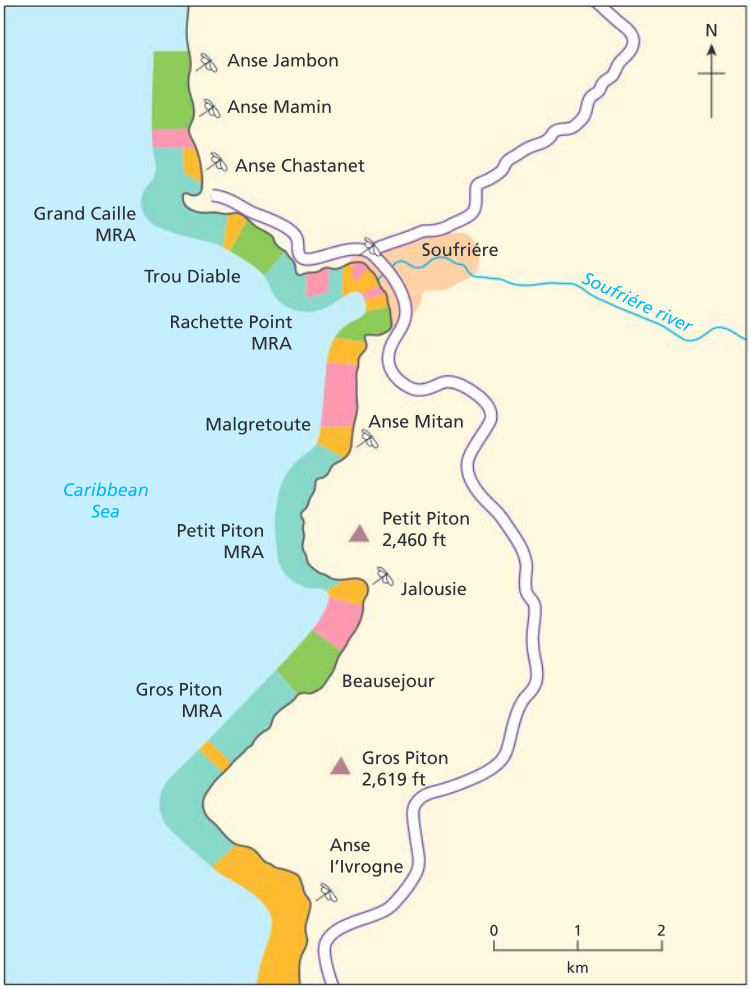
Research has shown that coastal stewardship is successful when there is a clear benefit to be derived by those involved. If there are no perceivable benefits, as has been the case with beach-monitoring activities, such actions are often given low priority.

During the 1980s resource use conflicts in the area increased dramatically as a result of the expansion of the tourism sector, technological changes

▲ **Photo B.15:** Soufrière Bay, St Lucia

Activity 11

Describe the attractions of Soufrière, as shown in Photo B.15.



Marine Reserves
Allows fish stocks to regenerate and protects marine flora and fauna. Access to the area is by permit and can be enjoyed by divers and snorkellers.

Fishing Priority Areas
Commercial fishing has precedence over all other activities in these areas.

Yachting areas
Yachting is not allowed in the SMMA. Moorings are provided in these areas only.

Multiple-use areas
Fishing, diving, snorkelling and other legitimate uses are allowed.

Recreational areas
Areas for public recreation – sunbathing, swimming.

▲ **Figure B.29:** Land-use zoning at Soufrière

in the fishing industry, and an increase in negative impacts from land-based activities, notably agriculture, industry and construction. These conflicts manifested themselves in increased competition between seine fishers and yachters regarding the use of fishing areas, and disputes between pot fishers and recreational divers in respect of the use of reefs.

The SMMA provided a new zoning plan (fishing priority areas, marine reserves and multiple-use areas), a range of management measures (user fees, incentives and so on) and a new institutional arrangement. However, by 1996 it was clear that there were difficulties in the implementation of the SMMA. In 1997 the SMMA began a thorough review process, which involved all relevant stakeholders.

A number of lessons were learned.

- All stakeholders must be involved in planning and negotiating stages – one group that had been overlooked were the fishermen who lived in nearby agricultural communities and not in the coastal town of Soufrière where the regular fishermen lived.
- Stakeholder groups and communities are far from homogeneous – there are a variety of fishermen, tourism operators, hotel operators and farmers.
- Effective representation is difficult.
- When carried out in a participatory fashion, stakeholder analysis is an instrument of dispute resolution.
- Natural resource management and development processes are constantly evolving. After the SMMA was formally created in 1995, a hotel and an agro-processing factory closed. These were two of the main employers in the area. Also, several reef areas were destroyed by Hurricane Lenny in 1999.
- Conflicts cannot be resolved; they can only be managed. The challenge, therefore, is to establish conflict management institutions that are capable of responding equitably, effectively and efficiently to emerging changes, evolving issues and new needs.

The SMMA agreement establishes five different types of zones within the area.

- Marine reserves: these are designed to protect natural resources. No extractive activity is allowed and entry into a reserve is subject to approval by the Department of Fisheries.

- Fishing priority areas: these areas are designed for maintaining and sustaining fishing activities, which take priority over any other use of the area.
- Recreational areas: include terrestrial (beaches) and marine (swimming and snorkelling) areas which are reserved for public access and recreation.
- Yachting areas: the SMMA only provides moorings – yachting takes place outside the SMMA.
- Multiple-use areas: these are areas where activities are regulated by existing legislation, notably the Fisheries Act and by provisions of the SMMA Management Agreement (2000). Activities that may take place in these areas include fishing, diving, snorkelling and other recreational activities.

Recent surveys suggest that the SMMA has seen an increase in the amount of fish caught and in fish biodiversity. Moreover, there has been less damage to coral reefs resulting from human activity.

Activity 12

1. Explain the need for planning and management in the Soufrière coastal zone.
2. Describe the **land-use zoning** in Figure B.29. How does this help reduce conflict?

Managing coral reefs and mangrove swamps

Coral reefs are often described as the "rainforests of the sea" on account of their rich biodiversity. Some coral is believed to be 2 million years old, although most is less than 10,000 years old. Coral reefs contain nearly a million species of plants and animals, and about 25 per cent of the world's sea fish breed, grow, spawn and evade predators in coral reefs. Some of the world's largest coral reefs include Australia's Great Barrier Reef, many of the reefs around the Philippines and Indonesia, Tanzania and the Comoros, and the Lesser Antilles in the Caribbean (Figure B.15).

▲ **Photo B.16:** Coral reef off the coast of Antigua

Environmental and economic value of coral reefs

Coral reefs are of major biological and economic importance. About 4,000 species of fish and 800 species of reef-building corals have been discovered. Countries such as Barbados, the Seychelles and the Maldives rely on tourism. Coral reefs generate large profits for some users. Tourism generated by the Great Barrier Reef is worth about A$4.6 billion annually to Queensland alone. Estimates suggest that the economic value of the coral reefs off Martinique and Saint Lucia amount to $50,000 per square kilometre each year, thanks largely to tourism. The global value of coral reefs in terms of fisheries, tourism and coastal protection is estimated to be $375 billion.

Coral reefs provide many advantages. These include the following.

- **Biodiversity:** coral reefs provide a breeding ground for many species of fish. The NPP (**net primary productivity**) of coral reefs is over 2,000 g/m^2/year and its biomass is 2 kg/m^2. Coral reefs have more than simply existence value; they are important not only for biodiversity, but also to the human population. There are many advantages.
- **Seafood:** in LICs, coral reefs contribute about one-quarter of the total fish catch, providing food for up to 1 billion people in Asia alone. If properly managed, reefs can yield, on average, 15 tonnes of fish and other seafood per square kilometre per year.

▼ **Photo B.17:** Coral and tourism, Jolly Harbour, Antigua

- **New medicines:** coral reef species offer particular hope because of the array of chemicals produced by many of these organisms for self-protection. Corals are already being used for bone grafts, and chemicals found within several species appear useful for treating viruses, leukaemia, skin cancer and tumours.
- **Other products:** reef ecosystems yield a host of other economic goods, ranging from corals and shells made into jewellery and tourism curios, to live fish and corals used in aquariums, and sand and limestone used by the construction industry.

Coral reefs offer a wide range of environmental services, some of which are difficult to quantify, but they are of enormous importance to nearby inhabitants. These services include:

- **Recreational value:** the tourism industry is one of the fastest-growing sectors of the global economy. Coral reefs are a major draw for snorkellers, scuba divers and recreational fishers.
- **Coastal protection:** coral reefs buffer adjacent shorelines from wave action and the impact of storms. The benefits from this protection are widespread, and range from maintenance of highly productive **mangrove** fisheries and wetlands to supporting local economies built around ports and harbours, where, as is often the case in the tropics, these are sheltered by nearby reefs.

Overfishing, tourism and pollution are short-term pressures on coral reefs, whereas growing levels of greenhouse gases are a longer-term problem, causing oceanic acidification and warming oceans, both of which lead to coral bleaching. There have only been three global occurrences of coral bleaching. The first coincided with El Niño in 1997–98 and killed off about 16 per cent of corals. The second was in 2010. The third, which began in 2015 may have affected 38 per cent of the world's corals.

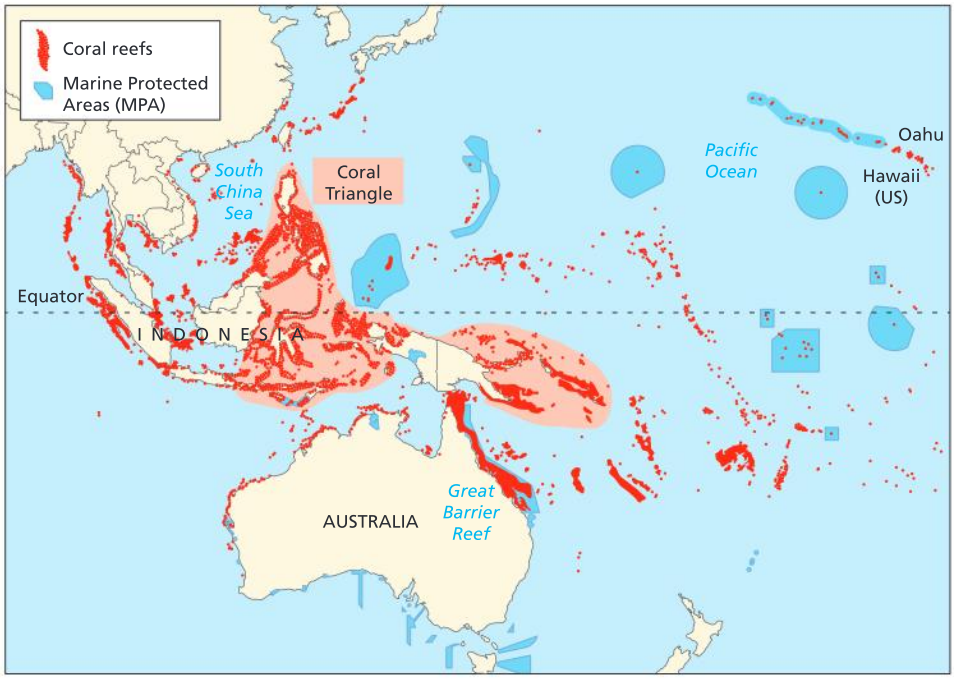
The richest reefs are in the "coral triangle" in South East Asia (Figure B.31). This area of 86,500 km^2 contains two-thirds of the world's coral species and more than 3,000 species of reef fish – twice as many as are found anywhere else.

The World Resources Institute estimates that about 60 per cent of reefs face immediate threats. In the 50 years to 2016, about a quarter of all coral cover has died. The reefs that are in worst shape are those off the most popular beaches where suncream gets into the water. In addition, fertilizer run-off from farms leads to algal blooms, which block the light that the corals need. Fishing close to reefs reduces the number of herbivorous fish, allowing vegetation to grow out of control. Some fishing methods are particularly harmful. For example, blast fishermen in Colombia and Tanzania use dynamite to stun and kill fish without regard to the harm done to reefs. In the South China Sea, island building and fishing for giant clams are changing some reefs beyond the possibility of recovery.

The problems vary spatially, hence policies must be adapted locally. The three countries with the largest number of people who fish on reefs are all in the coral-triangle region: Indonesia, Papua New Guinea and the Philippines. In Indonesia and in the Philippines, up to 1 million people's livelihoods depend on reefs. Trying to get all of these people on board

with conservation measures will prove difficult.

One approach is to give ecologically sensitive areas special status, such as marine protected areas (MPAs). In theory, activities that are deemed harmful, such as fishing, drilling and mining, can then be restricted or banned, with penalties for rule-breakers. The Aichi Targets, agreed in 2010 under the UN Convention on Biological Diversity, seek to have at least 17 per cent of inland water and 10 per cent of coastal and marine areas under conservation by 2020. Most countries have signed up. However, less than 3 per cent of the ocean's surface is within an MPA.



▲ **Figure B.30:** Coral reefs and Marine Protected Areas in the western Pacific Ocean

The most urgent action is regarding fishing vessels. A global register of fishing vessels would help to identify wrongdoers. Moreover, simply declaring an area protected does not necessarily safeguard it. In 2009 George W. Bush, then president of the USA, established three national marine monuments in the Pacific, including nearly 518,000 km^2 of coral islands and surrounding areas. Their remoteness makes it hard to stop vessels entering illegally; Hawaii's coastguard is already stretched. Satellites are sometimes used to police MPAs. In the future, sailing robots could play a larger role. The USA's National Oceanic and Atmospheric Administration (NOAA) has been working with a private firm, Saildrone, on drones that could roam remote ocean regions for months. They each cost around $500, making them far cheaper than manned boats. Such drones could photograph rogue fishing vessels as well as monitoring ocean temperature and acidity or tracking endangered species that have been tagged.

In poor countries, low-tech methods of surveillance are needed. Just 0.09 per cent of Malaysia's territorial waters, and those within its exclusive economic zone, are protected by an MPA. However, a national programme requires fishermen to paint their vessels according to how far out they have permission to fish within the nearshore area. Other fishermen can then spot when a rogue vessel has strayed. In Barbados, a pilot project charges visitors to enter a coastal MPA.

Mangrove swamps

Mangroves are salt-tolerant forests of trees and shrubs that grow in the tidal estuaries and coastal zones of tropical areas (Photo B.18). The muddy waters, rich in nutrients from decaying leaves and wood, are home to a huge variety of sponges, worms, crustaceans, molluscs and algae. Mangroves cover about 25 per cent of the tropical coastline, the largest being the 570,000 ha of the Sundarbans in Bangladesh.

▼ **Photo B.18:** Mangrove trees

Mangroves have many uses, such as providing large quantities of food and fuel, building materials and medicine. One hectare of mangrove in the Philippines can yield 400 kg of fish and 75 kg of shrimp. Mangroves also protect coastlines by absorbing the force of hurricanes and storms. They also act as natural filters, absorbing nutrients from farming and sewage disposal.

Pressures on mangroves

Despite their value, many mangrove areas have been lost to rice paddies and shrimp farms. As population growth in coastal areas is set to increase, the fate of mangroves looks bleak. Already most Caribbean and South Pacific mangroves have disappeared, while India, West Africa and South East Asia have lost half of theirs.

Managing mangrove forests

▲ **Photo B.19:** Mangrove (Sarawak, Malaysia)

Mangroves provide humans with many ecological services. These include products such as fuelwood, charcoal, timber, thatching materials, dyes, poisons, and food such as shellfish and crustaceans. Many fish species, both commercially farmed and farmed for subsistence, use mangrove swamps and seagrass beds as nurseries. In addition, mangrove trees provide protection from tropical storms and act as sediment traps.

Nevertheless, over-exploitation of mangroves has led to significant declines in their extent in recent decades. In Indonesia, over 2,000 km^2 of mangroves produce 250,000 of woodchip each year, and in Sabah, over 40 per cent of the total mangrove area was set aside for woodchip production. In many parts of South East Asia mangrove forests have been removed to make way for aquaculture ponds for prawns, crabs and other fish. In other areas, such as Singapore, mangroves have been removed to allow urban expansion. Rapid coastal development is squeezing mangrove forests. Urban population growth is exceeding the expansion of waste-treatment facilities, and some coastal areas are becoming heavily polluted.

Rapid population growth and the destruction of mangrove and seagrass beds has prompted the development of Integrated Coastal Zone Management (ICZM) techniques. Conflicts between human users of mangrove forests and conservationists, and sustainable use of mangroves requires careful planning.

Attempts to protect mangroves date back to 1760 when King José of Portugal ensured that mangrove trees could not be cut for other uses unless its bark was used for its tannins – so fuelwood was obtained from less valuable species. Intensive management of mangroves has occurred in the Sundarbans of Bangladesh and India since 1759 and in the Metang of Malaysia since 1902. In most cases, sustainable silviculture occurs on a 30–year cycle of planting and harvesting.

Restoration and afforestation

There are numerous places where mangrove trees have been planted, including afforestation programmes to produce the Nypa mangrove for roofing material, protection from tropical storms, timber, fuelwood, erosion control, fisheries enhancement, aesthetic appeal around landfill (in Rio de Janeiro) and even as fodder for livestock. Mangrove trees have been introduced to the Marshall Islands, French Polynesia and the Middle East.

Managed realignment

As a result of rising sea levels and coastal subsidence, many areas of mangrove are being constrained by the coastline and need to be allowed to migrate inland. This is known as managed realignment. It allows the mangroves to continue to provide ecological services. However, many farmers are unwilling to see their land holding reduced in size to allow mangroves to continue to flourish.

Flow restoration

The Diawling National Park in Senegal was established mainly for its bird population. However, due to the construction of a dam upstream, the wetlands began to dry out, the mangrove suffered, and the area became saltier. Prompt management led to the artificial flooding of the wetland, the recovery of the mangroves, and the restoration of the local fisheries and bird population.

Generic protection

A number of countries, such as Brazil, Mexico, Cambodia, El Salvador and Tanzania, have introduced legislation to protect mangrove trees. In Brazil, all coastal vegetation is protected (in theory) and tourist and aquaculture developments are regulated. In the Philippines there are strict rules over the establishment of aquaculture ponds. Australia and the USA operate a "no net loss" policy, while in Kenya and Malaysia, all mangroves fall under state ownership. However, not all of these schemes have prevented exploitation.

Protected area

Some 1,200 areas worldwide, accounting for about 25 per cent of the remaining mangrove, are said to be protected. The sites range in size from just a few trees to the vast Sundarbans. Permitted activities range from conservation to sustainable forestry.

Table B.7: Examples of mangrove restoration

Geographic location	Notes
Australia – Brisbane airport	11 ha; approximately 50,000 plants along a drainage canal, partial offset for losses during runway construction
Bangladesh	148,500 ha
Pakistan	19,000 ha; 16,000 ha of plantation and 3,000 ha of assisted natural regeneration
Thailand	Mangrove restoration in abandoned shrimp ponds

ATL Research and communication skills

Visit http://wwf.panda.org/about_our_earth/blue_planet/coasts/mangroves/mangrove_importance/ and http://www.endangeredspeciesinternational.org/coralreefs5.html and use the information to give a brief presentation to your class on the value of mangroves and coral reefs.

Sovereignty rights of nations

Exclusive economic zone (EEZ)

Exclusive economic zones are areas in which a coastal nation has **sovereign rights** over all of the economic resources of the sea, seabed and subsoil, extending up to 200 nautical miles from the coast (the international nautical mile is 1.852 km). They have a profound impact on the management and conservation of ocean resources since they recognize the right of coastal states to control over 38 million square miles of ocean space. Coastal states are free to "exploit, develop and manage and conserve all resources – fish or oil, gas or gravel, nodules or sulphur – to be found in the waters, on the ocean floor and in the subsoil of an area, extending almost 200 nautical miles from its shore." Almost 90 per cent of all known oil reserves under the sea fall under some country's EEZ. So too do the rich fishing areas – up to 98 per cent of the world's fishing regions fall within an EEZ.

Online case study

Geopolitical conflict: The Falkland Islands (Las Malvinas)

Ascension – an EEZ in the South Atlantic?

The UK has claimed ownership of 200,000 km^2 of the Atlantic seabed surrounding Ascension Island. The mountainous ocean floor up to

TOK

To what extent can any country have a claim over another in the middle of the ocean? Comment on the UK's territorial claim over the Falkland Islands (also South Shetland, South Orkney and the South Sandwich Islands).

560 km from the isolated island in the South Atlantic is believed to contain extensive mineral deposits. With no near neighbours, other states are unlikely to challenge the claim.

Ascension Island is small, having a land area of around 100 km^2, but due to its isolated location it generates an EEZ comparable to an area of more than 440,000 km^2. As mineral and energy prices have risen, there has been growing international interest in exploring the seabed for increasingly scarce reserves.

The waters around Ascension Island are generally deeper than the Pacific and probably beyond current technological limits for extraction. However, the mid-Atlantic ridge contains similar volcanic black smoker vents that help to concentrate valuable minerals. Britain has lodged, or is preparing, claims to underwater territories around Rockall in the North Atlantic, and in the Bay of Biscay.

Concepts in context

There many forms of **power**, including the power of nature, the power of countries, TNCs, different industries, individuals' wealth, and so on. How a stretch of coastline is managed depends on the power of these different users and forces. Powerful physical events may require large-scale, expensive management. Some poorer countries may be unable to afford this. Some nations have more economic power than others. Nations have sovereignty rights within their own territories. These territories extend into the oceans to form Exclusive Economic Zones. There is often conflict over competing territorial rights. In addition, some countries once had colonies and claimed territorial rights around those places.

Check your understanding

1. Explain the meaning of the term "managed retreat".
2. What is meant by "land-use zoning"?
3. Identify two causes of storm surges.
4. Explain the term "beach nourishment".
5. Outline the advantages of coral reefs.
6. Define the term "coastal management".
7. What are the benefits of sea walls?
8. Outline some of the disadvantages of using sea walls as a form of coastal management.
9. Explain the term "exclusive economic zone".
10. Define the term "geopolitics".

4 Ocean management futures

Developing abiotic resources

Many people have for years believed that the seabed is paved with minerals. Roughly a quarter of the ocean floor is strewn with manganese nodules, usually about the size of an apple, which contain not just manganese but also cobalt, copper and nickel. Gathering the nodules is technically difficult, mainly because most of them lie in 4 km of water, and it is not popular with environmentalists since the necessary dredging stirs up sediment that kills everything nearby.

The economics of mining has changed though. Industrial commodity prices are much higher than in the 1970s, and technology has advanced. That means it may now become profitable to exploit the manganese crusts and other minerals recently discovered. Since 2004 China, France, Germany, India, Japan, Russia, South Korea and a consortium of east European countries have all been awarded licences by the International Seabed Authority to explore mining possibilities on the deep-ocean seabed. The Canadian company Nautilus Minerals hopes to be the first deep-water mining company to start production. Its plan is to bring up ore containing copper and gold from the bottom of the Bismarck Sea north of Papua New Guinea, using technology developed by the offshore oil industry.

Deep-water discoveries

Hydrates

Hydrates are compounds that usually consist of methane molecules trapped in a cage of water. They were first found in permafrost in the 1960s and then, in the 1970s, on the slopes of continental shelves deep beneath the ocean surface. Some scientists believe these hydrates together contain more energy than all of the known deposits of fossil fuels, a possibility that makes them highly attractive to countries such as Japan and India, with little or no oil or gas. The oil companies, though, are cautious. Hydrates occur naturally in fault lines, and they are unpopular because they clog the flow of oil. Extracting them would be very difficult. And methane, though it burns more cleanly than coal, absorbs a wider range of wavelengths of the Earth's outgoing radiation than CO_2. Therefore, it traps more heat, making it an even more pernicious greenhouse gas. Some scientists argue that methane hydrates contain less energy than the energy needed to release and secure them.

Oil

All over the world, oil spills regularly contaminate coasts. Oil exploration is a major activity in regions such as the Gulf of Mexico, the South China Sea and the North Sea. The threats vary. There is growing evidence of widespread toxic effects on benthic (deep sea) communities on the floor of the North Sea in the vicinity of the 500-plus oil production platforms in British and Norwegian waters. Meanwhile, oil exploration

Conceptual understanding

Key question

What are the future possibilities for managing the oceans as a **global commons**?

Key content

- Causes and consequences of increasing demand for the abiotic resources of oceans, including minerals, oil and gas.
- Trends in biotic resources use (fish and mammals) and the viability of alternatives to overfishing, including aquaculture, conservation areas and quotas.
- Strengths and weaknesses of initiatives to manage ocean pollution, including local and global strategies for radioactive materials, oil and plastic waste.
- The strategic value of oceans and possible sources for international conflict or insecurity, including the contested ownership and control of islands, canals and transit choke points.

Case study

Oil pollution in the Gulf of Mexico – Deepwater Horizon

In April 2010 the Deepwater Horizon oil rig exploded and collapsed. Estimates suggest that, in total, up to 4.9 million barrels of oil entered the Gulf of Mexico. Over 160 km of coastline was affected, including oyster beds and shrimp farms. The cost to BP, who operated the rig, reached $20 billion.

BP's attempts to plug the oil leak by pumping huge quantities of mud into the blowout preventer (BOP) were unsuccessful. BP made three separate attempts to block the well using a total of 30,000 barrels of heavy mud. However, the pressure forcing the oil upwards was greater than the force of the mud. Previous attempts included using robot submarines to try to activate the well's built-in safety mechanisms. BP also lowered a concrete container over the leak, but the container became clogged with icy crystals. And it tried to use a riser insertion tool in the leaking pipe to collect the oil. This was only partially successful.

Dispersants were used to break up the oil slick, but BP was ordered by the US government to limit their use, as they could cause even more damage to marine life in the Gulf of Mexico.

BP's attempts to plug the oil leak were eventually successful.

ATL Thinking skills

In what ways does the map of international seabeds (Figure B.31) influence the development of polymetallic sulphides?

in the deep waters of the North Atlantic, north-west of Scotland, threatens endangered deep-sea corals. There is also evidence that acoustic prospecting for hydrocarbons in these waters may deter or disorientate some marine mammals.

Shipping is also a huge cause of pollution. Since ships burn bunker oil, the dirtiest of fuels, that means not just more CO_2 but also more particulate matter, which may be responsible for about 60,000 deaths each year from chest and lung diseases, including cancer. Most of these occur near coastlines in Europe and East and South Asia. Some action is being taken. Oil spills have become rarer since 2010, when all single-hulled ships were banned.

Efforts are also being made to prevent the spread of invasive species through the taking on and discharging of ships' ballast water. Similarly, a UN convention may soon ban the use of tributyltin, a highly toxic chemical once added to the paint used on almost all ships' hulls in order to kill or prevent were algae and barnacles.

ATL Research skills

Look at the International Seabed Authority website at http://www.isa.org.jm/authority and find out about the Mining Code for the seabed. See also http://www.cares.nautilusminerals.com/ for Nautilus Minerals community accountability and environmental responsibility.

Visit http://www.isa.org.jm/files/images/maps/Crusts_Pacific_3D.jpg for a map of cobalt-rich crusts on seamounts and guyots and http://www.isa.org.jm/files/images/maps//Sulphides_Global.jpg for polymetallic sulphide deposits.

Describe the distribution of polymetallic sulphide deposits on the sea floor. Suggest reasons to account for their distribution.

TOK

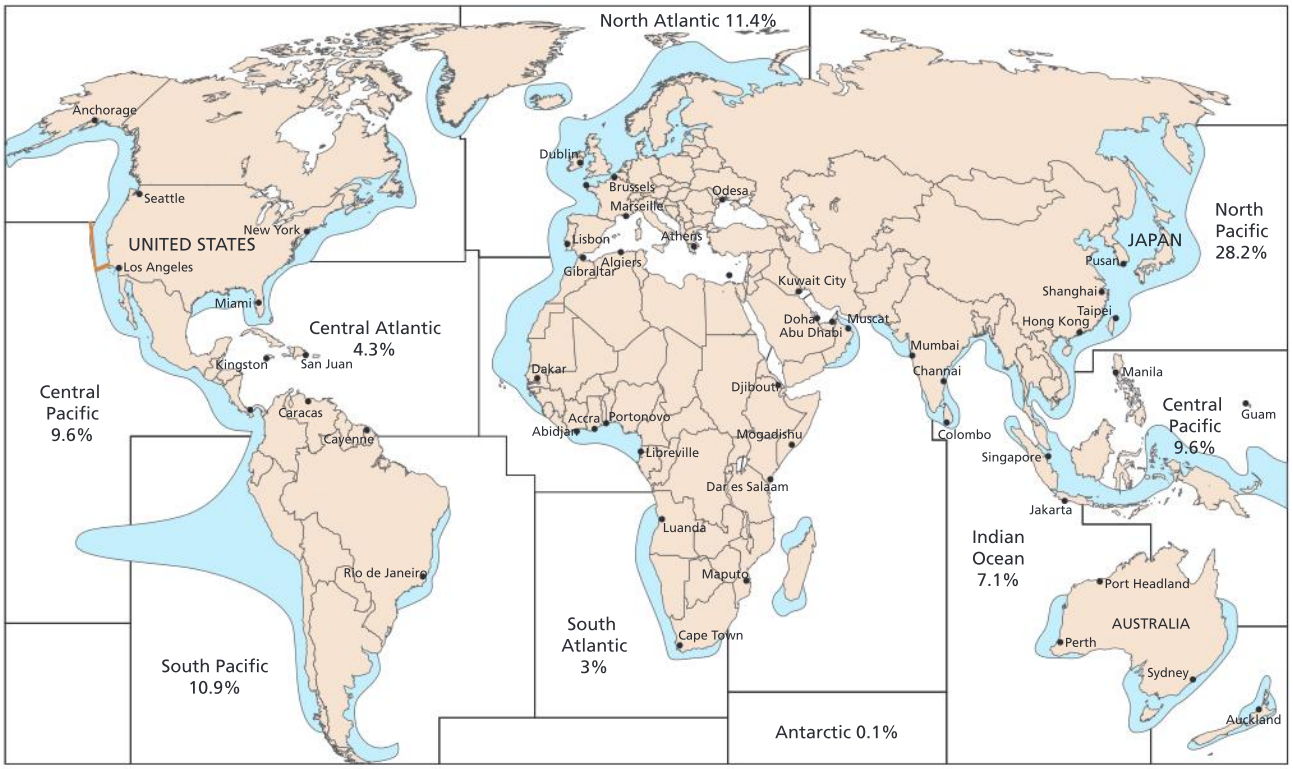
Is the oil producer BP to blame for the Deepwater Horizon accident, or is Transocean, the owner of the rig, responsible? Who should be in charge of maintenance of the rig – the owner or the user?

The environmental, economic and geopolitical consequences of overfishing

World fisheries

World fisheries and aquaculture contributed almost 160 million tonnes of fish in 2012, valued at over $215 billion. Over 136 million tonnes were used as food for people.

The world's supply of fish as food has grown dramatically since 1961, with an average growth rate of 3.2 per cent per year compared with a growth rate of 1.6 per cent per year for the



▲ **Figure B.31:** The world's main fishing grounds, showing percentage of global catch

world's population. World food fish supply increased from an average of 9.9 kg per capita in the 1960s to 19 kg in 2012. Fish consumption was lowest in Africa, while Asia accounted for two-thirds of total consumption. Consumption in Asia reached 85.4 million tonnes, of which 42.8 million tonnes was consumed outside China.

Although annual per capita consumption of products has grown steadily in low-income countries, it is still considerably lower than in high-income countries, but the gap is narrowing.

China has been responsible for much of the increase in world per capita fish supply owing to the substantial increase in aquaculture. China's share in world fish production grew from 7 per cent in 1961 to 35 per cent in 2010.

Globally, fish provides about 3.0 billion people with almost 20 per cent of their intake of animal protein.

Overall, global capture fisheries production (that is, fish caught in marine and freshwater environments) remains relatively stable at about 94 million tonnes. Global catches of tuna and tuna-like species set a new record of more than 7 million tonnes in 2012.

The north-west Pacific and western central Pacific have the largest and still growing catches. The North Atlantic areas and the Mediterranean and Black Sea again showed shrinking catches for 2011 and 2012. Catches in the south-west and south-east Atlantic have been recovering more recently.

▲ **Photo B.20:** The Tokyo fish market – unsustainable demand for fish (shown here are tuna)

Activity 13

Comment on the proportion of marine fish stocks that have been over-fished since 1974.

Fish stocks

Total global capture production of 93.7 million tonnes in 2011 was the second-highest ever, slightly below the 93.8 million tonnes of 1996. Moreover, 2012 showed a new maximum production (86.6 million tonnes) when the highly variable anchoveta catches are excluded.

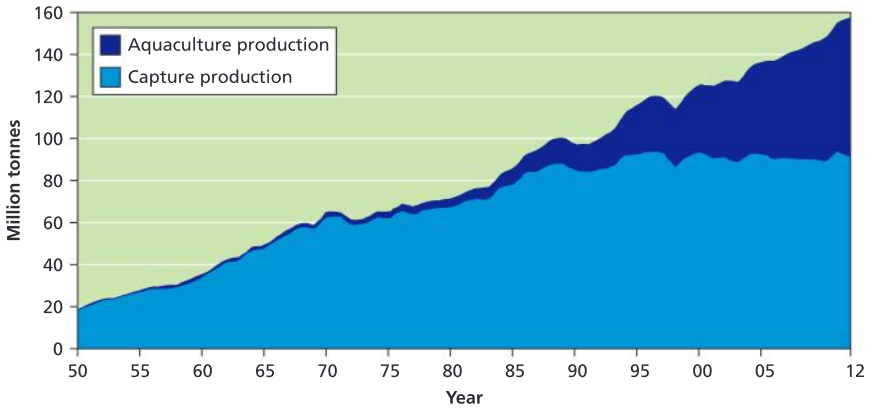
The decline of fish stocks

Fishing fleets now catch fewer large **predatory fish** but more smaller fish further down the food chain. The most prized food fish, for example cod, which tend to be top-level predators, are declining leaving smaller, less-desirable fish. This not only affects the type of fish available for human consumption, it could change marine ecosystems for ever.

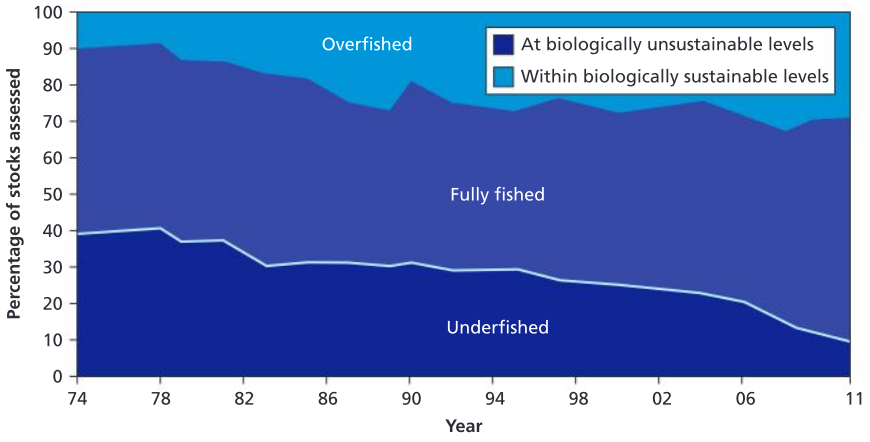
Larger, predatory fish need to eat large quantities of smaller fish. As their numbers fall, the numbers of smaller fish increases. This is why despite **overfishing** of cod and other important species, total fish catches have remained high. However, the type of fish being caught is changing.

Despite larger boats and better technology, fish catches of species like cod are falling. World fish stocks have declined rapidly – some species have even become extinct. More and more ships are chasing fewer fish, and prices have risen quickly. Despite many attempts to save the fish industry, for example through quotas and bans, there has been little success.

Nearly 70 per cent of the world's stocks are in need of management. Cod stocks in the North Sea are less than 10 per cent of 1970 levels. Fishing



▶ **Figure B.32:** World capture fisheries and aquaculture, 2012
Source: *The State of World Fisheries and Aquaculture.* The Food and Agriculture Organization of the United Nations, 2014.



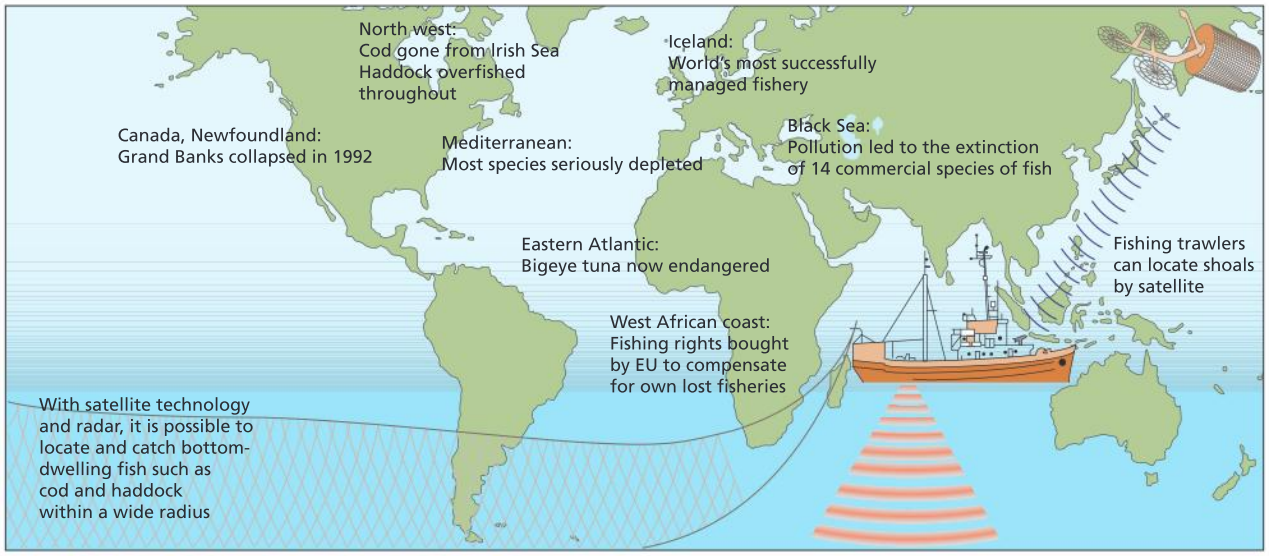
▶ **Figure B.33:** Global trends in the state of the world's marine fish stocks, 1974–2011
Source: *The State of World Fisheries and Aquaculture.* The Food and Agriculture Organization of the United Nations 2012.

boats from the EU regularly fish in other parts of the world, for example Africa and South America, to make up for the shortage of fish in EU waters. More than half of the fish consumed in Europe is imported.

Strategies for the European fishing industry

A World Bank and FAO report in 2008 showed that up to $50 billion per year is lost due to poor management, inefficiency and overfishing in world fisheries. The report puts the total loss between 1978 and 2008 at $2.2 trillion. The industry's fishing capacity continues to increase. The number of vessels is increasing slowly. However, each boat has greater capacity due to improved technology. Due to over-capacity, much of the investment in new technology is wasted. The amount of fish caught at sea has barely changed since 2006. Fish stocks are depleted, so it takes more effort to find and catch the remaining fish.

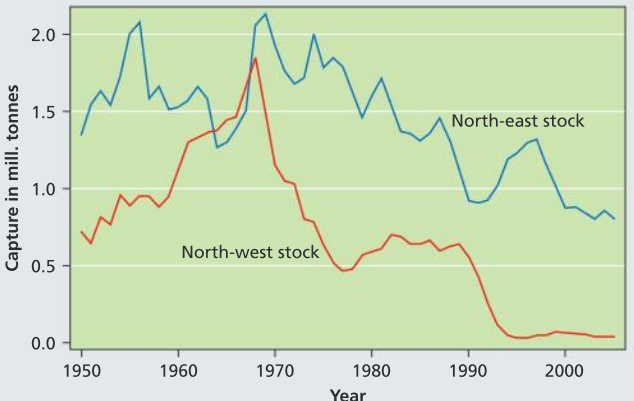
▼ **Figure B.34:** Fishing grounds under threat



Case study

Grand Banks

Once a fish stock is overfished it is very difficult for it to recover. The Grand Banks off Newfoundland was once the world's richest fishery. In 1992 it had to be closed to allow stocks to recover. It was expected to be closed for three years – but fish numbers, especially cod, have not yet recovered and it is still closed. The cod's niche in the ecosystem has been taken over by other species, such as shrimp and langoustines.



▲ **Figure B.35:** The decline of Atlantic cod

Table B.8 suggests some possible strategies for the future, but clearly there are no simple solutions to the problems associated with such a politically, economically and environmentally sensitive industry.

Table B.8: Strategies for the European fishing industry for the future

Action	Type of measure	Objectives
Conservation of resources		
Technical measures	Small meshed nets, minimum landing sizes, boxes	Protect juveniles and encourage breeding, discourage marketing of illegal catches
Restrict catches	Total allowable catches (TACs) and quotas	To match supply to demand, plan quota uptake throughout the season, protect sensitive stocks
Limit number of vessels	Fishing permits (which could be traded inter- or intra-nationally)	System applicable to EU vessels and other countries' vessels fishing in EU waters
Surveillance	Check landings by EU and third-country vessels (log books, computer/satellite surveillance)	To apply penalties to overfishing and illegal landings
Structural	Structural aid to the fleet	Finance investment in fleet modernization (although commissioning of new vessels must be closely controlled) whilst providing reimbursement for scrapping, transfer and conversion
Reduction in unemployment leading to an increase in productivity	Inclusion of zones dependent on fishing in Objectives 1, 2 and 5b of Structural Funds	To facilitate restructuring of the industry, to finance alternative local development initiatives to encourage voluntary/early retirement schemes
Markets		
Tariff policy	Minimum import prices, restrictions on imports	To ensure EU preference (although still bound under WTO)
Other measures		
Restrict number of vessels	Fishing licences	Large licence fees would discourage small, inefficient boats
Increase the accountability of fishermen	Rights to fisheries	Where fish stay put (for example shellfish) sections of the seabed can be auctioned off
–	–	Where a whole fishery is controlled, quotas could be traded which would allow some to cash in and leave the sea

ATL Research and communication skills

Visit http://ec.europa.eu/fisheries/cfp/index_en.htm and find out about the Common Fisheries Policy of the European Union.

Prepare a brief presentation with details about the following.

- What is the Common Fisheries Policy of the European Union?
- When was it introduced?
- What happened to North Sea cod stocks in 2008?
- What are the arguments for and against a common fisheries policy?

Visit http://ec.europa.eu/fisheries/cfp/fishing_rules/tacs/index_en.htm and research TACs (total allowable catches). Scroll down for a link to a map of TACs by species and countries.

Illegal fishing

The scale of illegal and unreported fishing is difficult to estimate. The Pew Charitable Trusts, an American research group, believes that around one fish in five sold in restaurants or shops has been caught illegally. That may amount to 26 million tonnes of fish every year, worth more than $23 billion. This illegal trade, though not the only cause of overfishing, is an important one. As well as the economic cost, there is an environmental one – since the 1960s one in four fisheries has collapsed.

A new monitoring system has been developed by the Satellite Applications Catapult. It uses data from various sources, notably ships' automatic identification systems (AIS). These broadcast a vessel's identity, position and other information to nearby ships and coastal stations, and also to satellites. An AIS is mandatory for all commercial vessels, fishing boats included, with a gross tonnage of more than 300. However, enforcement of AIS is patchy. Some captains believe they have a legitimate reason for turning it off, so as not to alert other boats to profitable shoals.

A virtual watch room can track vessels anywhere in the world. It uses AIS data, satellite data, radar, photographic images and radio transmissions, and it gives alerts when a vessel enters prohibited waters and slows down to fishing speed. It can also see when a vessel's catch is transferred to another vessel.

Nevertheless, this system will require government funding and the support of the industry, as well as retailers and restaurants if it is to tackle illegal fishing. Firms may be able to trace where their fish have come from. Customer pressure and satellite technology may prove to be a powerful weapon to combat illegal fishing.

There is an irony in this development. Overfishing is the product not just of human greed, but also of technologies such as sonar that have made finding and catching fish far more efficient in recent decades. Technology is now up to the task of catching illegal fishermen as well as fish.

Activity 14

Maximum Sustainable Yield (MSY) is the largest yield that can be taken from a natural resource without long-term depletion. The formula for calculating MSY is as follows:

$S_n = S_{n-1} + G + R - M - C$

Where: S_n = stock size now

S_{n-1} = stock size one year ago

G = growth or biomass added by fish stock

R = recruitment or biomass added by young fish

M = biomass lost by mortality

C = biomass caught

When MSY is achieved the fish population remains stable. What is the maximum tonnage of fish that can be removed in one year without damaging the ocean's ability to recover its stock?

Extension work

Watch a short video clip that explains how the Virtual Watch Room operates: http://worldmaritimenews.com/archives/150115/video-eyes-on-the-seas-fixated-on-pirate-fishing/.

Aquaculture

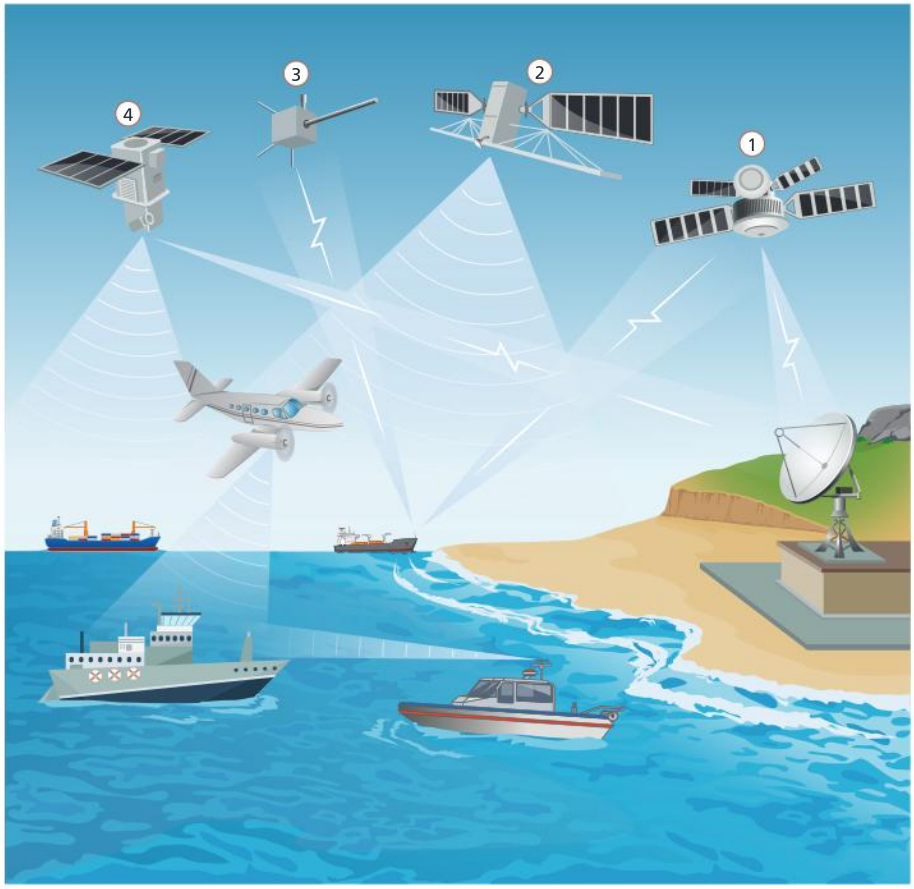
Aquaculture involves raising fish commercially, usually for food. In contrast, a fish hatchery releases juvenile fish into the wild for recreational fishing or to supplement a species' natural numbers. The most important fish species raised by fish farms are salmon, carp, tilapia, catfish and cod. Salmon makes up 85 per cent of the total sale of Norwegian fish farming. Farming was introduced when populations of wild Atlantic salmon in the North Atlantic and Baltic seas declined due to overfishing.

Global aquaculture

Between 1980 and 2010, world aquaculture grew by, on average, 8.8 per cent per annum. World aquaculture production in 2012 was estimated at 66 million tonnes, worth $140 billion.

Aquaculture production is vulnerable to adverse impacts of disease and environmental conditions. Disease outbreaks in recent years have

Figure B.36: The Virtual Watch Room



1 Vessel Monitoring Systems, or **VMS,** aboard vessels broadcast GPS coordinates, speed and other data to a fisheries monitoring centre via satellite.

2 Synthetic Aperture Radar, or **SAR,** satellites circle the globe day and night, independent of weather conditions, and can detect vessels in remote areas.

3 Automatic Identification Systems, or **AIS,** broadcast a vessel's identity, position and other information by VHF radio to nearby vessels and coastal stations and are mandatory under the International Convention for the Safety of life at Sea for all commercial vessels larger than 300 gross tonnes.

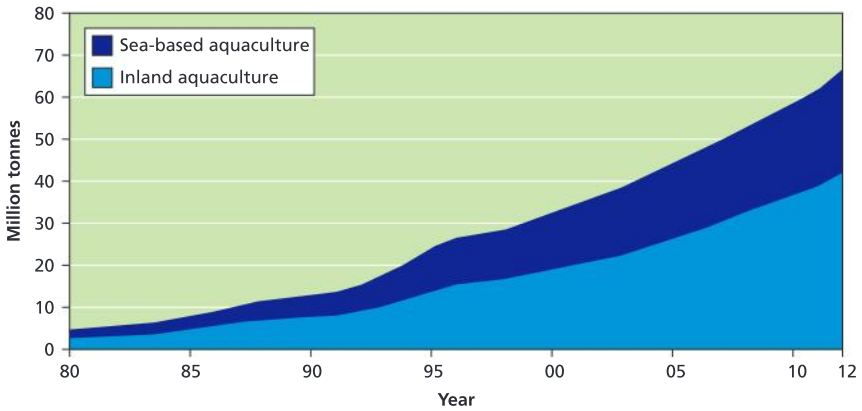
4 Optical Satellite Sensors provide high-resolution imagery and oceanographic and atmospheric data and can continuously cover one small area.

TOK

The Tragedy of the Commons is an idea which states that a commonly held resource is over-exploited. Nobody owns the high seas, which are therefore vulnerable to a perfectly legal free-for-all. Much of the overfishing occurs in territorial waters that stretch 12 nautical miles from a country's coastline, as well as so-called exclusive economic zones that stretch to 200 nautical miles beyond coastlines, over which a more limited sovereignty exists.

Visit https://www.theguardian.com/environment/the-coral-triangle/2015/jan/14/indonesias-new-marine-laws-threaten-sustainable-fisheries to read a case study on the problems of managing Indonesia's fishing industry.

Figure B.37: Growth in aquaculture
Source: *The State of World Fisheries and Aquaculture*. 2014. The Food and Agriculture Organization of the United Nations



affected farmed Atlantic salmon in Chile, oysters in Europe, and marine shrimp farming in several countries in Asia, South America and Africa.

In 2012, China produced over 40 million tonnes of food fish and 13.5 million tonnes of aquatic algae. Some HICs, notably the USA, have reduced their aquaculture output in recent years, mainly due to competition from countries with lower production costs.

Characteristics of aquaculture

Technological costs are high, and include using drugs such as antibiotics to keep fish healthy, and steroids to improve growth. Breeding programmes are also expensive. Outputs are high per hectare and per farmer, and efficiency is also high.

Environmental effects can be damaging. Salmon are carnivores and so need to be fed pellets made from other fish. It is possible that farmed salmon actually represent a net loss of protein in the global food supply as it takes 2–5 kg of wild fish to grow 1 kg of salmon. In contrast, most global aquaculture production (about 85 per cent) uses non-carnivorous fish species, such as tilapia and catfish, for domestic markets. Fish like herring, mackerel, sardines and anchovy are used to produce the feed for farmed salmon, and so the production of salmon leads to the depletion of other fish species on a global scale. Other environmental costs include the sea lice and diseases that spread from farmed salmon into wild stocks, and pollution (created by uneaten food, faeces and chemicals used to treat the salmon) contaminating surrounding waters. Organic debris of this type, with steroids and other chemical waste, can contaminate coastal waters.

Accidental escape of fish can affect local wild fish gene pools when escaped fish interbreed with wild populations, reducing their genetic diversity, and potentially introducing non-natural genetic variations. In some parts of the world, fish that have escaped from fish farms threaten native wild fish as salmon is an alien species (for example, the British Columbia salmon farming industry has inadvertently introduced a non-native species – Atlantic salmon – into the Pacific ocean).

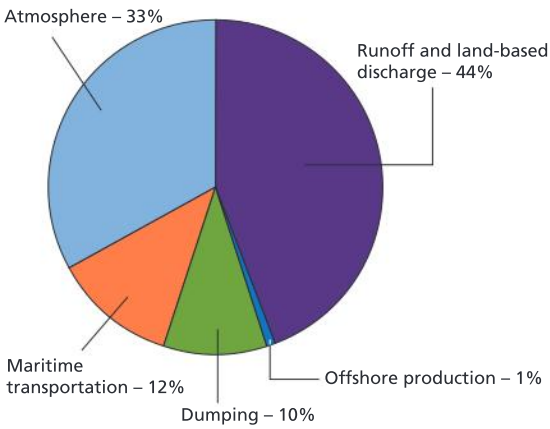
The positive environmental benefits of not removing fish from wild stocks, but growing them in farms, are huge. Wild populations are allowed to breed and maintain stocks, whilst the farmed variety provides food.

▼ **Photo B.21:** A Brunei fish farm

Initiatives to manage oceanic pollution

Every year, millions of tonnes of pollution ends up in the ocean worldwide, turning it into the world's biggest "landfill" and thus posing environmental, economic, health and aesthetic problems.

Marine-based activities that lead to pollution include the fishing industry, shipping (for example transport, tourism, fishing), offshore mining and extraction, illegal dumping at sea and discarded fishing gear. The main sources of marine litter include land-based activities such as discharge from stormwater drains, industrial outfalls, untreated municipal sewerage, littering of beaches and rivers. In the North Sea, half of the litter comes



▲ **Figure B.38:** Sources of waste entering the sea

from ships. The amount of pollution in the sea, and its sources, makes depressing reading. For example:

- approximately 80 per cent of marine litter is land-based
- in 2014, marine water samples contained six times more plastic than plankton; that is, out of 7 kg, there were 6 kg of plastic and 1 kg of plankton
- each day cruise ships release into the oceans around 95,000 m^3 of sewage from toilets and 5,420,000 m^3 of sewage from sinks, galleys and showers
- 250,000 kg of waste are removed from the North Sea each year.

Marine litter can cause serious economic damage: losses for coastal communities, tourism, shipping and fishing. Potential cost across the EU for coastal and beach cleaning was assessed at almost €630 million per year, while the cost to the fishing industry could amount to almost €60 million, which would represent approximately 1 per cent of total revenues of the EU fishing fleet. Marine litter may be one of the fastest-growing threats to the health of the world's oceans.

Alternatives to ocean dumping include recycling, producing less-wasteful products, saving energy and changing the dangerous material into more benign waste.

Radioactive waste

Radioactive effluent also makes its way into the oceans. Between 1958 and 1992, the Arctic Ocean was used by the Soviet Union, or its Russian successor, as the resting place for 18 unwanted nuclear reactors, several still containing their nuclear fuel. Radioactive waste is also dumped in the oceans and usually comes from the nuclear power process, medical and research use of radioisotopes and industrial uses. Nuclear waste usually remains radioactive for decades. Following the explosion of the nuclear power station at Fukushima Daiichi, in Japan, radioactive waste was carried across the northern Pacific Ocean towards Canada and the USA.

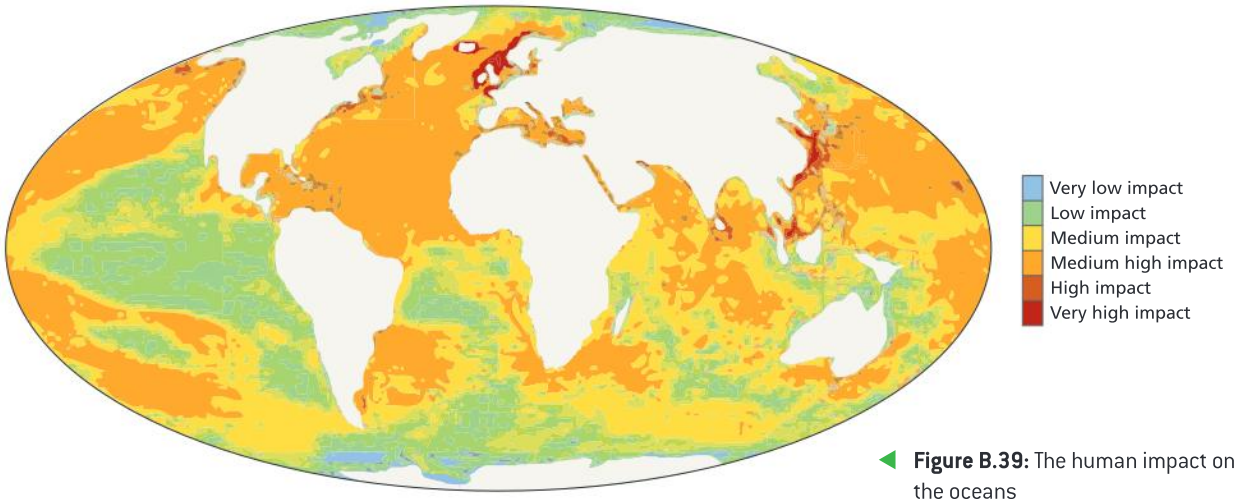


Figure B.39: The human impact on the oceans

Plastic

More alarming still is the plague of plastic. The UN Environment Programme reckoned even as far back as 2006 that every square kilometre of sea held nearly 18,000 pieces of floating plastic. Much of it was, and is, in the central Pacific, where scientists believe as much as 100 million tonnes of plastic jetsam are suspended in two separate gyres of garbage over an area twice the size of the USA.

About 90 per cent of the plastic in the sea has been carried there by wind or water from land. It takes decades to decompose or sink. Turtles, seals and birds inadvertently eat it, and not just in the Pacific. A Dutch study of 560 fulmars picked up dead in countries around the North Sea found that 19 out of 20 had plastic in their stomachs – an average of 44 pieces in each. Moreover, when plastic breaks up it attracts toxins, which become concentrated in barnacles and other tiny organisms and thus enter the marine food chain.

The GPGP formed due to the concentration of marine pollution by ocean currents. The GPGP is a large, relatively slow-moving mass, surrounded by the North Pacific gyre. Circulation of the gyre leads to the accumulation of pollutants from countries bordering the North Pacific Ocean. Currents carry debris from the west coast of North America to the gyre in about six years and debris from Asia in about five years.

Approximately 80 per cent of the waste comes from land-based sources and the other 20 per cent from shipping. According to a report from the US Environmental Protection Agency in 2011: "The primary source of marine debris is the improper waste disposal or management of trash and manufacturing products, including plastics (for example littering, illegal dumping) … Debris is generated on land at marinas, ports, rivers, harbors, docks, and storm drains. Debris is generated at sea from fishing vessels, stationary platforms and cargo ships" (*Marine Debris in the North Pacific,* US EPA, November 2011).

The size of the GPGP is unknown, although it is known to be very large. Estimates vary from 700,000 km^2 to more than 15 million km^2. The GPGP is also estimated to contain about 100 million tonnes of rubbish.

Photodegradation of plastics

Plastic never biodegrades. It does not break down into natural substances. Instead it goes through a photodegradation process, splitting into smaller and smaller particles that are still plastic. It takes a plastic bottle about 450 years to photodegrade, and a disposable nappy takes 500 years to photodegrade.

As a result of photodegradation, much of the plastic particulates in the GPGP are too small to be seen. A 2001 study counted 334,721 pieces of plastic particles per square kilometre. The United Nations Environment Programme suggests that each square mile of ocean water contains 46,000 pieces of floating garbage. The overall concentration of plastics was seven times greater than the concentration of zooplankton. Samples collected from deeper points found much lower concentrations of plastic particles.

Activity 15

1. Outline the main sources of ocean pollution.
2. Study Figure B.39.
   a. Suggest reasons for the locations of very high human impacts.
   b. Identify, and suggest reasons for, a region of very low human impact.

Extension work

Visit http://www.greenpeace.to/publications/dead-zones.pdf for information on dead zones and red tides.

Case study

The Great Pacific Garbage Patch

The **Great Pacific Garbage Patch** (GPGP) is an area of marine garbage located in the Pacific Ocean roughly between 135° and 155° west and between 35° and 42° north. The GPGP has extremely high concentrations of plastics and other rubbish that have been trapped by the currents of the North Pacific gyre. These currents create a circular effect that pulls in debris from North America, Asia and the Hawaiian islands. It consists mainly of small particles in the upper water layers.

▲ **Photo B.22:** Effects of plastics on albatrosses

Effect on wildlife

Due to the fact that many of the plastics take a long time to photodegrade, some of these partly degraded small plastics end up in the stomachs of marine birds and animals.

Midway Atoll (also known as Midway Islands) is an atoll (coral reef) situated in the middle of the North Pacific Ocean. It has been severely affected by the GPGP. Most of the 1.5 million Laysan albatrosses that nest on the island have plastic in their digestive system, and about one-third of their chicks die. An estimated 20 tonnes of plastic debris is washed up on Midway Atoll every year and about one-quarter of this debris is fed to albatross chicks.

Marine plastics can also enable the spread of invasive species. Some species may attach to floating plastic in one region and drift long distances to colonize other ecosystems.

ATL Research skills and social skills

Use the following sources to prepare a presentation on possibilities for managing pollution in the world's oceans.

United Nations Convention on the Law of the Sea (1982) http://www.un.org/Depts/los/index.htm – this regulates in a comprehensive way numerous maritime issues.

https://www.isa.org.jm/ – the means by which the UN organizes and controls activities relating to the deep seabed's mineral resources in the international seabed area, beyond the limits of national jurisdiction.

Treaty on the Prohibition of the Emplacement of Nuclear Weapons on the Sea-bed and the Ocean Floor and in the Subsoil Thereof (Sea-bed Treaty) 1971 http://www.nti.org/learn/treaties-and-regimes/treaty-prohibition-emplacement-nuclear-weapons-and-other-weapons-mass-destruction-seabed-and-ocean-floor-and-subsoil-thereof-seabed-treaty/– bans the placing of nuclear weapons, or any weapon of mass destruction, on the seabed or ocean floor.

Ocean health index http://www.oceanhealthindex.org/.

Chinese expansion in the South China Sea

The South China Sea is a vital trade artery, accounting for about 30 per cent of the world's trade passes, over £3 trillion in value. China is now threatening more than 70 years of American naval supremacy in the western Pacific.

In 2015–16 China is alleged to have installed two launch batteries for surface-to-air missiles on Woody Island in the Paracel archipelago (Figure B.40). China claimed its right to limited and necessary self-defence facilities. The Paracels are also claimed by Vietnam and Taiwan. China insists that virtually all of the sea belongs to it.

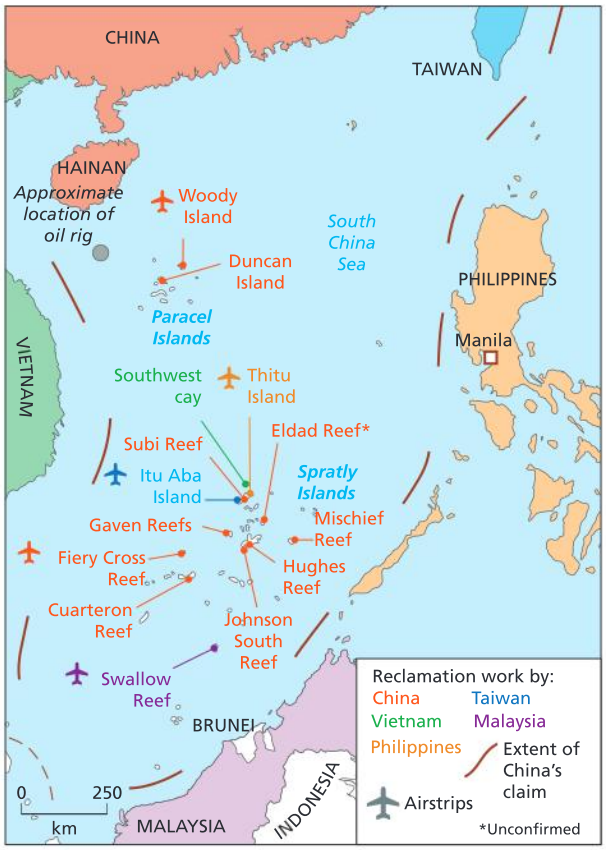
It also built over some coral reefs in the Spratly Islands, creating artificial land on rocks and reefs also claimed by the Philippines, Taiwan and Vietnam. The construction, like the missiles, flouts the spirit of a declaration that China signed in 2002 with the Association of South East Asian Nations (ASEAN), in which the parties promised to "exercise self-restraint" in the sea. China has built over 4 km^2 of artificial land mass in the Spratly Islands to create land with facilities that could be utilized for military use, including an air strip with a 3,000 m runway. The region is also rich in oil and gas.

In 2016 China delegates visited Itu Aba, the biggest natural island in the Spratly archipelago in the South China Sea, garrisoned by Taiwan but also claimed by China, the Philippines and Vietnam. Under the UN Convention on the Law of the Sea (UNCLOS), Itu Aba is a rock that cannot sustain human life, so it is entitled to 12 nautical miles of territorial waters, but not the 200 mile exclusive economic zone accorded to habitable islands.

By 2030, on current trends, the South China Sea will be virtually a Chinese lake, as the Caribbean and Gulf of Mexico are for the USA today.

Three approaches are being tried to moderate China's behaviour – legal, diplomatic and military. The legal case that the Philippines brought to the UNCLOS is to show that China's historic claim – a "nine-dash line" on maps encompassing most of the sea (Figure B.40) has no legal basis. Diplomatically, China prefers to negotiate with ASEAN members individually. As for military deterrence, a marked increase in defence spending across the region in recent years still leaves the USA as the only power capable of standing up to China.

The USA also wants to turn two Pacific islands into a military training ground. Tinian and Pagan are two US territories that form part of the Commonwealth of the Northern Mariana Islands. The US Navy has proposed using the two islands for live fire exercise for at least 16 weeks each year. Pagan has been largely uninhabited since a volcanic eruption in 1981, and would be used as a training ground for a potential conflict in the South and East China Seas.



▲ **Figure B.40:** Geopolitical conflict in the South China Sea
Sources: www. amti.csis.org; www. janes.com; www. lawfareblog.com

Changes in the Arctic and the global geopolitical opportunities and challenges they bring

The fact that Arctic sea ice is disappearing has been known for decades. This is opening up potential trade routes, and also giving access to the vast oil and gas reserves believed to lie beneath the Arctic.

ATL Research skills

Look at http://www.geopoliticsnorth.org/ for an article on Geopolitics in the High North, and add to your notes.

ATL Research skills

Find out about the complaint that the Philippines lodged with the UN Permanent Court of Arbitration, and why China says it will not engage with the case.

Case study

The Arctic

Canada is establishing a year-round Arctic presence on land and sea as well as in the air. Denmark is trying to prove that a detached part of the underwater Lomonosov Ridge is an extension of Greenland, which is Danish territory. Russia has staked a claim by sending a submersible to plant a corrosion-resistant titanium flag some 4 km below the North Pole. In 2008 Canada, Denmark, Norway, Russia and the USA met in Greenland to discuss how to divide up the resources of the Arctic Ocean.

According to the US Geological Survey, it could hold a quarter of the world's undiscovered gas and oil reserves. This amounts to 90 billion barrels of oil and vast amounts of natural gas. Nearly 85 per cent of these deposits, they believe, are offshore. The five countries are racing to establish the limits of their territory, stretching far beyond their land borders.

There is also increased potential for fishing. At the Arctic Frontiers conference in 2015 it was announced that, increasingly, planktonic animals such as copeopods and krill were

Case study (continued)

abundant and feeding on the smaller plankton that could survive the Arctic winter. The increase in primary productivity could support a larger cod population. As water temperatures rise, cod populations are being found as far north as 80°N.

Environmental groups have criticized the scramble for the Arctic, saying it will damage unique animal habitats, and have called for a treaty similar to that regulating the Antarctic, which bans military activity and mineral mining.

Under the 1982 UN Law of the Sea Convention, coastal states own the seabed beyond existing 370 km zones if it is part of a continental shelf of shallower waters. While the rules aim to fix shelves' outer limits on a clear geological basis, they have created a tangle of overlapping Arctic claims.

Concepts in context

There are many **possibilities** for managing oceanic resources for the benefit of humans. Much of the ocean is part of the Global commons, and is not owned by any single country. However, there is a danger that ocean resources will be over-exploited or degraded. Therefore, they need careful management. Trying to achieve consensus may be difficult.

Even in remote areas, such as Antarctica, there are pressures on resources. In areas close to large populations, pressures on resources are greater, and may be contested. The battle between economics and environment is likely to intensify, and it may well be complicated by conflicts between different countries.

Check your understanding

1. Identify two oceanic abiotic resources.
2. Explain the terms "quotas" and "conservation areas".
3. Outline the main sources of ocean pollution.
4. Name two strategies to manage ocean pollution.
5. Identify one ocean area in which there is international conflict or insecurity.
6. Identify the countries involved in the conflict/insecurity (question 5) and the source of the conflict.
7. Explain the difference between capture fisheries and aquaculture.
8. Explain what the Virtual Watch Room is.
9. Explain how technology has helped to catch fish as well as protect them.
10. Outline the environmental problems associated with aquaculture.

Synthesis and evaluation

- Changes in one part of an ocean or coastal margin may bring about change in other parts. This can be small-scale and artificial, as in the case of groynes, or large-scale and natural, as in the case of El Niño events.
- The exploitation of oceanic resources may also vary in scale from highly localized cases of aquaculture to large-scale capture fisheries. The management of oceans also varies from small-scale nature reserves to large-scale fisheries policies.
- The cost benefits and effectiveness of management depends on the perspective of the stakeholder – industrialists, energy developers, conservationists and fishermen, have different opinions as to how oceans should be managed.

The map shows a coastal landform.

(a) **(i)** Identify the landform shown on the map. (1 mark)

(ii) Explain how this landform has been formed. (3 marks)

(iii) Outline the conflicting pressures on managing a coastal area, such as that shown on the map. (6 marks)

(b) Either

Examine the view that the ocean requires more global management than local management. (10 marks)

Or

Evaluate the costs and benefits of two or more named and located coastal protection strategies. (10 marks)

OPTION C
EXTREME ENVIRONMENTS

Key terms

Sustainability	Social, economic and environmental use of resources in a way that allows future generations to maintain their standard of living.
Arid and semi-arid	Arid areas receive less than 250 mm rainfall per year whereas semi-arid areas receive between 250 mm and 500 mm per annum.
Infertility	A lack of nutrients or bases in soils, caused by low weathering rates, a lack of biomass; insufficient nutrients to support arable farming.
Periglacial	Snow and ice cover on the fringe of glaciated areas ("peri" means edge) usually associated with permafrost or ground that remains frozen for at least two years. These regions include high mountain and tundra areas of northern Eurasia and North America.
Permafrost	Permanently frozen subsurface. To be classified as a permafrost the land must have been frozen for at least two years.
Weathering and erosion	Weathering is the breakdown (denudation) of the Earth's surface in situ (on the spot, that is, without a moving force) whereas erosion is the breakdown of the Earth's surface by a moving force, for example glaciers, rivers, wind.
Desertification	The spread of desert or desert-like conditions.
Indigenous people	People native to an area and who have been there for many generations.
Resource nationalism	The use of a country's resources to benefit that country rather than allowing a TNC or another country to benefit from the resources.

This optional theme considers two different kinds of extreme, terrestrial environment:

- cold and high-altitude environments (polar, glacial areas; periglacial areas; high mountains in non-tropical latitudes)
- hot, arid environments (hot deserts and semi-arid areas).

These environments are relatively inaccessible and tend to be viewed as inhospitable to human habitation. Despite this, they provide numerous opportunities for settlement and economic activity. This theme examines the essential landscape characteristics of the two kinds of extreme environment, together with the natural processes operating in them, the way in which people have responded to the opportunities they offer, how they have adapted to extremes of weather and climate, and the challenges these environments pose for management and sustainability.

This theme will develop an understanding of processes, places, power and geographical possibilities. More specialized concepts include glacial systems risk and adaptation (in relation to climate change) and resource nationalism (in relation to land ownership).

Key questions

1. Why can some **places** be considered to be extreme environments?
2. How do physical **processes** create unique landscapes in extreme environments?
3. How does the **power** of different stakeholders to extract economic value from extreme environments vary?
4. What are the future **possibilities** for managing extreme environments and their communities?

1 The characteristics of extreme environments

Conceptual understanding

Key question

Why can some places be considered to be extreme environments?

Key content

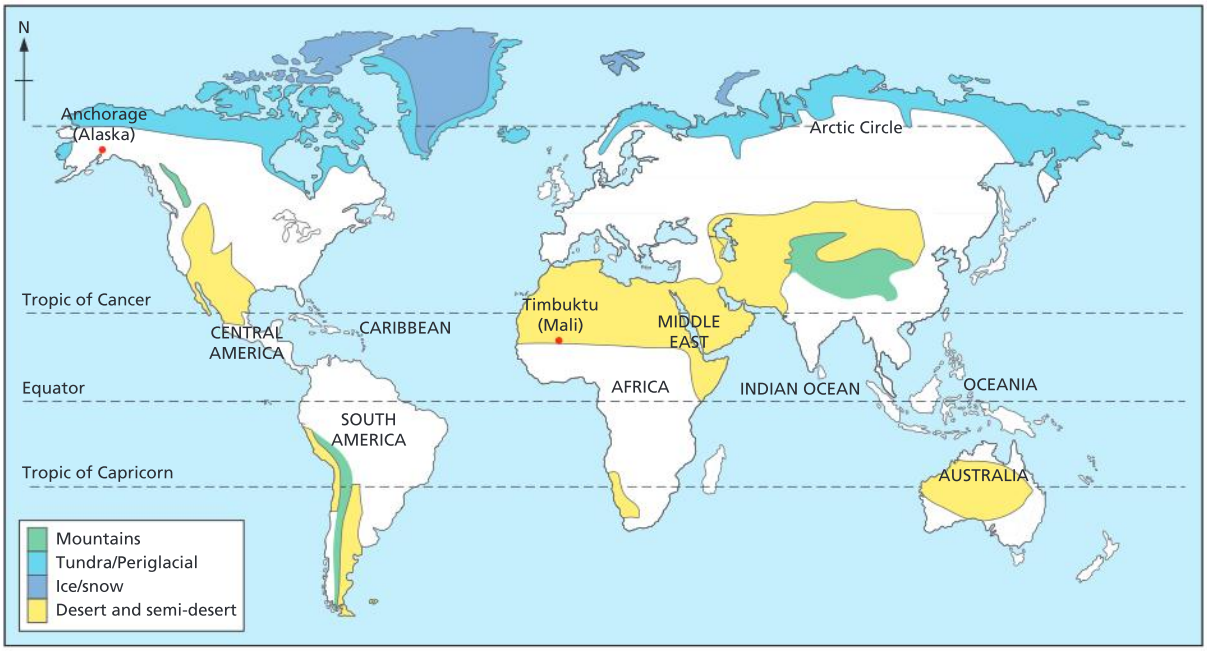
- Global-scale distribution of cold and high-altitude environments (polar, glacial areas, periglacial areas, high mountains in non-tropical latitudes) and hot arid environments (hot deserts and semi-arid areas).
- Relief and climatic characteristics that make environments extreme (including the unreliability and intensity of rainfall in arid environments and the resulting risk of flash floods).
- How relief, climate, human discomfort, inaccessibility and remoteness present challenges for human habitation and resource development.
- The changing distribution of extreme environments over time, including the advance and retreat of glaciers and natural desertification.

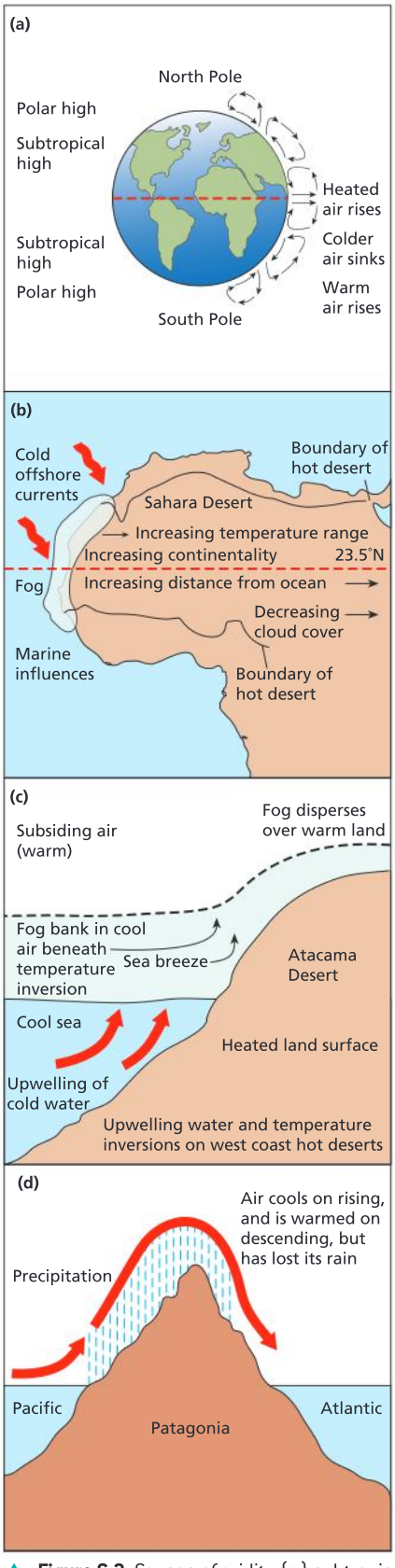
The global distribution of extreme environments

Cold and high-altitude environments

The distribution of cold environments is very uneven. In general, cold environments are found in high latitudes and at high altitudes. Polar

▼ **Figure C.1:** The distribution of extreme environments





▲ **Figure C.2:** Causes of aridity (a) subtropical high pressure, (b) continentality, (c) cold offshore current and (d) rain shadow.

environments are located towards the North Pole and the South Pole, where levels of insolation (solar radiation) are very low. In the northern hemisphere, there is a belt of **periglacial** environments. This zone is generally not found in the southern hemisphere except in small areas, given the relative lack of land mass at around 60°–65°S.

Other cold environments are associated with high mountains. There are extensive areas of high ground in Asia, associated with the Himalayas. Other high-altitude areas include the Andes and the Rockies, located in the Americas. On average, temperatures decrease by about 10°C per 1,000 m, so high-altitude areas will be cooler than surrounding low-altitude areas.

Desert and semi-arid environments

Desert and semi-desert areas cover as much as a third of the Earth's surface. They are generally located around the tropics and are associated with permanent high-pressure systems which limit the potential for rain formation. Four main factors determine the location of the world's main deserts (Figure C.2). They include:

- the location of stable, **high-pressure conditions** at the tropics, for example the Sahara and the great Australian deserts
- large distance from the sea (known as **continentality**), such as the central parts of the Sahara and Australia and also parts of the south-west USA
- **rain-shadow effects**, as in Patagonia (South America) and the Gobi Desert in central Asia
- proximity to **cold upwelling currents**, which limit the amount of moisture held in the air, for example off the west coast of South America, helping to form the Atacama Desert, and off the west coast of southern Africa, helping to form the Namib desert.

Conditions in extreme environments

Cold and high-altitude environments

Cold environments are very varied in their characteristics. Mountain environments can be characterized by warm days and very cold nights. They may also receive large amounts of rainfall due to relief rain. In contrast, some mountain areas receive low rainfall because they are in a rain shadow. Polar areas generally receive low rainfall. They are, in effect, cold deserts.

Activity 1

Study Figure C.2. Explain how the following factors influence the development of arid and semi-arid areas:

1. Atmospheric pressure
2. Ocean currents
3. Relief
4. Continentality

Activity 2

1. Study Figure C.3. Outline the ways in which this environment may be considered an extreme environment.
2. In what ways can the environment in Figure C.4 be considered extreme?

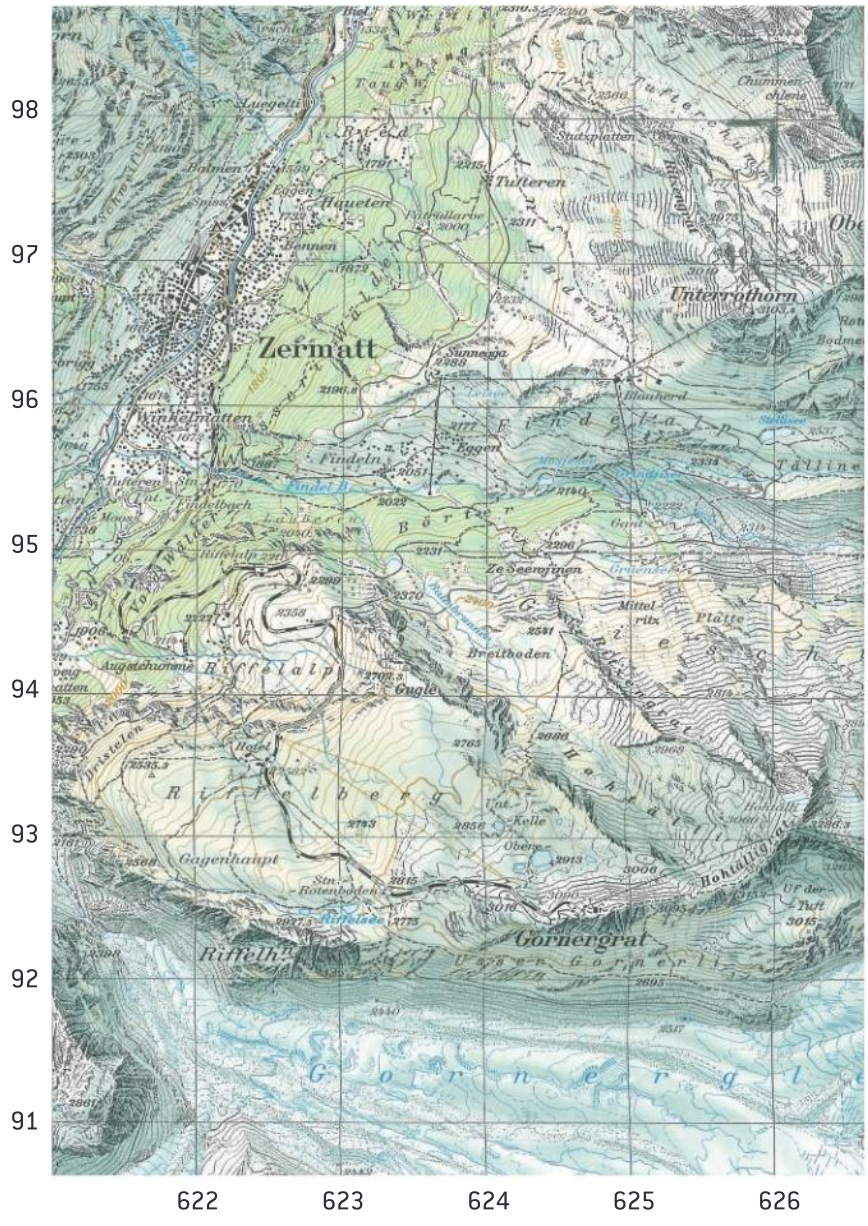
Owing to their steep nature, mountains are difficult areas to build on, and they act as barriers to transport (Figure C.3). Soils are often thin, and suffer from high rates of overland run-off and **erosion**. In contrast, in periglacial areas – or tundra regions – the low temperatures produce low rates of evaporation, and soils are frequently waterlogged. The growing season is relatively short: temperatures are above 6°C for only a few months of the year. Nevertheless, some periglacial areas support large numbers of people, and there may be important settlements adjacent to some high-altitude environments.

Desert and semi-arid environments

In desert areas, such as areas adjacent to the Gulf of Aden or the Red Sea, the lack of water acts as a major constraint for development. Temperatures are high throughout the year but, in the absence of freshwater, farming is almost impossible. In semi-arid areas, annual rainfall varies between 250 mm and 500 mm, so there is some possibility for farming, especially where water conservation methods are used. On the other hand, the guarantee of warm, dry conditions could be excellent for tourism developments, especially in coastal areas such as the Red Sea coast of Egypt. Other desert areas may be characterized by a mixture of steep slopes, flat areas, seasonal streams and flash floods (Figure C.4).

People in extreme environments

Extreme environments are characterized by low population densities (Figure C.6). Examples include densities of three people per square kilometre in central Australia, Iceland and northern Canada, two people per square kilometre in Namibia and just one per square



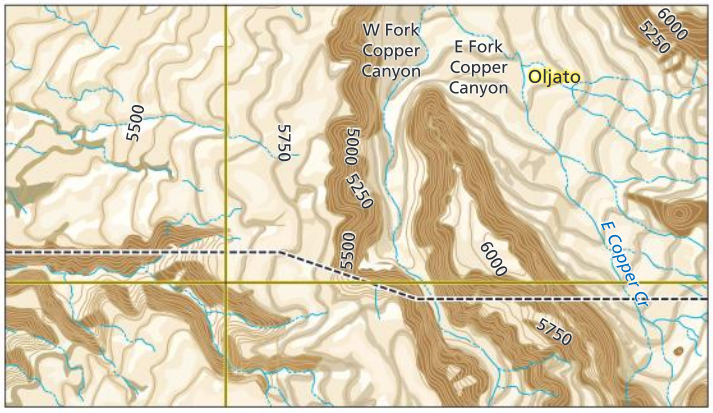
▲ **Figure C.3:** Zermat and the Gorner Glacier

▼ **Table C.1:** Climate data for Anchorage, Alaska

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	20	18	13	11	13	25	47	64	64	47	28	24
Average temperature (°C)	−11	−7	−4	3	9	13	15	13	9	2	−5	−10

▼ **Table C.2:** Climate data for Timbuktu, Mali

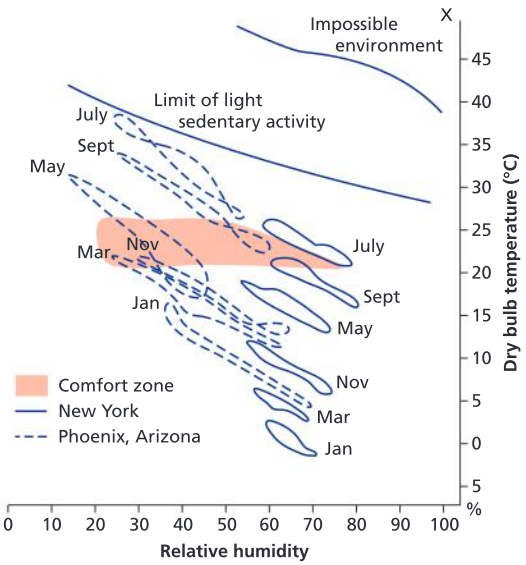
Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	0	0	0	1	4	20	54	93	31	3	0	0
Average temperature (°C)	22	25	28	31	34	34	32	30	31	31	28	23



▲ **Figure C.4:** OS map of Monument Valley region of Utah, USA

Activity 3

1. Plot the climate data for Anchorage and Timbuktu presented in Tables C.1 and C.2. Make sure that you use the same scale for temperature and rainfall for both locations.
2. Describe the main differences in climate between the two places.
3. Suggest reasons for the differences that you have noted for question 2.



Note how the climates of New York and Phoenix fall outside the comfort zone in most of the six months plotted.

▲ **Figure C.5:** Comfort zones

kilometre in the western Sahara. Much of this can be put down to the extremes of climate: insufficient heat in Iceland and Canada, and insufficient water in the other three areas are largely to blame. None of these environments is particularly "comfortable"; they all fall a long way outside the recognized "comfort zones for human habitation" (Figure C.5).

Other factors are important, too. Iceland is relatively remote and isolated. This makes communications costly, and often difficult. It also increases the cost of materials, which have to be imported, such as timber for building. Similarly, Namibia is a long way from the economic core of southern Africa, and this increases the costs of imports and exports. Coastal areas are better off than inland areas but are still relatively undeveloped.

Coping with periglacial environments

Traditionally, the Inuit peoples of the Arctic regions of Alaska, Canada and Greenland have used periglacial pastures for herding or hunting caribou. The Inuit tend to be migratory, moving north into the tundra during the brief months of summer and heading southwards to the forest margins in winter. The Sami of Scandinavia also follow this pattern.

To make up for the lack of good pasture on land, many **indigenous people** have turned to rivers and the oceans. Fishing is extremely important in periglacial environments. For the Nenets of the Yamal Peninsula in Siberia, fish are an important supplement to their diet.

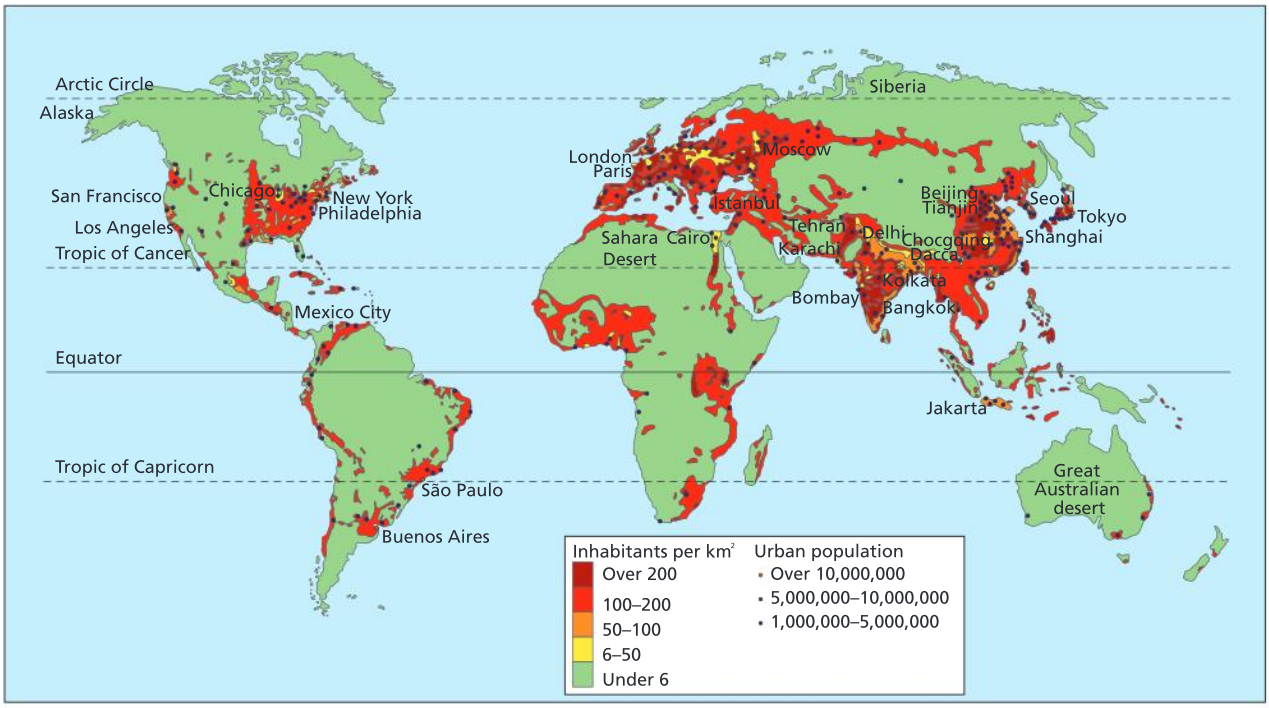
At the other end of the scale, fishing and fish-related products accounted for up to 70 per cent of Iceland's GDP. To cope with the cold conditions Inuit populations have evolved a layer of fat that protects them from the extreme cold.

Building on permafrost

Building on **permafrost** is challenging. Heated buildings can thaw the permafrost underneath them. Once the permafrost thaws, it sinks, damaging the building it supports. Engineers solve this problem by raising buildings above the ground on a steel frame, so that cold air can flow under them and stop the permafrost from thawing. Another way to stop damage from thawing permafrost is to thaw the ground first. This method makes the ground more stable to build on because the structure keeps the ground from freezing.

Activity 4

1. Describe the conditions of the comfort zone as shown in Figure C.5.
2. Explain why conditions are impossibly uncomfortable for humans at X.



▲ **Figure C.6:** Extreme environments have low population densities

Water supplies

In places with large, continuous stretches of permafrost, finding water takes a lot of effort. People can sometimes get water from nearby lakes and rivers or by melting ice or snow, but they cannot get liquid water directly out of the ground in the winter. Water pipes from the water supply to the buildings have to be protected so that water inside the pipe does not freeze and the ground around the pipe does not thaw.

Transport

Transport infrastructure such as roads and bridges may be damaged by frost heave, and need constant repair to keep them safe. Soil under roads can be replaced with gravel so that water drains better and there is less frost heave, or roads may be painted white to reflect more heat and keep them cooler. A cooler road surface helps prevent frozen ground from thawing underneath. In some places with permafrost, the top layer of ground thaws during the summer, creating marshland, so people can only drive on these areas during the winter, on ice roads at least a metre thick built on top of the frozen marshes. Trucks weighing up to 64 tonnes can then drive across them and haul supplies to mines and drill sites in northern Canada and Alaska. Ice roads are also built on frozen lakes for winter travel. In summer the roads melt, and they must be rebuilt each winter.

▲ **Photo C.1:** Thingvellir, Iceland – a periglacial region in which the North America plate (left) is pulling away from the European plate

Coping with arid environments

Relief

Many hot, arid areas contain a mixture of rugged slopes and flat slopes. The steep slopes make travel and transport difficult. The buttes and mesas of Monument Valley, for example, contrast with the flat plains and plateau tops there. Movement on the plains is easy – there have even been attempts at world speed records. For example, the Bonneville Speedway track is an area of salt flats in Utah that is used for racing.

Rainfall

Rainfall in desert areas is unreliable and very low. In Timbuktu, for example, the average rainfall is less than 210 mm, while in Cairo it is less than 30 mm. In general, the lower the rainfall total (per year) the greater the inter-annual variability is. For example, areas with less than 250 mm have an annual variability of about 50 per cent (that is, between 125 mm and 375 mm), whereas areas with an annual rainfall of 500 mm have an annual variability of about 30 per cent (between around 340 mm and 660 mm). Moreover, flash floods may occur in deserts. Due to the dry surfaces, these result in sheet flow (water flowing over large surface areas rather than in distinct channels) and lead to erosion and severe disruption of economic activities.

ATL Research skills

Research environments and human adaptation at http://ameeta.tiwanas.com/files/presentations/physical/Environment_and_Human_adaptation.pdf and Alpine protected areas at http://www.alparc.org/index.php.

▲ **Photo C.2:** Oryx-Antelope crossing red sand dunes at Sossusvlei, Namib-Naukluft National Park

Climate and human discomfort

Hot arid areas are characterized by extremes. Daytime temperatures are extremely high – over 40°C is not uncommon in summer. Night-time temperatures can be very low, close to freezing, since the lack of cloud cover allows maximum reradiation at night.

Like the traditional peoples of periglacial areas, desert inhabitants are also migratory. The Bedouin of the Arabian Peninsula and the Fulani of Africa, for example, have learned to cope with the extreme temperatures by avoiding the direct sun and taking a rest during the middle of the day. They tend to travel in early morning and late afternoon. Their clothing – long, loose-fitting garments – also helps them to cope with high temperatures. It reduces sweating and allows them to remain reasonably comfortable.

Some migrants trying to get into the USA or Europe may be forced to travel through hot arid areas, and fatalities are not uncommon. Most of the fatalities in desert areas are due to dehydration.

Inaccessibility

Many hot desert areas are inaccessible. This is partly due to the lack of permanent water. Where there are permanent sources of water, such as along the Nile Valley, providing settlements and transport infrastructure is much easier. Some river valleys in desert areas form canyons and wadis, such as the Grand Canyon and Wadi Rum. Here transport is difficult due to the narrow nature of the gorge.

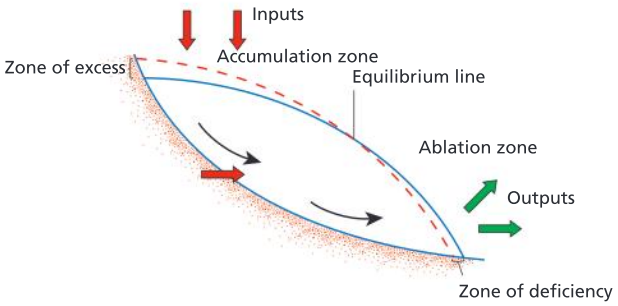
Remoteness

Many desert areas are remote due to the sheer scale of the desert. The Sahara Desert covers many countries and is larger than the USA or Europe. So, inevitably, some areas will be remote, especially those that are away from the coast and habitable areas such as river valleys.

The changing distribution of extreme environments

The advance and retreat of glaciers

A glacial system is the balance between inputs, storage and outputs. Inputs include accumulation of snow, avalanches, debris, heat and meltwater. The main store is that of ice, but the glacier also carries debris, moraine and meltwater. The outputs are the losses due to ablation, the melting of snow and ice, and sublimation of ice to vapour, as well as sediment (Figure C.7).



▲ **Figure C.7:** Accumulation and ablation in a glacier

The regime of the glacier refers to whether the glacier is advancing or retreating:

- if accumulation > ablation, the glacier advances
- if accumulation < ablation, the glacier retreats
- if accumulation = ablation, the glacier is steady.

Glacial systems can be studied on an annual basis or over a much longer timescale. The size of a glacier depends on its regime, that is, the balance between the rate and amount of supply of ice and the amount and rate of ice loss. The glacier will have a positive regime when the supply is greater than loss by ablation (melting, evaporation, calving, wind erosion, avalanches and so on) and so the glacier will thicken and advance. A negative regime will occur when the wasting is greater than the supply (for example the Rhône glacier today) and so the glacier will thin and retreat. Any glacier can be divided into two sections: an area of accumulation at high altitudes generally, and an area of ablation at the snout.

Activity 5

Compare the distribution of ice in the northern hemisphere during the late Pleistocene with that of today.

Natural desertification

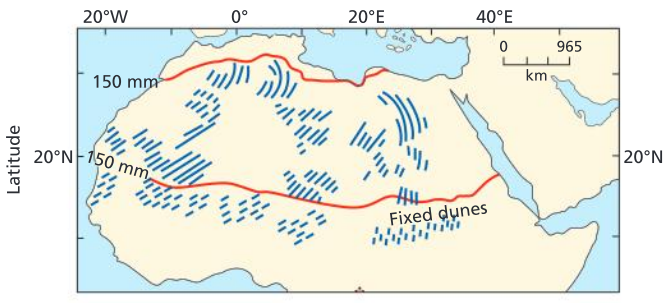
Deserts also change in their distribution. This is partly due to long-term changes in climate, for example increasing aridity in today's desert areas compared with wetter "pluvials" (rainy periods) which occurred around the same time as glacial advances in temperate areas. Part of the evidence for changes in the distribution of deserts is shown in Figure C.8. The fixed dunes were formed during arid conditions, but are located in areas that receive over 150 mm of rain. Areas that receive over 150 mm of rain have some vegetation which is able to stabilize the dunes. In contrast, the bare dunes are only located in areas that receive less than 150 mm of rain.

There is a range of evidence to suggest that the area now occupied by the Sahara Desert was much wetter in the past (Figure C.10).

In addition, there are annual and decadal variations in rainfall. This can cause deserts to expand, and at other times contract. This is a natural form of **desertification**.

Activity 6

1. Briefly explain how bare dunes and fixed dunes help to explain climate change.
2. Outline the evidence for climate change in the Sahara.



▲ **Figure C.8:** The distribution of bare and fixed dunes in North Africa

TOK

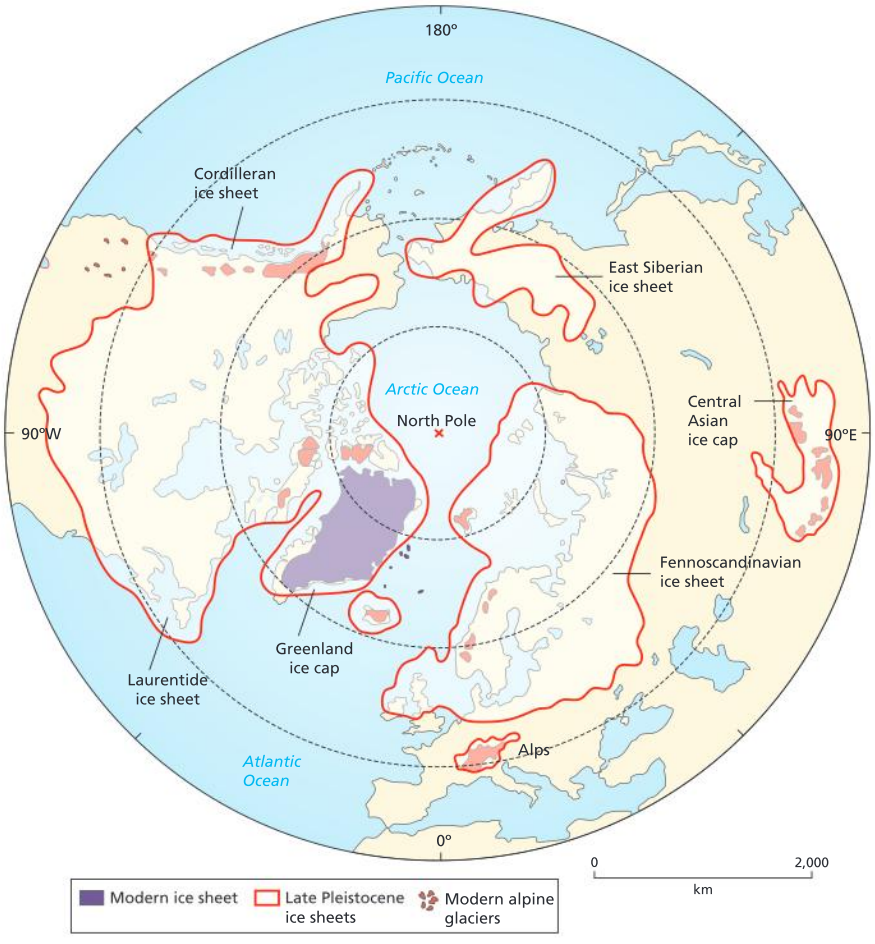
To what extent does physical geography set limits on human activities?

Explain how we know that harsh climate, high altitudes and difficult terrain are no longer barriers to human habitation because of technological advances.

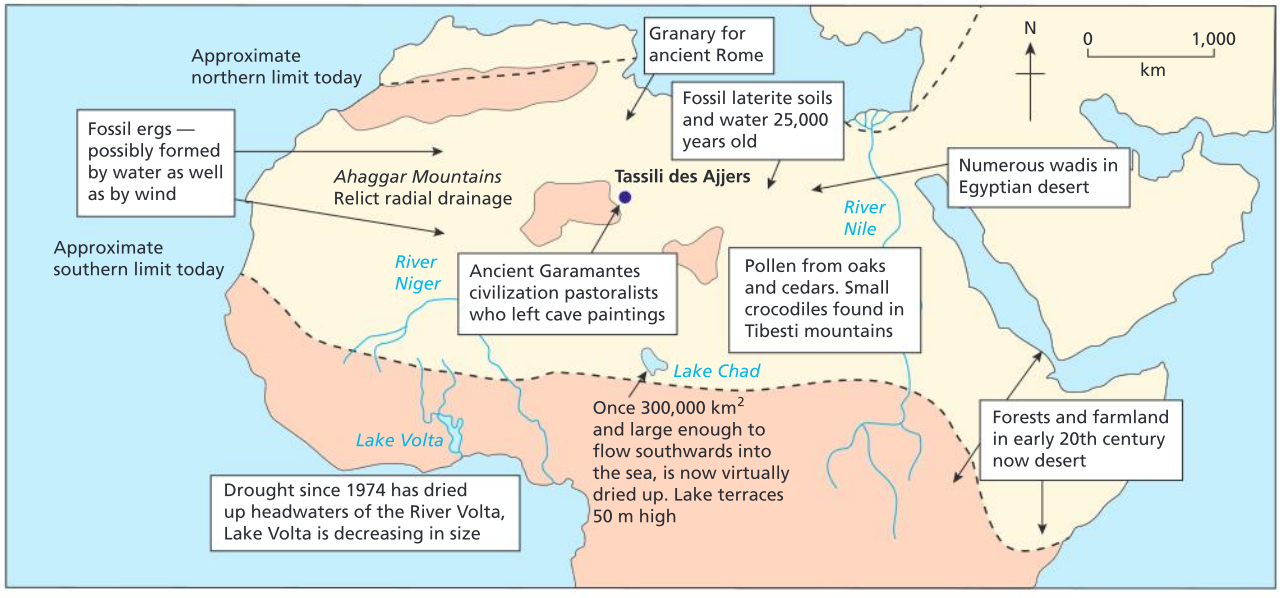
Common mistake

✗ Many students believe that all climate change is recent and due to global warming.

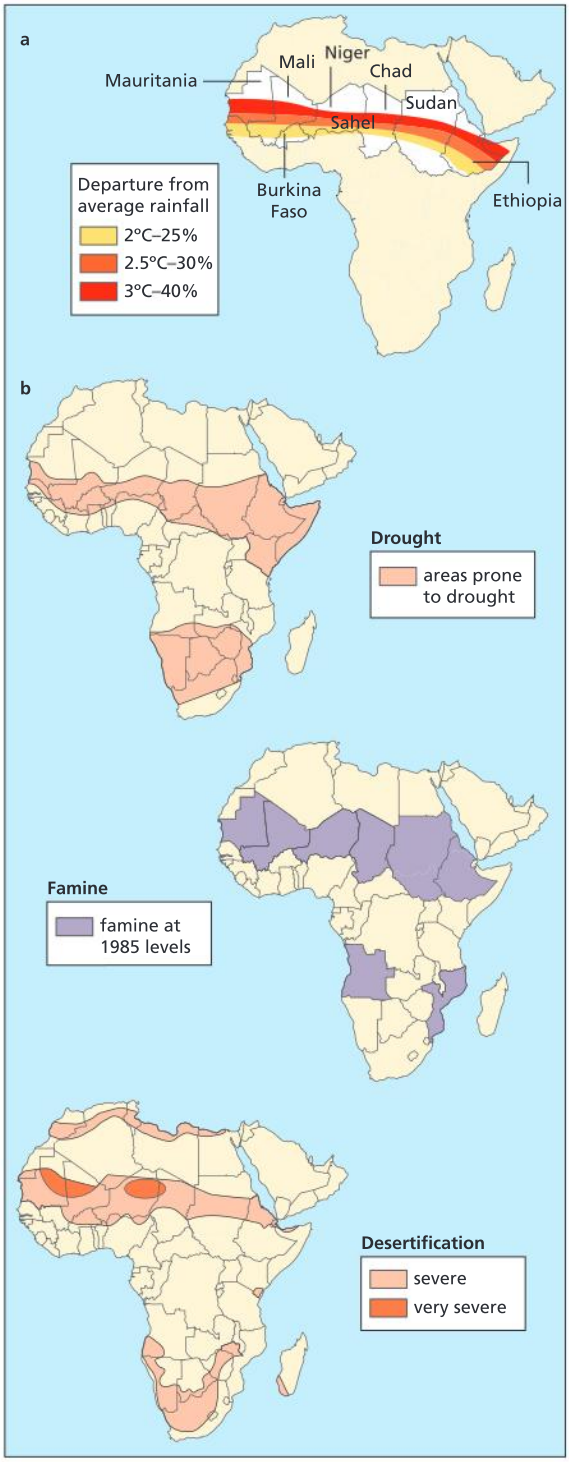
✓ Climate change has been happening throughout the Earth's geological past, and there is evidence both for long-term climate change and recent climate change (as shown in Figures C.9 and C.10).



▲ **Figure C.9:** The past and present distribution of ice sheets and ice caps in the northern hemisphere



▲ **Figure C.10:** The evidence for climate change in the Sahara



▲ **Figure C.11:** The relationship between rainfall variability, drought, desertification and famine in Africa **(a)** The Sahel and **(b)** the relationship between drought, desertification and famine in Africa

Concepts in context

There are many types of extreme environments. There are considerable differences in **places** in extreme environments. Some are cold, others hot, some very dry and some very wet. In addition, some extreme places are located in rich countries and some are located in poor countries.

How a population or community manages to cope with extreme conditions varies with the resources at their disposal. Indigenous peoples have generally learnt to live with nature and have adapted to the extreme environment. This is true both in hot, arid environments and cold environments. In contrast, in some richer communities, they avoid the extreme conditions by living in an environment modified by technology – this may include air conditioning or desalination for example. Moreover, economic activity varies in extreme environments – some have farming and fishing, some mining, and others tourism. This creates great variety in places among extreme environments.

Check your understanding

1. Name two types of cold environment.
2. Describe the main characteristics of a hot, arid climate.
3. Outline reasons for the location of hot, arid environments.
4. Define the term "permafrost".
5. Name an indigenous population that live in periglacial areas.
6. Describe the method of farming used by those identified in question 5.
7. Name an indigenous group that live in a hot, arid environment.
8. Describe the traditional clothing worn by those in your answer to question 7.
9. What climatic pressure system are hot, arid environments associated with?
10. Name one similarity between hot deserts and periglacial environments.

2 Physical processes and landscapes

Conceptual understanding

Key question

How do physical processes create unique landscapes in extreme environments?

Key content

- Glacial processes of erosion, transport and deposition, and landscape features in glaciated areas, including cirques/corries, lakes, pyramidal peaks/horns, arêtes, glacial troughs, lateral, medial and terminal moraine, and erratics.
- Periglacial processes of freeze–thaw, solifluction and frost heave, and landscape features in periglacial areas, including permafrost, thermokarst, patterned ground and pingos.
- Physical and chemical weathering in hot arid environments, and erosion, transportation and deposition by wind and water.
- Landscape features in hot, arid areas including dunes, wadis, rock pedestals, mesas and buttes.

Glacial erosion

The amount and rate of erosion depend on local geology, the velocity of the glacier, the weight and thickness of the ice, and the amount and character of the load carried. The methods of glacial erosion include plucking and abrasion.

Plucking

This occurs mostly at the base of the glacier and to an extent at the side. It is most effective in jointed rocks or those weakened by freeze–thaw. As the ice moves, meltwater seeps into the joints and freezes to the rock, which is then ripped out by the moving glacier. Plucking involves downward pressure caused by the weight of the ice and downhill movement. Once the material has been ripped out of the bedrock, it can be used for abrasion.

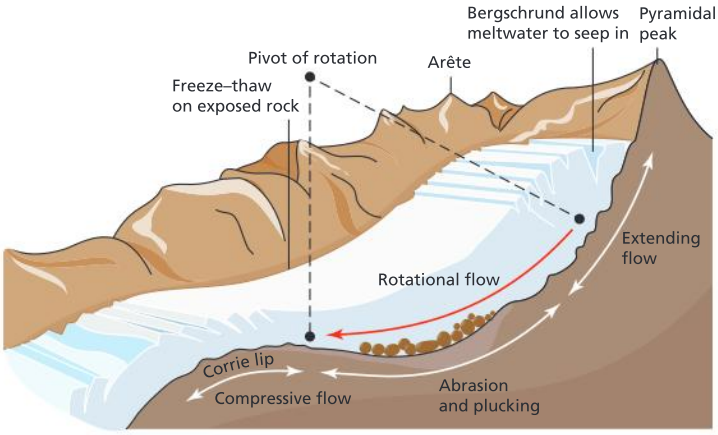
Abrasion

The debris carried by the glacier scrapes and scratches the rock, leaving striations, or grooves, in the rock. The coarser material will scrape, scratch and groove the rock. The finer material will smooth and polish the rock. As ice movement continues, the glacier load will be worn down to form a rock floor.

Other mechanisms

Other mechanisms of erosion include meltwater, freeze–thaw **weathering** and pressure release. Although neither strictly glacial nor erosional, these processes are crucial in the development of glacial scenery.

Although glaciers move slowly – usually at a rate of a few centimetres a year – the force of gravity and the sheer weight of their ice give



▲ **Figure C.12:** Processes of weathering and erosion in a cirque

▼ **Table C.3:** Factors affecting glacial abrasion

Relative hardness of particles and bedrock	The most effective abrasion occurs when hard particles at the glacier base pass over a soft bedrock.
Ice thickness	The greater the thickness, the greater the vertical pressure exerted on the particles of rock at the glacier base and the more effective abrasion is.
Basal water pressure	Up to a point, presence of water at the glacier base speeds up glacier movement and leads to an increase in abrasion. However, basal water pressure may "lift" the glacier above the levels of particles at the base, and may reduce abrasion.
Sliding of basal ice	The faster the rate of basal sliding, the greater the rate of abrasion. Ice frozen to the bedrock cannot erode.
Movement of debris towards the glacier base	Unless particles at the glacier base are constantly renewed, they become polished and less effective at abrasion. Movement of sediment from the glacier surface, via crevasses, decelerating flow and plucking brings fresh sediment to the base of the glacier.
Removal of fine debris	Meltwater at the base of the glacier may remove fine debris, therefore leaving larger, coarser, angular debris in contact with the underlying surface.
Debris particle size and shape	Large angular debris abrades much more efficiently than smaller, rounder debris.
Presence of debris in basal ice	Pure ice is unable to abrade solid rock. The rate of abrasion will increase with debris concentration up to the point at which basal sliding is reduced.

▼ **Table C.4:** Rates of abrasion

Location	Abrasion	Ice thickness	Ice velocity
French Alps Glacier (d'Argentiere)	36 mm/year	100 m	250 m/year
Breidermerkurjokull (Iceland)	Marble 3.4 mm/year	15 m	19.5m/year
	Basalt 0.9 mm/year	40 m	9.6 m/year
	Marble 3.75 mm/year	32 m	15.4m/year

them tremendous power to erode the landscape. As it moves downhill, the ice picks up and transports rock fragments produced by freeze-thaw weathering. Some of the material can be carried on top of the ice (supraglacial moraine), under the ice (subglacial) or within the ice (englacial). As the glacier melts and retreats, it leaves behind these rock fragments and sediments in a process called deposition. The rocks and sediments form till, erratics, moraine and other depositional features.

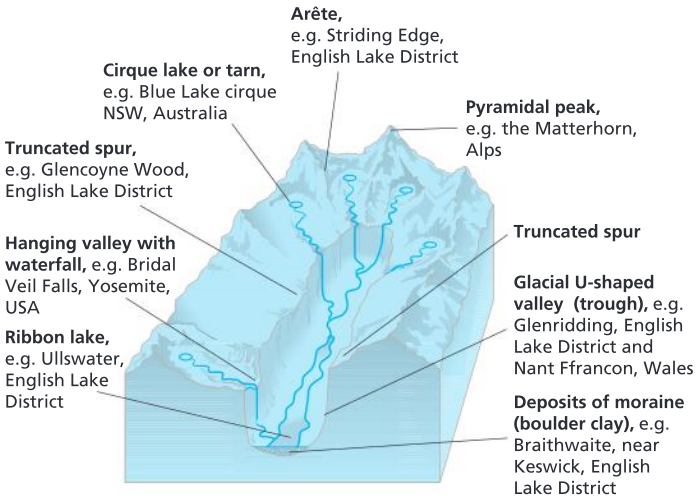
▲ **Photo C.3:** Glacial landscape

Landforms produced by glacial erosion

Cirques

A cirque (or corrie) is an amphitheatre-shaped valley that has been scooped out by erosion at the head of a glacier. In the northern hemisphere cirques are generally found on north- or east-facing slopes, where accumulation is highest and ablation is lowest. They are formed in stages:

1. A preglacial hollow is enlarged by nivation (freeze–thaw and removal by snowmelt).
2. Ice accumulates in the hollow.



▲ **Figure C.13:** Landforms of a glaciated valley

3. Having reached a critical weight and depth, the ice moves out in a rotational manner, eroding the floor by plucking and abrasion.
4. Meltwater trickles down the bergschrund (a crevasse that forms when the moving glacier ice separates from the non-moving ice above), allowing the cirque to grow by freeze–thaw.

After glaciation, an armchair-shaped hollow remains, frequently filled with a lake, for example Blue Lake cirque in New South Wales, Australia, and the Cirque de Gavarnie in the Central Pyrenees, France.

Arêtes, peaks, troughs, basins and hanging valleys

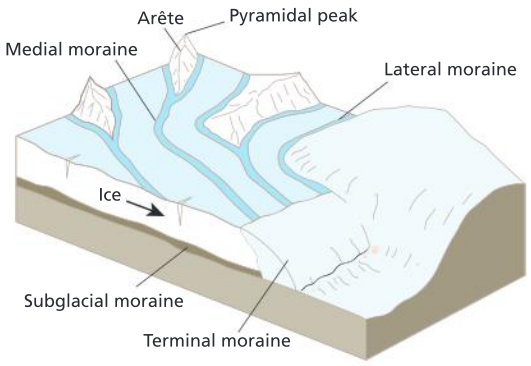
Other features of glacial erosion include arêtes and pyramidal peaks (horns) caused by the headward recession (cutting back) of two or more cirques. Glacial troughs (or U-shaped valleys) have steep sides and flat floors. In plan view they are straight, since they have truncated the interlocking spurs of the preglacial valley. During warm interglacial phases, and with the return of periglacial conditions, there will be further weathering of the rock surfaces previously stripped of their weathered material by passing ice. The present form of most glacial troughs depends on the geomorphological activity (such as weathering or mass movement) that has taken place since the last glaciation. The sides of many glacial troughs are covered by scree while the bases contain hummocky moraines deposited by the retreating ice.

The ice may also carve deep rock basins frequently filled with ribbon lakes. Hanging valleys are formed by tributary glaciers, which, unlike rivers, do not cut down to the level of the main valley but are left suspended above. For example in Yosemite National Park, California, the Ribbon and Bridal Veil falls both involve drops of several hundred metres down the side of the main valley. They are usually marked by waterfalls.

A roche moutonnée (or sheepback) is a bare mound of rock that can vary in size from a few metres to hundreds of metres high. These rocks are smoothed and polished on their up-valley side (stoss) by abrasion but plucked on their down-valley side (lee) as ice accelerates. They can be several kilometres long. There are examples in the Cairngorms in Scotland and Glacier Bay, Alaska.

Activity 7

1. Describe how cirques are formed.
2. Explain why rates of glacial erosion vary.



▲ **Figure C.14:** Glacial landscape during glaciation

Activity 8

1. Briefly explain one form of weathering likely to occur in cold environments.
2. Identify two landforms of glacial erosion shown in Photo C.3. Explain briefly how one of these landforms was formed.

Glacial deposition

The characteristics of glacial deposits

Till is often subdivided into lodgement till, material dropped by actively moving glaciers, and ablation till, deposits dropped by stagnant or retreating ice. Till has the following characteristics:

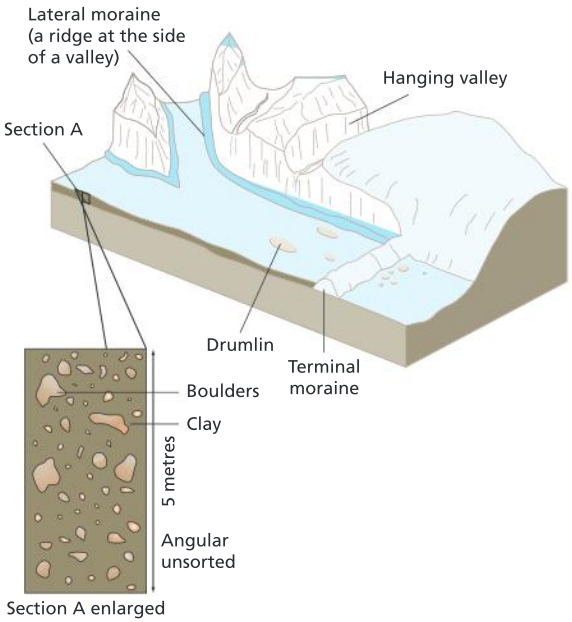
- poor sorting – till contains a large range of grain sizes, for example boulders, pebbles, clay
- poor stratification – no regular sorting by size
- mixture of rock types – from a variety of sources
- striated and subangular particles
- long axis orientated in the direction of glacier flow
- some compaction of deposits.

▲ **Photo C.4:** Medial and lateral moraines on the Gorner Glacier

The characteristics of moraine

Moraines are loose rocks, weathered from the valley sides and carried by glaciers. At the snout of the glacier is a crescent-shaped mound or ridge of terminal moraine. It represents the maximum advance of a glacier, and its character is determined by the amount of load the glacier was carrying, the speed of movement and the rate of retreat. The ice-contact slope (up-valley) is always steeper than the down-valley slope. Cape Cod in Massachusetts, USA, is a fine example of a terminal moraine.

Lateral moraine is a ridge of loose rocks and sediment running along the edge of a glacier where it meets the valley side. The lateral moraines on the Gorner Glacier in Switzerland are good examples. Where two glaciers merge and the two touching lateral moraines merge in the middle of the enlarged glacier, the ridge is known as a medial moraine. Again, the Gorner Glacier contains many examples of medial moraines.



▲ **Figure C.15:** Depositional features after glaciation

The characteristics of drumlins

Drumlins are small oval mounds up to 1.5 km long and 100 m high, for example the drowned drumlins of Clew Bay in County Mayo, Ireland. One of the largest concentrations is in New York State, where there are over 10,000 drumlins. They are deposited as a result of friction between the ice and the underlying geology, causing the glacier to drop its load. As the glacier continues to advance it streamlines the mounds.

The characteristics of erratics

Erratics are glacier-transported rock fragments that differ from the local bedrock, and may be embedded in till or on the ground surface. They range in size from pebbles to huge boulders. One example is the Madison Boulder in New Hampshire, USA, estimated to weigh over 4,600 tonnes. Erratics that have moved over long distances – some more

Activity 9

1. Describe the main characteristics of glacial deposits.
2. Identify the features of glacial deposition shown in Photo C.4.

▲ **Photo C.5:** Drowned drumlins in Clew Bay, County Mayo, Ireland

than 800 km – generally consist of rock resistant to the shattering and grinding effects of glacial transport. Erratics composed of distinctive rock types can be traced to their place of origin, indicating the direction of glacial movement that brought them to their resting place.

These features can be used to determine the direction of glacier movement. Erratics pinpoint the origin of the material; drumlins and the long axes of pebbles in glacial till are orientated in the direction of glacier movement.

Periglacial environments

Periglacial areas are found on the edge of glaciers or ice masses. More than one-third of the Earth's land surface has experienced periglacial conditions at some time. Periglacial environments are characterized by **permafrost**, usually hundreds of metres deep, and freeze–thaw action, which continuously alters the ground surface so that large quantities of angular, fractured rock (frost-shattered rock) are common. Summer temperatures in these environments briefly rise above freezing, so ice in the soil near the surface melts.

Three types of periglacial region can be identified: Arctic continental, alpine and Arctic maritime. These vary in terms of mean annual temperature and therefore the frequency and intensity with which periglacial processes operate.

Landforms and processes associated with periglacial environments

Periglacial environments show a wide range of different processes that relate to the action of permafrost and freeze–thaw weathering. These processes include mass movement, a common phenomenon during the warmer seasons, which usually occurs in four forms: solifluction, gelifluction, frost creep and rockfalls.

Freeze–thaw

Freeze–thaw weathering is an extremely important process in periglacial environments. It occurs when the temperature fluctuates above and below freezing point (0°C). When water freezes it expands by 9–10 per cent. This can place great pressure on rocks, especially jointed rock, which may be broken to angular fragments of scree. The scree slopes in Photo C.6 have been created by freeze–thaw weathering. It is most effective where there are many cycles of freeze–thaw each year, a supply of water and jointed rocks.

Mass movements

See also Option D, Geophysical hazards (pages 163–211) for more details on mass movements.

Solifluction literally means flowing soil. In winter, water freezes in the soil, causing expansion of the soil and segregation of individual soil particles. In spring the ice melts and water flows downhill. It cannot infiltrate the soil because of the impermeable permafrost. As it moves over the permafrost it carries segregated soil particles (peds) and deposits them further downslope as a U-shaped solifluction lobe or terracette.

In periglacial environments, solifluction occurs only when temperatures are well above zero and free liquid water is available in the active layer. Solifluction is common when surface sediments are poorly drained and saturated with water.

Frost creep is a type of solifluction that occurs because of frost heaving and thawing. The process begins with the freezing of the ground surface, elevating particles at right angles to the slope. The particles rise up because cold temperatures cause water inbetween particles to freeze and expand. As the ice thaws in the warm season, turning back to water, the contracting surface drops the particles in elevation. This drop, however, is influenced by gravity, causing the particles to move slightly downslope.

Rockfalls occur when fragments of rock break away from a cliff face, often as a result of freeze–thaw weathering.

▲ **Photo C.6:** Scree slopes and cliffs – an alpine periglacial environment, Silent Valley, the Italian Dolomites

Activity 10

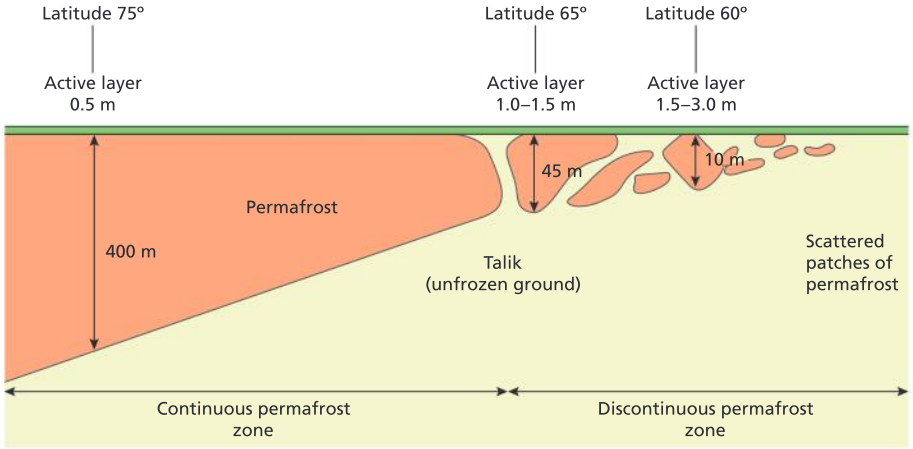
1. Outline the main characteristics of periglacial environments.
2. Describe two forms of mass movement that occur in periglacial environments.

Permafrost

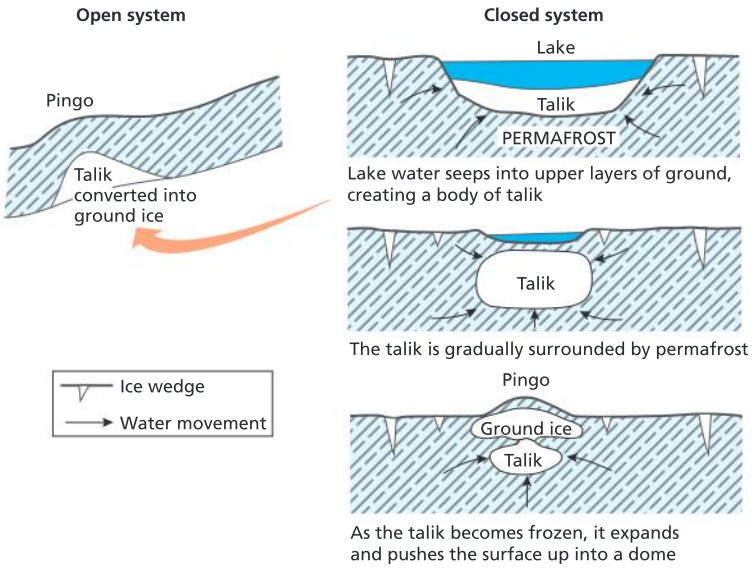
Permafrost is permanently frozen ground. It has been estimated that the mean annual temperature must be as low as –4°C for permafrost to develop. Approximately 20 per cent of the world's surface is underlain by permafrost. Three types of permafrost exist: continuous, discontinuous and sporadic, and these are associated with mean annual temperatures of –5° to –50°C, –1.5° to –5°C, and 0° to –1.5°C, respectively. Above the permafrost is the active layer, a highly mobile layer which seasonally thaws out and is associated with intense mass movements. The depth of the active layer depends on the amount of heat it receives, and varies in Siberia from 0.2–1.6 m at 70°N to 0.7–4 m at 50°N.

Latitude and altitude are the main factors controlling the depth of the active layer. Other factors include:

- rock type – coarse gravels thaw more quickly than clays
- aspect – the direction a slope faces has considerable effect on the amount of insolation received
- the presence or absence of an "insulating" peaty soil
- the nature of the vegetation cover.



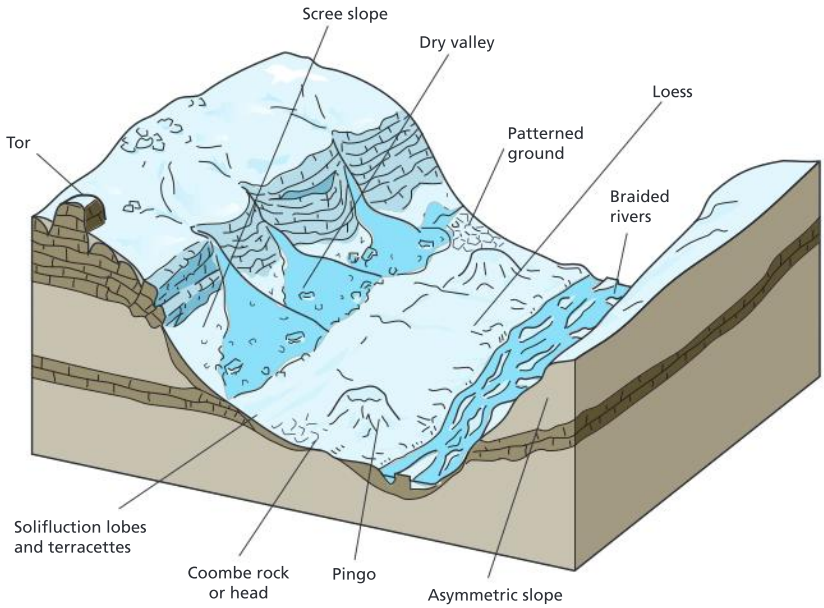
▲ **Figure C.16:** Types of permafrost



▲ **Figure C.17:** Open- and closed-system pingos

Pingos

A pingo is an isolated, conical hill up to 90 metres high and 800 metres wide, which can only develop in periglacial areas. Pingos form as a result of the movement and freezing of water under pressure. Two types are generally identified: open-system and closed-system pingos. Where the source of the water is a distant elevated source, open-system pingos form, whereas if the supply of water is local, and the pingo arises as a result of the expansion of permafrost, closed-system pingos form. Nearly 1,500 pingos are found in the Mackenzie Delta of Canada. When a pingo collapses, ramparts and ponds are left.



▲ **Figure C.18:** Features of the periglacial environment

Thermokarst

Thermokarst refers to a landscape of hummocks and wet hollows resulting from subsidence caused by the melting of permafrost. This may be because of broad climatic changes or local environmental changes. The processes involved in creating thermokarst include:

- the thawing of ice wedges to leave elongated depressions
- the thawing of pingos to produce circular craters with raised rims
- the removal of vegetation causing the subsurface to become exposed
- fire
- climate warming.

Patterned ground

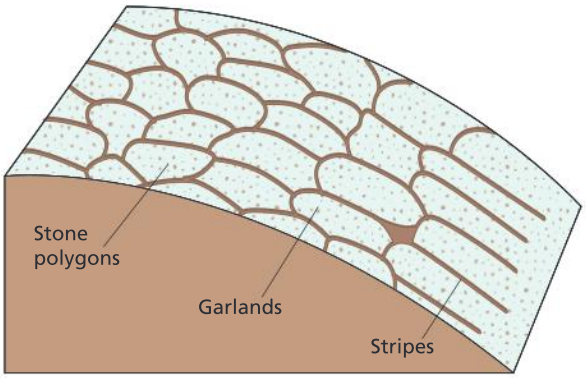
Patterned ground refers to the array of stone stripes, polygons and garlands that may be found in periglacial areas (Figure C.19). They are formed by a variety of processes including frost heave (which brings the particles to the surface), cracking of the surface due to drying, heaving or thermal contraction, and mass displacement. Soils are subjected to intense frost action, for example on the slopes of Kerid crater, southern Iceland. On steeper slopes, stone stripes replace stone circles and polygons. Their exact mode of formation is unclear, although ice sorting, differential frost heave, solifluction and the effect of vegetation are widely held to be responsible.

Activity 11

1. Briefly explain the formation of pingos.
2. Describe the variations in patterned ground, as shown in Figure C.19.

Hot arid environments

Various processes of erosion, weathering and deposition shape desert landscapes. Their distinctive topography is carved by water: although rainfall is low, it is an important climatic factor in the formation of desert erosion features. As a result of the dryness, wind and mechanical weathering also play an important part in desert erosion. The lack of moisture and scant vegetation make the wind a more powerful agent of erosion in deserts than in humid environments. Sand and sediments are blown along the surface, eroding rocks and other objects with which they come into contact. However, wind lifts the sand only up to a metre above the ground, so higher features have been eroded by water.



▲ **Figure C.19:** Patterned ground – "Seldom has so much been written about so little" (Price, 1972)

Weathering in deserts

- **Salt crystallization** causes the decomposition of rock by solutions of salt. There are two main types of **salt crystal growth**. First, in areas where temperatures fluctuate around 26–28°C, sodium sulphate (Na_2SO_4) and sodium carbonate (Na_2CO_3) expand by about 300 per cent. This creates pressure on joints, forcing them to crack. Second, when water evaporates, salt crystals may be left behind. As the temperature rises, the salts expand and exert pressure on rock. Both mechanisms are frequent in hot desert regions where low rainfall and high temperatures cause salts to accumulate just below the surface.
- **Disintegration** is found in hot desert areas where there is a large diurnal temperature range. In many desert areas, daytime temperatures exceed 40°C, whereas at night they are little above freezing. Rocks heat up by day and contract by night. As rock is a poor conductor of heat, stresses occur only in the outer layers. This causes peeling or **exfoliation** to occur. Griggs (1936) showed that moisture is essential for this to happen. In the absence of moisture, temperature change alone does not cause rocks to break down. It is possible that the expansion of many salts such as sodium, calcium, potassium and magnesium can be linked with the exfoliation.

▼ **Table C.5:** Rates of weathering

	Area	Rate of weathering (mm/year)
Arid	Egypt	0.00001–2.0
Semi-arid	Australia	0.6–1.0

Weathering produces regolith, a superficial and unconsolidated layer above the solid rock. This material is easily transported and eroded, and may be used to erode other materials.

▲ **Photo C.7:** Patterned ground on the side of the Kerid crater, Iceland

▲ **Photo C.8:** Salt weathering

▲ **Photo C.9:** Desert landscape showing evidence of weathering

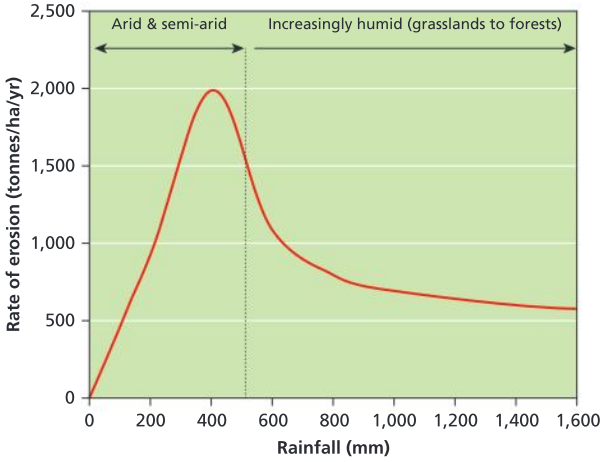
The work of water in deserts

Not only is water vital for the development of many desert landforms, it is also important for the operation of mechanical and chemical weathering in deserts. There are a number of sources of water in deserts: rainfall, the water table (which may be exposed by deflation to produce an oasis) and rivers.

Desert rains may fall as short torrential downpours over the normally dry ground, and there is a high amount of run-off. The flash floods rush down desert mountains in networks of channels, gullies or canyons, carrying large amounts of rock fragments that have great erosive power. At the bottom of the desert mountain the streams spread out, depositing the transported material to build an alluvial fan. Channels in the fan carry any water that has not sunk into the ground or evaporated, along with finer silt, to the toe of the fan. It then spreads out still more as it washes down to the lowest part of the basin, where it may form a playa lake, which then evaporates over a few days to form a salt pan.

Rivers that flow through deserts can be classified as exotic (exogenous), endorheic or ephemeral.

Exotic or exogenous rivers are those that have their source in another, wetter environment and then flow through a desert. The Nile in Egypt is an exotic river, being fed by the White Nile, which rises in the equatorial Lake Victoria, as are the Blue Nile and Atbara, which rise in monsoonal Ethiopia.

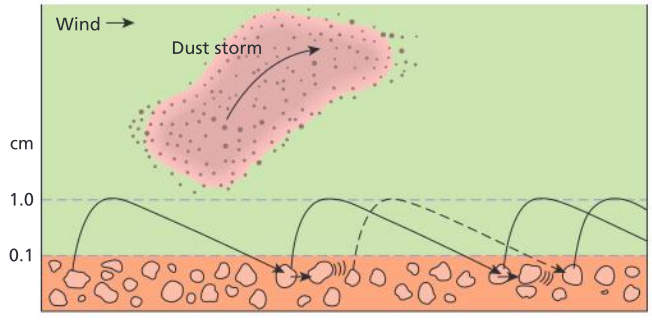


▲ **Figure C.20:** Rainfall and soil erosion

Endorheic rivers are those that drain into an inland lake or sea. The River Jordan, which drains into the Dead Sea, is a good example.

Ephemeral rivers are those that flow seasonally or after storms, and often have high discharges and high sediment levels. Even on slopes as gentle as 2°, overland flow can generate considerable discharges. This is a result of factors including:

- an impermeable surface (in places)
- limited interception (lack of vegetation)
- rainsplash erosion displacing fine particles, which in turn seal off the surface and make it impermeable.



▲ **Figure C.21:** Wind action in deserts

Wind action in deserts

Many of the world's great deserts are dominated by subtropical high-pressure systems. Large areas are affected by trade winds, while local winds are important too. Wind action is important in areas where winds:

- are strong (over 20 km/hour)
- are turbulent
- come largely from a constant direction
- blow for a long period of time.

Near the surface, wind speed is reduced by friction (but the rougher the ground the more turbulent it becomes).

Sediment is more likely to be moved if there is a lack of vegetation, and it is dry, loose and small. Movement of sediment is induced by drag and lift forces, but reduced by particle size and friction. Drag results from differences in pressure on the windward and leeward sides of grains in an airflow.

There are two types of wind erosion.

- **Deflation** is the progressive removal of small material, leaving behind larger materials. This forms a stony desert, or reg. In some cases, deflation may remove sand to form a deflation hollow. One of the best known is the Qattara Depression in Egypt, which reaches a depth of over 130 metres below sea level.
- **Abrasion** is the erosion carried out by wind-borne particles. They act like sandpaper, smoothing surfaces and exploiting weaker rocks.

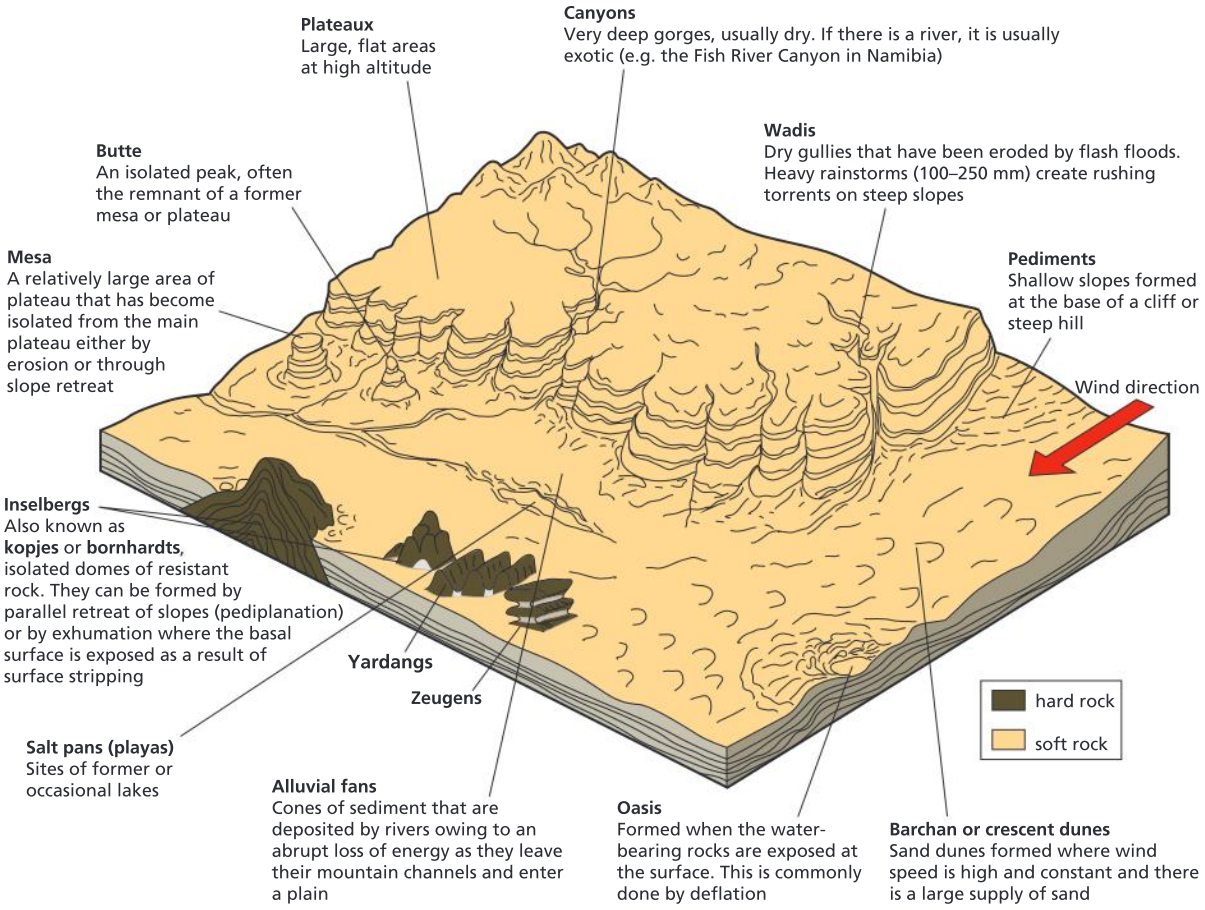
Activity 12

Study Figure C.20.

1. Describe the relationship between the rate of soil erosion and the amount of rainfall.
2. Suggest reasons for the relationship you have described.
3. Describe two types of weathering that occur in hot deserts and semi-arid areas.

▼ **Table C.6:** Peltier's classification of regions and their distinctive processes

	Annual temp (°C)	Annual rainfall (mm)	Processes
Semi-arid	5–30	250–600	Strong wind action, running water
Arid	15–30	0–350	Strong wind action, slight water action



▲ **Figure C.22:** Landforms in the arid landscape

Activity 13

1. Distinguish between the processes of weathering and erosion in arid and semi-arid areas. Refer to specific landform features in your answer.
2. Distinguish between the terms exotic, endorheic and ephemeral in the context of rivers, and give two examples in each case. (Note that making a distinction means picking out the differences, not just defining the terms.)

▲ **Photo C.10:** Wind action in deserts – Finger of God, Tenerife

Features of the arid landscape

What differentiates deserts and arid landscapes from other ecosystems is not only the extreme climate but also the landforms scattered across their surfaces. The popular assumption is that deserts are largely dunescape, but only a fifth of deserts are covered with sand. Pediments, wadis, canyons, salt pans, alluvial fans and plateaux are among other typical features of arid environments.

Dunes

Sand dunes may cover thousands of square kilometres and be up to 500 metres high. They all have a gentle slope on the windward side and a steep slope on the leeward side, but are classified into many types according to shape. Their shape and size depends on the supply of sand, direction of wind, nature of the ground surface, and presence of vegetation. The most common types are barchan or crescent dunes, which are U-shaped. They form around shrubs or large rocks, which hold the main part of the dune in place. **Barchan dunes** are crescent-shaped and are found in areas where sand is limited but there is a constant wind supply. They have a gentle windward slope and a steep leeward slope up to 33°. Variations include barchans ridges and transverse ridges, the latter forming where sand is abundant, and where the wind flow is checked by a topographic barrier, or increased vegetation cover. Barchans can be as wide as 30 metres.

Yardangs and zeugens

Wind erosion only takes place when the wind is loaded with loose materials, especially sand grains. Dust particles are ineffective. The wind throws the particles of sand against rock faces, creating abrasion or corrasion (a sand-blast effect). Large rock fragments, too heavy to be transported by the wind, are worn down on the windward side – these worn fragments are called ventifacts. In areas of homogeneous rock, the wind will smooth and polish the surface. However, if the rocks are heterogeneous, for example weakened by joints or faults, some dramatic landforms will result from wind erosion, with rock faces etched, grooved, fluted and honeycombed, forming towers, pinnacles and natural rock pedestals.

Yardangs and zeugens are wind-eroded landforms where the softer rock strata are removed, leaving the more resistant layers to form either mushroom-shaped features (zeugens) where strata are horizontal, or long ridges (yardangs) where the strata are vertical. These ridges could be as high as 100 metres and stretch for many kilometres.

Activity 14

1. Distinguish between zeugens and yardangs.
2. Outline the main features of sand dunes in hot, desert areas.

Wadis

Wadis are river channels that vary in size from a few metres in length to over 100 kilometres. They are generally steep sided and flat bottomed. They may be formed by intermittent flash floods or they may have been formed during wetter pluvial periods in the Pleistocene. The relative infrequency of flash floods in some areas where wadis are found could suggest that they were formed at a time when storms were more frequent and more intense. In contrast, **arroyos** are channels that have been enlarged by repeated flooding. They are common in semi-arid areas on alluvium and solid rock.

Mesas

Mesas (the Spanish word for table) are plateau-like features with steep sides. They represent the remnant of a former extensive layer of resistant rock. As the mesa is reduced in size by cliff retreat, it retains its flat top and altitude.

Buttes

Buttes are similar to mesas, but much smaller. These represent the final stage of development of erosion before the resistant rock is finally eroded. Water has eroded most of the rock, leaving a thin pillar.

Activity 15

1. Contrast the landforms that result from erosional and depositional glacial processes.
2. Outline the importance of wind and water in the development of landforms in one named extreme environment.

Concepts in context

In this section we have seen **processes** that operate in cold environments and hot environments. The processes are varied and include erosion, weathering, mass movement, transport and deposition. The processes that occur exhibit power. Glaciers, wind action and water action show immense power at certain times and in different places. When they lose their power they change their work from erosion to deposition. Processes change over time – in present-day hot deserts there is evidence of water action from the past, and in some present-day periglacial areas there is evidence of glacial activity.

Check your understanding

1. Identify two forms of glacial erosion.
2. Briefly explain two factors that affect the rate of glacial abrasion.
3. Give an example of a pyramidal peak.
4. Describe a drumlin.
5. Outline the formation of a pingo.
6. Distinguish between exotic rivers and endorheic rivers.
7. Outline the main forms of weathering in hot arid areas.
8. Identify the main types of wind erosion in hot arid areas.
9. Explain the formation of alluvial fans.
10. Outline the factors needed for the formation of barchan dunes.

3 Managing extreme environments

Conceptual understanding

Key question

How does the power of different stakeholders to extract economic value from extreme environments vary?

Key content

- Agricultural opportunities and challenges in hot arid and semi-arid areas, including the distinction between aridity and infertility, access to technology and use of irrigation, the risk of salinization, and land ownership issues.
- Human and physical opportunities and challenges for mineral extraction in cold environments, including inaccessibility, permafrost and resource nationalism.
- Human and physical opportunities and challenges for mineral extraction in arid environments, including inaccessibility and climatic and political factors.
- Opportunities and challenges for tourism in extreme environments, including the role of local populations.

Agriculture in arid areas

Hot arid areas

Hot arid areas offer a number of opportunities for agriculture. There is an abundance of heat and sunlight, favouring a lengthy growing season. In areas where water is available (either due to exotic rivers, desalination and/or irrigation), the potential for farming is good.

The main type of farming in most hot, arid areas is nomadism. True nomads wander with their herds of camels, goats, sheep and/or cattle in search of water and new pasture. Semi-nomadic movement may occur if there is a wet and dry season.

Oases, desalination plants and exotic rivers provide opportunities for settled agriculture. The oasis at Douz, Tunisia (Photo C.11) produces dates, figs and oranges. Date palm is a particularly useful crop – the bark can be used for thatching or fencing, the leaves can be made into ropes and mats, and the dates can be eaten.

Rivers, such as the Nile, provide water for farming. Dams can control the supply of water so that there is enough in the dry season. In a number of oil-rich countries, such as Saudi Arabia and UAE, desalination plants provide a plentiful supply of water. With such a plentiful supply of water, hydroponics (the growing of plants in water rather than soil) is possible.

There are many challenges for agriculture in hot, arid areas. Agriculture in most arid and semi-arid areas is dominated by lack of freshwater, an abundance of heat and sunlight, very low rainfall or a short rainy season, saline soil or water, strong dry winds, poor soil structure, overgrazing, and limited technological development. Poor transport can also make agriculture challenging.

The shortage of water and the high temperatures determine many of the characteristic processes in arid and semi-arid areas as well as many of the characteristics of their soils and ecosystems. All arid and semi-arid areas have a negative water balance. That means the outputs from evapotranspiration and stores of water exceed the input from precipitation (pEVT > ppt).

Desert soils are arid (dry) due to low rainfall and high evapotranspiration. They are infertile due to:

- a low organic content because of the low levels of biomass
- being generally very thin with few minerals
- lack of clay (the amount increases with rainfall)
- not generally being leached because of the low rainfall; hence soluble salts remain in the soil and could be toxic to plants.

Salinization may occur in areas where annual precipitation is less than 250 millimetres. In poorly drained locations like valley floors and basins in the continental interior, surface run-off evaporates and leaves behind large amounts of salts. The pH of soils affected by salinization is usually below 8.5. The saline soils adversely affect the growth of most crop plants by reducing the rate of water uptake by roots, and plants die as a result of wilting and reverse osmosis. Some crops, such as date palm and cotton, are more salt tolerant. See also Option A Freshwater for more information on irrigation and salinization.

Thus, agriculture in hot arid areas could be made more sustainable by:

- reducing herd size and pressure on limited amounts of vegetation
- using solar panels to produce energy rather than using animal dung
- using animal dung as fertilizer
- planting vegetation to provide fodder for animals
- using more efficient types of irrigation (drip and sprinkler rather than whole-field flooding)
- lining irrigation channels with concrete to reduce seepage
- building check dams (Photo C.12) and diguettes to collect water
- using more salt-tolerant (halophytic) plants.

▲ **Photo C.11:** Date palm farming at Douz oasis, Tunisia

▲ **Photo C.12:** Check dam to collect water and soil

Semi-arid areas

Case study

The establishment of drought-resistant fodder

Pastureland in the Eastern Cape region of South Africa is especially fragile due to drought and overgrazing. In the former homelands, Ciskei and Transkei, there are additional problems of population pressure and, sometimes, the absence of land ownership policies. During prolonged drought, levels of cattle, sheep and goats decrease significantly. However, trying to reduce herd size has been unpopular and unsuccessful. An alternative is to produce drought-resistant fodder crops, for example American aloe and the prickly pear, saltbush and the indigenous gwanish.

The American aloe (Photo C.13) has traditionally been used for fencing, for kraals (animal compounds) and for soil conservation, but it has been used as fodder in times of drought. It has a number of advantages:

- it requires little moisture
- it is not attacked by any insects
- although low in protein, it increases milk production in cows
- it can be used for soil conservation
- after 10 years it produces a pole that can be used for fencing or building
- it can act as a wind break
- the juice of the aloe is used in the production of tequila.

▲ **Photo C.13:** American aloe

Case study (continued)

Saltbush provides protein-rich fodder which is eaten by sheep and goats. Goats, in particular, thrive on saltbush. It requires less than half the water that other crops such as lucerne require, and once established requires no irrigation. It remains green throughout the year and therefore can provide all year fodder. However, it is difficult to propagate and needs high-quality management.

The spineless cactus or prickly pear (Photo C.14) features prominently in the agriculture of many countries, such as Mexico, Peru and Tunisia where it is used as a fodder crop and as a fruit crop for 2–3 months each year. It is becoming more widespread in the Eastern Cape. Two varieties are common – one, insect-resistant, is used as fodder in times of drought, while the other, which needs to be sprayed to reduce insect damage, yields high-quality fruit. The fruit is sold at prices comparable with apples and oranges. Pruning is needed annually. This provides up to 100 tonnes of fodder per hectare per year.

▲ **Photo C.14:** Cactus and prickly pear

In the former Ciskei region of the Eastern Cape, drought in the 1980s prompted the government to embark on a series of trials with prickly pear, saltbush and American aloe in order to create more fodder. One of the main advantages of the prickly pear is its low water requirements. This makes it very suitable to the region where rainfall is low and unreliable. Although there are intensive irrigation schemes in the region, such as at Keiskammahoek, these are expensive and inappropriate to the area and the people.

Although prickly pear is mainly used as a fodder and fruit crop, it is also used for the production of carminic acid for the dye industry and as a means of soil conservation. Nevertheless, prickly pear has been described by development planners as a "weed, the plant of the poor, a flag of misery … inconsistent with progress".

Activity 16

1. Outline the advantages of the American aloe plant.
2. Comment on the advantages and disadvantages of using the prickly pear.

Case study

Essential oils

About 65 per cent of the world production of essential oils is produced by developing countries such as India, China, Brazil, Indonesia, Mexico, Egypt and Morocco. The South African essential oils industry has only recently emerged. Currently the South African essential oils industry exports mainly to developed economies such as Europe (49 per cent), the US (24 per cent) and Japan (4.5 per cent). The most significant essential oils produced by South Africa are eucalyptus, citrus, geranium and buchu.

Globally, the essential oils industry – valued at around $10 billion – is enjoying huge expansion. Opportunities include increasing production of existing products and extending the range of crops grown.

Factors that make South Africa an attractive essential oils market include:

- much of the demand is in the northern hemisphere and seasonal effects make southern hemisphere suppliers globally attractive

Case study (continued)

- having traditionally strong trade links with Europe as a major importer of fragrance materials
- South Africa is being established as a world-class agricultural producer in a wide range of products.

The Eastern Cape is set to become one of the main contributors to South Africa's burgeoning essential oils industry, with 10 government-sponsored trial sites currently in development throughout the province. Six of these form part of the Essential Oil Project of Hogsback, where approximately eight hectares of communal land is being used.

The production of essential oils holds considerable potential as a form of sustainable agricultural development in the former Ciskei region of the Eastern Cape. Not only are the raw materials present, but it is a labour-intensive industry and would utilize a large supply of unemployed and underemployed people.

The essential oils industry has a number of advantages:

- it is a new or additional source of income for many people
- it is labour intensive and local in nature
- many plants are already known and used by the people as medicines, and are therefore culturally acceptable
- in their natural state the plants are not very palatable, and they are not very valuable so are unlikely to be stolen
- many species are looked upon as weeds. Removing these regularly improves grazing potential as well as supplying raw materials for the essential oils industry.

Some species such as geranium, peppermint and sage require too much land, labour and water to be very successful. Wilde als (*artemisia afra*) is an indigenous mountainous shrub used to treat colds. Its oil has a strong medicinal fragrance and is used in deodorants and soaps. Double cropping in summer when the plant is still growing and in autumn at the end of the growing season yields the best results. It is increasingly being cultivated as a second crop. It requires minimal input in terms of planting, tillage, pest control and so on. and it is relatively easy to establish and manage. Moreover, it can stabilize many of the maize fields and slopes where soil erosion is a problem. The local population are very enthusiastic, especially given the right economic incentives.

Activity 17

1. Suggest reasons why the essential oils industry has developed in the Eastern Cape province.
2. Explain the extent to which the essential oils industry could be considered a form of sustainable development.

Mineral extraction in hot, arid areas

There is huge potential for the development of mineral resources in hot, arid areas. Oil and gas in the Middle East, copper in Chile, south-west USA and Australia, and uranium mining in Australia illustrate the potential riches that occur in hot, arid areas. Many of these deposits are significant in size and have the potential to generate large earnings for the TNCs/countries that develop them.

However, exploitation may be difficult because many of these areas are remote, and investment in transport is expensive. In addition, housing and basic utilities such as water, energy and waste disposal need to be provided at the mines and in the settlements where miners live.

The shortage of water may require desalination plants to be built or groundwater reserves to be tapped. This could cause the groundwater to decline. In addition, given the remote and inaccessible nature of many hot, arid areas, transporting the resources to the coast to be exported is difficult and expensive. In some hot, arid areas mineral resource infrastructure has been the target of military activity.

Resource exploitation in hot, arid areas can have adverse environmental impacts. The movement of vehicles and people can introduce exotic species. The mines and their wastes can be an eyesore, and mines can be a major source of dust that is linked to an increase in respiratory problems.

Case study

Rosemont Copper, Arizona

Rosemont Copper is a copper mining project in Pima County, Arizona, an undeveloped area approximately 50 km south-east of Tucson (Figure C.23). In general, opponents argue that open-pit copper mines pollute surrounding air and water supplies with mercury, lead, arsenic or other elements and that the mine will damage regional tourism.

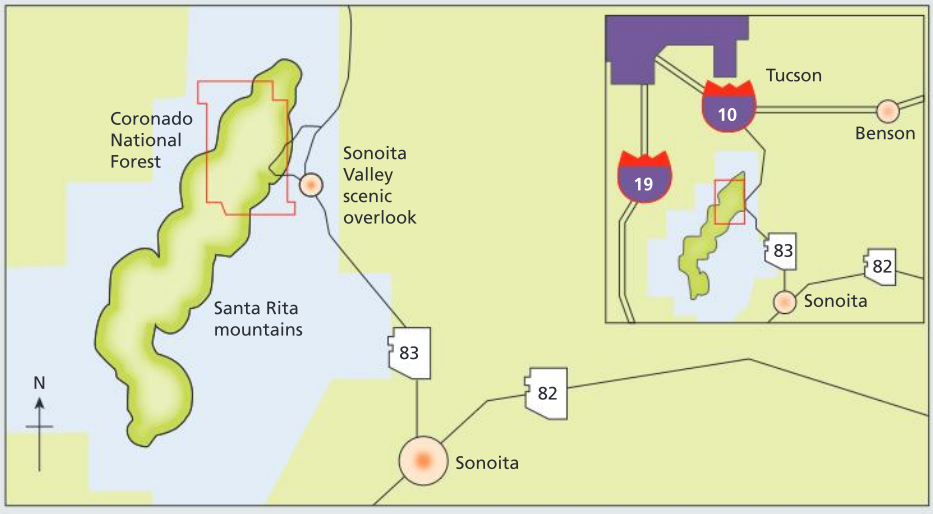
Proponents argue that the project will create jobs, generate tax revenue and reduce American dependence on foreign sources of copper. The controversy over the proposed Rosemont Copper mine revolves around potential risks to the environment, with water being a major concern.

The Rosemont Copper Mine is projected to earn about $7 billion in profit over the course of its 21-year lifespan and become the third largest copper mine in the USA.

Tourism and outdoor recreation account for nearly $3 billion annually in Santa Cruz and Pima Counties. The mine site falls in the middle of three important wildlife corridors used by the only known jaguar in the United States. Habitat destruction would also threaten various endangered cactus, frog, fish and bat species.

Rosemont Copper expects to mine 550 million tonnes of ore and an additional 1.3 billion tonnes of waste rock. Most of this rock would be heaped in massive piles called tailings. Intended as an aural and visual buffer between the mine and the highway, the tailings could rise several hundred feet.

Arizona's other copper mines consume around 25 gallons of water for every pound of copper produced, but Rosemont's usage could be less than one-third that amount. The trade-off is a more energy-intensive process that would cut into the company's profit but show its commitment to corporate social responsibility. Industry and mining make up about 5 per cent of Arizona's total water use (approximately 126 billion gallons per year).



▲ **Figure C.23:** Proposed mine at Rosemont Ranch, Arizona

Case study (continued)

Table C.7 The arguments for and against Rosemont Copper

Arguments in favour of the proposal	Arguments against the proposal
• Copper is an essential component of a clean-energy economy. For example, hybrid cars contain twice as much copper as conventional cars. • The mine would import 105% of the water needed for operations and leave a 5% net water gain to the Tucson Active Management Area basin. • The used land will be reclaimed from the beginning of the mine's operations. • The mine would create a much-needed economic boost to the region, employing 400 people directly for at least 19 years and supporting 1,700 indirect jobs. Historically, mining jobs are among the highest-paying positions in Arizona, and experienced workers in the copper industry in the south-west can earn an average of $59,000 per year. • The project would support ancillary industries – contractors and vendors providing goods and services to the mine operation during the nearly two decades of operation.	• Open-pit copper mines such as that proposed by Rosemont pollute the air and nearby water supplies with mercury, lead arsenic or other poisons. • The mine structures would be visible from Arizona State Route 83, a designated scenic route. • The economies of the Santa Rita Mountains communities are largely driven by outdoor recreation and tourism. Even modest impact from the Rosemont Mine could discourage tourism to the region, and destroy more than the number of new jobs the mine would create. • Mining jobs represent a small percentage of total Pima County jobs. Jobs created by the proposed Rosemont mine would represent just 0.3% of total employment in Pima and Santa Cruz counties. • Destruction of habitat and individuals representing nine endangered and threatened species, including the only known jaguar species living in the USA. • Complete loss of 85 historic properties that include Native American remains and prehistoric sites, and resource-gathering locations thousands of years old. • Degradation of air quality throughout the region, including Saguaro National Park East and West, from mine vehicles, dirt roads, crushers and conveyors. • Significant traffic increases along Highways 83 and 82, as the mine would generate 55–88 round-trip truck shipments daily.

ATL Research skills

Visit the websites of Save the Santa Ritas at http://www.scenicsantaritas.org/ and Rosemont Copper http://www.rosemontcopper.com/ and discuss whether copper mining at Rosemont Ranch is good, and for whom?

Activity 18

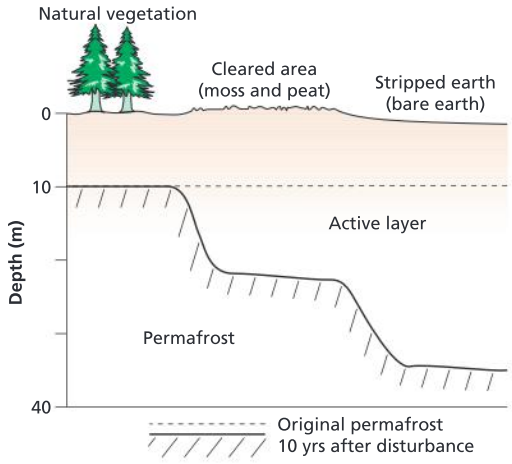
Outline the climatic challenges of arid areas for the provision of infrastructure.

Photo C.15: Rosemont valley prior to development

Mineral extraction in periglacial environments

The exploitation of periglacial areas

The exploitation of periglacial areas for their mineral and fossil fuel resources creates both opportunities and challenges. Resource development can improve the economies of these regions, but it can also



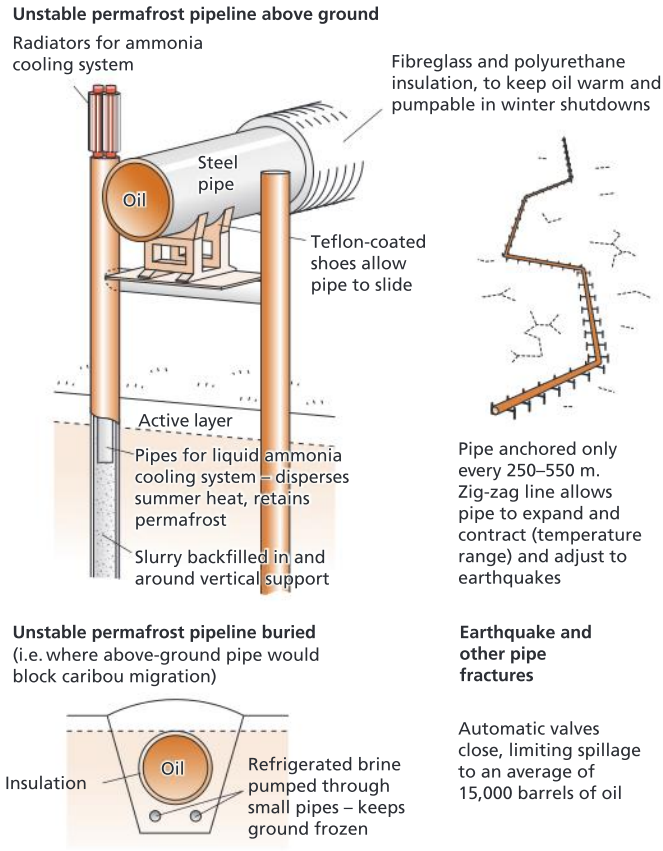
▲ **Figure C.24:** Permafrost disruption

put their fragile environment under pressure and create conflicts among local communities.

Fragility of periglacial areas

Periglacial areas are fragile for three reasons:

- the ecosystem is highly susceptible to interference because of the limited number of species involved
- the extremely low temperatures limit decomposition, and hence pollution, especially from oil, has a very long-lasting effect on periglacial ecosystems
- permafrost is easily disrupted, posing significant problems. Heat from buildings and pipelines, and changes in the vegetation cover rapidly destroy it. Thawing of the permafrost increases the active layer, and subsequent settlement of the soil causes subsidence. Consequently, engineers have had to build special structures to cope.



▲ **Figure C.25:** Problems with pipelines

Frost heave

Close to rivers, owing to an abundant supply of water, frost heave is very significant and can lift piles and structures out of the ground. Piles for carrying oil pipelines have therefore needed to be embedded deep in the permafrost to overcome mass movement in the active layer. In Prudhoe Bay, Alaska, they are 11 metres deep. However, this is extremely expensive.

The human impact on periglacial areas

The hazards associated with the use of periglacial areas are diverse and may be intensified by human impact. Problems include mass movements, flooding, thermokarst subsidence, low temperatures, poor soils, a short growing season and a lack of light.

For example, the Nenets tribe in the Yamal Peninsula of Siberia has suffered as a result of the exploitation of oil and gas. Oil leaks, subsidence of railway lines, destruction of vegetation, decreased fish stocks, pollution of breeding grounds and reduced caribou numbers have all happened directly or indirectly as a result of human attempts to exploit this remote and inhospitable environment.

The case of ANWR

The Arctic National Wildlife Refuge (ANWR) is the largest protected wildlife area in the USA, with 9 million hectares in the remote north-east of Alaska. It includes a range of natural habitats such as tundra, boreal forest, barrier islands and coastal lagoons, and is home to many rare birds and animals. There has been long-running political controversy over the future of ANWR, because oil companies active in Prudhoe Bay to the west want to drill for oil further east along the northern coastal plain, within the protected area.

▲ **Figure C.26:** Periglaciation and the primary economy

Case study

Oil mining in Alaska

Alaska, at 60° north and covering 20° of latitude, has some remarkable periglacial landforms. Climatic conditions range from mild, maritime and wet in the south to arid and very cold in the north. The region covers 40 per cent of the USA's surface and is rich in primary resources; it possesses 20 per cent of the USA's oil, as well as gold and abundant fish and timber reserves. However, the exploitation of these resources is technically difficult and compounded by the possibility of tectonic activity. The cold climate, extensive permafrost and inaccessibility have created difficulties for developers, but exploitation of these resources is justified by the economic benefits.

Heat generated by infrastructure such as central heating, hot water and sewerage systems causes melting of the permafrost below it, disturbing the active layer and causing subsidence. Dark materials with low albedo such as tarmac have the same effect. Drilling for oil generates frictional heat, which also melts the permafrost, and drilling vibration leads to permafrost breakage.

The trans-Alaska pipeline

Construction began in 1975 and was completed in 1977 at a cost of $8 billion. The 1,300 kilometre pipeline crosses the Brooks and Alaska mountain ranges and 800 rivers and streams. Oil is pumped through the pipeline at 80°C because air temperatures drop as low as –50°C and the oil needs to flow. To prevent melting of the permafrost, the pipeline sits on top of an insulated support about 3 metres above the ground. The pipeline is also built on sleepers to allow for displacement of 6 metres horizontally and 1.5 metres vertically during an earthquake. Any disruption or oil leakage would be environmentally and ecologically damaging. In Alaska the tundra ecosystem to the north-west and the boreal forest to the east have limited biodiversity and short food chains. These ecosystems are fragile and slow to recover from any kind of trauma, and oil spillage is particularly destructive and long-lasting.

▲ **Photo C.16:** The trans-Alaska pipeline, on the north slope of the Brooks mountain range

Greenland and resource nationalism – on hold

The melting of the Arctic ice has been mirrored by the thawing of political tensions in some parts of the Arctic. Since the 1990s, the Arctic countries have largely agreed to mark out their territories in accordance with the UN Convention of the Sea. For one country, Greenland, it looked as though it was about to become quite rich and independent. However, things have taken a turn.

In 2014 Greenland found itself on the cusp of a resource boom that could transform its economic future and underwrite its independence from Denmark. The melting ice had prompted a scramble for the resources beneath Greenland and its seas. Greenland has a population of just 56,000 people. It is still in the process of "nation building". The discovery of iron ore, gold and rare earth deposits has attracted prospectors and mining companies from around the world. Major oil companies, such as Dutch Shell, Statoil and Cairn Energy, have been exploring in the region for decades. Cairn Energy discovered traces of oil beneath Greenland's waters in 2010.

Greenland has major physical and political obstacles to development. Greenland's waters are some of the most hostile on Earth. The country is geographically isolated and lacks both the physical and human infrastructure to support rapid development. Some 80 per cent of the land mass is covered in thick ice. Nuuk, the capital, has a population of just 16,000, and Sisimiut and Ilulssat have about 5,000 each. There are no roads connecting the scattered communities and a single ship serves the settlements on the western side of the island.

There has been a long history of mining in Greenland. Cryolite was mined for 130 years between 1857 and 1987. It provided a useful asset for the Americans who occupied Greenland during the First World War. Cryolite was processed in Copenhagen and used in aluminium production. Denmark remained in control of Greenland's resources until the 1990s.

In 2009, Nuuk achieved full home rule, including control of natural resources, leaving Denmark in charge of security and foreign affairs. This **resource nationalism**, that is, when a country maintains control over its own resources, was expected to bring great benefits to Greenland. Aleqa Hammond was elected Prime Minister in 2013 on a pro-independence platform, and saw this as a springboard for mineral exploitation, and a way of financing full independence. However, the collapsing price of crude oil has frustrated Greenland's hopes of becoming an independent country for the short term. Greenland is still dependent on an annual subsidy from Denmark, that amounts to over $600 million.

The oil price collapse in 2014 has made Arctic oil exploration too expensive and not worthwhile. Three companies – Norway's Statoil, France's GDF Suez and Denmark's Dong Energy – returned their licences in 2014. Thus the expected bonanza that oil and other minerals would have provided Greenland is not happening – at least in the short term. Development of other, non-conventional sources of oil and natural gas may make exploration in Greenland less attractive than in less extreme environments. For the Greenland population, they face a future still dependent on Denmark to subsidize their development.

▲ **Photo C.17:** Nuuk, the capital of Greenland

ATL Communication skills

Identify the different arguments both for and against the exploitation of oil and or other minerals in cold environments. Present your arguments through discussion or formal debate by adopting different roles, such as indigenous people, a transnational corporation, a government and a conservationist. Write a summary of the arguments and draw a conclusion.

Cold and high environments: tourism

Clean air, breathtaking scenery, rare species, cultural interest and heroic potential make mountain zones the second most popular international tourist destination, after coasts. They have become increasingly accessible and attractive to tourists looking for adventure holidays in pristine landscapes. Whereas trekking and skiing have been the traditional attractions, the tourist economy of many mountain areas has diversified to include other activities such as mountain biking, snowboarding, paragliding and white-water rafting. Indigenous populations and archaeological sites also generate interest.

Tourism is a means of economic development for some of the world's poorest countries, and it can generate growth and reduce regional disparity through the multiplier effect and social disparity through the trickle-down effect. However, the economic and social success of tourism depends on careful management of the primary resources that the tourists come to see. Mountain environments have a low carrying capacity and are sometimes referred to as fragile. This means that the environment is easily damaged by human impact because of steep slopes, thin erodible soil and vegetation that does not regenerate easily.

The tourism industry in many landlocked mountainous countries such as those in the Himalayas has grown dramatically since the 1970s. The development of mountain tourism therefore brings benefits, but presents some contentious environmental and social issues which are difficult to resolve. (See also Option E, Leisure, tourism and sport for more details about tourism in remote areas.)

Environmental degradation around Mount Everest

The Khumbu region of Nepal, containing Kathmandu and Mount Everest, can comfortably hold about 40,000 people, but during peak tourist season in the lower valley there can be as many as 700,000. Supplying local people with electricity and water is problematic in this mountainous country, but the demands of tourists for hot water and showers put this under further pressure. Increasing resource consumption is matched by increasing waste generation, and the infrastructure is inadequate. The tonnes of rubbish discarded on Everest include climbing equipment, food, plastics, cans, glass, clothes, papers, tents and even electronic equipment.

In 2008 a geological team, sponsored by the United Nations Environment Programme (UNEP), found signs that the landscape of Mount Everest had changed significantly since Sir Edmund Hillary and Tenzing Norgay first conquered the peak in 1953. Tourism was found to be a major cause of environmental problems, but global warming is likely to have even more far-reaching effects. The government is willing to consider a strategy to manage trekking in the Everest region now that a 10-year era of political unrest is no longer distracting attention from the environmental issues.

Closing down the mountain is no solution as far as the local Sherpa population is concerned. A Sherpa reaching the summit of Everest will make about $1,600, five times the per capita GNI. Trekking provides this population with the most significant part of their income, and so closing

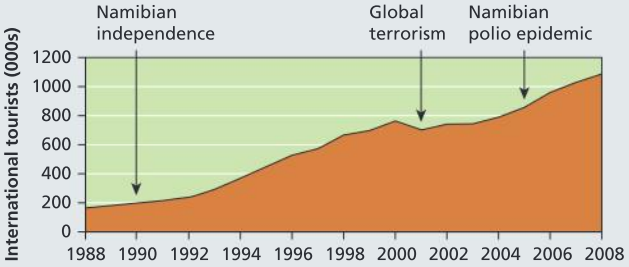
the area around Everest would be devastating to their economy. Critics say it is no surprise that the Nepali authorities have no plans to scale back tourism in the region: even to set foot on the slopes of Everest, each team of seven climbers must pay a royalty of £50,000 to the Nepalese government.

Case study

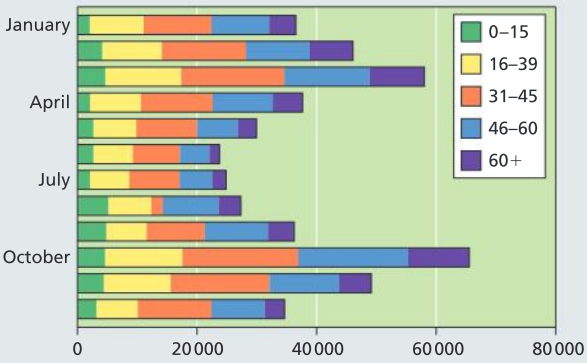
Tourism in Nepal

Nepal's development has been restricted by its remote and landlocked location, difficult terrain and shortage of natural resources for industrialization. Traditionally, its economy has depended on agriculture, with little participation in world trade until tourism began to develop as a major industry in the 1980s. Tourism's annual contribution to GDP is now 6 per cent, it employs 5 per cent of the working population and is predicted to grow at 4 per cent per year. Nepal's unique physical features have attracted increasing numbers of tourists since the 1960s. These include the 10 highest mountains in the world, such as Mount Everest. It is also culturally diverse, with two major religions – Hinduism and Buddhism – existing side by side, and 12 major ethnic groups.

Tourism in Nepal has increased erratically since the 1950s; in 1961 4,000 tourists were recorded in Nepal, almost all of them trekkers. It was only after 1990 that Nepal's tourism increased dramatically, until the hijacking of an Indian Airlines flight from Kathmandu in 1999 caused it to decline. The Royal massacre of 2001 and the growing Maoist insurgency pushed it to the brink. Following the signing of a peace agreement in 2006 between the government and the Maoists, tourist demand began to recover.



▲ **Figure C.27:** International tourist arrivals in Nepal by country of origin, 1990–2008



▲ **Figure C.28:** Age structure and seasonal trends in tourist arrivals for Nepal, 2012

The benefits of tourism for Nepal

Tourism presents Nepal with many opportunities:

- international recognition and integration into the global economy
- a rise in foreign revenue to help clear national debts
- improvement in local income and employment, generating a multiplier effect, especially to big towns and cities such as Kathmandu and Pokhara
- improved cultural understanding as a result of the locals learning new skills.

The costs of tourism in Nepal

Increasing tourist demand for Nepal presents the following problems:

- Deforestation and road construction disrupt drainage patterns and may cause excessive run-off and flooding downstream.

Case study (continued)

- Landslides, mudslides and rock falls result from the destabilization of soil and regolith on steep slopes. This is compounded by torrential monsoon rain between June and September, when slopes become unstable.
- Mountain trekking can destroy vegetation and wildlife habitats.
- Trails of litter now line most of the mountaineering, tramping and trekking routes, especially around mountain base camps. Inadequately covered toilet pits and makeshift toilets pollute streams and rivers, and have become a serious health issue.

Tourism and climate change – threats to Mount Everest

Climbing Mount Everest has become increasingly popular. It has become the focus of trekking activity and is beginning to suffer as a result. Its extreme topography and monsoon climate reduce its resilience as a tourist destination. There are several reasons for these threats.

- Sherpa threats: Gradually, the Sherpas (traditional porters) are being replaced by other ethnic groups who are badly paid and ill-treated. The International Porters' Protection Group (IPPG) was founded by Chris Bonington in 1997 as a response to this exploitation. The IPPG helps build porter shelters, health posts and warm-clothing banks. These facilities have reduced Nepali porter deaths.
- Increasing use of resources: In the Sherpa town of Namche Bazaar there is a new five-mile pipeline to bring water to satisfy tourist demand for showers and flush toilets. This will avoid sewage over-burden of the local stream during the peak tourist seasons in March and October, but the provision of hot water will demand more fuel.
- Pollution: Raw garbage is taken down to the lower settlements and buried in large pits where inevitably it will threaten the surrounding area with toxic leachates.
- Road-building: The road network is rapidly increasing to ensure the in-flow of tourists and their wealth. Unfortunately, the road-building programme has had to be rapid and little attention is given to safety regulations. Processes such as cut-and-fill have led to erosion and landslides.
- Congestion: Four people died on one day in 2014 when 150 people made the ascent. It has been claimed that human traffic jams contributed to the tragedy. Everest has become an overcrowded destination for extreme tourists who can afford to pay $10,000–$50,000 for this exotic experience. Technological changes, better clothes and better oxygen supplies make what once took years of planning now an easy and accessible adventure. The ascent of Everest is no longer the daring achievement it was in 1953. By 2073, the infrastructure on the mountain could include a helipad

▲ **Photo C.18:** Changing patterns of tourism on Mount Everest

▲ **Photo C.19:** The queue for Everest – a two-hour wait

on the South Col bringing tourists breathing bottled oxygen. In the meantime, they are transforming the potential for rescuing both climbers and the far more numerous trekkers heading as far as base camp.

- Climate change: If temperatures increase as predicted by 1.2°C by 2050 and 3°C by the end of the century, there may be far-reaching consequences for mountainous regions and countries adjoining them and fed by their meltwaters.

The Himalayas have the largest concentration of glaciers outside the polar region, but these glaciers are a freshwater reserve; they provide the source for nine major river systems in Asia – a lifeline for almost a third of humanity. There is clear evidence that Himalayan glaciers have been melting at an unprecedented rate in recent decades. This trend causes major changes in freshwater flow regimes and is likely to have a dramatic impact on drinking-water supplies, biodiversity, hydropower, industry and agriculture. These in turn give rise to an increase in the potential threat of glacial lake outburst floods (GLOFS) occurring. Such disasters often cross boundaries: the water from a lake in one country may threaten lives and property of people in another country.

Regional cooperation is needed to formulate a strategy to deal with both the risks of outburst floods and waste-water management issues. Long-term shrinkage of Himalayan glaciers will severely reduce run-off from major rivers such as the Indus, Yellow River and the Mekong.

The combination of climate change and tourism is putting the whole of the Himalayas under threat, but the stress is concentrated on the Everest region.

Developing tourism in hot, arid areas

Case study

Zuni Pueblo, New Mexico, USA

Zuni Pueblo is the largest of the 19 New Mexican Pueblos, with more than 1800 km^2 of land and a population of over 10,000. It is considered the most traditional of all the New Mexico Pueblos, with a unique language, culture and history resulting in part from its geographic isolation in a remote area of one of the most sparsely populated regions of the USA.

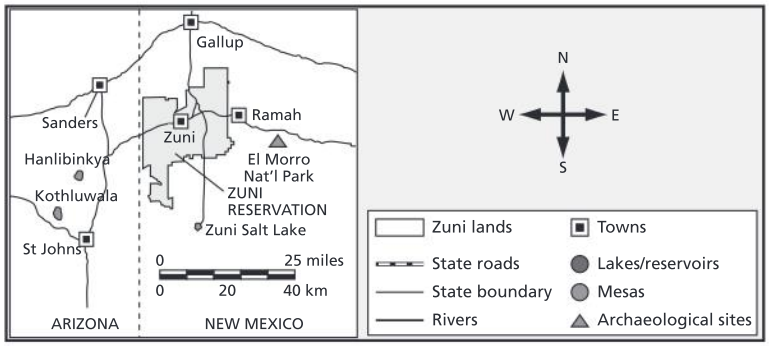
Zuni is on the south-west tourist itinerary as one of the stops in Indian country. Its attractions include its heritage and its physical geography, including its climate. Many visitors are familiar with Zuni because of the reputation of Zuni jewellery, arts and crafts. Visitors are also attracted to the landscape of the Zuni river valley and the dramatic sandstone mesas.

Zuni needs to develop tourism in ways compatible with maintaining and enhancing the lifestyle and sense of community that currently exists there, and in ways that conserve the natural and cultural resources of Zuni. Tourism is a double-edged sword. More often than not tourism destroys what it originally set out to enhance.

At present most of the population derive their income from art. There are efforts to increase the share of income from agriculture and tourism. Tourism is an attractive option because of the relatively low capital investment and the potentially high economic returns. However, there are many long-lasting negative impacts of unregulated, hasty tourism development.

Case study (continued)

- Check-in with the Visitor Center before starting your visit to Zuni Pueblo. Remember, you are visiting an active community of residents' daily lives and homes – not a museum or theme park.
- Consider capturing visual memories instead of photographs! Assume that ALL "cultural" activities within the Pueblo are off-limits to photograph, video or audio record or sketch unless specifically informed otherwise. Always inquire first and ask permission before photographing any activity involving people. NO photography is permitted of images inside the Old Mission.
- Observe with quiet respect any traditional dances and events that you may encounter. Applause is as inappropriate as in a church setting.
- Exercise common sense by not climbing around fragile archaeological structures or adobe walls. Removal of artifacts or objects from these areas is a Federal offence.
- Respect our community by not using alcohol or drugs and not bringing weapons.
- Hike only in designated areas (check at Visitor Center) and not around archaeological ruin sites.



▲ **Figure C.29:** Responsible tourism in Zuni

Sociocultural concerns

Zuni needs to control the development of tourism in order to safeguard against the negative consequences that could affect the social and cultural life there. As a result there has been very limited external involvement and influence in the demands to develop tourism. Although there have been proposals for motel complexes, casinos and golf courses, none have been implemented.

Zuni culture continues to retain its integrity and social traditions in spite of its existence within the USA. For example, photographic, audio or video recordings, drawings or other documentation of Zuni religious events is prohibited.

Environmental concerns

Water, air, soil and biodiversity are resources that can be easily affected by tourism. Water, in particular, is a basic issue in Zuni, as its domestic water supply is limited. Some developments are allowed. For example, big-game hunting by non-Indians is allowed as long as there is a Zuni guide.

Overall, the impact of tourism has been limited largely because it has been controlled. Tourism in Zuni has evolved in a way that allows culture and environment to survive. Nevertheless, tourism will almost certainly become a part of Zuni society, and in the early stages Zuni has been careful to consider the social, economic and environmental costs.

Look at http://www.nmlegis.gov/lcs/handouts/ERDT%20101315%20Item%207%20Tourism%20at%20Zuni%20Pueblo.pdf to see how the Zuni council wants to develop tourism and the also the issues they have over a gravel pit (dated 2015).

Activity 19

1. Using Figure C.27, explain the changes in the origins of international tourists arriving in Nepal.
2. Describe the trend shown by Figure C.28. (Remember to quantify your answer by referring to the data given.)
3. Using the information given in both graphs, describe and explain the characteristics of tourists visiting Nepal.
4. Suggest how the characteristics of international tourists to Nepal may change in the future.

ATL Research skills

Use a search engine to find images of Zuni Pueblo, its physical setting and its culture, for example traditional dress and art. The following websites may be of interest: http://www.ashiwi.org/ and http://www.zunitourism.com/ the homepage of Zuni tourism.

ATL Research skills

Research pro-poor tourism here http://www.propoortourism.org.uk/16_stats.pdf, and summarize one case study in an extreme environment.

Concepts in context

In this section, we have seen how and why some extreme environments need to be managed. Different stakeholders, such as TNCs, indigenous communities, conservationists, national governments and shareholders, for example, have different interests and concerns about the use of extreme environments. Some of these stakeholders are very **powerful**, for example TNCs and some national governments, whereas others are not, for example indigenous communities. There are many challenges in attempts to develop extreme environments sustainably. Not all users are interested in sustainable development but want the wealth/power that it can offer. It is likely that the pressures to develop extreme environments will increase in the future due to varied forces, such as population growth, rising standards of living, climate change and resource depletion.

Check your understanding

1. Distinguish between aridity and infertility.
2. Explain why essential oils may be a better use of semi-arid areas than livestock farming.
3. State a named and located mineral resource development in a hot, arid environment.
4. Outline the main problems associated with the development of mineral resources in hot, arid areas.
5. State a named and located mineral resource development in a periglacial environment.
6. Outline the main problems associated with the development of mineral resources in periglacial areas
7. Explain the term "resource nationalism".
8. Describe the problems associated with tourism in cold environments.
9. Briefly explain the advantages of tourism to hot, arid areas.
10. Suggest how tourism in hot, arid environments can be made more sustainable.

4 Extreme environments' futures

Conceptual understanding

Key question

What are the future possibilities for managing extreme environments and their communities?

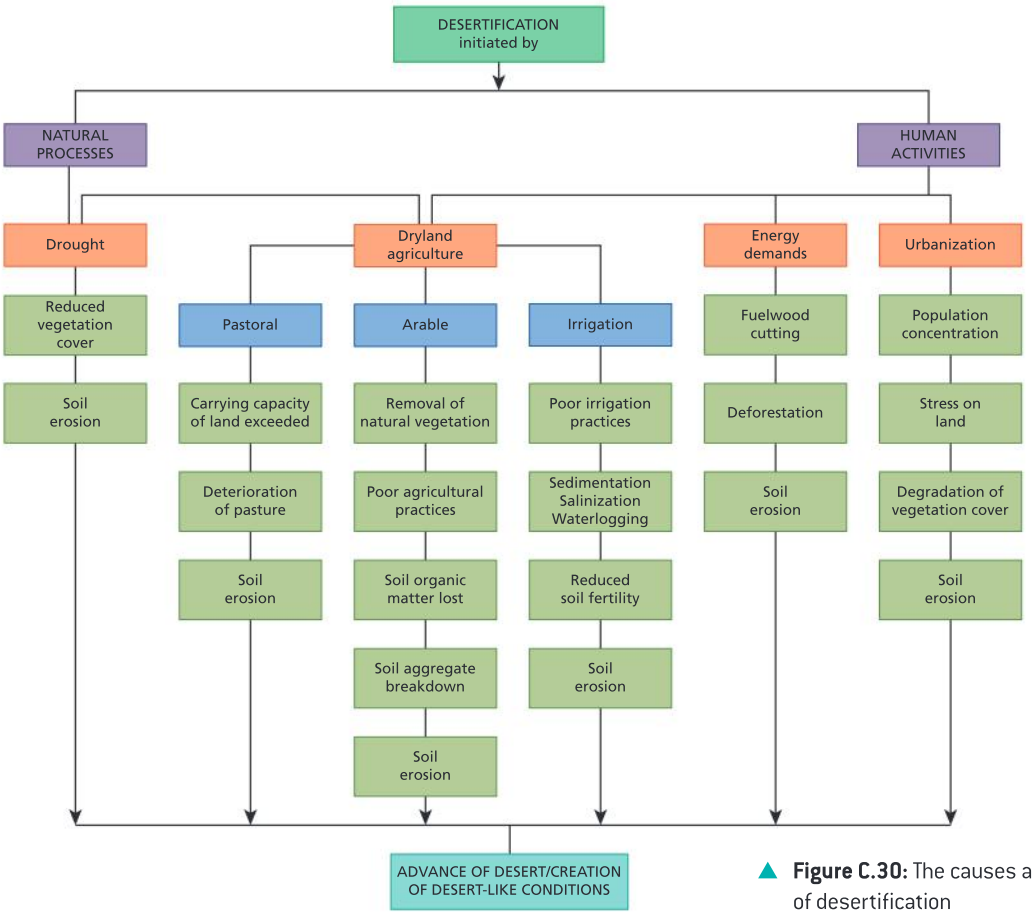
Key content

- The causes, acceleration, consequences and management of desertification, including land use, conflict and climate change
- Increasing international competition for access to resources in extreme environments, including the role of indigenous groups, civil society organizations, transnational corporations (TNCs) and militia groups
- New technology and sustainable development in extreme environments, including greater use of solar power and desalination
- The impacts and management of global climate change on extreme environments, including adaptation by local populations

TOK

How does classification help our understanding in Geography?

Figure C.30 categorizes the causes of desertification into natural processes and human activities. There are many ways of classifying the causes of desertification, and you might think of alternatives. Do we need to classify at all?



▲ **Figure C.30:** The causes and development of desertification

The causes, acceleration, consequences and management of desertification

Desertification is defined as land degradation in humid and semi-arid areas – that is, not including non-desert (arid) areas. It involves the loss of biological and economic productivity and it occurs where climatic variability (especially rainfall) coincides with unsustainable human activities. For example, if the surface cover is removed and the surface colour becomes lighter, its reflectivity (albedo) changes. It reflects more heat, absorbs less, and so there will be less convectional heating, less rain and possibly more drought. Desertification occurs in discontinuous and isolated patches – it is not the general extension of deserts as a consequence of natural events like prolonged droughts, as in China in the 2000s.

Desertification leads to a reduction in vegetation cover and accelerated soil erosion by wind and water, lowering the carrying capacity of the area affected. Desertification is one of the major environmental issues in the world today. At present, 25 per cent of the global land territory and nearly 16 per cent of the world's population are threatened by desertification.

Causes of desertification

Desertification can be a natural process intensified by human activities. All the areas affected by desertification are marginal and characterized by highly variable rainfall. An exception to this is the parts of the rainforest desertified following inappropriate farming techniques.

Natural causes of desertification include temporary drought periods of high magnitude and long-term climate change towards aridity. Many people believe that it is a combination of increasing animal and human population numbers, which causes the effects of drought to become more severe. Desertification occurs when already fragile land in arid and semi-arid areas is over-exploited. This overuse can be caused by overgrazing, when pastoralists allow too many animals to graze on a fixed area of land; overcultivation, where the growing of crops exhausts soil nutrients; and deforestation, when too few trees are left standing after use as firewood to act as windbreaks or to prevent soil erosion.

- Overgrazing is the major cause of desertification worldwide. Vegetation is lost both in the grazing itself and in being trampled by large numbers of livestock. Overgrazed lands then become more vulnerable to erosion as compaction of the soils reduces infiltration, leading to greater run-off, while trampling increases wind erosion. Fencing, which confines animals to specific locations, and the provision of water points and wells have led to severe localized overgrazing. Boreholes and wells also lower the water table, causing soil salinization.
- Overcultivation leads to diminishing returns, where the yield decreases season by season, requiring an expansion of the areas to be cultivated simply to maintain the same return on the agricultural investment. Reducing fallow periods and introducing irrigation are also used to maintain output, but all these contribute to further soil degradation and erosion by lowering soil fertility and promoting salinization.

- Deforestation is most obvious where land has been cleared to extend the area under cultivation and in the surrounds of urban areas where trees are stripped for firewood. The loss of vegetation cover increases rainsplash erosion and the absence of root systems allows easy removal of the soil by wind and water.

Other factors are involved, including the following:

- The mobility of some people has been limited by governments, especially where their migratory routes crossed international boundaries. Attempts to provide permanent settlements have led to the concentration of population and animals, with undesirable consequences.
- Weak or non-existent laws have failed to provide environmental protection for marginal land by preventing or controlling its use.
- Irrational use of water resources has caused water shortages or salinization of soil.
- International trade has promoted short-term exploitation of land by encouraging cash crops for export. This has disrupted local markets and created a shortage of staple foods.
- Civil strife and war diverts resources away from environmental issues.
- Ignorance of the consequences of some human actions, and the use of inappropriate techniques and equipment, have contributed to the problem.

Activity 20

1. Suggest a definition for the term "desertification".
2. Outline the main natural causes of desertification.
3. Briefly explain two examples of desertification caused by people.
4. Comment on the effects of desertification.
5. To what extent is it possible to manage desertification?

Consequences of desertification

There are some serious consequences of desertification (Table C.8).

Table C.8: Consequences of desertification

Environmental	Economic	Social and cultural
Loss of soil nutrients through wind and water erosion Changes in composition of vegetation and loss of biodiversity as vegetation is removed Reduction in land available for cropping and pasture Increased sedimentation of streams because of soil erosion and sediment accumulations in reservoirs Expansion of area under sand dunes	Reduced income from traditional economy (pastoralism and cultivation of food crops) Decreased availability of fuelwood, necessitating purchase of oil/ kerosene Increased dependence on food aid Increased rural poverty	Loss of traditional knowledge and skills Forced migration due to food scarcity Social tensions in reception areas for migrants

Combating desertification

There are many ways of combating desertification, which depend on the perceived causes (Table C.9).

▼ **Table C.9:** The strategies for preventing desertification, and their disadvantages

Cause of desertification	Strategies for prevention	Problems and drawbacks
Overgrazing	Improved stock quality: through vaccination programmes and the introduction of better breeds, yields of meat, wool and milk can be increased without increasing the herd size. Better management: reducing herd sizes and grazing over wider areas would both reduce soil damage.	Vaccination programmes improve survival rates, leading to bigger herds. Population pressure often prevents these measures.
Overcultivation	Use of fertilizers: these can double yields of grain crops, reducing the need to open up new land for farming. New or improved crops: many new crops or new varieties of traditional crops with high-yielding and drought-resistant qualities could be introduced. Improved farming methods: use of crop rotation, irrigation and grain storage can all increase and reduce pressure on land.	Cost to farmers. Artificial fertilizers may damage the soil. Some crops need expensive fertilizer. Risk of crop failure. Some methods require expensive technology and special skills.
Deforestation	Agroforestry: combines agriculture with forestry, allowing the farmer to continue cropping while using trees for fodder, fuel and building timber. Trees protect, shade and fertilize the soil. Social forestry: village-based tree-planting schemes involve all members of a community. Alternative fuels: oil, gas and kerosene can be substituted for wood as sources of fuel.	Long growth time before benefits of trees are realized. Expensive irrigation and maintenance may be needed. Expensive. Special equipment may be needed.

Increasing international competition for access to resources in extreme environments

The North Pole ice cap has decreased by 40 per cent since 1979. Approximately 30 per cent of the world's undiscovered natural gas and 15 per cent of its oil lie in the Arctic. But the majority, 84 per cent, of the estimated 90 billion barrels of oil and 47 trillion cubic metres of gas remain offshore.

As ice caps are melting, a military race is also building in the region. The USA and Russia are competing for extremely valuable resources in the Arctic. The region is opening up two major shipping lanes, and oil and gas reserves are worth trillions of dollars. The potential for economic competition is fierce, especially among the eight members of the Arctic Council: Canada, Denmark, Norway, Iceland, Finland, Sweden, Russia and the USA.

Russia's president has called for full government funding for "socio-economic development" from 2017 to 2020, including a system of Russian naval bases that would be home to ships and submarines allocated specifically for the defence of national interests that involve the protection of Russian oil and gas facilities in the Arctic. Russia is also attempting to accelerate the construction of more icebreakers to take part in its Arctic strategy.

The Russian Federation has staked a claim in the Sea of Okhotsk for 52,000 km^2, and has prepared an Arctic water claim for 1.32 million km^2. Russian oil fields, which contribute significantly to the country's revenue, are in decline – forcing Russian oil companies to actively explore the Arctic region. In 2013 Russian energy giants, Gazprom and Rosneft, were granted rights to develop large hydrocarbon deposits in the Pechora and Kara seas.

Already the Arctic has seen powerful warships from Russia's Northern Fleet, strategic bomber patrols, and airborne troop exercises. Russia's militarization in the Arctic region is only a part of its increasing activity around the globe.

The Arctic, which was once a more hands-off region of the world that provided international cooperation and stability, is now the subject of a race for sovereignty and resources claims – as evidenced by the increasing military presence of Russia, Canada and the USA. Canada is now allocating part of its defence budget to armed ships that will patrol its part of the Arctic Circle while the USA has planned a strategy of its own. However, the USA is falling behind in Arctic preparations.

Russia is developing a strong military presence in a potentially competitive region. Russia wants to be the first established dominant force in a new region that will host economic competition and primary shipping lanes, albeit in a harsh environment that makes it difficult to extract resources.

Although the Arctic holds a mass of the world's oil and gas deposits, the extreme environment and remote location make it difficult to produce energy quickly and efficiently. Despite this, the Russian Federation is focused on developing disputed hydrocarbon areas that it claims are part of the country's continental shelf area. (See also Option B, Oceans and coastal margins, for a discussion of conflicts over ocean resources.)

If the Arctic region continues to melt and open up vital shipping lanes, there must be international cooperation to provide security and rescue elements for commercial shipping. Since Russia has significant territorial claims and the longest coastline in the Arctic, it would be natural for the Russian Federation to have a wide security presence in the region, but this must be coupled with international cooperation in commercial shipping lanes and by providing support elements, such as search and rescue.

The USA wants to be a leader and sees itself as the driving force in the future planning of the Arctic. The USA is keen to militarize the Arctic Ocean. It has to do it via its relations with Canada and NATO, through the participation of Norway and Denmark in NATO. It has also called upon Sweden and Finland to join NATO with a view to establishing a NATO agenda in the Arctic. However, the USA has been keen to emphasize the need for conservation, protection and stewardship. According to one Alaskan government official, the lack of US activity in the Arctic represents "a stunning attack on our sovereignty and our ability to develop a strong economy". In contrast, in 2013 Russia announced the resumption of a constant armed presence in the Arctic, which was abandoned by the military after the fall of the USSR.

Case study

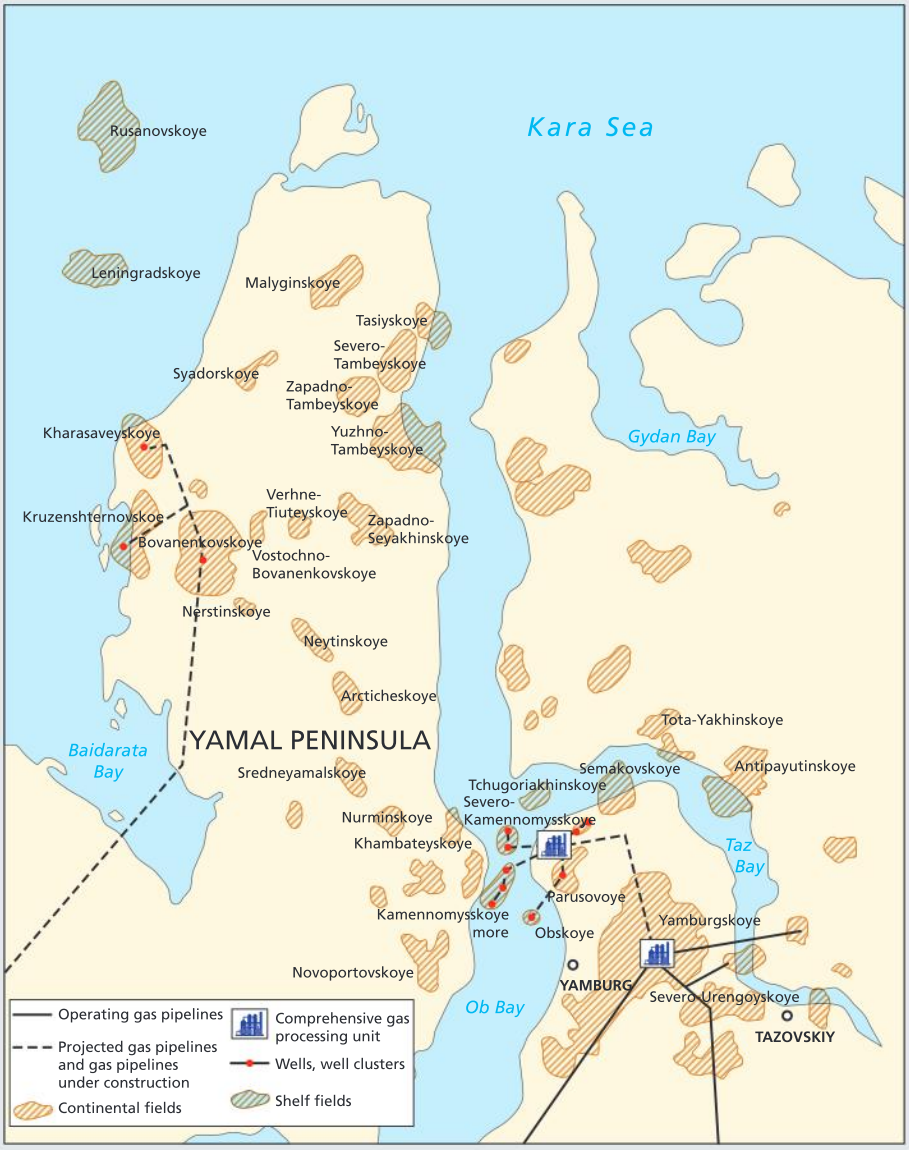
The Yamal megaproject and the Nenets of Siberia

The Nenets are indigenous nomadic reindeer herders who have used the Yamal Peninsula for over 1,000 years. The Yamal Peninsula extends from Northern Siberia to the Kara Sea. Yamal is a remote, wind-blasted region underlain by permafrost. The Nenets graze their reindeer in the Yamal during the summer and move south during the winter. Some are semi-nomadic, residing in towns during the winter.

Some Nenets have abandoned their traditional way of life. Following the collapse of communism, many young adults left their villages for large cities. Many have failed to adapt to life away from nomadism, and there have been reports of high levels of unemployment, alcoholism and mental health problems. For the Nenets who retained their traditional ways, their lands and their herds are vital to their existence.

The Nenets are now facing threats from climate change and also from oil and gas exploration. The Arctic is changing fast. As temperatures rise and the tundra's permafrost thaws, it releases methane and carbon dioxide into the atmosphere. With ice melting earlier in the spring and not freezing until much later, the herders are being forced to change centuries old migration patterns. Melting permafrost is also causing some of the tundra's freshwater lakes to drain, which is leading to a decline in fish supplies.

Yamal holds Russia's (and the world's) largest natural gas reserves. An estimate of the gas reserves here is 55 trillion cubic metres (tcm). Russia's largest energy project in history puts the future of nomadic herding at considerable risk. Roads and pipelines are difficult for reindeer to cross, and oil pollution is threatening the quality of pasture and freshwater. The Russian corporation Gazprom is developing the region's huge oil and gas reserves in a project known as



▲ **Figure C.31:** Yamal oil and gas fields

Case study (continued)

▲ **Figure C.32:** Yamal Peninsula – a region of "strategic importance" for Gazprom and Russia

the Yamal Megaproject. The project was initiated in the 1990s, and the first of its gas supplies from the Bovanenkovo field was produced in 2012. A 570 km railway line from Obskaya to Bovanenkovo (the world's most northerly rail line) was opened in 2011.

Yamal has over 16 tcm of proven gas reserves and a further 22 tcm of expected reserves. Over 2,500 of pipelines will be built to transport the gas. Transport infrastructure is poorly developed in the Yamal Peninsula, so development of the region will require developments to the railway and aviation networks.

Oil and gas operations in the Yamal Peninsula destroyed over 64,000 km^2 of tundra in just 10 years of exploration. Fish yields on the River Ob have decreased, fish spawning grounds have been polluted. The River Ob used to provide 60 per cent of the Former Soviet Union's fish catch; nearly 30 fisheries on tributaries of the Ob have been destroyed. Reindeer's migratory routes have been bisected by railroads, and some reindeer have been shot.

According to a spokesperson from Survival International, "Gazprom's website calls the Yamal Peninsula a strategic oil and gas bearing region of Russia. This sums up how they view the Nenets' ancestral homeland". The statement concludes, "The Nenets people have lived on and stewarded the tundra's fragile ecology for hundreds of years. No developments should take place on their land without their consent, and they need to receive fair compensation for any damages caused".

Militia attacks on Russia have, in the past, led to the temporary suspension of economic activity in the Yamal. In 1998, exploration on the Yamal was abandoned as Russia's war efforts in Chechnya were consuming too many resources.

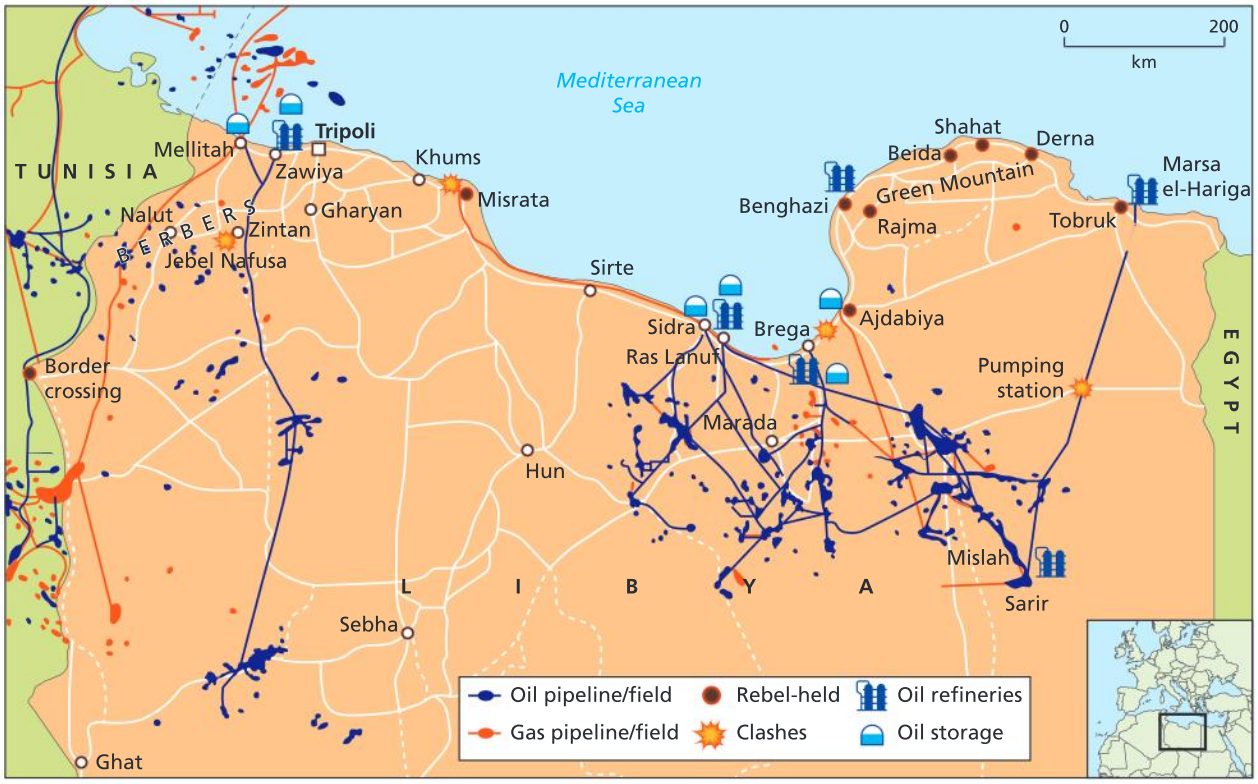
▲ **Photo C.20:** Traditional Nenet tent (*choom* or *mya*)

Oil conflicts in the Middle East

There are many conflicts over oil, not all of them in the Middle East; for example, in Iraq, Syria, Nigeria, South Sudan, Ukraine, the East and South China. Many are the result of long-standing historic disputes, which have developed into the desire to control valuable oil and natural gas assets. Oil and gas are, after all, the world's most important and valuable commodities and constitute a major source of income for the governments and corporations that control their production and distribution. The economic world has become energy-centric, and access to energy resources provides strength and power for some countries, whereas lack of resources leads to vulnerability for other countries. Countries with surplus energy reserves, and the ability to export energy, often have disproportionate influence on the world stage. The struggle over energy resources has been a recurring factor in many recent conflicts, including the Iran/Iraq War of 1980–1988, the Gulf War of 1990–1991 and the Sudanese Civil War of 1983–2005.

The Islamic State (ISIS) is a Sunni extremist group that controls large parts of western Syria and northern Iraq. It is a well-armed organization intent on creating an Islamic caliphate in the areas it controls. Nation-building is expensive. ISIS controls key oil-producing areas of Syria and oil-refining facilities in Iraq. This, in part, allows it to pay for its military.

Such conflicts make it difficult for countries that depend on Middle Eastern oil. Losses from Libya, Iraq and Syria have reduced supply, while reduced investment is threatening future supplies.



▲ **Figure C.33:** Major oil reserves and infrastructure in Libya

Oil in Libya

Oil reserves in Libya are the largest in Africa and among the 10 largest globally. Libya has over 70 years of reserves at current production rates. Libya is considered a highly attractive oil area due to its low cost of oil production and proximity to European markets. Oil production was over 1.5 million barrels per day (MMbpd) before the Arab Spring of 2011. In 2016 production was 360,000 MMbpd. Oil infrastructure has been sabotaged. Groups claiming to be affiliated with ISIS also damaged pipelines and vital equipment. In 2015 attacks by gunmen on oil fields prompted the National Oil Corporation to shut down operations at 11 oil fields.

Activity 21

Study Figure C.34.

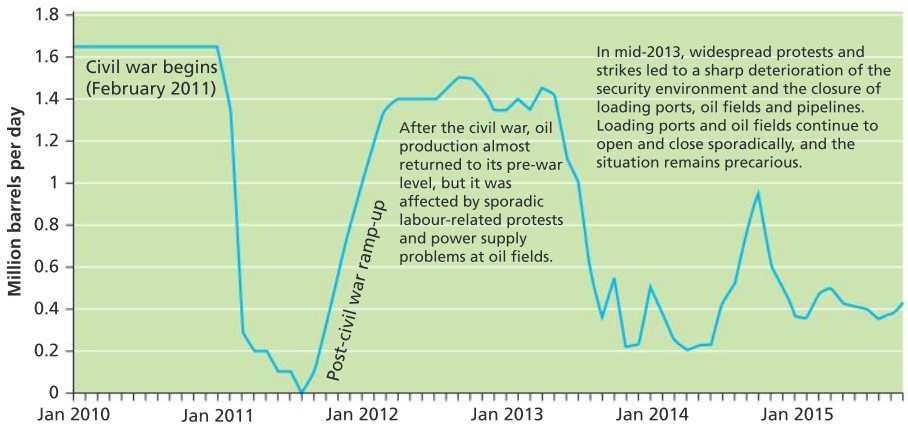
1. Outline two reasons for the decline in oil production in Libya.
2. Suggest why this would have a major impact on European countries.

ATL Research skills

Visit https://www.eia.gov/beta/international/analysis_includes/countries_long/Libya/libya.pdf to investigate the importance of Libya's oil industry.

Resource security in the Middle East

There has been conflict in the Middle East for millennia. Recent conflicts have included those triggered by the Arab Spring and faction fighting within countries such as Yemen. Due to Yemen's location, both Saudi Arabia and Egypt became involved in the conflict. Although Yemen is not a major oil producer, it is strategically located adjacent to the Red Sea and the Gulf of Aden, a major transit route for oil. Along with Yemen, Eritrea and Djibouti create a narrow passing point. In 2002, Al-Qaeda attacked a French super-tanker off the south-east coast of Yemen.



▲ **Figure C.34:** Crude oil production in Libya, 2010 to 2015

The situation in Yemen is an opportunity for ISIS and other terrorist organizations to gain a stronger hold in the region and to destabilize the area. Since 2004, there has been fighting between the Yemeni government and the Houtis, a Shia minority. There have been many protests, escalating to violence and attacks on government buildings and facilities. Since 2011 the Houtis have expanded their influence, resulting in increasing attacks on the government and pro-government supporters. In 2015, the Houtis attacked the presidential palace and key government facilities. The Yemeni president took refuge in Saudi Arabia. In 2015, Saudi Arabia launched air strikes against the Houtis and their supporters. A month later, the Saudi Arabian government announced that it had completed its mission and that it was changing its actions to focus on humanitarian aid and political dialogue. The Houtis still control much of western Yemen.

If war were to break out in the region, oil supply could be reduced and energy security in a number of countries around the world could also be reduced.

ATL Research skills

Visit http://www.aljazeera.com/news/middleeast/2014/08/yemen-houthis-hadi-protests-201482132719818986.html and http://www.bbc.co.uk/news/world-middle-east-29319423 to find out more about the conflict in Yemen and its implications for the wider Middle East region and oil security.

TOK

Organize a class debate called "The benefits of the Yamal megaproject outweigh the needs of the Nenets people".

ATL Research skills

Visit the websites of Survival International http://www.survivalinternational.org/ and the Gazprom megaproject http://www.gazprom.com/about/production/projects/mega-yamal/.

New technology and sustainable development in extreme environments

Sustainable development is development that improves basic standards of living without compromising the needs of future generations. New technologies such as desalinization, solar power, wind power and ICT have the ability to increase levels of wealth and development for many communities. However, some of these technologies are expensive, and beyond the means of many communities.

Sustainable farming in Egypt

The Nile provides Egypt with almost all of its water, 85 per cent of which goes to agriculture, but population growth and increased demands for water is putting a strain on water resources. Up to 95 per cent of Egypt's population lives in the Nile Valley and Delta, increasing the pressure on land resources. The same area accounts for the bulk of Egyptian food production. Although one-third of Egypt's annual share of the Nile is used for irrigation, it contains pollutants and pesticides from upstream countries and from Egypt itself. Since chemical pesticides were first introduced to Egypt in the early 1950s, a million tonnes have been released into the environment. To compound the matter, Ethiopia is building the Grand Ethiopian Renaissance Dam on the Blue Nile, which is likely to cut supplies of fresh water to Egypt.

However, Egypt is developing forms of sustainable agriculture. One of the leading individuals is Faris Farrag, who has developed aquaponics at his farm outside Cairo called "Bustan" (Arabic for orchard). Aquaponics is an integrated form of farming that originated in Central America. It enables farmers to increase yields by growing plants and farming fish in the same closed freshwater system.

Bustan is the first commercial aquaponics farm in Egypt. Water circulates from tanks containing fish through hydroponic trays that grow vegetables including cucumber, basil, lettuce, kale, peppers and tomatoes. Each tank contains about a thousand tilapia fish, which are native to Egypt and are known for resisting slight variations in the pH and temperature of water. Water from the pond is then used to irrigate the olive trees that produce a high-quality olive oil.

This organic and closed system mimics natural processes and enables waste to be efficiently reused. The fish tanks provide 90 per cent of the nutrients plants need to grow. The ammonia that results from the fish breathing is naturally transformed into nitrogen and absorbed by the plants before being sent back to the fish tanks, ammonia-free and healthy. Just outside the fish tanks lies a large pond covered with a slimy layer of duckweed, a highly nutritious floating plant that is regularly scraped, dried and fed to the fish as vegetable protein.

Bustan uses 90 per cent less water than traditional farming methods in Egypt. It produces 6–8 tonnes of fish per year and could potentially yield 45,000 heads of lettuce if it were to grow just a single type of vegetable. Hydroponics can make lettuce grow 20 per cent faster than average.

Bustan is a labour-intensive farm and uses sustainable biological pest-control methods, such as ladybirds to kill aphids, in order to avoid chemical inputs. Farrag intends to establish a permaculture system by introducing chickens that would feed on compost and produce natural fertilizers for the soil.

This method of farming could serve as a means of income generation for unemployed women, as well as a means of education for sustainable farming. However, it is quite costly, especially for those on a low income. Inside Bustan, the pumps used to filter water require a source of energy, mainly oil. Farrag has invested more than $43,500 to develop this scheme.

Small hydroponic units could be established for rooftops, balconies and kitchens. Vertical and rooftop farming, in light of the country's serious water and food crisis, is also an effective way to grow organic food while cutting transportation costs, emissions and waste.

ATL Research skills

Find out more about sustainable farming options in Egypt, including fish farms in the desert and rooftop farms in cities.

Desalination

Desalination or **desalinization** removes salt from seawater. More generally, desalination may also refer to the removal of salts and minerals from seawater and from soil. Seawater is desalinated to produce fresh water fit for human consumption (potable water) and for irrigation.

Due to high energy input, the costs of desalinating seawater are generally higher than the alternatives, but alternatives are not always available and depletion of reserves is a problem in certain locations. According to Global Water Intelligence, around 1 per cent of the world's population are dependent on desalinated water to meet their daily needs, but by 2025, it will rise to around 14 per cent. In 2011, there were around 16,000 desalination plants operating worldwide, producing 66.5 million cubic metres per day, providing water for 300 million people. The world's largest single desalination project is Ras Al-Khair in Saudi Arabia, which produced over one million cubic metres per day in 2014. In Israel over 40 per cent of domestic water comes from seawater desalination, the largest contribution to any one country.

In 2004 Israel relied entirely on groundwater and rain; it now has four seawater desalination plants running, of which Sorek is the largest. By 2050, seawater desalination is expected to account for 70 per cent of Israel's water supply.

The main criticism regarding desalination and the use of reverse-osmosis technology is that it costs too much. The process uses a great deal of energy to force salt water against membranes that have pores small enough to let fresh water through while holding salt ions back. However, new technology is bringing the cost of desalination down.

The Sorek plant produces the cheapest water from seawater in the world. Desalination is becoming more popular, especially among wealthy countries. Australia, Singapore and several countries in the Persian Gulf

Common mistake

✗ Some students think that there is no agriculture in hot, desert areas.

✓ Agriculture does occur in hot, desert areas as long as there is water. Sources of water include exotic rivers, groundwater, oases and desalinated water. However, there is little rainfall (less than 250 mm/year).

ATL Research skills

Visit https://www.youtube.com/watch?v=RYRuQCMG1Uk to watch a short video on the Al Khafi desalination plant.

are already heavy users of seawater desalination, and California is also starting to embrace desalination.

A major desalination plant is planned for San Diego in the USA. The Carlsbad Desalination Project in San Diego county will soon be the largest seawater desalination plant in the western hemisphere. At a cost of $1 billion, there are not many communities that can afford such a development.

After three years of drought in California, drought-plagued farmers cannot irrigate: the state's reservoirs contain more mud than water. When operational, the Carlsbad plant will provide up to 50 million gallons of water daily to San Diego county's 3 million residents. Still, that's only 7 per cent of the region's water needs. Many environmentalists argue that water conservation is a much cheaper option, assuming that there is water available to conserve.

Seawater is becoming a critical resource as global freshwater supplies come under increasing stress, but conventional desalination is an expensive, energy-sucking process. Renewable energy offers a chance to reduce costs and emissions.

In 2015 Saudi Arabia announced the development of the Al Khafi desalination plant. The plant will have a 15 megawatt solar array using polycrystalline solar cells. The project includes energy recovery, energy storage and other efficiency systems to complement the solar array, as well as the desalination of seawater.

Solar power

Case study

Using the desert to power the world

A plan to use the Sahara Desert to power Europe with solar energy has been abandoned, although several North African solar power projects are still going ahead despite concerns over their sustainability. In 2005 a researcher from Germany, Nadine May, suggested that only a small amount of the Sahara would be needed to produce enough solar energy for the world. Her data was used to produce a map suggesting how much of the Sahara would be needed to power the world, and to power Europe, and just Germany (Figure C.35).

For example, the article states that, "in just six hours, the world's deserts receive more energy from the sun than humans consume in a year".

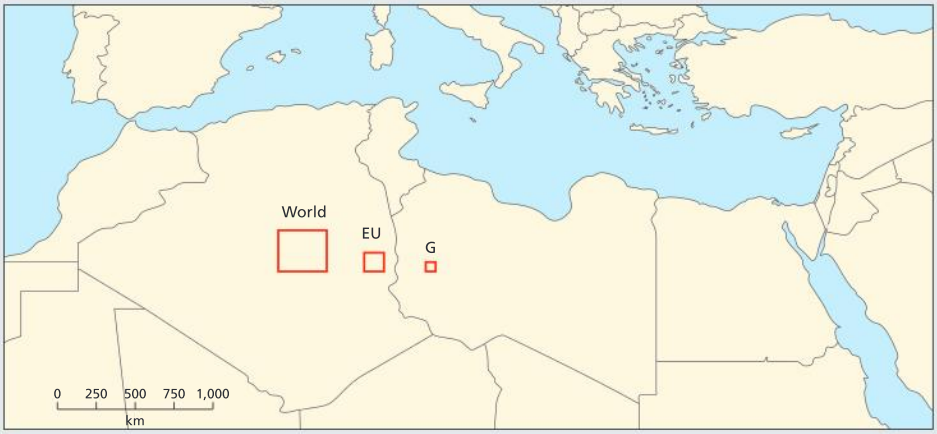
In 2009 the Desertec Foundation was established. Its aim was to supply as many people and businesses as possible with renewable energy from the world's deserts. Also in 2009, the Desertec Industrial Initiative was formed, as a largely German-led private sector initiative with the aim of transforming the Desertec concept into a profitable business. Desertec was also attempting to diversify energy supply in Europe, promote energy security and reduce dependence on Russia.

In part, Desertec was a response to the issues of climate change, the Russian–Ukrainian gas conflicts in 2006 and 2009, fears of peak oil, and the global food crisis of 2009. However, if Desertec wanted to address these crises, arguably it should have targeted the structural causes. To use new technology to overcome these problems without fundamental change, critics argued, was not addressing issues of inequality.

Moreover, they argued that large-scale engineering-focused "solutions" like Desertec tend to present climate change as a shared problem with no political or socio-economic context. Such a view ignores the historical actions of western countries and energy TNCs,

Case study (continued)

the problems of the capitalist energy model, and the differences between countries in the core and the periphery. The spread of solar energy initiatives utilizes scarce water resources. If the energy is just to provide for rich consumers, this detracts from sustainable development. As it happened, the fall in the price of solar panels and wind turbines in the EU led Desertec to conclude in 2013 that Europe could produce most of its renewable energy from within its own borders.



▲ **Figure C.35:** The amount of the Sahara Desert needed to power the world, the European Union and Germany

Solar energy in the Northern Sahara is still going ahead, with projects in Tunisia, Morocco and Algeria. The Tu Nur project in Tunisia will send power to Europe in 2018. This seems inappropriate as Tunisia depends on neighbouring Algeria for some of its own energy. The Moroccan government has attracted funding from overseas lenders to develop the world's largest concentrating solar power (CSP) plant at Ourzazate. Originally it was planned as an export project to Spain, but it is now promoted as a project to increase Morocco's supply of renewable energy. However, the role of TNCs in the company has attracted criticism. Critics argue that the increasing control exerted by TNCs on electrical energy production in Morocco is a threat to national sovereignty.

For development to be sustainable, projects must be grounded in local communities and focused on providing for the energy needs of local communities. In the context of the recent upheavals in the MENA region (the "Arab Spring") and the demands for national sovereignty, social justice, freedom and improved access to food, projects involving TNCs which have a top-down approach increase the risk of displacement, alienation and pollution. Without community involvement, there is no guarantee that such schemes will reduce poverty and unemployment or preserve the natural environment.

Activity 22

1. Explain one advantage and one disadvantage of desalination in extreme environments.
2. Explain one advantage and one disadvantage of the Desertec plans for solar power in the Sahara Desert.

ATL Research skills

Visit http://www.nurenergie.com/tunur/ to find out about Tu Nur solar energy projects and the prospects for the UK from Tunisia http://www.bbc.co.uk/news/science-environment-29551063.

Find out about the world's largest solar energy plant at Ourzazate, Morocco here: http://www.theguardian.com/environment/2016/feb/04/morocco-to-switch-on-first-phase-of-worlds-largest-solar-plant.

The impacts and management of global climate change in extreme environments

Climate change and food security

The predicted rise in temperature for the Sahel area is likely to be 1.0–2.75°C, and arid conditions will probably worsen even where precipitation is likely to increase. Higher temperatures will raise

evaporation levels and reduce precipitation effectiveness. Environmental hazards such as floods and droughts will become more common in the Sahel, causing disruption to agricultural systems. These hazards are likely to reduce food production and availability and increase prices, food insecurity and hunger. Poverty will therefore exacerbate the impacts of climate change in Sahel.

Activity 23

Study Figure C.37 Rainfall in the Sahel region.

1. Describe the trends in rainfall variability shown.
2. The rainfall as an average for the period is shown as 0 on the graph. Describe the value of using an index in this way.
3. "The extent to which countries accommodate climate change depends more upon human factors than physical factors." Discuss this view.

Coping strategies adopted in Senegal

Senegal has a projected 20 per cent reduction in rainfall and a 4°C increase in temperature from a baseline of 1961–1990. Climate change will reduce food yields by approximately 25 per cent in relation to current yields, leading to up to an additional 4 million people at risk of food insecurity by 2050. Overgrazing, over-population of marginal lands and natural soil erosion are leading to desertification. Senegal is investigating various coping strategies that can be applied at the household or local level. These include:

- improving soil fertility by the careful use of fertilizers
- improving the efficiency of irrigation systems and pest control
- adopting water and soil conservation techniques using diguettes (stone rows) to reduce run-off on slopes
- developing the Great Green Wall of the Sahara and the Sahel Initiative (GGWSSI), that is, a massive line of trees across the southern Sahara and Sahel to combat the combined effect of resource degradation (deforestation and soil erosion) and drought/desertification.

Case study

Coping in semi-arid regions – the African Sahel

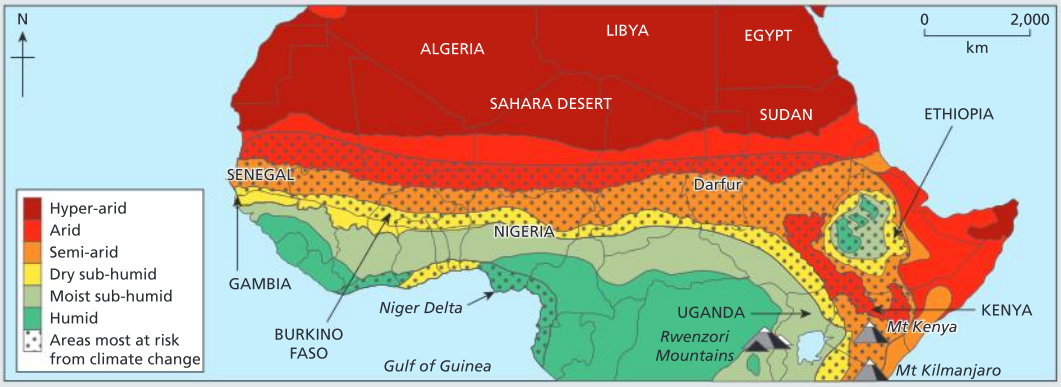
The indigenous people of the semi-arid Sahel region, located between the Sahara desert and the humid subtropics of sub-Saharan Africa, have adapted to the extreme environmental conditions by a combination of strategies. As pastoralists, they make use of the limited resources of the Sahel, and combat over-grazing by migration to areas of seasonal growth. In doing so, they tend to leave vegetation around more permanent water sources for times when they will need it later. Such migration patterns also utilize arid areas that are not suitable for cultivation. The livestock herds are diversified – cattle are kept for income in the meat market, sheep and goats for milk and meat for subsistence consumption. Herd diversification also allows pastoralists to make use of a greater variety of the available vegetation resources because the animals have different grazing patterns. The diet of the indigenous people varies with conditions. More milk is consumed in wetter periods, with meat being more common in the drier periods. Their animals are bartered with sedentary farmers for grain.

Unreliable rainfall and drought are normal features of the climate of Sahel. However, the pattern has changed since the 1970s, and droughts have become more frequent, and sometimes, as in the 1980s, they bring devastation and famine. These changes in rainfall may be the result of global climate change, more specifically the enhanced greenhouse effect. Current climate projections predict increases in temperature that are likely to have environmental and socio-economic consequences, both in the Sahel and beyond. The implications of climate change are serious and far-reaching, and can threaten the lives of individuals and households, and also international security.

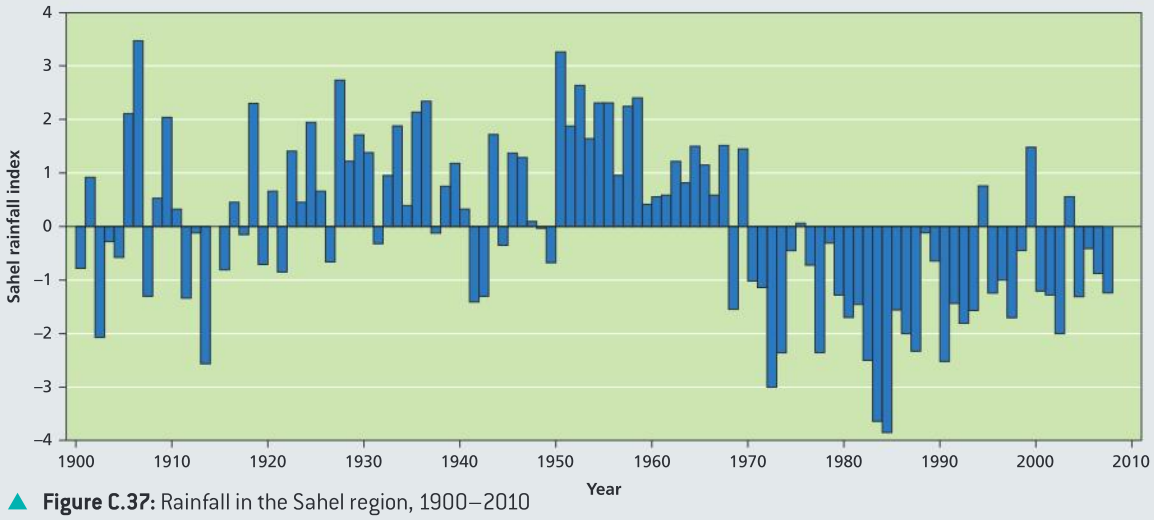
The primary **environmental effects** of climate change include:

- reduced agricultural production and increased food insecurity

Case study (continued)



▲ **Figure C.36:** Areas of Sahel at risk of desertification



▲ **Figure C.37:** Rainfall in the Sahel region, 1900–2010

- additional pressure on water availability, water accessibility and water demand
- flooding of low-lying areas
- changes in humidity likely to encourage the spread of disease by mosquitoes and other vectors.

The secondary **sociopolitical** effects of climate change may include:

- conflict over resources such as water and pasture
- loss of territory and border disputes due to transborder migration and pressure on resources, for example the conflict between Darfuri tribes in Sudan
- environmentally induced migration, often resulting in urban overcrowding
- tension over energy supplies resulting from deforestation and competition for charcoal
- international political tension which cannot be resolved without global arbitration.

TOK

Study Figure C.37 Rainfall in the Sahel region.

- How reliable is statistical data?
- How can we draw conclusions from a limited sample?
- Who collected the data and how reliable was their method?
- Can we draw conclusions from such a small timescale?

ATL Research skills

Research and develop a case study for the impact and management of climate change on a local population in one named hot, arid environment.

Coping with water shortages in dry areas

Some solutions are "natural" and require farmers to adapt to the natural environment. Adaptations to water shortages include:

- increased mobility (the traditional way)
- management of size and composition of herds
- exchange of livestock and livestock products
- increased use of drought-tolerant species
- utilization of wild species and tree crops
- windbreaks to reduce wind erosion of bare soil
- irrigating with silt-laden river water to restore soil
- dune stabilization using straw bales and xerophytic plants
- land enclosure to reduce wind erosion.

The impacts of climate change on cold environments

Any increase in temperature is likely to have a greater impact in areas where the mean annual temperature is only a little below freezing point. Very cold glacial areas (such as in central Antarctica) will remain well below freezing even if they experience a major rise in temperature. The greatest changes are likely to occur in periglacial areas where the mean temperature is just below 0°C. Up to 40 per cent of permafrost areas are at risk of degradation and the development of thermokarst (subsidence).

ATL Research skills

Visit http://www.psi.org.uk/ehb/projectskeenan.html for information on the effects of climate change and tourism on the Tuareg people of the Sahel.

Until recently, Canada paid little attention to its northern region. Only about 100,000 of the country's 33 million people live north of 60°N. Two factors are now forcing them to pay attention to the north:

- climate change – just when prices of minerals are high, the warming climate has made accessible minerals that were once locked in the ice
- the people who live in the north are demanding and getting more of a say in their future.

There is no question that the Arctic is warming. Arctic temperatures have increased at almost twice the global average rate in the last 100 years. Up to 70,000 km^2 of sea ice (an area about the size of Ireland) are disappearing annually. It is not good news. The north-western Alaskan village of Kivalina is built on a remote and narrow strip of sand next to the Chukchi Sea. The US Army Corps of Engineers predicts that Kivalina will be completely uninhabitable by 2025, a victim of melting ice, coastal erosion and rising sea levels. The villagers may become the USA's first climate change refugees.

▲ **Photo C.21:** Kivalina village, north-west Alaska, at risk of coastal erosion and flooding due to global climate change

Many settlements are located at river mouths, river confluences or islands. Melting permafrost, coastal erosion, increased flooding and a rise in sea level due to climate change will take a toll on buildings, ports, bridges and roads.

A warming climate brings many problems for the Inuit. Unpredictable sea ice can be fatal. Life is becoming more expensive: snowmobiles must take longer routes, buildings are weakened by melting permafrost and, ironically, the local council in Kunjuaq, Quebec (Canada) bought 10 air conditioners in 2006 after temperatures reached 31°C! For many, the

traditional hunter-gatherer existence is proving difficult as changes in the environment make their traditional way of life harder.

Rising temperatures may have impacts on economic activities. Farming may become more productive as net primary productivity increases and the length of the growing season increases. In some places, forestry, especially coniferous forestry, may be possible. As ocean temperatures change, there has been migration of fish species. People relying on fishing will either have to go further to catch the same fish, or alter their fishing to take into account changes in species composition. For those that rely on seals and whales, changes in their distribution may have far-reaching effects. There may also be increased possibilities for tourism. For example, Greenland had nearly 80,000 tourists visit and stay in paid accommodation during 2014.

The effect of climate change – more shipping, mining, and oil and gas exploration – may threaten the environment and with it the Inuit's traditional life, based on hunting and fishing. In 2006, Nunavut's economy grew by nearly 6 per cent, second only to that of oil-rich Alberta. Much of the boost came from the opening of the territory's first diamond mine. Of the 130 companies operating in Nunavut in 2009, 32 were looking for uranium. Others were seeking gold, diamonds, silver, zinc, nickel, copper, iron ore and sapphires.

The impact of climate change in the Himalayas

If temperatures increase by 1.2°C by 2050 and 3°C by the end of the century, there may be far-reaching consequences for mountainous regions and countries adjoining them or fed by their meltwaters.

The Himalayas have the largest concentration of glaciers outside the polar region. These glaciers are a freshwater reserve; they provide the headwaters for nine major river systems in Asia – a lifeline for almost a third of humanity. There is clear evidence that Himalayan glaciers have been melting at an unprecedented rate in recent decades. This trend causes major changes in freshwater flow regimes and is likely to have a dramatic impact on drinking water supplies, biodiversity, hydropower, industry and agriculture.

One result of glacial retreat has been an increase in the number and size of glacial lakes forming, impounded behind terminal moraines. These in turn give rise to an increase in the potential threat of glacial lake outburst floods (glofs) occurring. Such disasters often cross boundaries: the water from a lake in one country threatens the lives and properties of people in another.

Regional cooperation is needed to formulate a strategy to deal effectively both with the risk of outburst floods and with water management issues. Long-term shrinkage of Himalayan glaciers may severely reduce run-off in major rivers such as the Indus, Yellow River and Mekong, with impacts on water supplies.

Experts have identified 25 potentially dangerous glacier lakes in Bhutan, and predict a worst-case scenario of massive flooding at any time down the Punakha-Wangdi valley. UNDP is working to establish an early warning system for glacier lake outburst floods, strengthen disaster risk-management plans, and improve the preparedness of local communities.

ATL Research skills

Use a search engine or other source of information to research to what extent local populations in extreme environments can adapt to and/or manage the global climate change.

TOK

Conduct a class debate. The motion is: "Local populations can and should do something to manage and adapt to climate change". The alternative view is that "Local populations are unable to manage or adapt to climate change".

Table C.10: Factors enabling adaptation to climate change

Factor	Details
Communications	The presence of diversified media and accessibility of information about weather in general and hazards in particular
Transport	A system which functions even during extreme events
Finance	Access to banking, credit and insurance products which spread risk before, during and after extreme events
Economic diversification	Access to a range of economic and livelihood options
Education	Basic language and other skills necessary to understand risks and shift livelihood strategies as necessary
Organization and representation	Right to organize and to have access to and voice concerns through diverse public, private and civil society organizations
Knowledge generation, planning and learning	The social and scientific basis to learn from experience, proactively identify hazards, analyse risk and develop response strategies that are tailored to local conditions

There are a number of factors that will enable adaptation to climate change (see Table C.10).

In an unprecedented effort, a project has been launched to lower the water level of Lake Thorthormi, a glacial lake ranked as one of the most dangerous in the country. Such a controlled drainage effort requires detailed surveys, an evacuation plan in case the lake collapses, a sound engineering plan and training and evaluation. Once completed, the project will provide valuable experiences to countries with similar problems, such as China, Nepal, Pakistan, India and Chile.

ATL Research skills

Use a search engine or other source, to investigate management of climate change in one named extreme environment. How far can the factors in Table C.10 help to plan for and manage the impacts of climate change?

The impact of climate change on the alpine ski industry

Up to half of Switzerland's ski resorts face economic hardship or bankruptcy because of global climate change. Low altitude resorts in Italy, Germany and Austria may also have to move uphill in the future. Others may have to rely on snow-making machines. Climate scientists have repeatedly warned that due to emissions of greenhouse gases, temperatures could rise by over 5°C by 2100. The European ski industry is a multi-billion dollar industry.

Climate change will have the effect of pushing more and more winter sports higher up mountains, concentrating impacts in an ever-decreasing number of high-altitude areas. Since 2000, some patches of permafrost that have existed for tens of thousands of years have disappeared.

Switzerland has around 230 ski resorts. Only 85 per cent of these are now classified as "snow reliable" and these are in areas where the snowline is above 1,200 m. Over the next 30–50 years, snow could become unreliable at altitudes below 1,500 m. The proportion of "snow-reliable" resorts would drop to 63 per cent. In one scenario, the snowline could rise to 1,800 m, which could lead to a tourism loss of nearly $1.4 billion compared with the present.

ATL Research skills

Muir Glacier, named after the pioneering environmentalist John Muir, has retreated by about 5 miles since 1970. Another, Portage Glacier, is retreating at a rate of 50 metres a year and is no longer visible from its visitor centre. Visit these websites to find out about the most recent changes to Alaska's environment:

University of Alaska: Arctic Climate Impact Assessment at www.acia.uaf.edu.

Kenai Fjords National Park at www.nps.gov.kefj/index.htm.

Glacier Bay National park at www.nps.gov/glba.

Concepts in context

There are a number of **possibilities** regarding the future of extreme environments. One is the scale of change, for example whether climate change is limited to 2°C or whether it races ahead to 5°C or more. Such climate change may open possibilities for mineral extraction, tourism, transport and farming in some extreme environments. Some of the change will be positive, such as increased opportunities for farming and tourism, but some of the impacts will be negative such as increased risk of desertification, coastal erosion and sea-level change. The possibilities will also vary with stakeholders – governments and TNCs have much more economic and political power at their command than some indigenous populations. Some TNCs may not operate in an environmentally sustainable way, and this may have an impact on the traditional lifestyles of indigenous populations.

Check your understanding

1. State the name of the eight members of the Arctic Council.
2. Identify the two main mineral resources that exist in the Arctic Ocean.
3. Which resources in hot, arid areas have been identified as the most likely to lead to future conflicts?
4. State the name of the indigenous population group who live for part of the year in the Yamal Peninsula.
5. Identify the resources that this indigenous group makes use of.
6. State the purpose of the Yamal Megaproject.
7. Outline the environmental impact of oil exploration in the Yamal region.
8. Define the term "desertification".
9. Outline the main causes of desertification.
10. Outline the likely impact of global climate change on Europe's ski industry.

Synthesis and evaluation

- People and places in extreme environments do not exist in isolation, but are affected by spatial interactions (social, economic, environmental and political) with other places.
- The scale of the processes and challenges varies, in terms of the pressure exerted, resilience of the extreme environment and the role of national governments, TNCs, civil societies.
- There are many perspectives on the ways in which extreme environments are managed and these include the views of indigenous communities, TNCs, economic migrants, conservationists, and governments.
- Glacial systems are best represented by a systems diagram showing inputs and outputs. Climatic data are best represented by means of a climate graph (bar chart and line graph).

Study the 1:50,000 map extract of Zermat and the Gorner Glacier.

(a) (i) Locate and identify two features resulting from glacial erosion. (2 marks)

(ii) Identify the map evidence that suggests tourism is important in this area. (2 marks)

(b) Explain three reasons why the area in the map can be considered an extreme environment. (2 + 2 + 2 marks)

(c) Either

"Mineral resources in extreme environments rarely bring benefits to those who live there." Discuss this statement. (10 marks)

Or

"Agricultural development in hot, arid environments inevitably leads to desertification." Discuss this statement. (10 marks)

OPTION D
GEOPHYSICAL HAZARDS

Key terms

Hazard event	The occurrence (realization) of a hazard, the effects of which change demographic, economic and/or environmental conditions.
Disaster	A major hazard event that causes widespread disruption to a community or region, with significant demographic, economic and/or environmental losses, and which the affected community is unable to deal with adequately without outside help.
Risk	The probability of a hazard event causing harmful consequences (expected losses in terms of death, injuries, property damage, economy and environment).
Vulnerability	The geographic conditions that increase the susceptibility of a community to a hazard or to the impacts of a hazard event.
Hazard perception	The degree to which a hazard is considered to be a threat by different people.
Secondary hazards	Indirect effects or secondary effects of a natural hazard occurring after the initial primary hazards.
Hazard	A threat (whether natural or human) that has the potential to cause loss of life, injury, property damage, socio-economic disruption or environmental degradation.
Resilience	The ability to protect lives, livelihoods and infrastructure from destruction, and to the ability to recover after a hazard has occurred.
Adaptation	Ways in which human activities/ actions are altered to take into account the increasing risk of hazards.

This optional theme focuses on geophysical hazard events. Geophysical hazards include internal earth processes, such as earthquakes and volcanic activity, and mass movements such as landslides, rockslides, debris or mud flows. The theme also includes the human impacts and responses. It considers the concepts of risk and vulnerability, resilience and adaptation.

You will read case studies about contrasting geophysical hazard events (contrasting can be interpreted as severity of impacts and/ or locations with different socio-economic realities):

- two earthquake hazard events of similar magnitudes but with very contrasting human impacts
- two volcanic hazard events in contrasting plate boundary locations
- two mass movement hazard events with contrasting physical characteristics (fast/ slow; solid/loose).

Key questions

1. How do geophysical **processes** give rise to geophysical events of differing types and magnitudes?
2. How do geophysical systems generate hazard risks for different **places**?
3. How does the varying **power** of geophysical hazards affect people in different local contexts?
4. What are the future **possibilities** for lessening human vulnerability to geophysical hazards?

1 Geophysical systems

Conceptual understanding

Key question

How do geophysical **processes** give rise to geophysical events of differing types and magnitudes?

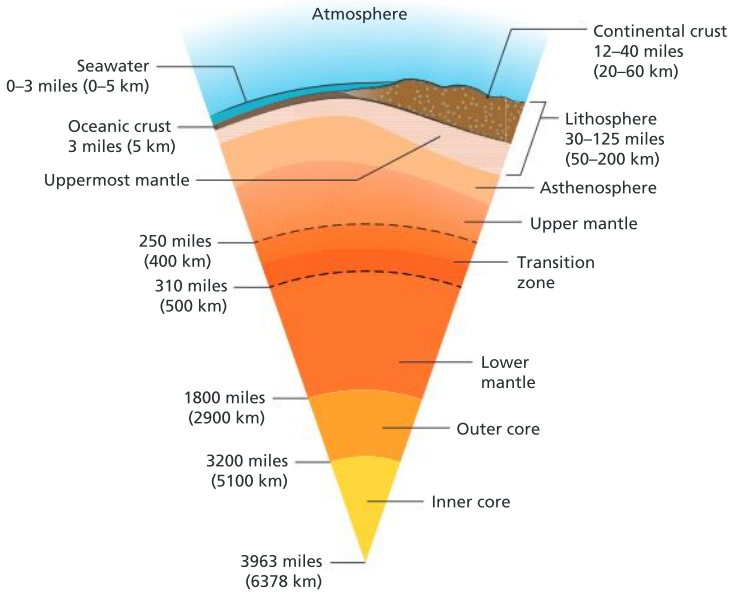
Key content

- Mechanics of plate movement including internal heating, convection currents, plumes, subduction and rifting at plate margins
- Characteristics of volcanoes (shield, composite and cinder) formed by varying types of volcanic eruption, and associated secondary hazards (pyroclastic flows, lahars, landslides)
- Characteristics of earthquakes (depth of focus, epicentre and wave types) caused by varying types of plate margin movement and human triggers (dam building, resource extraction) and associated secondary hazards (tsunami, landslides, liquefaction, transverse faults)
- Classification of mass movement types according to cause (physical and human), liquidity, speed of onset, duration, extent and frequency

Mechanisms of plate movement

The theory of plate tectonics states that the Earth is made up of a number of layers (Figure D.1). On the outside there is a very thin rigid crust, that is composed of thicker continental crust and thinner oceanic crust. Underneath is a flowing but solid mantle that makes up 82 per cent of the volume of the Earth. Deeper still is a very dense and very hot core, the outer core being liquid and the inner core solid. In general these concentric layers become increasingly more dense towards the centre. The density of these layers is controlled by temperature and pressure.

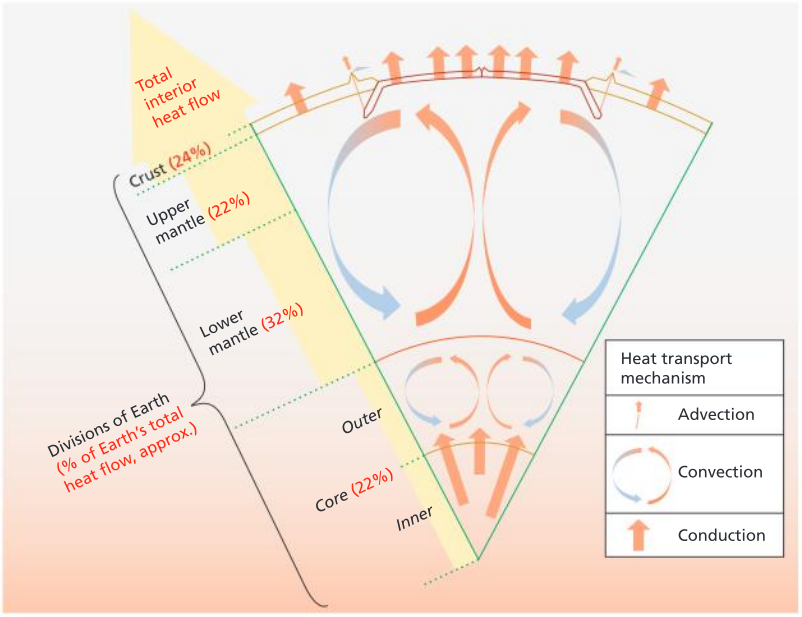
▼ **Figure D.1:** The internal structure of the Earth



The flow of heat from the Earth's interior to the surface comes from two main sources – radiogenic (that is, radioactive decay of materials in the mantle and the crust) and primordial heat (that is, the heat lost by the Earth as it continues to cool from its original formation). Earth heat transport occurs by convection, conduction and volcanic advection. Most of the Earth's internal heat flow is due to mantle convection, with the remaining heat mainly originating in the Earth's crust. Only about

1 per cent is due to volcanic activity, earthquakes and mountain building. Almost all of the Earth's internal heat loss at the surface is by conduction through the crust.

Large-scale convection currents occur in the Earth's interior. Hot magma rises through the core to the surface and then spreads out at mid-ocean ridges. The cold solidified crust sinks back into the Earth's interior because it is heavier and denser than the surrounding material. The cause of the movement is radioactive decay of uranium and potassium in the mantle.

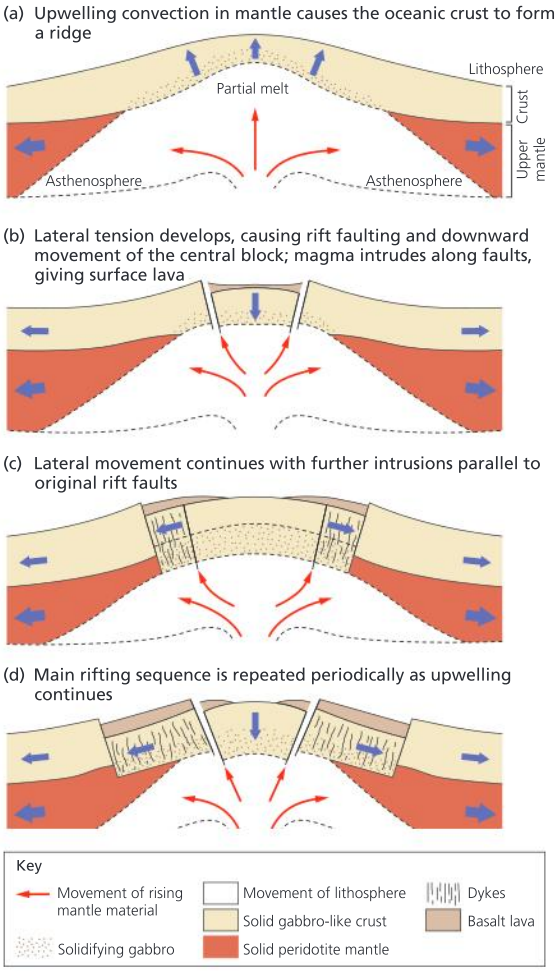


▲ **Figure D.2:** Global internal heat flow
Source: Percentages based on review in Dye, ST. 2012. "Geoneutrinos and the radioactive power of the Earth". *Reviews of Geophysics*, 50(3); and Arevalo Jr, R, McDonough, WF and Luong, M. 2009. "The K/U ratio of the silicate Earth: Insights into mantle composition, structure and thermal evolution". *Earth and Planetary Science Letters*, 278(3). Pp 361–69.

Subduction refers to the plunging of one plate beneath another. Subduction zones form where an oceanic lithospheric plate collides with another plate – whether continental or oceanic. The density of the oceanic plate is similar to that of the **aesthenosphere**, so it can be easily pushed down into the upper mantle. Subducted (lithospheric) oceanic crust remains cooler, and therefore denser than the surrounding mantle, for millions of years; so once initiated, subduction carries on, driven, in part, by the weight of the subducting crust. The subducting plate drags or pulls the rest of the plate behind it. Plates are hot at the mid-ocean ridge but cool as they move away.

A plume refers to a small area of unusually high heat flow. Plumes or hotspots can cause movement, that is, the outward flow of viscous rock from the centre may create a drag force on the plates and cause them to move. Most plumes are found near plate margins and they may be responsible for the original rifting of the crust. However, the world's most abundant source of lava, the Hawaiian Hotspot, is not on the plate margin.

Rifting occurs at constructive plate boundaries, for example the East Africa Rift Valley or the rift at Thingvellir, Iceland, where the North American Plate and the Eurasian Plate are moving away from each other. In each case, hotspot activity is believed to be the main cause of rifting. The rift valleys created consist of rock that is hotter and less dense than the older, colder plate. Hot material wells up beneath the ridges to fill the gaps created by the spreading plates.



▲ **Figure D.3:** Rifting

Activity 1

1. Describe the main internal heat flows within the Earth.
2. Explain how convection currents may lead to rifting.

▲ **Photo D.1:** Mount Etna showing many craters and a restaurant

ATL Research skills

Use a search engine to find images of the volcanoes mentioned in the text. Describe the main characteristics of at least two contrasting volcanoes.

Volcanoes

There are many types of volcano formed by various kinds of eruption. Three of the most common are shield, composite and cinder volcanoes.

Shield volcanoes

Shield volcanoes build up when there is no explosive activity, therefore no ejected fragments. Shield volcanoes are formed from very hot, runny basaltic lava. Because it is so hot, the lava can flow great distances. It builds up shield volcanoes, which have gently sloping sides, a shallow crater and a large circumference.

This type of volcano can be found in Hawaii, for example Mauna Loa which has a shallow crater and side with a slope of just 6°. The circumference of Mauna Loa is 16 km whereas the diameter of the volcano is 110 km at sea level. The summit is 4,171 m above sea level, but the total height from its base on the sea floor is 9,750 m, and its diameter on the sea floor is 500 km. The volcano is still active and there were many large-scale lava flows during the 20th century.

Composite volcanoes

Composite (or strato) volcanoes are the most common type of volcano and are formed by alternating eruptions of fragmental material followed by lava outflows. These volcanoes are characterized by slopes of 3° near the summit and 5° near the base. The highest volcanoes in the world are of this type, for example Mount Etna and Vesuvius in Italy, Chimborazo and Popacatepetl in Mexico.

The main cone consists of layers of ash and lava, fed from the main pipe, which accumulates in a crater. In some cases, a large explosion may blow the top off the cone and form a much larger crater within which a secondary cone may develop. Frequently, parasitic cones grow on the sides, as for example on Mount Etna. Sometimes a volcano can suffer a very violent eruption after a long period of inactivity. The pipe becomes plugged with cooled lava, the pressure of gas builds up and the result is a violent explosion, for example Vesuvius in AD 79. The volcano erupted violently and a large part of the crater was blown away.

Cinder volcanoes

Cinder volcanoes are formed by fragments of solid material which accumulate as a steep conical hill around the vent to form a cone. The shape depends on the nature of the material. It is usually concave as the material spreads out near the base and has a steep angle of 30°–40° depending on the size of the material. Cinder and ash cones are not usually very high (up to 300 m) with the exception Volcano Du Fuego in Guatemala which is 3,350 m and all ash. There are many ash and cinder cones in the western USA such as Big Cinder Butte and Inferno Cone.

The eruptions are violent – lava is ejected into the atmosphere and breaks up into cinders, ash and other fragments.

Volcanic eruptions

Lava eruptions

The amount of silica in a lava eruption is what makes the difference between the volcanoes in Iceland and Hawaii (which erupt continuously) and those in Japan and the Philippines (where eruptions are infrequent but violent). Lava released where the oceans meet the continents absorbs silica-rich sediments. This causes the lava to become more viscous and block the vents until enough pressure has built up to break them open.

Icelandic lava eruptions are characterized by persistent fissure eruption (Figure D.4). Large quantities of basaltic lava may build up vast horizontal plains. On a large scale these have formed the Deccan Plateau and the Columbia Plateau.

Unlike the Icelandic lava eruptions, Hawaiian eruptions involve a central vent. Occasional pyroclastic activity occurs, but this is less important than the lava eruption. Runny basaltic lava flows down the sides of the volcano and gases escape easily.

Pyroclastic eruptions

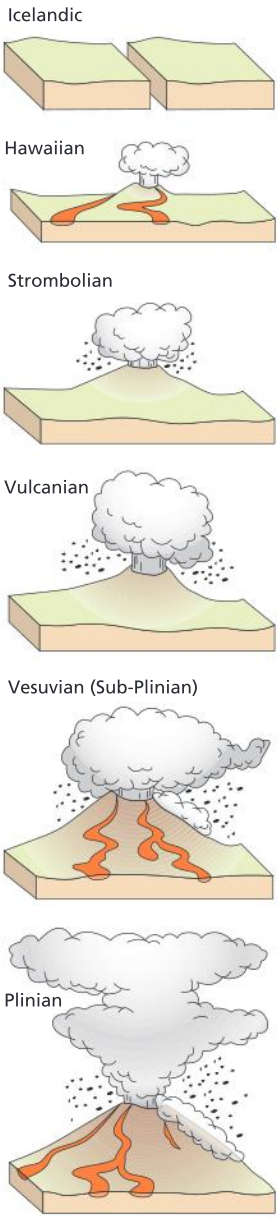
Strombolian eruptions are explosive eruptions that produce pyroclastic rock. Eruptions are commonly marked by a white cloud of steam emitted from the crater. Frequent gas explosions blast quantities of runny lava into the air, and when these settle and cool they form the cone.

Vulcanian eruptions are violent and occur when the pressure of trapped gases in viscous magma becomes sufficient to blow off the overlying crust of solidified lava. Often the eruption clears a blocked vent and spews large quantities of volcanic ash into the atmosphere. Violent gas explosions blast out plugs of sticky or cooled lava. Fragments build up the cone of ash and pumice.

Vesuvian eruptions are characterized by very powerful blasts of gas that push ash clouds high into the sky. Lava flows also occur. Ash falls to cover the surrounding area.

Plinian eruptions are extremely violent eruptions characterized by huge clouds of pulverized rock and ash that are kilometres thick. Gas rushes up through the sticky lava and blasts ash and fragments into the sky in huge explosions. Gas clouds and lava can also rush down the slopes. Part of the volcano may be blasted away during the eruption.

Large quantities of viscous magma are erupted in Pelean eruptions. Named after the 1902 Mount Pelee eruption, these are violent eruptions of viscous magma, forming glowing ash ("nuee ardentes") associated with pyroclastic flows, which produce steep-sided conical volcanoes.



▲ **Figure D.4:** Volcanic eruptions and their effect on relief

▲ **Photo D.2:** A pyroclastic flow, Soufrière Hills, Montserrat

Volcanic hazards

There are a number of primary and secondary hazards associated with volcanic eruptions. The primary **hazards** are the direct impacts of the eruption, for example lava flows, ash fallout, pyroclastic flows and gas

emissions. Secondary hazards may be due to the way that the ejected material reacts or changes form. For example, ash may join with rainwater to form mudflows (lahars), or heat from the volcano may melt snow and ice to trigger a glacial flood (jokulhlaup).

Ash and debris that has travelled through the air and fallen to the ground is known as pyroclastic fall deposits. These can be very dangerous, especially as the fine ash particles can damage people's lungs. Also ash is fairly heavy – a small layer only a few centimetres thick can be enough to cause a building to collapse. Dust and fine particles cause havoc with global climate patterns. Pyroclastic flows are powerful enough to knock down trees and to leave a trail of destruction. Some of them are extremely hot – up to 700°C – and can travel at speeds of over 500 km/hour.

The hazards associated with volcanic eruption also vary spatially. Close to the volcano people are at risk from large fragments of debris, ash falls and poisonous gases. Further away pyroclastic flows may prove hazardous, and mudflows and debris flows may have an impact on more distant settlements.

Landslides are also associated with volcanic activity. Two main types occur – debris avalanches and lahars. Debris avalanches commonly occur around the same time as an eruption, and they may also help the eruption to occur. One of the most famous is the massive landslide on Mt St Helens in 1980 which was triggered by an earthquake. The landslide contained over 1 km^3 of material, and released pressure on the flank of Mt St Helens and was partially responsible for the horizontal blast from the volcano.

Lahars are a form of landslide (mass movement). A combination of heavy rain and unstable ash increases the risk of lahars. One particularly serious lahar occurred on the volcanic deposits on Casita Volcano in Nicaragua. The debris became saturated with rainwater from Hurricane Mitch. The lahar killed over 2,000 people as it flowed down towards the towns of El Porvenir and Rolando Rodriguez.

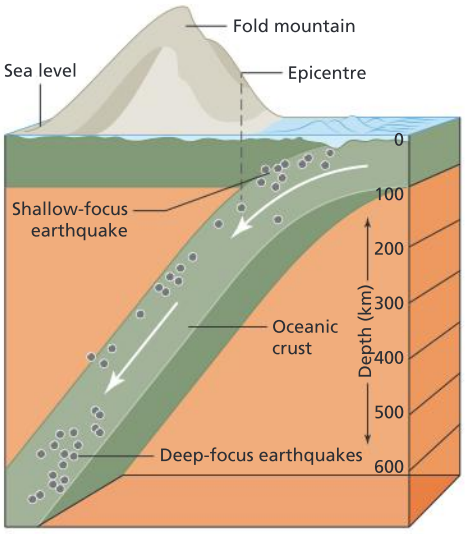
Volcanic gases are an example of a direct or primary hazard. Cameroon lies just north of the equator in West Africa. It contains a large number of deep-crater lakes, such as Lake Nyos, formed as a result of tectonic activity. In August 1986 a huge volume of gas escaped from the lake and swept down into neighbouring valleys for a distance of up to 25 km. The ground-hugging clouds of gas were up to 50 m thick and travelling at speeds of over 70 km per hour. Some 1,700 people were suffocated, 3,000 cattle died, and all other animal life in the area was killed. Plants, however, were unaffected. The gas was carbon dioxide. Because it is heavier and denser than oxygen, the 50 m cloud deprived people and animals of oxygen, so they were asphyxiated. The source of carbon dioxide was a basaltic chamber of magma, deep beneath Cameroon.

Earthquakes

An earthquake is a series of seismic vibrations or shock waves which originate from the **focus** – the point at which the plates release their tension or compression suddenly (Figure D.5). The **epicentre** marks the point on the surface of the Earth immediately above the focus of the earthquake.

Shallow-focus earthquakes occur relatively close to the ground surface, whereas deep-focus earthquakes occur at considerable depth under the ground. Shallow-focus earthquakes have greater potential to do damage as less of the energy released by the earthquake is absorbed by overlying material.

A large earthquake can be preceded by smaller tremors known as foreshocks and followed by numerous aftershocks. Aftershocks can be particularly devastating because they damage buildings that have already been weakened by the first main shock. Seismic waves are able to travel along the surface of the Earth and also through the body of the Earth.



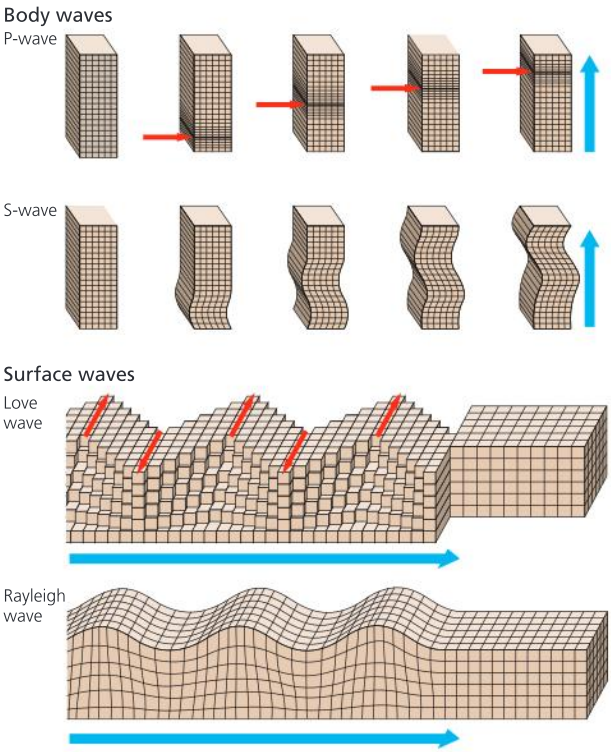
▲ **Figure D.5:** Shallow- and deep-focus earthquakes, and the epicentre

Wave types

When an earthquake occurs it creates different types of shock waves. Two main types of waves occur: body waves and surface waves (Figure D.6). Body waves are transmitted upwards towards the surface from the focus of the earthquake. Shock waves inside the Earth include the following.

- Primary (P) waves or pressure waves are the fastest and can move through solids and liquids – they shake the earth backwards and forwards.
- Secondary (S) waves or shear waves move with a sideways motion and are unable to move through liquids – they make the ground move horizontally, causing much damage.

When P-waves and S-waves reach the surface, some of them are transformed into surface waves:



▲ **Figure D.6:** Body waves and surface waves

▲ **Photo D.3:** Lahars, Montserrat

- Love waves cause the ground to move sideways.
- Rayleigh waves cause the ground to move up and down.

Love waves and Rayleigh waves travel slowly through the crust, but they cause the most damage.

P-waves and S-waves are transmitted from the earthquake focus to the surface. By contrast, surface waves are produced in the ground by the transformation of some body waves once they reach the surface.

P-waves travel fastest (up to 6.1 km/sec); hence, the first movement felt is from a P-wave. The deeper that the wave is in the mantle, the faster it travels. By contrast, the waves are slowed down and refracted in the semi-liquid core. P-waves travel faster than S-waves because they are condensational/compressional, like sound waves, compressing and expanding rock and liquid in the same direction in which they move. When a P-wave reaches the surface, it makes the ground move, mostly vertically. (It also compresses the air, which can create the sound of an explosion when an earthquake occurs.)

S-waves, by contrast, are distortional. They move with a side-to-side shearing motion, making them slower (they travel at 4.1 km/sec) and are unable to travel through liquids. They make the ground move both vertically and horizontally. Since buildings cannot withstand much horizontal stress, S-waves do far more damage than P-waves.

Activity 2

1. Describe the main differences between P-waves and S-waves.
2. Outline the differences between Love waves and Rayleigh waves.

Earthquakes and plate boundaries

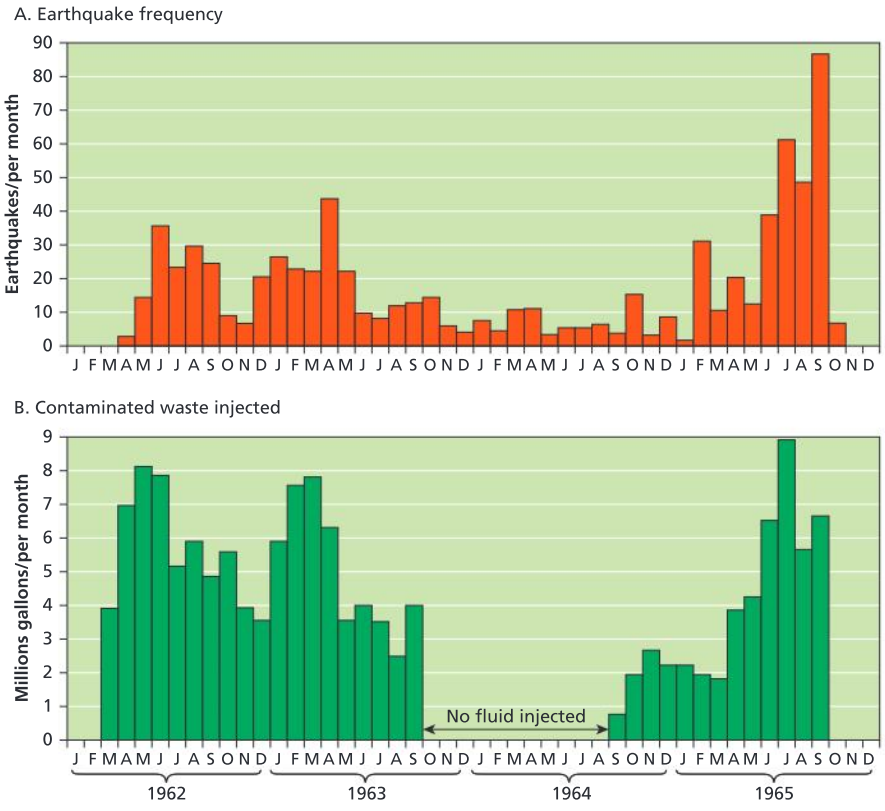
The movement of oceanic crust into the subduction zone creates some of the deepest earthquakes recorded, up to 700 km below the ground. When the oceanic crust slides into the hotter fluid mantle it takes time to warm up. As the slab descends, it distorts and cracks and eventually creates earthquakes. However, subduction is relatively fast, so by the time the crust has cracked it has slid several hundred kilometres down into the mantle.

In areas where there is a lot of earthquake activity the chances of an earthquake grow as the length of time since the last earthquake increases. Plates move at a rate of between 1.5 cm and 7.5 cm a year (the rate of fingernail growth). However, a large earthquake can involve a movement of a few metres, which could occur every couple of hundred years rather than movements of a few centimetres each year. Many earthquakes are caused by the pressure created by moving plates. This increases the stress on rocks, the rocks deform and eventually give way and snap. The snapping is the release of energy, namely the earthquake. The size of the earthquake depends upon the thickness of the descending slab and the rate of movement. Along mid-ocean ridges brittle faults occur as magma cools, solidifies and then cracks due to upwelling magma from below. Earthquakes here are small because the brittle faults cannot extend more than a few kilometres.

Human triggers

Nevertheless, many earthquakes occur a long way from any plate boundary. Some of these are related to human activity, such as the construction of large dams, mining, fracking and the testing of nuclear weapons.

For example, during the 1960s waste water from the Rocky Mountain Arsenal in Denver, Colorado, was injected into underlying rocks. The water had been contaminated by chemical warfare agents, and the toxic wastes were too costly to transport off site for disposal. Thus it was decided to dispose of it down a disposal well that was over 3,500 m deep. Disposal began in March 1962, and soon afterwards there was a series of minor earthquakes in an area previously free of earthquake activity. None of the earthquakes caused any real damage, but they caused alarm. Between 1962 and 1965 over 700 minor earthquakes were monitored in the area.



▲ **Figure D.7:** Earthquake frequency and underground liquid waste disposal

The injection of the liquid waste into the bedrock lubricated and reactivated a series of deep underground faults which had been inactive for a long time. The more waste water that was pumped down the well, the larger the number of minor earthquakes (Figure D.7). When the link was discovered, disposal stopped. The well was filled in 1966 and the number of minor earthquake events detected in the area fell sharply.

Man-made earthquakes have been known about in the UK since at least 1755, when collapsing lead mines in Derbyshire shook the ground. According to an article in the *Guardian* (9 September 2015), at least three earthquakes occur in the UK every year as a result of human activity.

A study of the 8,000 earthquakes recorded under the UK (excluding the sea) between 1970 and 2012 found that in 1991 more than 40 earthquakes linked to human activities were recorded in the UK. But with the gradual closure of the deep coal mines, the number of tremors has fallen by 95 per cent.

Since 1970, at least one in five earthquakes under the UK have been man-made.

Fracking (also known as hydraulic fracturing) is a process in which water, containing certain chemicals, is injected at very high pressure into rocks in order to open up their pore spaces and release natural

Activity 3

Study Figure D.7 which shows the relationship between earthquake frequency and underground liquid waste disposal. Describe the relationship between the two variables. Suggest reasons to explain the relationship.

gas contained within the rocks. Fracking has been associated with the triggering of earthquakes in the UK. In 2011, fracking led to a 2.3 magnitude earthquake in Lancashire.

To date, the biggest published example of a fracking earthquake is 4.4 magnitude in Canada, which occurred in 2014. Experts believe that the man-made earthquakes in the UK's shale-bearing rocks are unlikely to be greater than magnitude 3, which rarely cause any damage. Tremors under magnitude 2 are not usually felt by people.

Underground nuclear testing has triggered earthquakes in a number of places. In 1968 underground testing of a series of 1,200 tonne bombs in Nevada set off over 30 minor earthquakes in the area over the following three days. Since 1966, France has carried out over 80 underground nuclear explosion tests on the Polynesian island of Moruroa. More than 120,000 people live on the island. In 1966 a 120,000 tonne nuclear device was detonated, producing radioactive fallout which was measured over 3,000 km downwind.

Earthquakes can be caused by adding increased loads on previously stable land surfaces. For example, the weight of water behind large reservoirs can trigger earthquakes. In 1935 the Colorado river was dammed by the Hoover Dam to form Lake Mead. As the lake filled, and the underlying rocks adjusted to the new increased load of over 40 km^3 of water, long-dormant faults in the area were reactivated, causing more than 6,000 minor earthquakes over the next 10 years. Over 10,000 events were recorded up to 1973, about 10 per cent of which were strong enough to be felt by residents. None caused damage.

Resultant hazards of earthquakes

Most earthquakes occur with little if any advance warning. Some places, such as California and Tokyo which have considerable experience of earthquakes, have developed "earthquake action plans" and information programmes to increase public awareness about what to do in an earthquake.

Most problems are associated with damage to buildings, structures and transport systems (Table D.1). The collapse of building structures causes many injuries and deaths, and it also affects the work of the emergency services. In some cases, more damage is caused by the aftershocks that follow the main earthquake, as they shake the already weakened structures. Aftershocks are more subdued but longer lasting and more frequent than the main tremor. Buildings partly damaged during the earthquake may be completely destroyed by the aftershocks.

Some earthquakes involve large-scale earth movement, generally along fault lines. This may lead to the fracture of gas pipes as well as causing damage to transport routes and lines of communication. The cost of repairing such fractures is considerable.

Transverse faults occur where the movement is horizontal but the fracture is vertical, and they are the product of earthquakes. The San Andreas Fault in California is a transverse fault between the North American and Pacific plates. It does not move smoothly but intermittently following the build-up of pressure.

ATL Research and communication skills

Use the *New Scientist* article "How fracking caused earthquakes in the UK" (https://www.newscientist.com/article/dn21120-how-fracking-caused-earthquakes-in-the-uk/) and the full *Guardian* article discussed above (http://www.theguardian.com/environment/2015/sep/09/uk-experiences-three-earthquakes-a-year-due-to-human-activity-study-says) and make a short presentation to your class called "Outline of the evidence for the human causes of earthquakes".

Earthquakes may cause other geomorphological hazards such as landslides, **liquefaction** and **tsunamis**. For example, the Good Friday earthquake (magnitude 8.5) that shook Anchorage, Alaska, in March 1964 released twice as much energy as the 1906 San Francisco earthquake, and was felt over an area of nearly 1.3 million km^2. More than 130 people were killed, and over $500 million of damage was caused. It triggered large avalanches and landslides which caused a huge amount of damage. It also caused a series of tsunamis through the Pacific as far as California, Hawaii and Japan.

The relative importance of factors affecting earthquakes varies a great deal. For example, the Kobe earthquake of January 1995 had a magnitude 7.2 and caused over 5,000 deaths. By contrast, the Northridge earthquake that affected parts of Los Angeles in January 1994 was 6.6 on the Richter scale but caused only 57 deaths. On the other hand, an earthquake of force 6.6 at Maharashtra in India, in September 1993, killed over 22,000 people.

Why did these three earthquakes have such differing effects? Kobe and Los Angeles are in known earthquake zones, and buildings are built to withstand earthquakes. In addition, local people have been prepared for earthquake events. By contrast Maharashtra has little experience of earthquakes. Houses were unstable and quickly destroyed, and people had little idea about how to manage the situation.

Another earthquake in an area not noted for seismic activity shows that damage is often most serious where buildings are not designed to withstand shaking or ground movement. In the 1992 Cairo earthquake, many poor people in villages and the inner city slums of Cairo were killed or injured when their old, mud-walled homes collapsed. At the same time many wealthy people were killed or injured when modern high-rise concrete blocks collapsed – some of these had actually been built without planning permission.

▼ **Table D.1:** Earthquake hazards and impacts

Primary hazard	**Impacts**
Ground shaking	Loss of life
Secondary hazard	Loss of livelihood
Ground failure and soil liquefaction	Total or partial destruction of buildings
Landslides and rockfalls	Interruption of water supplies
Debris flow and mudflow	Breakage of sewage disposal systems
Tsunamis	Loss of public utilities such as electricity and gas
	Floods due to collapsed dams
	Release of hazardous material
	Fires
	Spread of chronic illness due to lack of sanitary conditions

Mass movements

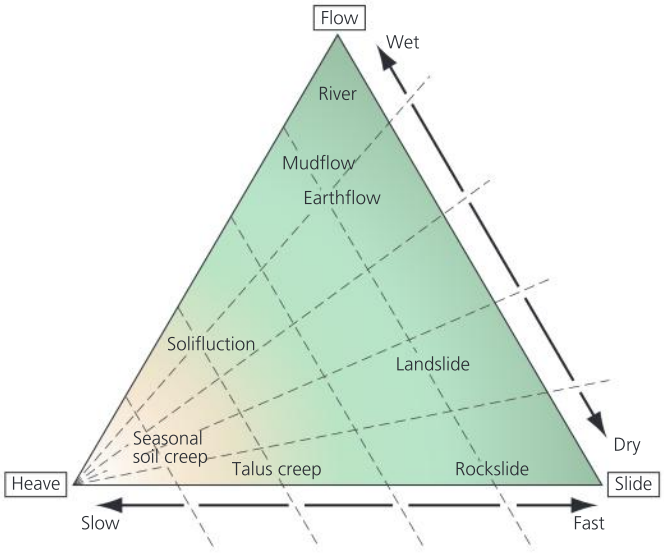
Mass movements include any large-scale movement of the Earth's surface that are not accompanied by a moving agent such as a river, glacier or ocean wave. They include:

- very slow movements, such as soil creep
- fast movement, such as avalanches
- dry movement, such as rockfalls
- very fluid movements, such as mudflows.

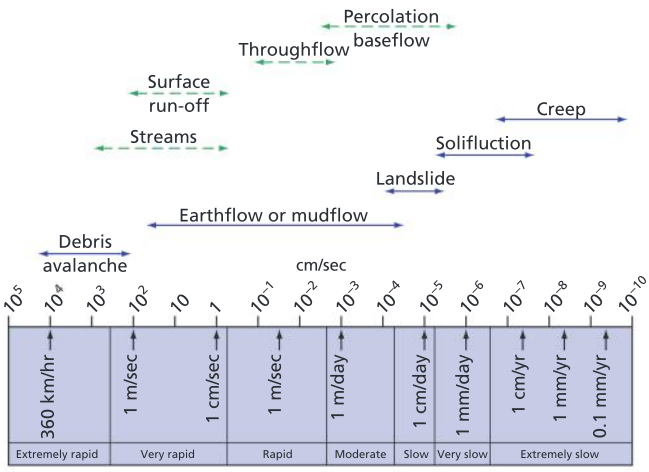
A range of slope processes (for example, overland flow and mudflows) occur, which vary in terms of magnitude, frequency and scale. Some are large and occur infrequently, notably rockfalls, whereas others are smaller and more continuous, such as soil creep. The types of processes can be classified in a number of different ways:

- type of movement: flows, slides, slumps (Figure D.8)
- speed of movement (Figure D.9)
- water content
- material.

▲ **Photo D.4:** Mass movement–landslide



▲ **Figure D.8:** Types of mass movement



▲ **Figure D.9:** A classification of mass movements by speed

Activity 4

1. Estimate the speed of **a)** earthflows and mudflows, and **b)** solifluction.
2. Classify the following mass movements: soil creep, solifluction and rockslides.

Activity 5

1. Explain how shear strength and shear stress affect a slope's potential to fail.
2. Outline the main primary and secondary hazards associated with earthquakes.

Causes of mass movements

The likelihood of a slope failing can be expressed by its safety factor. This is the relative strength or resistance of the slope compared with the force that is trying to move it. The most important factors that determine movement are gravity, slope angle and pore pressure.

Gravity has two effects. First it acts to move the material downslope (a slide component). Second it acts to stick the particles to the slope (a stick component). The downslope movement is proportional to the weight of the particle and slope angle. Water lubricates particles and in some cases fills the spaces between the particles. This forces them apart under pressure. Pore pressure will greatly increase the ability of the material to move. This factor is of particular importance in movements of wet material on low-angle slopes.

Slope failure is caused by two factors:

- a reduction in the internal resistance, or **shear strength**, of the slope
- an increase in **shear stress** – that is, the forces attempting to pull a mass downslope.

Both can occur at the same time.

▼ **Table D.2:** Increasing stress and decreasing resistance

Factor	Examples
Factors contributing to increased shear stress	
Removal of lateral support through undercutting or slope steepening	Erosion by rivers and glaciers, wave action, faulting, previous rockfalls or slides
Removal of underlying support	Undercutting by rivers and waves, subsurface solution, loss of strength by exposure of sediments
Loading of slope	Weight of water, vegetation, accumulation of debris
Lateral pressure	Water in cracks, freezing in cracks, swelling, pressure release
Transient stresses	Earthquakes, movement of trees in wind

Factor	Examples
Factors contributing to reduced shear strength	
Weathering effects	Disintegration of granular rocks; hydration of clay minerals; chemical solution of minerals (that is, the weathering of certain chemicals, notably calcium carbonate), in rock or soil
Changes in pore water	Saturation, softening of material pressure
Changes of structure	Creation of fissures in clays, remoulding of sands and clays
Organic effects	Burrowing of animals, decay of roots

Case study

Nepal landslides, 2015

Landslides are common in Nepal. The region, with its young geology, seismic activity, steep slopes and intense cloudbursts, has a history of earth-moving events. Factors that trigger landslides include seasonal rainfall, road construction and slopes weakened by previous slides. Unfortunately, all of these factors contributed to huge landslides in some parts of Nepal during the Gorkha earthquake of April 2015. One of the largest was an ice and rock avalanche at Langtang. This caused substantial loss of life as entire settlements were buried. The landslide consisted of a large mass of freefall rock and ice, shearing off more rock on its descent. The vertical distance was 700–800 m over a horizontal distance of 2–3 km. The valley below was severely obstructed and covered by debris. It looks like the threat of landslides will continue to exist in this impoverished and vulnerable country.

In contrast to Nepal, in many parts of the world people live on or near landslides that can be managed up to a point. The town of Taihape on the North Island, New Zealand, is built on a slow-moving earthflow. Monitoring is used to ensure that the town remains safe.

Concepts in context

There are many **processes** operating to produce geophysical hazards. Some of these are very long term, such as the radioactive decay in the Earth's core, helping to drive convection currents. Others are very short term, such as earthquakes, although their impact may be long term. Some are extremely powerful, such as a supervolcano, whereas others are not, such as soil creep and solifluction (types of mass movement). Human activities can be seen to be increasing the frequency of many geophysical hazards, including landslides and earthquakes.

Check your understanding

1. Identify the three main layers within the Earth.
2. Outline what the main internal heat flow is within the Earth.
3. Describe the process of subduction.
4. Outline the main differences between shield volcanoes and composite volcanoes.
5. Distinguish between primary and secondary volcanic hazards.
6. Distinguish between the focus and epicentre of an earthquake.
7. Compare primary (P) waves and secondary (S) waves.
8. Define the term "mass movement".
9. Briefly explain the term "shear strength".
10. Briefly explain the term "shear stress".

2 Geophysical hazard risks

Conceptual understanding

Key question

How do geophysical systems generate hazard risks for different places?

Key content

- The spatial distribution of geophysical hazard events (earthquakes, volcanoes, mass movements)
- The relevance of hazard magnitude and frequency/recurrence intervals for risk management
- Geophysical hazard risk as a product of economic factors (levels of development and technology), social factors (education, gender), demographic factors (population density and structure) and political factors (governance)
- Geographical factors affecting geophysical hazard event impacts, including rural/urban location, time of day and degree of isolation

Spatial distribution of geophysical hazard events

Earthquakes

Tectonic hazards include seismic activity (earthquakes), volcanoes and tsunamis. Most of the world's earthquakes occur in clearly defined linear patterns (Figure D.10). These linear chains generally follow plate boundaries. For example, there is a clear line of earthquakes along the centre of the Atlantic Ocean in association with the Mid-Atlantic Ridge (a constructive plate boundary). Similarly, there are distinct lines of earthquakes around the Pacific Ocean. In some cases these linear chains are quite broad. For example, the line of earthquakes along the west coast of South America and around the eastern Pacific is associated with the subduction of the Nazca Plate beneath the South American Plate, a destructive plate boundary. Broad belts of earthquakes are associated with subduction zones (where a dense ocean plate plunges beneath a less-dense continental plate), whereas narrower belts of earthquakes are associated with constructive plate margins, where new material is formed and plates are moving apart. Collision boundaries, such as in the Himalayas, are also associated with broad belts of earthquakes, whereas conservative plate boundaries, such as California's San Andreas fault line, give a relatively narrow belt of earthquakes (although this can still be over 100 km wide). In addition, there appear to be isolated occurrences of earthquakes. These may be due to human activities or to isolated plumes of rising magma known as hotspots.

Volcanoes

Most volcanoes are found at plate boundaries although there are some exceptions, such as the volcanoes of Hawaii, which occur over hotspots. About three-quarters of the Earth's 550 historically active

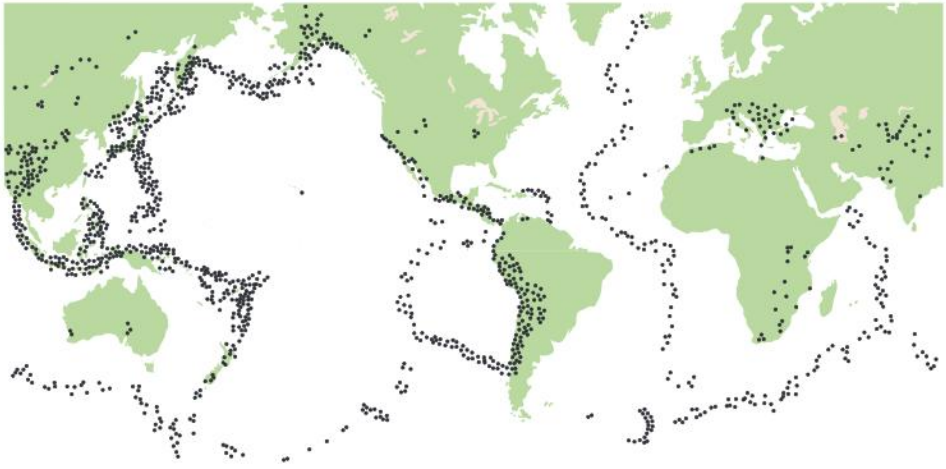


Figure D.10: Spatial distribution of earthquakes

volcanoes lie along the Pacific Ring of Fire (Figure D.11). This includes many of the world's most recent volcanoes, such as Mt Pinatubo (the Philippines), Mt Unzen (Japan), Mt Agung (Java), Mt Chichon (Mexico), Mt St Helens (USA) and Nevado del Ruiz (Colombia). Other areas of active vulcanicity include Iceland, Montserrat in the Caribbean and Mt Nyiragongo in the Democratic Republic of Congo. Most volcanoes that are studied are above ground, but some submarine volcanoes, such as Kick 'em Jenny off Grenada in the Caribbean, are also monitored closely.

Volcanoes are found along the boundaries of the Earth's major plates. Although the deeper levels of the Earth are much hotter than the surface, the rocks are usually not molten because the pressure is so high. However, along the plate boundaries there is molten rock (magma), which feeds the volcanoes.

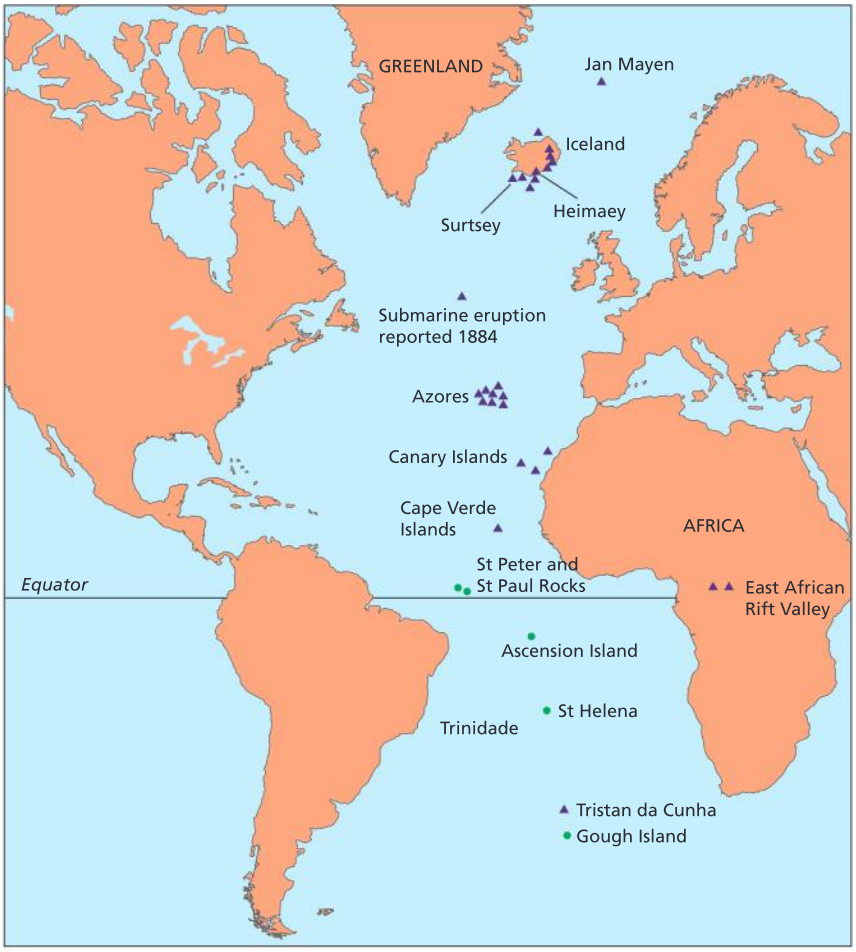
The volcanoes in the Pacific Rim or Ring of Fire are caused by the subduction beneath either the oceanic or continental crust. Subduction in the oceans provides chains of volcanic islands known as island arcs, such as the Aleutian Islands formed by the Pacific Plate subducting beneath the North American Plate. Where the subduction of an oceanic crust occurs beneath the continental crust, young fold mountains are formed. The Andes, for example, have been formed where the Nazca Plate subducts beneath the South American Plate.

Not all volcanoes are formed at plate boundaries. Those in Hawaii, for example, are found in the middle of the ocean. The Hawaiian Islands are a line of older volcanic islands that stretch north-west across the Pacific Ocean. These volcanoes have been caused by the movement of plates above a hot part of the fluid mantle. A **hotspot** or **mantle plume** – a jet of hot material rising from the deep within the mantle – is responsible for the volcanoes. There are a number of hotspots in the Atlantic and they are associated with volcanicity in the Canary Islands, Azores and Iceland (Figure D.12). Hotspots can also be found beneath continents, as in the case of the East African Rift Valley, and these can produce isolated volcanoes. These hotspots can play a part in the break-up of continents and the formation of new oceans.

Activity 6

1. Describe the spatial distribution of earthquakes.
2. Identify and locate:
   a. a constructive plate margin
   b. a destructive plate margin
   c. a collision zone.
3. Distinguish between continental and oceanic crust.

▼ **Figure D.11:** The Pacific Ring of Fire



▲ **Figure D.12:** Volcanicity in the Atlantic and the East African Rift Valley

Landslides

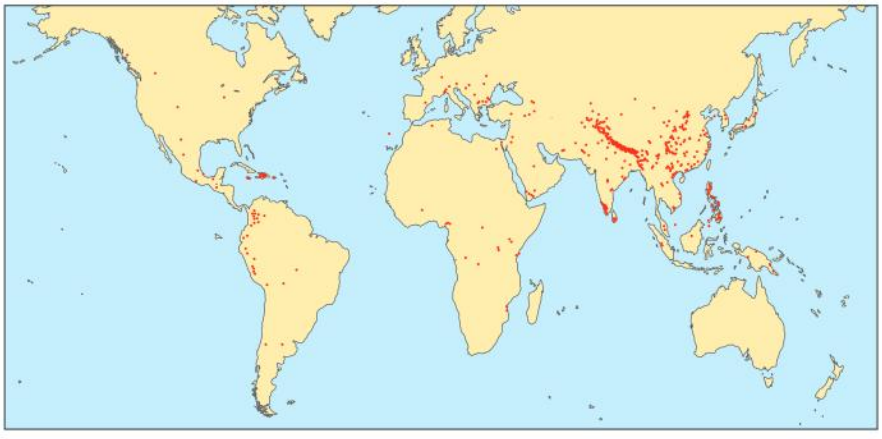
Landslides are naturally occurring phenomena in every environment on Earth, including the tropics, the temperate regions, the high latitudes and also the ocean. However, fatal landslides tend to be more common in areas that have:

- active tectonic processes that lead to high rates of uplift and occasional seismic events
- high levels of precipitation, including high annual totals and high short-term intensities
- a high population density.

Where one or two of these factors are absent, the risk of fatal landslides is reduced.

The map of fatal landslides (Figure D.13) shows that most fatal landslides occur in low-income countries where mitigation schemes are less likely to be in place. Those locations include:

- the southern edge of the Himalayan mountain chain
- central China
- south-west India
- along the western boundary of the Philippine sea plate through Japan, Taiwan and the Philippines
- central Indonesia, in particular the island of Java
- the Caribbean and central Mexico
- the western edge of South America, especially Colombia.



▶ **Figure D.13:** The distribution of fatal landslides, 2006–2007

There has also been a scattering of fatal landslides elsewhere, through Europe, tropical parts of Africa and North America.

The relevance of hazard magnitude and frequency/recurrence intervals for risk management

The **recurrence interval** or **return period** is the expected frequency of occurrence in years for an event of a particular size. In general, small events have a high frequency/short return period whereas large events have a very low frequency/high return period. Thus there are fewer highly destructive earthquakes but many minor ones (Table D.3 and Figure D.14). These are generalized into high-frequency/low-magnitude events versus low-frequency high-magnitude events. Low-frequency high-magnitude events cause the most destruction and require the greatest management.

Table D.3: Annual frequency of occurrence of earthquakes of different magnitude based on observations since 1900

Descriptor	Magnitude	Annual average	Hazard potential
Great	≥ 8	1	Total destruction, high loss of life
Major	7–7.9	18	Serious building damage, major loss of life
Strong	6–6.9	120	Large losses, especially in urban areas
Moderate	5–5.9	800	Significant losses in populated areas
Light	4–4.9	6,200	Usually felt, some structural damage
Minor	3–3.9	49,000	Typically felt but usually little damage

Photo D.5: St John's Cathedral, Antigua – rebuilt after a devastating earthquake in 1843

Left side of the chart shows the magnitude of the earthquake and right side represents the amount of high explosive required to produce the energy released by the earthquake. The middle of the chart shows the relative frequencies.

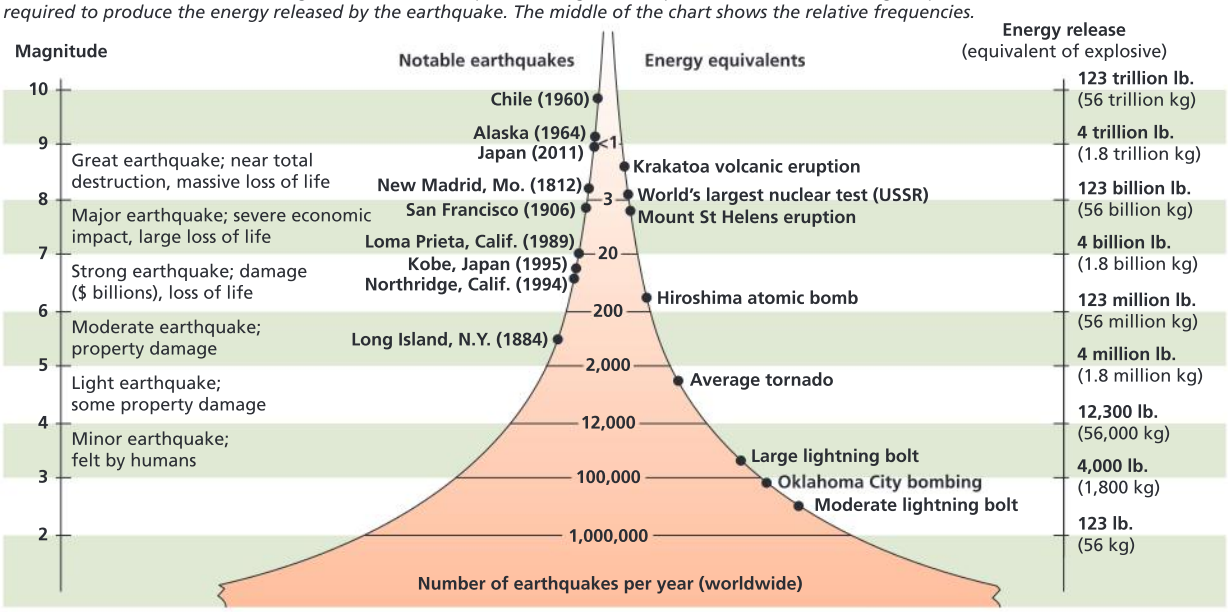


Figure D.14: Earthquake frequency and destructive power

Earthquake frequency and magnitude

In 1935 Charles Richter of the California Institute of Technology developed the Richter scale to measure the magnitude of earthquakes. The scale is logarithmic, so an earthquake of 5.0 on the Richter scale is 10 times more powerful than one of 4.0 and 100 times more powerful than one of 3.0. Scientists are increasingly using the **Moment Magnitude Scale (M)** which measures the amount of energy released and produces figures that are similar to the Richter scale. For every increase of 1 on the M scale the amount of energy released increases by over 30. Every increase of 0.2 represents a doubling of the energy released.

Measuring volcanoes

The strength of a volcano is measured by the Volcanic Explosive Index (VEI) (Table D.4). This is based on the amount of material ejected in the explosion, the height of the cloud it creates and the amount of damage caused. Any explosion above level 5 is considered to be very large and violent. A VEI 8, or supervolcano, ejects more than 1,000 km^3 of material, 10 times more than a VEI 7. The last eruption of a VEI 8 was about 74,000 years ago.

▼ **Table D.4:** Magnitude and frequency of volcanic eruptions

VEI	Classification	Description	Height of eruption column	Volume of materials erupted	Frequency of eruption	Example	Occurrences in last 10,000 years
0	Hawaiian	Non-explosive	<100 m	<10, 000 m^3	Daily	Kilauea	Many
1	Hawaiian/ Strombolian	Gentle	100–1,000 m	10,000 m^3	Daily	Hekla, Iceland (2000)	Many
2	Strombolian/ Vulcanian	Explosive	1–5 km	1,000,000 m^3	Weekly	Unzen, Japan (1990)	3,477
3	Vulcanian/ Pelean	Severe	3–15 km	10,000,000 m^3	Yearly	Nevado del Ruiz (1985)	868
4	Pelean/Plinian	Cataclysmic	10–25 km	0.1 km^3	≥10 years	Soufrière Hills (1995)	278
5	Plinian	Paroxysmal	25 km	1 km^3	≥50 years	Mt St Helens (1980)	84
6	Plinian/Ultra-Plinian	Colossal	25 km	10 km^3	≥100 years	Krakatoa (1883)	39
7	Plinian/Ultra-Plinian	Super-colossal	25 km	>100 km^3	≥1,000 years	Tambora	4
8	Plinian/Ultra-Plinian	Mega-colossal	25 km	>1,000 km^3	≥10,000 years	Toba (73,000 BP)	None

Table D.5: Selected catastrophic landslides of the 20th and 21st centuries and their impacts

Year	Location	Landslide volume (m^3)	Trigger	Impacts	Comments
1933	Diexi, Sichuan Province, China	150×10^9	M7.5 earthquake	2,400 killed; Min river dammed for 45 days	Draining of the lake by over-spilling
1963	Vaoint Dam, Italy	270×10^6	Heavy precipitation and high lake levels	2,000 killed; rockslide led to a catastrophic flood	A 100 m wave of water overtopped the hydroelectric dam; possible reactivation of a relict landslide
1970	Nevado Huascaran rock debris/avalanche (Peru)	305×10^6	M7.7 earthquake	18,000 killed; city of Yungay destroyed	Average velocity 280 km/hr; same peak affected by similar failure in 1962 (4,000–5,000 killed)
1980	Mt St Helens	2.8×10^9	Volcanic eruption	5–10 killed; most people evacuated; destruction of infrastructure; Spirit Lake dammed	Rotational rock slide; average speed 125 km/hr
1985	Catastrophic lahar, Nevado del Ruiz	90×10^6	Snowmelt lahar triggered by volcanic eruption	23,000 killed; city of Armero buried (40 km away)	Peak velocity 50–80 km/hr; economic losses $1 billion
1987	Val Pola landslide (Italy)	40×10^6	Severe rainfall	27 killed; losses of $400 million	Velocity over 300 km/hr
1999	Malpa rockfall and debris flow (India)	1×10^6	High-intensity rainfall	221 killed; Malpa river dammed; followed by outburst flood	Former landslides at the same site
2007	Guinsaugon rockslide/debris avalanche, Leyte Island, Philippines	15×10^9	Heavy rainfall	1,000 casualties; Guinsaugon village buried under 4–7 m deep debris	Failure of 450 m high, forested rock slope
2014	Nepal	5.5×10^6	Heavy rainfall	156	Creation of many temporary lakes
2015	Guatemala	220×10^6	Heavy rainfall	220	Some villages were covered by over 15 m of earth

Geophysical hazard risk as a product of economic, social, demographic and political factors

Environmental hazards occur when people and property are at risk. Although the cause of the hazard may be geophysical or biological, this is only part of the explanation. It is because people live in hazardous areas that hazards occur. So why do they live in such places?

The **behavioural** school of thought considers that environmental hazards are the result of natural events. People put themselves at risk by, for example, living on or at the foot of steep slopes. By contrast, the **structuralist** school of thought stresses the constraints placed on poor people by the prevailing social and political system of the country. Poor people live in unsafe areas – such as on steep slopes or floodplains

ATL Research skills

Use a search engine to find out about the Ashcroft landslides in Canada and their impact on transport routes.

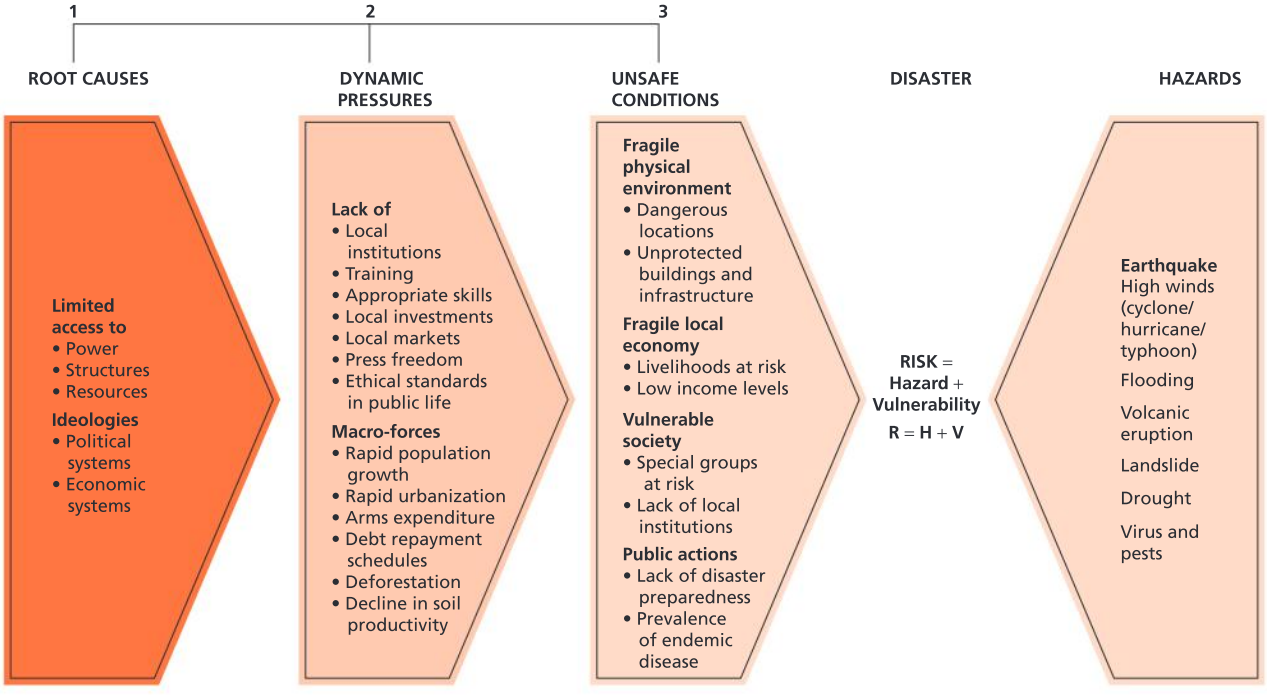
– because they are prevented from living in better areas. This school of thought provides a link between environmental hazards and the underdevelopment and economic dependency of many developing countries. Even in rich countries such as the USA, certain populations may be more at risk than others. For example, the impacts of Hurricane Katrina were greater on the poor, black population of the affected region than on other sections of society.

The concept of **vulnerability** includes not only the physical effects of a natural hazard but also the status of people and property in the affected area. A number of factors can increase people's vulnerability to natural hazards, especially catastrophic events. Aside from the simple fact of living in a hazardous area, vulnerability depends on a large number of factors.

Economic factors include the following:

- Levels of wealth and development: this influences the quality of housing that people live in, their car ownership and their ability to afford insurance. Many of the world's poor have no option but to live in shanty towns. In 1976, 20,000 people were killed in Guatemala City. Most of the fatalities were in the ravines and gorges where low-quality housing was located. Most of the middle and upper classes survived. This earthquake was widely recognized as having a markedly class impact.
- Construction styles and building codes: there was criticism during the Sichuan earthquake that whereas government buildings remained standing many schools were destroyed (suggesting that the schools were poorly built).
- Access to technology: in Japan, earthquake and tsunami warnings are issued to people via smartphones; people with greater access to communications are better able to keep up to date with warnings and forecasts.

Figure D.15: The process of vulnerability



- Insurance cover: generally it is the poor who have no insurance cover and they are most likely to be affected in a natural hazard as their housing quality is poor.

Social factors include the following:

- Education: people with a better education generally have a higher income and can afford better-quality housing and vehicles. They may also have a greater understanding of the nature and the potential of natural **hazard events**.
- Public education: educational programmes in Japan have helped to reduce the number of deaths as a result of earthquakes.
- Awareness of hazards: the 2004 tsunami in South Asia alerted many people to the dangers that tsunamis present.
- Gender: many women are carers for their children and/or their parents and they may feel responsible for them following an event. In some societies, women may not have the means to leave an area even if they want to.

Demographic factors include the following.

- Population density: a large number of rapidly growing cities are in hazardous areas; large urban areas such as Port-au-Prince in Haiti are especially vulnerable to natural hazards.
- Age: 65 per cent of those who died in the Japanese tsunami in 2011 were aged over 60.
- Migrants: when people move to an area they may be unaware of some of the natural hazards present in that environment.
- Disability: the mortality rate of the disabled in the Japanese tsunami of 2011 was twice that of the normal population.
- Cultural factors: some of the cultural factors that influence public response to warnings are: the extent of trust in government, scientists or other authority figures; the extent and success of social networks; the amount of control or autonomy that a community feels it has; and the perceived hazard level.

Political factors include the following.

- The nature of society: the failure of the Burmese government to allow aid to the victims of Cyclone Nargis in 2008 increased the number of deaths from disease and malnutrition.
- Effectiveness of lines of communication: the earthquake in Sichuan (China) in 2008 brought a swift response from the government, which mobilized 100,000 troops and allowed overseas aid into the country.
- Availability and readiness of emergency personnel: there were few deaths from the eruption of Mt Pinatubo in 1991 due to the successful prediction of the eruption by the USGS (US Geological Survey) who had monitored the volcano closely.

Many of these factors help to explain why less-developed countries are much more vulnerable to natural hazards than industrialized countries.

▲ **Photo D.6:** Vulnerability to hazards is increased by proximity to features such as volcanoes; pictured here is the former church at Plymouth, Montserrat

ATL Research skills

To find out more, visit http://webra.cas.sc.edu/hvri/, the Hazards and Vulnerability Research Institute from the University of South Carolina. The site includes the Social Vulnerability Index (SOVI). Type SOVI into the search box at the top of the webpage.

Activity 7

Describe the distribution of social vulnerability to natural hazards in the USA.

Geographic factors affecting the impacts of geophysical events

The impacts of geophysical events depend on a number of interrelated factors.

- The magnitude and the frequency of events: for example, the stronger the earthquake, the more damage it can do. An earthquake of 6.0 on the Richter scale is 100 times more powerful than one of 4.0; the more aftershocks there are the greater the damage that is done. Earthquakes that occur close to the surface (shallow-focus earthquakes) are potentially more damaging than earthquakes deep underground (deep-focus earthquakes) since overlying rocks will absorb more of the energy of the deep-focus earthquakes. Volcanic eruptions of VEI 6 or 7 (such as Krakatoa and Tambora) will have greater impacts than VEI 0 (for example, Kilauea).
- Population density: a geophysical event that hits an urban area of high population density, such as in the Tokyo area of Japan, could inflict far more damage than one that hits a rural area of low population and building density. Most of the deaths in the 1985 Mexico City earthquake occurred in the city, despite the focus being over 200 km away.
- Type of buildings: high-income countries generally have better-quality buildings that have been built to be earthquake resistant. The 2010 Port-au-Prince earthquake destroyed more buildings than the 2010–2011 New Zealand earthquakes although they were of comparable magnitude. People in high-income countries are also more likely to have insurance cover than those in low-income countries, so recovery after the event is easier.
- Time of day: an earthquake during a busy time, such as rush hour, may cause more deaths than one at a quiet time. There are fewer people in industrial and commercial areas on Sundays; at night more people are at home. Time of day is less of a factor in the case of volcanic eruptions, and these do not generally have such a sudden onset.
- Distance from the geophysical event: the impact of a volcano may decrease with distance from the volcano, whereas the effect of an earthquake may be greater further away from the epicentre. Most damage will occur where there are the most buildings and people, particularly if structures have not been built to strict construction standards.
- Types of rocks and sediments: loose materials may act like liquid when shaken, a process known as liquefaction. Solid rock is much safer, and buildings built on flat areas of solid rock are more earthquake resistant. Unconsolidated volcanic sediments are at high risk of landslide compared with solid geology, for example the Casita volcano in Nicaragua following Hurricane Mitch.
- Secondary hazards: these may cause more fatalities than the original event. For example, more people died due to lahars following the Pinatubo eruption and Nevado del Ruiz than during the volcanic eruption. Other secondary hazards include tsunamis, fires, contaminated water, disease, hunger and hypothermia.

Common mistake

✗ Some students think that the most destructive geophysical events, and those causing the greatest loss of life, are those of largest magnitude.

✓ The impact of a geophysical event depends on many factors such as population density, quality of buildings, the location of the event (submarine/deep underground, close/distant) as well as the magnitude of the event.

Activity 8

1. Work out the total number of global deaths for each hazard over the 10-year period shown in Table D.6.
2. Work out the total number of deaths from geophysical events in each of the years. Comment on the trend in deaths as a result of geophysical events.
3. Work out the average number of deaths for each hazard per year.
4. Identify the natural hazard that caused the greatest number of deaths.
5. State the natural hazard that caused the least loss of life.
6. Compare the number of deaths by main cause of death in 2004 and 2012.

- Economic development: high-income countries will generally have a better level of preparedness and more effective emergency response services, better access to technology and better health services. There will be more funds to cover the cost of coping with **disasters**. The responses to the Christchurch earthquakes in New Zealand were more effective than the responses to the Port-au-Prince earthquake in Haiti.

Table D.6: Number of deaths attributed to geophysical hazards, 2004–2014 (worldwide)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Earthquakes and tsunamis	227,290	76,240	6,690	780	87,920	1,890	226,740	20,950	710	1,120	662
Mass movements	610	650	1650	270	620	690	3,400	310	520	280	N/A
Volcanic eruptions	2	3	5	10	20	N/A	320	3	N/A	N/A	55

N/A indicates that no data is available

ATL Research skills

Visit http://www.ldeo.columbia.edu/chrr/research/profiles/ for natural disaster profiles for 13 countries, showing information on subnational areas at risk from natural hazards. Some maps are weighted by mortality and others by the proportion of gross domestic product (GDP) impacted. Multi-hazard disaster maps show the combined risk from key hazard groups.

Visit http://www.cred.be, the Centre for Research on the Epidemiology of Disasters (CRED).

Activity 9

1. With the use of examples, examine the risk posed by natural hazards and their likely impacts in rich and poor countries.
2. Comment on the impact of hazards on mortality and economic loss.

Concepts in context

Some geophysical hazards mainly occur in distinct locations, such as volcanoes and earthquakes along plate boundaries, whereas others appear to be more varied in their location, for example mass movements. Very powerful geophysical hazards are quite rare, whereas low-magnitude geophysical hazards are more common. The recurrence interval of powerful geophysical hazards is very long. The impact of geophysical hazards varies with the characteristics of the population and **places** that it affects. Some parts of the population, for example women, the elderly, infirm and young, are more vulnerable to geophysical hazards. The level of development may affect the quality of buildings and the rescue/relief operations. Hence, geophysical hazards vary in power and impact from place to place.

Check your understanding

1. Describe the distribution of the world's main earthquakes.
2. Briefly describe the meaning of the term "Pacific Ring of Fire'.
3. Explain how hotspots cause chains of volcanoes.
4. Describe the distribution of landslide fatalities, 2006–2007.
5. Explain the term "recurrence interval".
6. Explain the term "supervolcano".
7. On average, how many earthquakes per year have a magnitude of over 8.0 on the Richter scale or the Moment Magnitude Scale?
8. State the range of annual deaths attributed to volcanoes, 2004–2014.
9. State the range of annual deaths attributed to mass movements, 2004–2014.
10. Identify the geophysical events that have had greatest impact in terms of loss of life, 2004–2014.

3 Hazard risk and vulnerability

Conceptual understanding

Key question

How does the varying power of geophysical hazards affect people in different local contexts?

Key content

- Geophysical hazard event profiles, including any secondary hazards.
- The varied impacts of these geophysical hazards on different aspects of human well-being.
- Reasons why levels of vulnerability vary between and within communities, including spatial variations in **hazard perception**, personal knowledge and preparedness.

Vulnerability

Vulnerability has been defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

Risk = Hazard × Exposure × Vulnerability

Vulnerability is the human dimension of disasters and is the result of the range of economic, social, cultural, institutional, political and psychological factors that shape people's lives and the environment that they live in.

Vulnerability is complex. It is not simply about poverty, although it is generally the poor who tend to suffer most from disasters. Poverty is both a cause and consequence of disaster risk because economic pressures force people to live in unsafe locations and conditions. Poverty and the other multidimensional factors and drivers that create vulnerability mean that susceptibility to the impacts of hazards is often, but not always, associated with certain groups, including women, children, the elderly, the disabled, migrants and displaced populations, among others.

Vulnerability relates to a number of factors, including:

- physical factors, for example poor design and construction of buildings, unregulated land use
- social factors, for example poverty and inequality, marginalization, social exclusion and discrimination by gender, social status, disability and age (among other factors) psychological factors, and so on
- economic factors, for example people working in the uninsured, informal (unregulated) sector; vulnerable rural communities; areas that are dependent on a single industry; workers facing economic pressure as a result of the globalization of business and supply chains
- environmental factors, for example poor environmental management, over-consumption of natural resources, decline of risk-regulating ecosystem services, climate change, and so on.

In addition, vulnerability is determined by historical, political, cultural, and institutional and natural resource processes that shape the social and environmental conditions that people find themselves existing within. Many of the underlying drivers of vulnerability, including poorly managed urban development, are increasing, resulting in vulnerability increasing in many countries and regions of the world.

Disaster risk not only depends on the severity of hazard or the number of people or assets exposed, but it is also a reflection of the susceptibility of people and economic assets to suffer loss or damage. Levels of vulnerability (and exposure) help to explain why some non-extreme

hazards can lead to extreme impacts and disasters, while some extreme events do not.

A vulnerability and capacity assessment (VCA) considers a wide range of environmental, economic, social, cultural, institutional and political pressures that create vulnerability and is approached through a number of different frameworks. A VCA can be applied as:

- a diagnostic tool to understand problems and their underlying causes
- a planning tool to prioritize and sequence actions and inputs
- a risk assessment tool to help assess specific risks
- a tool for empowering and mobilising vulnerable communities.

Risk

Risk or disaster risk is expressed as the likelihood of loss of life, injury, or destruction and damage from a disaster in a given period of time. Disaster risk is widely recognized as the consequence of the interaction between a hazard and the characteristics that make people and places vulnerable and exposed.

If current global patterns of increasing exposure, high levels of inequality, rapid urban development and environment degradation grow, then disaster risk may increase to dangerous levels. It is estimated that global average annual loss will increase to $415 billion by 2030.

Managing risk can be shared across a wide range of sectors, for example:

- the insurance sector, so that firms may be able to recover from disaster losses
- the construction sector, so that buildings are built according to building codes
- the land-use and urban planning sectors, so that the location of new developments takes into account the likelihood of a hazard event
- at the community level, an understanding of hazard events can inform and influence decisions on preparedness, including life-saving evacuation procedures and the location of facilities.

Disaster risk management (DRM) can be thought of as the implementation of disaster risk reduction (DRR) and includes building the capacity of a community, organization or society to anticipate, cope with, resist and recover from disasters through activities related to:

- prevention: the avoidance of adverse impacts of hazards (which is generally less costly than disaster relief and response)
- mitigation: the reduction of the adverse impacts of hazards
- preparedness: the knowledge and capacities of interested parties, for example governments, communities and individuals to anticipate, respond to and recover from the impacts of hazard events or conditions.

ATL Research skills

Visit http://www.unisdr.org/ and find out about the United Nations (UN) Plan of Action on Disaster Risk Reduction for Resilience.

Earthquakes

Case study

Haiti's earthquake, 2010

On 12 January 2010 an earthquake measuring 7.0 on the Richter scale occurred just 25 km west of Port-au-Prince, at a depth of only 13 km below the surface. Further aftershocks were as strong as 5.9, and occurred just 9 km below the surface, 56 km south-west of the city. A third of the population was affected: about 230,000 people were killed, 250,000 more were injured and around a million people were made homeless.

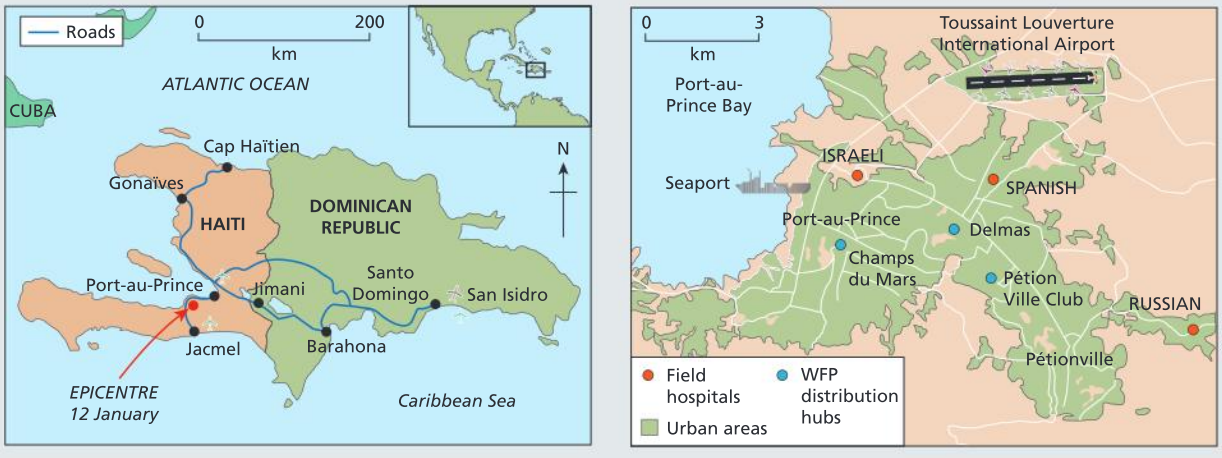
The island of Hispaniola (shared by Haiti and the Dominican Republic) sits on the Gonave microplate, a small strip of the Earth's crust squeezed between the North American and Caribbean tectonic plates. This makes it vulnerable to rare but violent earthquakes. The Dominican Republic suffered a serious quake in 1946. But the Enriquillo-Plantain Garden Fault, which separates the plates on the Haitian side of the border, had been accumulating stress during more than a century of inactivity. What magnified its destructive power was the position of its epicentre, so close to the densely populated capital and so shallow.

The city and the region around it are mainly shanty settlements of overcrowded, badly constructed buildings, hopelessly ill-suited to withstanding a shaking. Many of Port-au-Prince's 2 million residents lived in tin-roofed shacks perched on unstable, steep ravines. After a school collapsed in the suburb of Pétionville in 2008, the capital's mayor said that 60 per cent of its buildings were unsafe even under normal conditions.

The Red Cross estimated that 3 million people – a third of Haiti's population – needed emergency aid. Seven days after the earthquake, the United Nations had delivered food to only 200,000 people. Help – in the form of doctors, trained sniffer dogs, and tents, blankets and food – was pledged from other countries, including Mexico, Venezuela, China, Britain, France, Germany, Canada and Cuba. Crews of Dominicans, including engineers, telecoms technicians and the Red Cross, were among the first to join the relief effort.

Financial assistance also poured in. The World Bank led with a $100 million commitment, pending the approval of its board. The UN released $10 million from its emergency fund, and European countries pledged $13.7 million. Yet most of this aid arrived too late for the thousands who were trapped in rubble or awaiting treatment for their injuries.

Haiti's institutions were weak even before the disaster. Because the quake devastated the capital, the government, many non-governmental organizations (NGOs) and the UN (which has been trying to create a viable



▲ **Figure D.16:** The location of Haiti and the 2010 earthquake

Case study (continued)

government in Haiti since 2004) were destroyed, losing buildings and essential staff.

Haiti is one of the world's poorest countries, and it was overpopulated and vulnerable even before the disaster. The country had only two fire stations and no army – the Haitian army was abolished in 1995 – and it was powerless to do anything for itself. The earthquake degraded an already feeble health service by destroying many hospitals and clinics, including all three aid centres run by Médecins sans Frontières, an NGO. Crowded Haiti has long suffered from squabbling and corruption, extreme inequality and ecological stress.

A month after the disaster hospitals were working again, though not before thousands of survivors had died of their injuries. The World Food Programme (WFP) gave rice to 2.5 million people in the capital and nearby areas. Most streets in Port-au-Prince were cleared of rubble.

After the rescue and relief phase, the focus of aid changed to providing shelter robust enough to withstand the rains (and landslides) that normally begin in earnest in May, and the hurricanes that may follow from June onwards. Around 550,000 people gathered in hundreds of makeshift camps; almost as many were sleeping rough. With aftershocks continuing, many were too scared to venture back into their houses even if these had survived. Some were issued with tents. But relief workers reckoned that simple plastic tarpaulins, suspended on poles, were a more durable option.

Months after the disaster the camps were still crowded, so many families could not claim the 12 m^2 that aid workers deemed necessary. Tens of thousands of people were squatting on potentially dangerous steep slopes or riverbeds, and thousands were still without electricity. For most people proper housing is years away.

The 1989 earthquake near San Francisco in California was of similar magnitude to Haiti's, but it killed just 63 people, mainly because most buildings there are designed to withstand the shock. There are plenty of ideas for cheap earthquake-proofing: one is to fit rubber pads from recycled tyres between concrete blocks as shock absorbers. But the Haitian government has never enforced building codes, and can hardly do so now.

Rebuilding Haiti's homes, schools, roads and other infrastructure will take between $8 billion and $14 billion. Many Dominicans fear a flood of illegal migrants into their country due to the poverty in Haiti unless reconstruction is swift and effective.

A long-term strategy for rebuilding Haiti is vital. Even before the earthquake Haiti was poor, environmentally degraded, aid dependent and had few basic services. "Building back better" must be more than just a slogan.

Case study

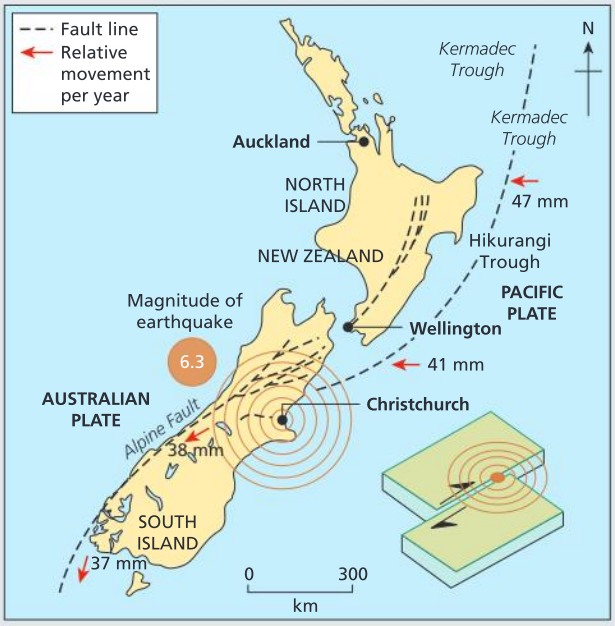
The Christchurch, New Zealand, earthquakes, 2010–2012

Christchurch is New Zealand's second-largest urban area with a population of 386,000. The 2010 Christchurch earthquake was a 7.1 magnitude earthquake which struck the South Island of New Zealand at 4.35 am (local time) on 4 September 2010. Aftershocks continued into 2012. The strongest aftershock was a 6.3 magnitude earthquake, which occurred on 22 February 2011. On account of this being so close to Christchurch, it was much more destructive, with 185 people being killed. In contrast, there was just one confirmed fatality of the 2010 earthquake (and another due to a heart attack which may have been associated with the earthquake).

The 2010 earthquake

The 2010 earthquake's epicentre was 40 km west of Christchurch, at a depth of 10 km. Insurance claims from the earthquake were confirmed at being between NZD2.75 billion and NZD3.5 billion (New Zealand dollars). Private insurance and individual costs were up to NZD4 billion.

Case study



▲ **Figure D.17:** Plate movement and the Christchurch earthquake
Source: Guinness, P and Nagle, G. 2014. London, UK. Hodder Education

Earthquakes capable of causing significant property damage and loss of life can occur in the Christchurch area on average every 55 years. Around 100 fault lines have been identified in the region, some as close as 20 km from central Christchurch. However, the 2010 quake occurred on a previously unknown fault. The earthquake epicentre was located about 80–90 km south-east of the current surface location of the Australia–Pacific boundary (Figure D.17).

By August 2012, over 11,000 aftershocks of magnitude 2.0 or more had been recorded, including 26 over 5.0 magnitude and 2 over 6.0 magnitude.

Impacts

There was a relative lack of casualties compared with the 2010 Haiti earthquake. The Haiti earthquake also occurred in similar proximity to an urban area, also at shallow depth and of very similar strength. The lack of casualties in New Zealand was partly due to the fact that the earthquake happened in the early hours of a Saturday morning, when most people were asleep, many of them in timber-framed homes. Moreover, building standards in New Zealand are high. Following the 1848 Marlborough and 1855 Wairarapa earthquakes, which both seriously affected Wellington, building standards were introduced. These were further strengthened following the 1931 Hawke's Bay earthquake. In contrast, Haiti had much lower building standards, which were poorly enforced and many buildings were made of hand-made, non-reinforced concrete, which is extremely vulnerable to seismic damage. Ground shaking in populated areas of Canterbury was also generally less strong than for the Haiti earthquake.

Sewers were damaged and water pipes were broken. The water supply at Rolleston, south-west of Christchurch, was contaminated. Power to up to 75 per cent of the city was disrupted. Christchurch International Airport was closed following the earthquake and flights in and out of it were cancelled.

Emergency response and relief efforts

Christchurch's emergency services managed the early stages of the response. Over 40 search and rescue personnel and three sniffer dogs were brought from the North Island to Christchurch on the day of the earthquake

The 2011 earthquake

The February 2011 Christchurch earthquake was a powerful natural event that severely damaged the city, killing 185 people. The 6.3 magnitude earthquake struck the region at 12.51 pm local time on Tuesday 22 February 2011. The earthquake was centred 2 km west of the port town of Lyttleton and 10 km south-east of the centre of Christchurch. The earthquake was probably an aftershock of the September 2010 earthquake.

The earthquake caused widespread damage across Christchurch, especially in the central city

Case study (continued)

and eastern suburbs. The damage was intensified on account of the 2010 earthquake and its aftershocks. Significant liquefaction affected the eastern suburbs, producing around 400,000 tonnes of silt.

People from more than 20 countries were among the victims. Over half of the deaths occurred in the six-storey Canterbury Television (CTV) building, which collapsed and caught fire during the earthquake. Between 6,600 and 6,800 people were treated for minor injuries.

The total cost to insurers of rebuilding was originally estimated at NZD15 billion. However, by April 2013 the total estimated cost had escalated to NZD40 billion. Some economists have estimated it will take the New Zealand economy 50 to 100 years to completely recover.

Although smaller in magnitude than the 2010 quake, the earthquake was more damaging and deadly for a number of reasons.

- The epicentre was closer to Christchurch.
- The earthquake was shallower at 5 km underground, whereas the September 2010 quake was measured at 10 km deep.
- The February 2011 earthquake occurred at lunchtime on a weekday when the central business district (CBD) was busy.
- Many buildings had already been weakened by previous earthquakes.
- Liquefaction was significantly greater than during the 2010 earthquake, causing the upwelling of more than 400,000 tonnes of silt.

The increased liquefaction caused significant ground movement, undermining many foundations and destroying infrastructure.

Up to 80 per cent of the water and sewerage system was severely damaged. Road and bridge damage occurred and hampered rescue efforts. Soil liquefaction and surface flooding also occurred. Around 10,000 houses would need to be demolished, and liquefaction damage meant that some parts of Christchurch could not be rebuilt on. Nevertheless, in Christchurch, New Zealand's stringent building codes limited the disaster.

Infrastructure and support

At 5 pm local time on the day of the earthquake, 80 per cent of the city had no power. However, power was restored to over 80 per cent of households within five days, and to 95 per cent within two weeks. Waste-water and sewerage systems had been so severely damaged that households had to establish emergency latrines. Over 2,000 portaloos and 5,000 chemical toilets from throughout New Zealand and overseas were brought in, with 20,000 more chemical toilets placed on order from the manufacturers.

Emergency management

A full emergency management programme was in place within two hours. The government response was immediate and significant and a National Emergency was declared. The New Zealand Fire Service coordinated search and rescue. Rescue efforts continued for over a week, then shifted to recovery mode.

Volcanic eruptions

Case study

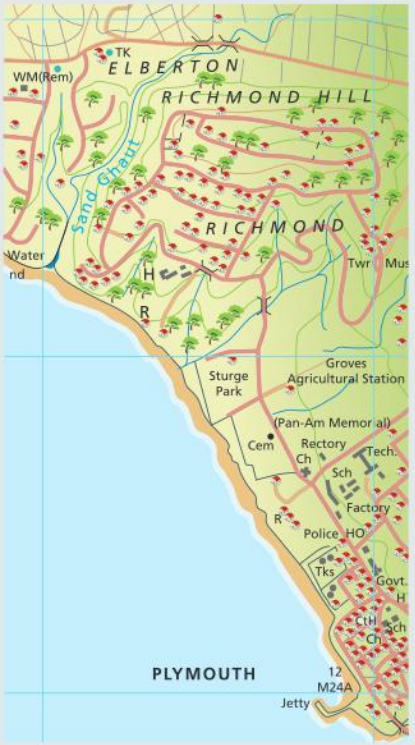
Soufrière Hills, Montserrat

Montserrat is a small island in the Caribbean, and it has been affected by a volcano since 1995. The cause of the volcano is the plunging of the South American Plate and North American Plate under the Caribbean Plate. Rocks at the edge of the plate melt and the rising magma forms volcanic islands.

In July 1995 the Soufrière Hills erupted after being dormant for nearly 400 years. At first the Soufrière Hills gave off clouds of ash and steam. Then in 1996 the volcano finally erupted. It caused mudflows and finally it emitted lava flows. Part of the dome collapsed, boiling rocks and ash were thrown out and a new dome was created. Ash, steam and rocks were hurled out, forcing all of the inhabitants to leave the south, the main agricultural part of the island. The largest settlement, Plymouth, with a population of just 4,000, was covered in ash and abandoned (Photo D.7). This has had a severe impact on Montserrat as Plymouth contained all of the government offices and most of the shops and services, such as the market, post office and cinema.

The hazard posed by the volcano was just one aspect of the risk experienced on Montserrat. For the displaced people there were other hazards. For example, up to 50 people had to share a toilet. Sewage tanks in the temporary shelters were often not emptied for weeks on end. The risk of contamination in water and the spread of diseases such as cholera is greatly increased when large numbers of people live in overcrowded, unhygienic conditions.

The southern third of the island had to be evacuated (Figure D.19). All public services (government, health and education) had to be moved to the north of the island. Montserrat's population fell from 11,000 to 4,500. Most fled to nearby Antigua. Some "refugees" stayed on in Montserrat living in tents.



▲ **Figure D.18:** 1:25,000 map of Soufrière and Plymouth

▲ **Photo D.7:** Destruction of Plymouth

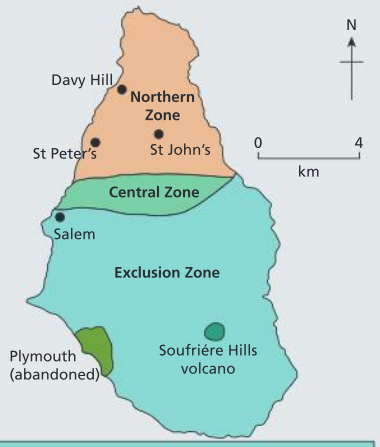
▲ **Photo D.8:** Hazards in Plymouth

Case study (continued)

The northern part of the island has been redeveloped with new homes, hospitals, crèches, upgraded roads, football pitches and expansion of the island's port. The population has risen again to over 5,000.

The risk of eruptions continues – scientists do not know when the current activity will cease. For now, Montserratians are learning to live with the volcano.

The volcano has been relatively quiet since 2005. Nevertheless, it continues to emit sulphur and ash. There was, however, an event in May 2006 that was relatively unreported. The Soufrière dome collapsed causing a tsunami that affected some coastal areas of Guadeloupe and English Harbour and Jolly Harbour in Antigua. The Guadeloupe tsunami was 1 m high whereas the one in Antigua was 20–30 cm. No one was injured in the tsunami but flights were cancelled between Venezuela and Miami, and to and from Aruba due to the large amount of ash in the atmosphere.



Exclusion Zone	No admittance except for scientific monitoring and national security matters.
Central Zone	Residential area only. All residents in state of alert. All have rapid means of exit 24 hours a day. All residents must have hard hats and dust masks.
Northern Zone	Significantly lower-risk, suitable for residential and commercial occupation.

Figure D.19: Volcanic hazard risk in Montserrat

Case study

Mount Sinabung

Mount Sinabung is a volcano in northern Sumatra, Indonesia, located about 40 km from the Lake Toba supervolcano. Indonesia is located on the Pacific Ring of Fire and has some 120 active volcanos. Sinabung is currently one of the most active volcanoes there. It erupted in 1600, and then it was dormant until 2010. Since 2010 it has been active. The volcano was created by the subduction of the Indo-Australian Plate under the Eurasian Plate. The area surrounding the volcano is populated due to the fertile plateau that the volcano has helped to form.

Photo D.9: The eruption of Mount Sinabung

The recent volcanic activity began in 2010. Over 30,000 villagers were evacuated from their homes. The Department of Health provided medicines and doctors to the evacuees, and the National Disaster Management Agency provided food and face masks. Kitchens were set up; blankets, sleeping mats and tents were provided by the government and the Agency. One fatality was reported – a person who suffered from respiratory problems. In 2013 it was reported that crops had failed due to the ash fall.

In February 2014 eruptions caused the deaths of at least 16 people. Ironically, this eruption occurred just after residents living more than 5 km from Sinabung were allowed to return to their homes. One positive aspect of the volcanic activity was that tourism and sightseeing had increased in the area.

In 2016 Sinabung erupted again, killing seven people. The victims were from Gembar, a village in the western province of North Sumatra.

ATL Research skills

Visit http://savethehills.blogspot.co.uk/ for more information about landslides in the Darjeeling-Sikkim Himalaya region.

ATL Research skills

Visit the following sites to watch close-ups of volcanic eruptions https://www.youtube.com/watch?v=0-shWVW1UBc and drones used to film a volcano erupting https://www.youtube.com/watch?v=zFIWWM0Iv-U.

Find out about recent volcanic activity on Mount Merapi – see http://volcano.oregonstate.edu/merapi.

Mass movements

Case study

Managing urban landslides

Kalimpong is a hill station located in West Bengal, India. It is located at a height of 1,250 m overlooking the Teesta river and overlooked by the summit of Khangchendzonga. Dumsi Pakha is an area of comparatively low wealth below the main town. This area shows how urban mismanagement in steep terrains can lead to landslide problems, with catastrophic outcomes for the residents. Dumsi Pakha has a large number of small houses sitting on the side of the steep hill.

Landslides affect communities like this in many ways, but the two key elements that cause the problems are poor water management and slope disruption. Water management on the slopes above Dumsi Pakha is a key factor. In Kalimpong town, water is discharged without any control into gullies that run through Dumsi Pakha.

The channel is dry towards the end of the dry season, and is choked with garbage. There is extensive instability on the flanks of the channel. This instability is being exacerbated by the large flows that the channel has to transport during the monsoon. Small landslides threaten many houses, while in some cases larger slips are developing on the channel flanks. These have the potential to slip into the channel, briefly blocking it and then allowing a catastrophic debris flow to develop.

But elsewhere in the settlement the problems are more local. Some houses are built by first creating a terrace by excavating into the slope. By creating a mini-terrace to build on, a steeper slope is made behind the terrace, and that increases instability. There are also cases of old landslides that have been reactivated as a result of human activity.

The community centre, which was completed in 2002, shows signs of movement.

The people living in Dumsi Pakha are not passive victims of these problems. In many cases they are trying to manage the risk – for example, they have built a retaining wall to try to stabilize a section of the slope that is particularly hazardous.

But the scale of the problems huge. Landslide accidents are inevitable in such settings unless there is better management of the slopes. Dumsi Pakha is not exceptional or unusual – these types of problems are very commonplace.

As the south-west monsoon approaches, the slopes become extremely hazardous. It is not possible to blast the steep slopes to reduce the hazard, so the only option is to monitor them and close the road when instability is noted.

Water management is a serious problem, with a lack of sewers and storm drains. Large volumes of water flow unregulated into natural channels during heavy rainfall, causing problems downstream. In addition to the impact on buildings, paddy fields have been eroded and enlarged as the gullies have been unable to carry greatly increased storm flows. Erosion in gullies is now triggering extensive landslips. Adjacent to the gullies there are slopes that are actively deforming – sliding into the channel – which will cause further erosion.

Close to the town, the dumping of construction waste in an uncontrolled manner is adding to the problem. Adding extra weight to the top of an active landslide will inevitably make the stability problem worse. Such practices should be prevented.

ATL Research and communication skills

Use a search engine to update the statistics for Sri Lanka's landslides.

Find out about the villages of Aranayake and Bulathkohupitiya. Why were these two villages affected by landslides? Why were they vulnerable? Has there been any reconstruction?

Make a presentation on why Sri Lanka is vulnerable to landslides.

Concepts in context

In this section, we have seen how geophysical hazards vary in terms of **power** and impact. Geophysical hazard events can be divided into high-magnitude low-frequency events (the ones that cause most loss of life and damage) and low-magnitude high-frequency events (the common events that do not cause much damage/loss of life). We have also seen that the hazards with the greatest impact are not necessarily the most powerful – the Haiti earthquake was not especially powerful, but it affected a very vulnerable population. For many geophysical hazard events the annual loss of life is quite low, in particular for volcanoes. Earthquakes and tsunamis have the greatest impact in terms of loss of life and damage to buildings. Nevertheless, even for geophysical hazard events with relatively low mortality, there are "hotspot" areas where the risk is greater.

Check your understanding

1. Identify the main plates that influence Haiti.
2. State the number of people in Haiti that needed emergency aid following the 2010 earthquakes.
3. State the magnitude and number of fatalities of **(a)** the 2010 Christchurch earthquake and **(b)** the 2011 Christchurch earthquake.
4. Identify the year in which the Soufrière Hills volcano started erupting.
5. Outline the range of hazards associated with the Soufrière Hills volcano.
6. Briefly explain why Kalinpong, West Bengal, experiences landslides.
7. Outline the main factors responsible for landslides in Sri Lanka.
8. **(a)** State the number of people who have been killed in eruptions of Mt Sinabung since 2010.

   (b) Identify one positive aspect of the ongoing eruption of Mt Sinabung since 2010
9. State the time of year when the landslide problem in Kalimpong is greatest.
10. Identify the type of plate boundary on which Mt Sinabung is found.

Table D.7: A range of costs commonly associated with landslide problems

Personal costs
Fatal accidents
Injuries
Psychiatric problems
Immediate costs
Evacuation and provision of temporary or replacement housing
Mobilization of relief workers and emergency services
Transport delays
Costs of investigation
Cost of repair
Indirect costs
Compensation
Increased insurance premiums
Depreciated property or land values
Costs of legal actions
Costs of public inquiries into causes and responsibilities
Cost of prevention
Research into the nature and extent of landslide problems at universities
Formation of planning policies related to development on unstable land
Coastal protection schemes
Design and construction of preventative measures including drainage and regrading
Costs of monitoring potentially unstable slopes

4 Future resilience and adaptation

Conceptual understanding

Key question

What are the future **possibilities** for lessening human vulnerability to geophysical hazards?

Key content

- Global geophysical hazard and disaster trends and future predictions, including event frequency and population growth estimates.
- Geophysical hazard adaptation through increased government planning (land-use zoning) and personal resilience (increased preparedness, use of insurance and adoption of new technology).
- Pre-event management strategies for mass movement (to include slope stabilization), earthquakes and tsunami (to include building design, tsunami defences), volcanoes (to include GPS crater monitoring and lava diversions).
- Post-event management strategies (rescue, rehabilitation, reconstruction) to include the enhanced use of communications technologies to map hazard/disasters, locate survivors and promote continuing human development.
- Impacts of hazards/disasters other than geophysical ones have been included to show the relative importance of geophysical events.

Global geophysical hazard and disaster trends and future predictions, including event frequency and population growth estimates

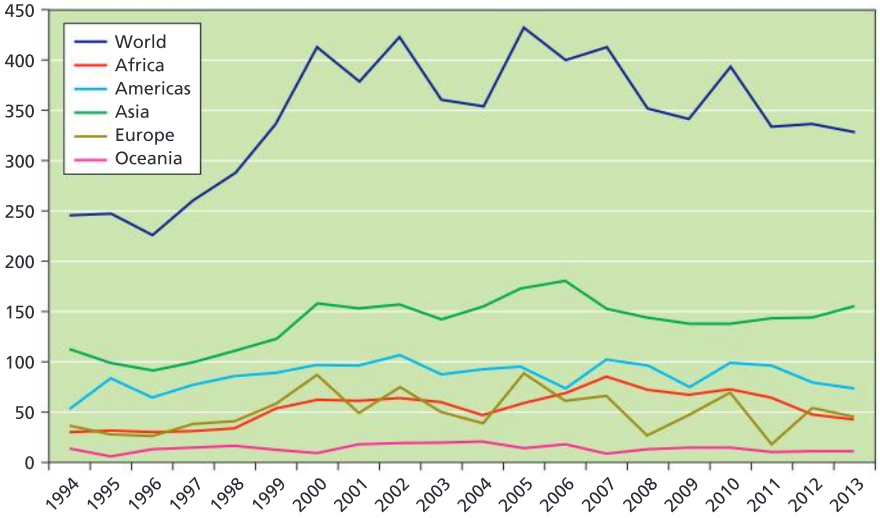
The frequency of geophysical disasters remained broadly constant between 1994 and 2013. In contrast, population growth and economic development have varied considerably. Earthquakes (including tsunamis) have killed more people than all other natural disasters put together. Tsunamis were the most deadly natural disaster. Asia bore the brunt of natural disasters, notably India and China. Low-income countries bear a disproportionate burden of natural hazards, including a huge disparity in death rates. Migration measures within LICs require significant improvement (Centre for Research on the Epidemiology of Disasters (CRED), 2015).

Between 1994 and 2013 an average of 218 million people were affected by natural disasters every year. Some 1.35 million people died during this period, an annual average of almost 68,000 deaths.

Megadisasters

A megadisaster is an event that kills more than 100,000 people. Three megadisasters occurred during the period 1994–2013:

- the Asian tsunami, which killed over 225,000 people in 12 countries
- Cyclone Nargis in 2008, which killed 138,000 in Myanmar
- the 2010 earthquake in Haiti, which was responsible for the loss of over 220,000 lives.



▲ **Figure D.20:** The number of disasters worldwide and by continent, 1994–2013

Table D.8: Number of people affected and number of deaths by disaster type, 1994–2013

	People affected – percentage of total (absolute number)	Number of deaths – percentage of total (absolute number)
Floods	55% (2.4 billion)	12% (160,000)
Drought	25% (1.1 billion)	2% (22,000)
Storms	15% (660 million)	18% (250,000)
Earthquakes	3% (121 million)	55% (750,000)
Extreme temperatures	2% (93 million)	12% (160,000)
Other (mass movement, volcanoes, wildfires)	<0.3% (13 million)	1% (20,000)

Earthquakes and tsunamis are rarer than floods but they can cause very high numbers of casualties in a short period of time, for example the South Asian tsunami and the Haitian earthquake. It is clear from Table D.10 that earthquakes and tsunamis were the deadliest natural disaster between 1994 and 2013.

Urbanization within highly seismic zones has increased significantly over recent decades. Slums and squatter settlements frequently expand onto high-risk areas such as slopes and embankments.

Table D.9: Proportion of occurrence of natural disaster by disaster type, 1994–2013

Disaster type	Proportion of occurrence, 1994–2013 (%)
Floods	43
Storms	28
Earthquakes	8
Extreme temperature	6
Landslides	5
Drought	5
Wildfires	4
Volcanic activity	1

TOK

Discuss the limitations of the data used in Table D.9. (Hint: length of a drought/flood versus a landslide; magnitude/strength.)

Table D.10: Proportion, mortality and people affected by geophysical disasters and their relative percentage of the global total, 1994–2013

	Proportion	Total deaths	Total affected	Occurrence (%)	Total deaths (%)	Total affected (%)
Ash fall	105	721	2,099,075	16.0	0.1	1.7
Ground movement	525	497,097	118,328,863	80.2	66.5	95.9
Tsunami	25	250,125	2,898,178	3.8	33.4	2.4
Total	655	747,943	123,326,116	100	100	100

People are becoming more susceptible to natural disasters, largely as a result of population growth and globalization. Disastrous outcomes are likely to increase unless improved ways of mitigation, forecasting and warning, community preparedness and resilience are developed. Solutions related to natural disasters go beyond scientific and technological approaches, and include economic, political, cultural, sociological and psychological approaches. That includes input from international agencies, national governments, NGOs and local communities.

Table D.11: Number of disasters and number of deaths per income group, 1994–2013

	Disasters (%)	Number of disasters	Deaths (%)	Number of deaths
High income	26%	1,700	13%	182,000
Upper middle-income	30%	1,992	19%	252,000
Lower middle-income	27%	1,751	35%	474,000
Low income	17%	1,119	33%	441,000

Some natural events may be increasing in frequency and intensity, although some geophysical events might not be. A more likely

ATL Research and communication skills

Use a search engine or use http://www.unisdr.org/files/8720_summaryHFP20052015.pdf to find out about the Hyogo Framework for Action and the Sendai Framework for Disaster Risk Reduction 2015–2030.

In what ways do these help to deal with geophysical hazards?

explanation for the increasing impact of geophysical events is that there are increasingly more people in high-risk areas. In addition, human activities may be changing the climate and land use, leading to greater impacts of landslides for example. The major occurrences of earthquakes, tsunamis and volcanoes are largely influenced by tectonic forces which operate over very long timescales. The frequency and intensity of these features is largely unchanged on a long-term, global scale. There is no evidence that the increase in impacts of earthquakes is due to greater frequency and intensity. Indeed, the impact of volcanoes may even be decreasing due to improvements in forecasting and management.

In addition, the concentration of people in large urban areas, combined with environmental degradation, makes communities more vulnerable to natural hazards. For example, in Iran urbanization has led to the development of several large cities, including Tehran (a megacity), that are built on active fault lines. Increased population size makes Tehran more vulnerable to the impacts of earthquake activity.

Environmental degradation can also increase vulnerability. Destruction of mangrove swamps in Sri Lanka increased the vulnerability of coastal communities to the 2004 Asian tsunami. In Limbe in south-west Cameroon, shanty towns have been built at the base of slopes that have been made unstable by undercutting. The result has been an increase in the number of landslides, most of which occur in the rainy season.

Impacts of extreme events

The potential consequences of extreme events include global economic crises, thousands of deaths, possible destruction of megacities, environmental refugees, environmental degradation, disruption of global food supplies, disruption of transport and communications, climate stress and pollution. This in turn may fuel famine, disease, political unrest and collapse of social order. In some parts of the Middle East and North Africa (MENA) region there have been glimpses of this already, although they were not caused by geophysical events.

It is only relatively recently that the threat from extreme geophysical events has moved into the public interest. For example, before the 2004 tsunami, there was relatively little public understanding of the causes and management of tsunami events. The increasing flows of people around the world – whether as tourists, economic migrants or refugees – is exposing more people to the threat of geophysical events. Nevertheless, there has also been international action to tackle some global environmental problems, such as the Montreal Protocol, the Kyoto Protocol (Amended by the Paris Agreement, 2015) and the Hyogo Framework for Action (HFA) 2005–2015: Building the resilience of nations and communities to disasters. The HFA Mid-Term Review highlights the fact that significant progress was made by 2010 in disaster risk reduction, and that the adoption of the HFA in 2005 has played a decisive role in promoting this progress across international, regional and national agendas.

Volcanic eruptions have the potential to impact the Earth, especially a VEI 8 eruption. The chances of this are slim. Likewise, a large earthquake under Los Angeles, Tehran, Istanbul or Tokyo could have national, if not international, significance. A volcanic eruption of

Vesuvius could devastate Naples. One problem with trying to manage extreme events is that they are, by definition, rare. Communities can cope better with high-frequency low-magnitude events than low-frequency high-magnitude events.

Identifying areas at risk

Although the science behind the formation of tsunamis was well known to the scientific community, and there had been predictions that suggested powerful tsunamis would occur off the Sumatra coast (and the Peruvian coast), the mechanisms to communicate the science and the risk was not communicated sufficiently to those who needed to know. Although it is not possible to predict the exact timing, magnitude and impact of earthquakes, for example, it is possible to identify high-risk areas, and mitigate the impacts when an earthquake occurs.

Population growth and urban growth

The world population is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion by 2100 according to a UN report. Between 2015 and 2050 half of the world's population growth is expected to be concentrated in nine countries: India, Nigeria, Pakistan, Democratic Republic of the Congo, Ethiopia, the United Republic of Tanzania, the USA, Indonesia and Uganda.

The concentration of population growth in the poorest countries presents its own set of challenges, making it more difficult to eradicate poverty and inequality, to combat hunger and malnutrition, to expand educational enrolment and health systems, and to provide adequate housing, all of which are crucial to the success of the new sustainable development agenda.

The 2015 Revision of World Population Prospects was the 24th round of official UN population estimates and projections that have been prepared by UN DESA's Population Division. It reported the following.

- Globally, more people live in urban areas than in rural areas, with 54 per cent of the world's population residing in urban areas in 2014. By 2050, this could rise to 66 per cent.
- Today, the most urbanized regions include North America (82 per cent), Latin America and the Caribbean (80 per cent) and Europe (73 per cent). In contrast, Africa and Asia remain mostly rural, with 40 per cent and 48 per cent, respectively, urbanized. Africa and Asia are urbanizing faster than the other regions and are projected to become 56 per cent and 64 per cent urban, respectively, by 2050.
- Continuing population growth and urbanization are projected to add 2.5 billion people to the world's urban population by 2050, with nearly 90 per cent of the increase concentrated in Asia and Africa.
- Close to half of the world's urban dwellers reside in relatively small settlements of less than 500,000 inhabitants, while only around one in eight live in the 28 megacities that have more than 10 million inhabitants.

Predictions, forecasts and warnings

Scientific predictions are used to provide precise statements on the time, place and size of a future event. Forecasts are more general statements about future events. They are commonly expressed as probabilities. Effective warning depends on science and technology, as well as communications systems and people's ability to interpret them. Earthquakes remain the most difficult natural hazards to predict and forecast, although areas that are "at risk" are well known.

The main ways of preparing for earthquakes include:

- better forecasting and warning
- improved building design and building location
- establishing emergency procedures.

There are a number of ways of predicting and monitoring earthquakes, which involve the measurement of:

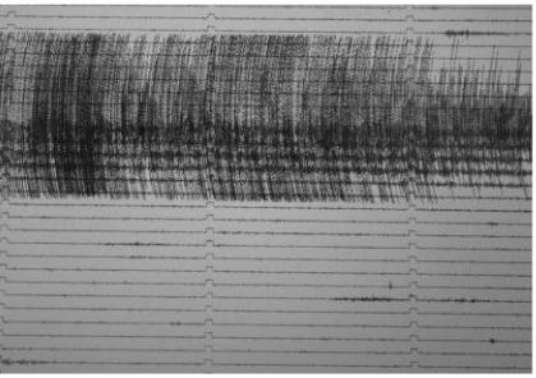
- small-scale ground surface changes
- small-scale uplift or subsidence
- ground tilt
- changes in rock stress
- micro-earthquake activity (clusters of small earthquakes)
- anomalies in the Earth's magnetic field
- changes in radon gas concentration
- changes in electrical resistivity of rocks.

▼ **Table D.12:** Monitoring for earthquake prediction

Instrument	Purpose
Seismometers	To record micro-earthquakes
Magnetometer	To record changes in the Earth's magnetic field
Near-surface seismometer	To record larger shocks
Vibroseis truck	To create shear waves to probe the earthquake zone
Strain meters	To monitor surface deformation
Sensors in wells	To monitor changes in groundwater levels
Satellite relays	To relay data to the US Geological Survey
Laser survey equipment	To measure surface movement

One intensively studied site is Parkfield in California, on the San Andreas Fault. Parkfield, with a population of fewer than 50 people, claims to be the earthquake capital of the world. It is heavily monitored by the following instruments:

- strain meters that measure deformation at a single point
- two-colour laser geodimeters that measure the slightest movement between tectonic plates
- magnetometers that detect alterations in the Earth's magnetic field caused by stress changes in the crust.



▲ **Photo D.10:** Use of seismographs at the Montserrat Volcano Observatory

Despite all of the monitoring, earthquakes can occur without warning. That was the case with the 1994 Northridge earthquake, which was not predicted and occurred on a fault that scientists did not know existed. Technology helps, but not all of the time.

The seismic gap theory states that over a prolonged period of time all parts of a plate boundary must move by almost the same amount. Thus if one part of the plate boundary has not moved and others have, then the part that has not moved is likely to move next. This theory has been used successfully to suggest that an earthquake was likely in the Loma Prieta segment of the San Andreas Fault. The Loma Prieta earthquake occurred

in 1989. Following the 2004 South Asian tsunami geologists identified a seismic gap in the Central Kuril segment of the Kuril-Kamchatka trench. Two earthquakes measuring 8.3 and 8.2 on the Richter scale occurred in November 2006 and January 2007 within the Central Kuril segment.

False alarms are a major problem for many geophysicists. The 1976 crisis at the Soufrière Volcano, Guadeloupe, is a good example. Unrest and uncertainty led to the evacuation of 70,000 people for three months. No significant eruption took place. Warning systems for tsunamis are quite sophisticated and can warn of an approaching wave minutes if not hours before it arrives.

Earthquake prediction – using animal behaviour

In Japanese folklore, Ryujin is the dragon god of the sea, and oarfish are its messengers. The message brought by dead oarfish is impending earthquakes. In 2011 20 oarfish washed up on beaches in the area where the Tohoku earthquake and tsunami later caused the most damage.

Earthquakes release large quantities of carbon monoxide that can affect large deep-sea creatures like the oarfish. The small emissions that occur before major earthquakes could leak enough of the gas to make the fish sick and beach themselves before dying. Another possibility is electricity. When an earthquake occurs, pressure in the rocks builds up which can cause electrically charged ions to be released into the water. This can lead to the formation of hydrogen peroxide, which is a toxic compound. This could either kill the fish or force them to leave the deep ocean and rise to the surface.

Animals sensing earthquakes

In 1975, a 7.3 magnitude earthquake struck the Chinese city of Haicheng. A day before it happened, city officials evacuated the city based in part on reports of strange animal behaviour. For example, hibernating snakes in the area abandoned their winter hideouts months before normal.

In the USA, in 2010, at the Smithsonian's National Zoological Park in Washington, DC, animals sought shelter or made distress calls in the minutes before a 5.8 magnitude quake struck the region. Nocturnal snakes like copperheads came out of hiding, apes moved into the treetops and flamingos huddled together tightly.

Scientists in Italy studied the breeding behaviour of the common toad. In April 2009, the toads suddenly abandoned the shallow pools in which they bred. Five days later a strong earthquake struck the region. Tectonic stresses in the Earth's crust send huge amounts of primarily positive air ions into the lower atmosphere. When these ions reach a body of water, they oxidize water to form hydrogen peroxide. The resulting compounds may irritate or be toxic to certain species of animals.

▲ **Photo D.11 :** Oarfish coming to the surface is taken as an indication of a forthcoming earthquake

Predicting volcanoes

Volcanic eruptions are easier to predict than earthquakes since there are certain signs. The main ways of predicting volcanic eruptions include:

- seismometers, to record swarms of tiny earthquakes that occur as the magma rises
- chemical sensors, to measure increased sulphur levels

Common mistake

✗ Some people think it is possible to predict the size, duration and magnitude of a volcanic event.

✓ Although there are signs that suggest volcanic events are imminent, it is not possible to predict exactly when a volcano will erupt, how large it will be on the VEI scale, or how long the eruption will go on for. Most predictions are stated in terms of probabilities.

- lasers/GPS, to detect the physical swelling of the volcano/crater
- ultrasound, to monitor low-frequency waves in the magma resulting from the surge of gas and molten rock, as happened at Pinatubo, El Chichon and St Helens
- observations, such as at Gunung Agung (Java).

However, it is not always possible to state exactly when a volcanic eruption will happen. The USGS successfully predicted the eruption of Mt Pinatubo in 1991, and evacuated the area. However, they wrongly predicted a volcanic eruption at Mammoth Mountain Ski Area in California, USA, and the prediction reduced visitor numbers to the resort and caused economic distress to local business people.

It is also difficult to predict the timescale of an eruption. Some volcanoes may erupt for days, while others go on erupting for years. Mt Pinatubo erupted for a few weeks, while the Soufrière Hills volcano on Montserrat erupted continuously between 1997 and 2005, and still vents ash in small quantities. Mt Etna in Sicily has been erupting intermittently for hundreds of years.

In general, volcanoes at destructive plate boundaries tend to produce more-explosive volcanoes, whereas those at hotspots, such as Hawaii, produce more frequent but less-explosive eruptions.

Geophysical hazard adaptation

Preparedness

Land-use zoning is an important aspect of geophysical hazard adaptation. Different land uses may be prevented from locations in a zone that is known to be at risk of a hazard. For example, densely populated buildings, hospitals and fire services should not be built close to the fault line or in areas at risk of landslides. In some volcanic areas, residents are evacuated, for example from the slopes of Mt Sinabung, and an exclusion zone may be formed, as in the case of Montserrat. Building codes can be enforced to ensure that buildings are of an adequate standard to survive a hazard event.

Nations and the international community are generally not well prepared for rare events. One method of preparedness is to take out insurance cover against hazard events. However, some geophysical events are considered by the insurance industry as "acts of God", and so insurance cover is not available. Another factor is that most LIC residents are unable to afford insurance, even if it is available. In addition, it is always much harder to justify spending money on an event that might not occur. It is far easier to spend money after an event has happened.

New technology can be used to record the swelling of volcanoes and changes in water chemistry, and mobile phones with GPS can be used to inform agencies about geophysical changes.

Tackling volcanoes: the result of lack of preparation in Indonesia

In 2014, Indonesia was affected by two volcanic eruptions. In February, poor preparedness left communities near Mt Sinabung more vulnerable

than those hit by the much larger Mt Kelud eruption later in the month. Nearly 20 people were killed when Mt Sinabung erupted. Less than two weeks later, Mt Kelud in East Java province ruptured, killing seven. More than 130,000 people were displaced. Following the two eruptions, experts questioned whether the country is adequately prepared to cope with similar events from the dozens of volcanoes that are found there.

According to the Indonesian national disaster management board (BNPB), there are around 100 million people living in places that are prone to disasters, including volcanoes, earthquakes and floods. In East Java the level of preparedness is good, and many lives were saved in the 2014 eruptions despite the large number of people who live there. In contrast, in Sinabung, people were unfamiliar with the behaviour of the volcano because it had been mostly dormant for hundreds of years.

Volcanic eruption without warning

In September 2014 Japan's Mt Ontake erupted without warning, spewing ash and rocks. The bodies of more than 50 hikers were found near the top of the volcano. The volcano is around 200 km (125 miles) west of Tokyo. About 250 people were trapped on the slopes of the popular beauty spot, but most got down safely.

Japan is one of the world's most seismically active nations – but there have been no fatalities from volcanic eruptions since 1991, when 43 people died at Mt Unzen in the south-west.

ATL Research and communication skills

Visit http://www.emdat.be/disaster_trends/index.html for an interactive website on disaster trends, and http://www.emdat.be/country_profile/index.html to create hazard profiles by country.

Pre-event management strategies

Managing landslides

There are a number of ways to reduce the risks associated with landslides. These include:

- the terracing of steep slopes and making them more secure
- drainage reduces the build-up of water in slopes and thereby makes them less likely to fail
- restraining structures such as gabions and stone walls keep the failed material behind the structure
- erosion control such as rock armour and revetments minimizes the forces acting at the base of cliffs.

Other methods, such as the diversion of roads away from active areas, or over them in the form of bridges are also important (Table D.13).

▼ **Table D.13:** Principal methods of slope stabilization

Approach	Methods
Excavation and filling	Remove and replace slipped material
	Excavate to unload the slope
	Fill to load the slope
Drainage	Lead away surface water
	Prevent build-up of water in tension cracks
	Blanket the slope with free-draining material

Approach	Methods
	Installation of narrow trench drains aligned directly downslope, often supplemented by shallow drains laid in a herringbone pattern
	Installation of interceptor drains above the crest of the side slope to intercept groundwater
	Drilling of horizontal drains into a slope, on a slightly inclined gradient
	Construction of drainage galleries or adits, from which supplementary borings can be made
	Installation of vertical drains which drain by gravity through horizontal drains and adits, by siphoning or pumping
Restraining structures	Retaining walls located under unstable ground
	Installation of continuous or closely spaced piles, anchored sheet or bored pile walls
	Soil and rock anchors, generally pre-stressed
Erosion control	Control of toe erosion by crib walls, very large boulders, rock armour, revetments, groynes
	Control of surface erosion
	Control of seepage erosion by placing inverted filters over the area of discharge or intercepting the seepage
Miscellaneous methods	Grouting to reduce ingress of groundwater into a slide
	Chemical stabilization by liming at the shear surface, by means of lime wells
	Blasting to disrupt the shear surface and improve drainage
	Bridging to carry a road over an active site
	Rock traps to protect against falling debris

Managing the risk of earthquakes

Most places with a history of earthquakes have developed plans that enable people to deal with them. The aim is to reduce the effect of the earthquakes and thus save lives, buildings and money. The ways of reducing earthquake impact include earthquake prediction, building design, flood prevention and public information.

More than a third of the world's largest and fastest-growing cities are located in regions of high earthquake risk.

It is difficult to stop an earthquake from happening, so prevention normally involves minimizing the prospect of death, injury or damage by controlling building in high-risk areas, and using aseismic designs (Figure D.21).

Building design

Buildings can be designed to withstand the ground-shaking that occurs in an earthquake. Single-storey buildings are more suitable than multi-storey structures as the potential for swaying is reduced. Some tall buildings are built with a "soft storey" at the bottom, such as a car park raised on pillars. This collapses in an earthquake, so that the upper floors sink down onto it and this cushions the impact. Basement isolation – mounting the foundations of a building on rubber mounts which allow the ground to move under the building – is widely used in earthquake-prone areas. This isolates the building from the tremors. Building reinforcement strategies include building on foundations built deep into underlying bedrock, and the use of steel-constructed frames that can

withstand shaking. Land-use planning is another important way of reducing earthquake risk.

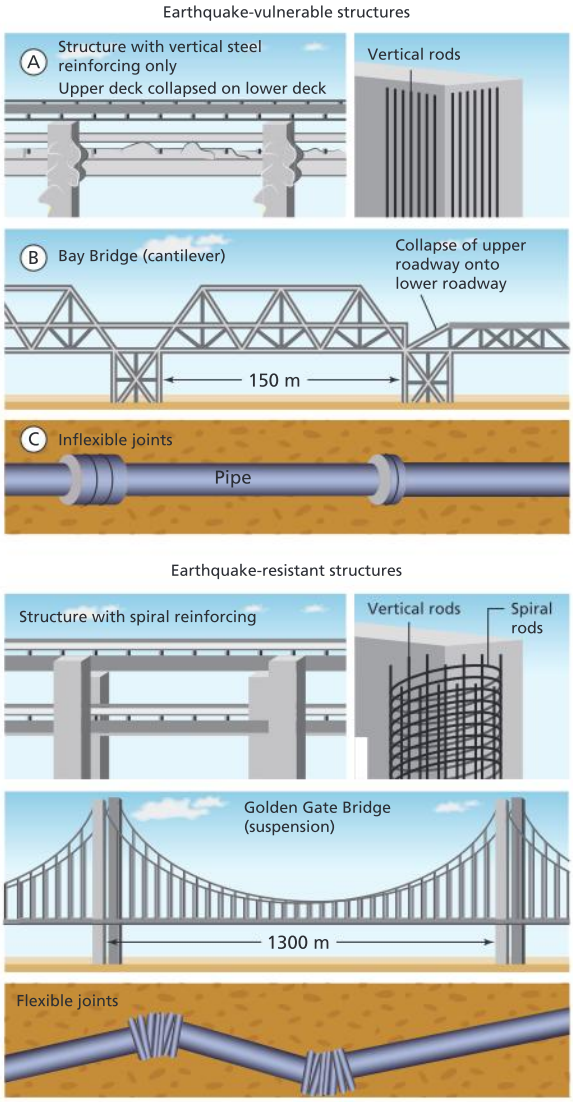
Safe houses

In wealthy cities in fault zones, the added expense of making buildings earthquake resistant has become a fact of life. Concrete walls are reinforced with steel, for instance, and some buildings even rest on elaborate shock absorbers. Strict building codes were credited with saving thousands of lives when a magnitude 8.8 earthquake hit Chile in February 2010.

But in less-developed countries, like Haiti, conventional earthquake engineering is often unaffordable. The earthquake in Haiti was a reminder that billions of people live in houses that cannot withstand shaking. Yet safer houses can be built cheaply – using straw, reinforced adobe and old tyres, for example – by applying a few general principles (Figure D.22).

In Peru in 1970 an earthquake killed around 70,000 people, many of whom died when their houses collapsed around them. Heavy, brittle walls of traditional adobe – cheap, sun-dried brick – cracked instantly when the ground started to buckle. Subsequent shakes brought roofs thundering down. Existing adobe walls can be reinforced with a strong plastic mesh installed under plaster – in an earthquake these walls crack but do not collapse immediately, allowing occupants to escape. Plastic mesh could also work as a reinforcement for concrete walls in Haiti and elsewhere.

Other engineers are working on methods that use local materials. Researchers in India have successfully tested a concrete house reinforced with bamboo. A model house for Indonesia rests on ground-motion dampers – old tyres filled with bags of sand. Such a house might be only a third as strong as one built on more sophisticated shock absorbers, but it would also cost much less and be more likely to be adopted in Indonesia. In northern Pakistan, traditional houses are built of stone and mud, but straw, which is readily available, is far more resilient and also warmer in winter.



▲ **Figure D.21:** Aseismic design

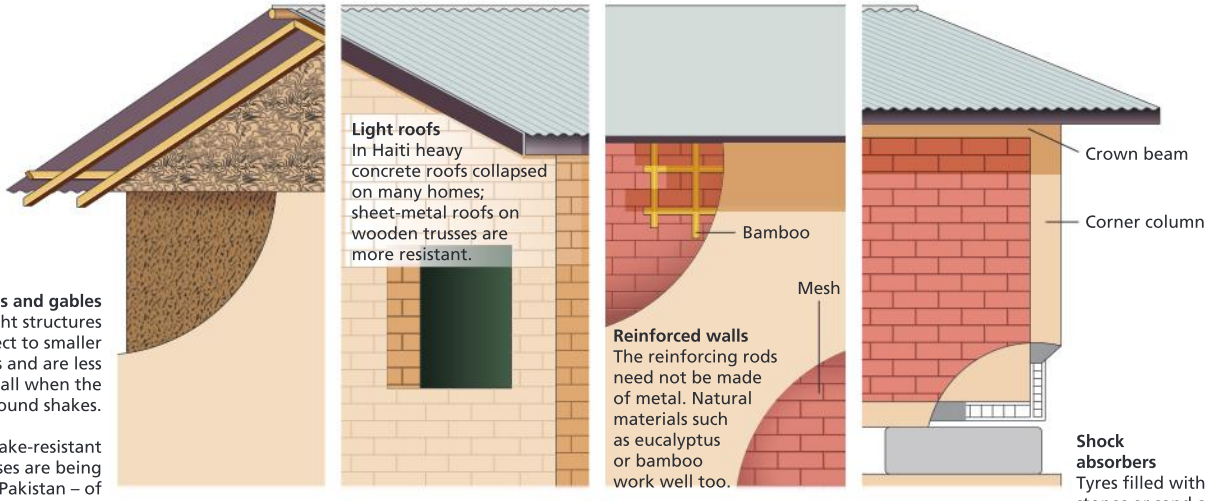
Controlling earthquakes

In theory, by altering the fluid pressure deep underground at the point of greatest stress in the fault line, a series of small and less-damaging earthquake events may be triggered. This could release the energy that would otherwise build up to create a major event. Additionally, a series of controlled underground nuclear explosions might relieve stress before it reaches critical levels.

Controlling volcanoes

It is possible to manage lava flows by diverting them – this has been successful on Mt Etna. Lava flows can be diverted either by the use of dry channels, explosives to divert the flow near its source, or by

	Pakistan	Haiti	Peru	Indonesia
Most destructive quake	8 October 2005	12 January 2010	31 May 1970	26 December 2004
Location	Northern Pakistan/Kashmir	Port-au-Prince area	Chimbote	Sumatra
Magnitude	7.6	7.0	7.9	9.1
Fatalities	75,000	222,500	70,000	227,900 (including the global tsumami deaths)



Light walls and gables
Lightweight structures are subject to smaller forces and are less likely to fall when the ground shakes.

Quake-resistant houses are being built in Pakistan – of straw. The compressed bales are held together by nylon netting and sandwiched between layers of plaster.

Small windows
Small, regularly spaced openings create fewer weak spots in walls. But the bigger problem in Haiti was that walls were not properly reinforced.

In Peru the walls of some adobe houses have been reinforced with a plastic mesh to prevent collapse.

Confined masonry
In Indonesia and elsewhere, brick walls can be framed and connected to the roof by corner columns and a crown beam of reinforced concrete. In a quake the structure moves as a unit.

Shock absorbers
Tyres filled with stones or sand and fastened between floor and foundation can serve as cheap ground-motion absorbers for many types of building.

Since 2007 some 22,500 houses in Peru have been strengthened with plastic mesh or other reinforcements.

▲ **Figure D.22:** Safe houses

pumping water onto the lava front to cool it. This was successfully carried out in Heimaey, Iceland, in 1973, but it required pumping over a six-month period. There is little that can be done to reduce the impacts from pyroclastic flows other than to evacuate the area, as was done with Mt Pinatubo and the Soufrière Hills volcano.

Tsunamis

Tsunamis are generally managed through the use of sea walls and early-warning systems. However, cost constraints usually dictate the height of the wall that can be built. Walls can only provide a certain amount of protection and will not stop bigger waves.

Post-event management strategies

Short-term, mid-term and long-term responses after an event

In the immediate aftermath of a disaster the main priority is to rescue people. This may involve the use of search and rescue teams and sniffer dogs. Thermal sensors may be used to find people alive among the wreckage. The number of survivors decreases very quickly. Few survive after 72 hours. Although there were reports from Sichuan of people surviving for nearly 20 days, the number was extremely low.

Rehabilitation refers to people being able to make safe their homes and live in them again. Following the UK floods of 2007, some people were unable to return to their homes for over a year. During December 2015 thousands of people were evacuated from their homes when storms Desmond and Eva brought record rainfall to many parts of the north of England. For some residents in New Orleans, rehabilitation was not possible after Katrina, and so reconstruction (rebuilding) was necessary. This can be a very long, drawn-out process, taking up to a decade for major construction projects. The timescales involved are shown in the model of disaster recovery (Figure D.23). The overall aim is to get communities back to their pre-disaster level, and to promote continuing human development.

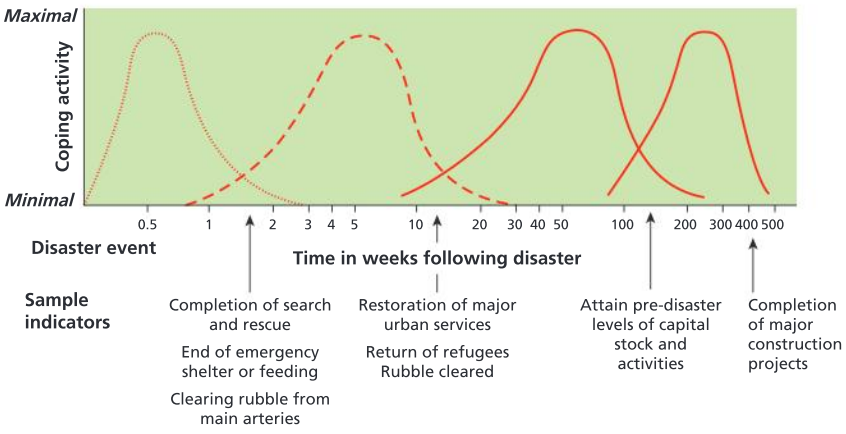
See also the case study on the Soufrière Hills volcano, Montserrat (pages 192–193), which looks at the event, the impacts and the post-disaster recovery and reconstruction.

As well as dealing with the aftermath of a disaster, governments try to plan to reduce impacts of future events. This was seen after the South Asian tsunami of 2004. Before the event, a tsunami early-warning system was not in place in the Indian Ocean. Following the event, as well as emergency rescue, rehabilitation and reconstruction, governments and aid agencies in the region developed a system to reduce the impacts of future tsunamis. It is just part of the progress needed to reduce the impact of hazards and to improve safety in the region.

Rescue, rehabilitation and reconstruction in practice

Following the 2004 South Asian tsunami, the Indonesian government produced a master plan for the rehabilitation and reconstruction of the region affected by the tsunami. It defined rescue, rehabilitation and reconstruction in the following ways:

- rescue – saving people so they can survive despite having only minimum life necessities
- rehabilitation – restoring the functions of public services, a process that needs one or two years
- reconstruction – rebuilding the public system, economic system, infrastructure and governance functions, predicted to take two to five years.



▲ **Figure D.23:** A model of disaster recovery for urban areas

In practice, the Indonesian government provided the following rescue services:

- immediately helping the disaster survivors
- immediately burying the victims' dead bodies
- immediately enhancing basic facilities and infrastructure to be able to provide adequate services for the victims.

ATL Research skills

Visit http://www.usindo.org/publications/Blue_Plan_Aceh.pdf and research, in detail, the plans of the Indonesian government for the rehabilitation and reconstruction of areas affected by the tsunami.

Case study

Reconstructing Haiti

Following the earthquake (see page 188), plans were discussed for the rescue, rehabilitation and reconstruction of Haiti. Reconstructing Haiti is a challenge to the international community, which has failed over decades to lift the island state out of poverty, corruption and violence. Between 2000 and 2010, more than $4 billion has been spent to rebuild communities and infrastructure devastated by hurricanes, floods and landslides, but mismanagement, lack of coordination and attempts by global institutions to use Haiti as an economic testbed are believed to have frustrated all efforts. A foreign debt of $1.5 billion has weighed down the economy.

Stage 1: Rescue, 1–10 weeks

The first step was emergency teams working with government and communities to rescue trapped people, clear rubble, and restore water and sanitation to prevent disease. Haiti has a number of self-help groups, NGOs, unions, faith groups, and youth brigades that helped mobilize the emergency effort.

Stage 2: Assessment, 6–10 weeks

The UN, government donors, the World Bank and charities needed to know what capability remained. Ports, hospitals, houses, schools and roads were in a dreadful state, and there was little piped water or electricity beyond the business area in the capital. Pumps and pipes had been severely damaged, government records had been lost, and teachers, doctors, engineers and professionals had been injured or killed. The extent of devastation needed to be fully understood in order for recovery to begin. There needed to be a pause, since planning was needed rather than reaction.

Attention was on the capital, Port-au-Prince, but cities like Carrefour and Jacmel were also damaged, as well as hundreds of rural communities.

Stage 3: Coordination, 1–10 weeks

The lesson of the 2004 tsunami and other disasters was that there was a real risk of wasting aid in the race to help. Coordination was needed at national and NGO level. The danger was that institutions could rush in, impose their own ideas, and duplicate efforts. The key, even at this emergency stage, was to think long term. Expectations also needed to be managed: people living in slums sometimes expect to get palaces after a hazard event has destroyed their home. When they do not, this can lead to problems.

Stage 4: Rehabilitation, 1–52 weeks

If, as the Red Cross suggested, 3 million people needed to be rehoused, the infrastructure of the country had to be rebuilt. Haiti's record of handling money is poor, and it is one of the world's most aid-dependent states. Hampering its recovery have been deep corruption, a poor civil service, and mistrust between the donor community and the government. Aid agencies have increasingly bypassed government, adding to administrative chaos.

Stage 5: Reconstruction, 1–40 years

Many countries and aid groups already have major reconstruction programmes in Haiti. Realistically, it will take decades to rebuild the country. It is likely that the international community will now follow the example of Aceh, where a government agency was set up exclusively to manage the reconstruction; it set up a multi-donor fund to coordinate aid efforts.

Responses are affected by a number of factors. These include:

- the magnitude of the hazard – the greater the event, the greater the reaction
- the predictability of the event – hurricanes are annual events, whereas earthquakes are more random in time
- the level of wealth – how much the individual household, national government and international organizations can raise
- the perceived level of risk – whether a volcano is likely to erupt or not, and its level on the VEI (volcanic explosivity index)
- the level of information provided in the media – probability of event, size of event, measures to be taken
- the degree of hazard event preparation – building codes, land-use zoning, drills
- personal factors – awareness of alternatives, ability to afford such alternatives, and so on.

Using phones to track missing children

RapidFTR is the brainchild of a New York student. It is an open-source app designed to reunite children with their families in rapidly developing disaster situations, and it is being actively developed by UNICEF. The app processes information about missing children in disaster situations, and has helped to reunite families.

Using android phones and laptops, the app enables humanitarian workers to register information about missing children, which is then uploaded to a database accessible by those responsible for child welfare. The quicker children are found, the less vulnerable they are to violence, exploitation and trafficking.

One of the main advantages of the app being open source is that it can be used and adapted by different teams on a range of different platforms. The central data system means that a range of cases, such as those involving children, vulnerable families or women at risk from violence, can be tracked over time. It could even be used in place of traditional birth registration.

Using phones for hazard mapping

The use of communication technologies allows information about the scale and location of the hazard to be distributed, and so aid with hazard mapping. In a project in Rio de Janeiro, UNICEF has been training young people to map social and environmental risk. As many teenagers are very competent with their phones, UNICEF believes that they will be able to alert the authorities, such as UNICEF, about natural hazards and problems in their home region, and so initiate a response.

Concepts in context

Geophysical hazard events will continue to affect a large number of people in the future. This is due to population growth and due to more people living in areas at risk of geophysical hazards, whether by choice or through lack of choice. Communities will need to make preparations to cope with geophysical hazards and they will have to change certain aspects of lifestyle – where they live/work/interact with the natural environment. There are a number of **possibilities**. Much of the post-event rehabilitation and reconstruction will depend on the level of wealth of a country, the aid/assistance that is offered, and the cooperation between different stakeholders (for example, multi-government organizations (MGOs), national governments, NGOs, community leaders/local government and the resident population). The possibilities will vary from place to place.

ATL Research skills

Visit http://www.rapidftr.com/ and look at the homepage of the rapid family tracing and reunification app.

Read about UNICEF's digital mapping to reduce disaster risks at http://www.unicefstories.org/2014/05/20/digital-mapping-technology-to-reduce-disaster-risks/ and http://i1.wp.com/unicefstories.files.wordpress.com/2013/11/urp-1.jpg to see a map of environmental issues identified by young people.

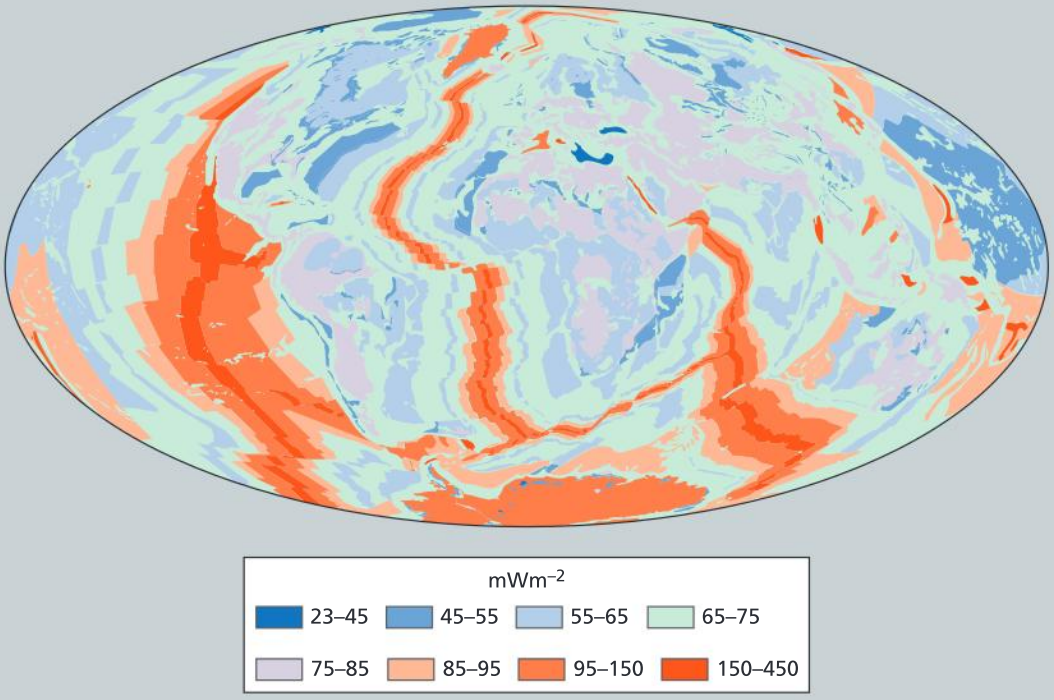
Check your understanding

1. State the proportion of the world's natural hazards between 1994 and 2013 that earthquakes accounted for.
2. State the proportion of deaths from natural hazards that occur in low–middle income and low income groups.
3. Suggest two reasons why population growth may increase the likely impact of geophysical hazards.
4. What is meant by the term "safe house"?
5. Identify two animals that are said to predict earthquakes.
6. Identify an example of a volcanic eruption that was successfully predicted and one false alarm.
7. Identify the Indonesian volcano that erupted in 2014 having largely been dominant for hundreds of years.
8. Outline the main methods of slope stabilization.
9. Identify the main differences between short-term and long-term responses to natural hazards.
10. How can GPS systems help to manage the impacts of natural hazards?

Synthesis and evaluation

Hazard risk is a result of spatial interactions between different human processes (for example, inequalities in wealth generation) and physical processes, such as tectonic processes. Some people, for example women, the young, the elderly and the poor, are more at risk than other groups. Physical processes vary in their spatial distribution – in addition, the scale/magnitude of events varies, and high-magnitude low-frequency events produce more damage than low-magnitude high-frequency events. People have different views on how risk can be managed – for example, whether they should accept the risk or adapt because of it. Risk is often shown by the use of simple line graphs, but can be shown by proportional symbols.

The map shows global flows of heat from the Earth's interior to the surface.



▲ Global map of the flow of heat, in mWm^{-2}, from the Earth's interior to the surface

(a) (i) Describe the global variations in the flow of heat from the Earth's interior. (3 marks)

(ii) Explain one impact of rising heat in some parts of the Earth. (2 marks)

(iii) Using examples, explain the relationship between hazard magnitude and frequency. (5 marks)

(b) Either

"The impact of geophysical hazards depends less on the natural hazard and more on human factors." Discuss this statement. (10 marks)

Or

"Geophysical hazards cannot be controlled – they can only be managed." Discuss this statement. (10 marks)

OPTION E
LEISURE, TOURISM AND SPORT

Key terms

Leisure	Any freely chosen activity or experience that takes place in non-work time. It includes sport, recreation and tourism.
Recreation	A leisure-time activity undertaken voluntarily and for enjoyment. It includes individual pursuits, organized outings and events, and non-paid (non-professional) sports.
Sport	A physical activity involving events and competitions at the national and international scale with professional participants.
Tourism	Travel away from home for at least one night for the purpose of leisure. This definition excludes day trips – some of which may be international trips. There are many possible subdivisions of tourism. Subgroups include **ecotourism** – tourism focusing on the natural environment and local communities.
Sustainable tourism	Tourism that conserves primary tourist resources and supports the livelihoods and culture of local people.
Global Commons	Resources that are outside the reach of any one nation, for example oceans, the atmosphere and Antarctica. Global commons may be exploited or degraded and so need to be managed carefully.
Niche tourism	Special interest tourism catering for small numbers of people who are crowd intolerant. It is usually more concerned with sustainability than mass tourism.
Ecotourism	A "green" and "alternative" form of tourism that aims to preserve the environment by managing it responsibly and sustainably.

This optional theme focuses on ways in which people in a growing number of global contexts make use of their leisure time. As more people join the "global middle class", they have disposable incomes allowing participation in tourism, including international travel and different types of sport. Sport can be an important use of leisure time for people on low incomes who cannot afford to participate in tourism.

While tourism often has an urban focus, rural areas provide another important geographical setting for touristic activities including walking, enjoying the wilderness, doing extreme sports or visiting heritage sites. The uses made of places vary greatly depending on physical geography, history and the level of economic development.

Through study of this optional theme, you will develop your understanding of processes, places, power and geographical possibilities. You will also gain an understanding of more specialized concepts including consumption (of landscape), carrying capacity and threshold (in relation to environmental stress) and sustainability (in relation to long-term management of touristic resources).

Key questions

1. How have human development **processes** given rise to the concept of leisure and leisure activities?
2. How do physical and human factors shape **places** into sites of leisure?
3. How do the variations in **power** of different countries affect their participation in global tourism and sport?
4. What are the future **possibilities** for management of and participation in tourism and sport at varying scales?

1 Changing leisure patterns

The growth and changing purpose of leisure time for societies in different geographic and developmental contexts

Leisure may be defined in terms of time, activities, or states of mind. In terms of time, leisure can be seen as free time. Leisure can also be defined as specific activities conventionally thought of as "leisurely". A more thorough definition may be based on what the majority of people would list as leisure activities, such as watching TV, participating in **sports** or exercise, reading, watching movies, and so on. Finally, leisure can be defined as a state of mind, meaning engaging in enjoyable or pleasurable activities.

Leisure activities are undertaken outside work for the purpose of pleasure, entertainment, improvement of knowledge, and relaxation. Leisure is associated with the time that is free from work and other personal care activities (eating, washing, sleeping and so on). However, some groups, such as the unemployed and the retired, have more free time than they would perhaps like.

Although eating is a biological necessity, it can also be a leisure activity, for example going out for a meal or cooking as a form of entertaining. Leisure pursuits range from informal and short-lasting to formal and long-lasting. A subset of leisure is hobbies which are undertaken for personal interest. They generate satisfaction and often result in the acquisition of new skills. They may be indoor or outdoor activities and may involve collection, competition and observation. The range of leisure activities is expanding rapidly with the development of societies to support enthusiasts. Substantial and fulfilling hobbies, particularly those that lead to personal development, may be considered as serious leisure activities.

For some people their leisure activities are passive, informal and time-filling, such as watching television. Others choose to participate in health-enhancing pursuits, such as going to the gym. There are also leisure activities that help people to find a life partner.

Figure E.1 shows that across 18 OECD countries people spend the largest proportion of their time in personal care activities. "Personal care" includes sleep, eating and drinking, and other household, medical and personal services (hygiene, visits to the doctor, hairdresser etc.). Variation in the share of time spent in personal care across these countries is comparatively small, ranging from a low of 43 per cent of total time in Canada, Sweden, Mexico and Norway to a high of 49 per cent in France.

Following personal care, leisure is typically the next largest time category, accounting for 22 per cent of time on average across the 18 regions. "Leisure" includes hobbies, games, television viewing, computer use, recreational gardening, sports, socializing with friends and family, attending events, and so on. Leisure time is greatest in Norway

Conceptual understanding

Key question

How have human development **processes** given rise to the concept of leisure and leisure activities?

Key content

- The growth and changing purpose of leisure time for societies in different geographic and developmental contexts.
- The categorization of touristic activities (cost, duration, destination) and sporting activities (cost, popularity, site).
- The link between economic development and participation in leisure activities.
- Factors affecting personal participation in sports and tourism including affluence, gender, stage in life cycle, personality, place of residence.

▲ **Photo E.1:** Magic Kingdom, Walt Disney World, Florida, USA

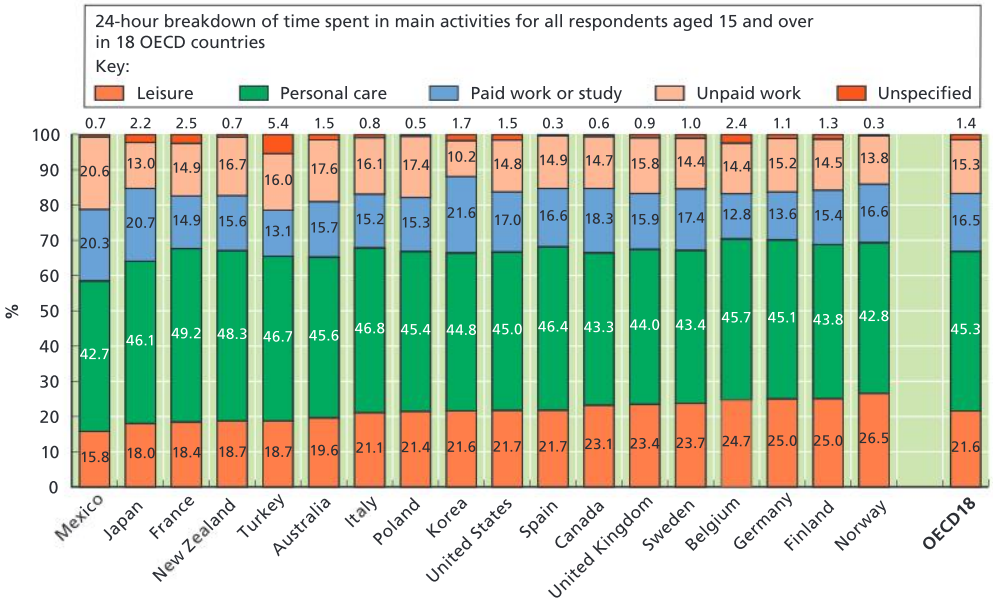


Figure E.1: Share of time taken by leisure and other activities across an average day

Source: OECD. 2009. "Measuring leisure in OECD countries". *Society at a Glance 2009, OECD Social Indicators*

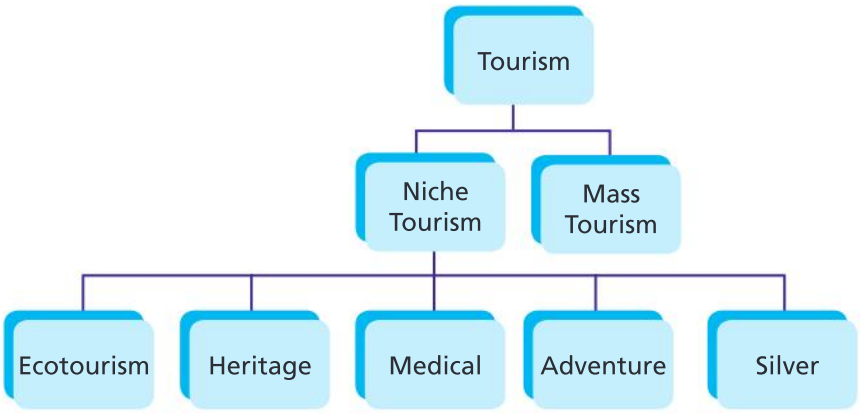
(27 per cent of time) and least in Mexico (16 per cent of time). Amounts of leisure time are also high in Belgium, Germany and Finland. Japan and Mexico are the only two countries where paid work represents a higher proportion of time than leisure, while paid work and leisure represent equal shares in Korea. All 15 of the other countries report more leisure time than paid work time. On average across the OECD18, the time spent in paid work is slightly less than in leisure, but the margin is fine. "Paid work" includes full-time and part-time jobs, breaks in the workplace, commuting to and from the workplace, time spent looking for work, time spent in school and commuting to and from school, and time spent in paid work at home. In contrast, "unpaid work" includes all household work (chores, cooking, cleaning, caring for children and other family and non-family members, volunteering, shopping, and so on).

The growth of leisure has been facilitated by a number of factors:

- a reduction in the length of the working day
- a reduction in the length of the working week
- an increase in wages
- an increase in disposable income
- the growth of leisure activities
- more early retirement
- an increase in self-employment and flexitime
- developments in technology (such as washing machines and freezers) which enable people to spend less time on chores, and other developments in technology, such as TVs and the Internet, which provide opportunities for leisure.

Similarly, agricultural machinery has freed up time for some farmers, but an increase in leisure activity is not necessarily a result.

For many people in HICs and emerging economies, having more leisure time and greater disposable income allows them to take part in more



▲ **Figure E.2:** Types of tourism

Activity 1

1. Define the terms "niche tourism" and "mass tourism".
2. Find an example of each of the types of tourism shown in Figure E.2.
3. Suggest why most geographers prefer niche tourism to mass tourism.

leisure activities. However, in poorer countries, and in countries where there is political turmoil, there is less opportunity for leisure activities, and not the "state of mind" of being "at leisure". For some indigenous populations, leisure activities may include story-telling and music. For others, their quality of life and standard of living is so low that it limits the amount of leisure time and leisure activities.

Gender differences can also be observed. Men generally have more leisure time than women (in Europe and the USA adult men normally have between one and nine hours more leisure time than women each week). This difference is usually due to their household and parenting responsibilities, although this is changing. In some more progressive households responsibilities are shared. Women's status in society is closely linked to the amount of leisure time they have.

Undoubtedly, there is a link between income and leisure activities. Societies in LICs have less disposable income and therefore less chance of engaging in leisure pursuits, particularly if this involves purchasing expensive equipment. However, there are differences in culture and the various perceptions of leisure that make comparisons difficult.

As life expectancy increases universally, pursuing leisure activities in retirement becomes more important. Older adults can benefit from the physical, social, emotional, cultural and spiritual aspects of leisure. The leisure industry has had to accommodate the needs of the over-65 age group who comprise 25 per cent of the population in many HICs.

TOK

1. Explain how gender influences leisure time in societies at different stages of development.
2. Present an argument that supports the idea that technology does not increase leisure time.

The categorization of tourist activities and sporting activities

For much of history, **tourism** and travel was difficult, expensive, uncomfortable and dangerous, so the desire to travel had to be very strong. Nowadays travel is considered a natural part of life for some people and many people expect to travel at least on an annual basis if not more often. As travel becomes less difficult and more affordable, more and more people travel and for a greater variety of reasons.

Tourism makes use of primary and secondary resources, ranging from the local scale (for example, a local attraction) to the global scale (for

▲ **Photo E.2:** Water park in Florida

example, a hotel chain). **Primary tourist/recreational resources** are the pre-existing attractions for tourism or **recreation** (that is, those not built specifically for the purpose), including climate, scenery, wildlife, indigenous people, cultural and heritage sites. These are distinguished from **secondary tourist/recreational resources**, which include accommodation, catering, entertainment and shopping.

There are many types of tourism (Figure E.2). These types of tourism vary greatly in terms of their cost, duration and destination. For example, skiing holidays are generally expensive due to the equipment needed. As they mainly occur in mountainous areas, much of the food and drink needed to cater for the tourists has to be imported, increasing the cost. Most tourists generally go skiing for one week (although nationals and local residents may go for shorter periods).

In contrast, mass tourism may be cheaper because it can achieve economies of scale. Mass tourism holidays often last for between 7 and 14 days. This type of tourism is most frequently found in coastal areas, for example the Costa del Sol, Spain. In contrast, **ecotourism** is largely a low-impact form of tourism. Nevertheless, some forms of ecotourism can be very expensive, such as gorilla watching, since it costs a great deal to get to the remote locations in which they occur.

ATL Research and communication skills

Plan a holiday for two adults and two children.

Choose two contrasting types of tourism, and research how much it would cost for two adults and two children, possible destinations and length of holiday. (If you choose grey (silver) tourism there will be no children.) Make a two-minute presentation to your class, outlining your findings.

▲ **Photo E.3:** Tourists at Geisir, Iceland, waiting for an eruption

Categorization of sporting activities

▼ **Table E.1:** Groupings of sports

Group 1 Athletics and rugby	American football; archery; curling; Gaelic sports; gymnastics; lacrosse; orienteering; rugby league; rugby union; track and field athletics; triathlon
Group 2 Dancing and yoga	Keep fit; aerobics; dance exercise; pilates; trampolining; yoga
Group 3 Outdoor sports	Angling or fishing; BMX; cyclo-cross; mountain biking; climbing/mountaineering; cycling for health, recreation, training; cycling to get to places (e.g. work, shops); hill trekking or backpacking; motor sports; rambling/walking for pleasure; shooting
Group 4 Swimming, cycling and gym	Health, fitness or conditioning activities; swimming or diving (indoor or outdoor); cycling for fitness or pleasure
Group 5 Racquet sports and running	Badminton; horse riding; ice-skating; jogging; cross-country; road running; squash; table tennis; tennis
Group 6 Bowling	Bowls – lawn/outdoor; bowls – indoor
Group 7 Cricket, football, pub sports and tenpin bowling	Cricket; croquet; darts; football (indoors and outdoors); golf; pitch and putt; putting; skittles; snooker; pool; billiards (excluding bar billiards); tenpin bowling

Group 8 Boxing, martial arts and weightlifting	Boxing; judo; karate; other martial arts (including self-defence); taekwondo; weight training (including body building); weightlifting
Group 9 Minor team sports	Baseball/softball; basketball; hockey; netball; rounders; volleyball
Group 10 Water sports	Any other water sport; canoeing; rowing; waterskiing; windsurfing or boardsailing; yachting or dingy sailing

Table E.1 shows a categorization of sporting activities. Some sports are very popular – such as football, fishing and jogging. Some are very expensive such as horse-riding and yachting, whereas others are cheap, such as running or football. Some take place in a particular place such as a swimming pool or a golf course, whereas others can be played in almost any space available, such as jogging.

Activity 2

Choose any two activities from two different groups, and comment on their likely cost, popularity and site.

The link between economic development and participation in leisure activities

The level of economic development of a country can affect the quality and range of leisure activities within it. The HICs have widespread leisure facilities with a great deal of government investment and all age groups catered for. In the LICs leisure is less important than survival and leisure facilities are extremely limited. Government expenditure on domestic leisure provision is small although investment in tourism is a means of development for some LICs.

As countries develop, there is a change in the leisure activities undertaken by most of their residents. This occurs for a number of reasons. Very poor people may not be able to afford appliances such as televisions. However, as people's incomes improve, televisions become one of the first appliances that they may purchase, and so watching TV becomes an important leisure activity. However, it is not just about being able to afford the leisure activity; it is also about having the time to enjoy the activity or partake in it. For example, as many newly industrialized countries (NICs) develop, there will be large numbers of migrant workers, many of whom will work long hours. Their potential to participate in leisure activities may be limited not only due to long working hours, but also to having to share accommodation, and sending money home. In addition, some may choose to spend their free time studying, so that they can qualify in a particular trade. For more wealthy countries/communities the combination of more income and more leisure time leads to a greater range of leisure activities, other than listening to the radio or watching TV.

In addition, in wealthy countries, leisure activities vary with age (and stage in the family life cycle, see Table E.2). The model shown in Table E.2 assumes that people have the time available for leisure activities, and can afford to participate. It shows how the type of leisure activity varies with age.

▲ **Figure E.3:** The four ages of sporting life
Source: Jane Upton

Table E.2: A traditional family life cycle and its impact on leisure and tourism

Stage in life cycle	Buying or behaviour patterns
1 Bachelor stage: young, single people not living at home	Few financial burdens; fashion opinion leaders; recreation-oriented; buy basic kitchen equipment, basic furniture, cars, equipment for the mating game, holidays.
2 Newly married couples: young, no children	Better off financially than they will be in near future; highest purchase rate and highest average purchase of durables; buy cars, refrigerators, cookers, sensible and durable furniture, holidays.
3 Full nest I: youngest child under six	Home purchasing at peak; liquid assets low; dissatisfied with financial position and amount of money saved; interested in new products; buy washers, dryers, TV, baby food, sleds, skates.
4 Full nest II: youngest child six or over	Financial position better; some wives work; less influenced by advertising; buy larger-sized packages, multiple-unit deals; buy many foods, cleaning materials, bicycles, music lessons, pianos.
5 Full nest III: older couples with dependent children	Financial position still better; more wives work; some children get jobs; hard to influence with advertising; high average purchase of durables; buy new, more tasteful furniture; go on motoring holidays; buy non-necessary appliances, boats, dental services, magazines.
6 Empty nest I: older couples, no children living with them, head in labour force	Home ownership at peak; most satisfied with financial position and money saved; interested in travel, recreation, self-education; make gifts and contributions; not interested in new products; buy holidays, luxuries, home improvements.
7 Empty nest II: older married couples, no children living at home, head retired	Drastic cut in income; keep home; buy medical-care products that improve health, sleep and digestion.
8 Solitary survivor, in labour-force	Income still good but likely to sell home.
9 Solitary survivor, retired	Same medical and product needs as other retired group; drastic cut in income; special need for attention, affection and security.

Source: Page, S. 1995. *Urban tourism*. London, UK. Routledge

Activity 3

1. Study Table E.2 which shows a traditional family life cycle and their buying or behaviour pattern. Describe and explain what types of holidays are likely to be taken at each of these stages.
2. Comment on the likely usefulness of the family life cycle model for leisure in (a) an HIC (b) an NIC and (c) a LIC. Suggest reasons to support your answer.
3. Comment on the differences between the leisure time activities for mothers and fathers in Figure E.4.

Children combining work and leisure in Sudan

Cindi Katz's study of children living in the village of Howa (a pseudonym) demonstrates how work and play are inseparable.

Children are expected to work from an early age. This may involve tasks such as:

- collecting water
- running errands to she shop
- weeding plots
- herding sheep and goats.

When doing these things, children introduce elements of play into their activities. For example, when boys are out herding, games such as shedduck are played which is play fighting where participants have to hop with one leg behind them. By combining games with overseeing the herds, boys can make the work more enjoyable and the time passes more quickly.

Children use scrap metal to make dolls, tractors, houses and models of local shops. They then use these to act out domestic life and agricultural

cycles. An awareness of how trade and wage labour operate is exemplified in their acting out of payment for crops using money made out of broken china.

Society in much of sub-Saharan Africa depends upon child labour, but despite this pressure on their time children are still able to combine work and play.

Leisure in BRICs

Growth of the leisure industry in the BRIC countries (Brazil, Russia, India and China) has been accelerating due to economic and social changes. These include:

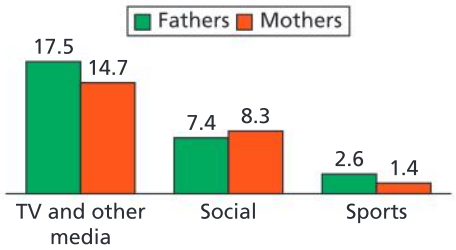
- rising disposable income
- a surging middle class
- rapid urbanizaton
- greater online connectivity
- an aging population.

BRIC leisure and recreation services are expected to grow by 132 per cent between 2014 and 2030. In 2013 the average BRIC household spent $287 on leisure and recreation, anything from durables for recreation such as radios and TVs to recreational and cultural services to gardens and pets, newspapers, magazines, books, stationery and package holidays.

Across the BRIC countries, visiting the cinema is a favourite pastime. India, with its insatiable appetite for Bollywood, led the world with 2.9 billion cinema attendances in 2013. Although cinema attendances have been falling in India relative to TV, gaming and other online entertainment, Brazil, Russia and China have all seen rising cinema attendance.

The BRIC population is aging rapidly; 15 per cent of them were over 65 in 2013. They make up a substantial market for the leisure industry, particularly those services that cater for the elderly such as health resorts, spas, theatres, concert halls, exhibitions and cruises.

Average number of hours per week on different leisure activities



Note: based on adults aged 18–64 with own child(ren) under 18 living in the household (N = 4,822). Other media includes computer, games, radio, etc.

▲ **Figure E.4:** How mothers and fathers spend their leisure time

Source: Pew Research Center analysis of 2010 American Time Use Survey

Changes in leisure in the USA

Since the 1960s there has been a large increase in the amount of leisure time that most American adults have, for some an extra 4–9 hours per week. This has been largely due to shorter working weeks. This has been especially the case among low wage earners. Research has shown that many Americans are spending much of their time away from work alone. More time is spent commuting, and up to 25 per cent of households consist of a single person.

A distinction can be made between the low wage/more free time population and the high wage/less free time workers. The high wage workers may spend a higher proportion of their income on eating out or buying takeaway meals. The low-wage group is less likely to eat out. Inequality is rising in the USA – in 1960, the wealthiest 1 per cent of households accounted for 10 per cent of wealth, but in the 2010s that has grown to over 20 per cent of wealth.

▲ **Photo E.4:** What does this suggest about young children's use of leisure time?

There has been a decline in the number of people playing in team games, but an increase in the number jogging and going to health clubs. Leisure is becoming more individualized. For example, many people use headphones and MP3 players and are essentially alone while they exercise. Students, on average, spent 15 hours a week watching TV, and about 5 hours per week in organized activities.

There is some variation in leisure activities with ethnicity. Going online (for example, to use social media or play games) was reported by 71 per cent of whites, 60 per cent of African-Americans and 56 per cent of Hispanics. This is likely to be related to education and wealth.

The size of facilities is also changing. Cinemas and theatres are increasingly being replaced by multiplex cinemas and theatres. Even in the home, the size of televisions has increased dramatically. In 1968 the Sony Trinitron colour TV screen was 13.7 inches – now there are TV screens that are over 100 inches. The increased prevalence of DVD players has allowed the development of the "home theatre".

Overall, while much leisure was provided in the home in the 19th century, during the 20th century more Americans sought leisure in cinemas, theatres, at restaurants and at sports matches. In the early part of the 21st century, there is a trend towards more leisure being provided within the home environment.

Factors affecting participation in sports and tourism

The decision to participate in sport and tourism is affected by a wide range of physical, demographic and socio-economic factors, including age, sex, economic circumstances, ethnicity, health, stage in life cycle, available time and other responsibilities. Other influences include peer group involvement, participation as a child and location (that is, where people live relative to available facilities).

There are significant spatial variations in the participation in sport and in international sporting success. The **participation rate** refers to the proportion of a population that takes part in a specific sporting activity.

Physical factors

A number of physical factors have an impact on participation in sport and tourist activities. For example:

- skiing and winter sports are associated with mountain areas, such as the Alps, that have regular and reliable snow in winter
- coastal areas with large plunging breakers produce ideal conditions for surfing, such as in Hawaii and California
- hilly areas can promote mountain biking, as in the case of Wales
- rivers and lakes promote fishing
- it has been suggested that the increase in red blood cell concentration at high altitude favours long-distance runners in the high-altitude regions of Kenya and Ethiopia
- areas with wide sandy beaches, and a reliable climate in summer (that is, hot and dry) will favour coastal/beach tourism, for example Miami Beach, Florida.

Activity 4

1. Comment on the figures shown in Table E.3.
2. Find out the population size for each country, and work out the average tourist expenditure per person for each of the countries.
3. Comment on the variation in average tourist expenditure between countries.

Case study

Changes in China's leisure activities

In 2015 the consulting firm Daxue Consulting reported that among China's adult and elderly population:

- 22 per cent of people spent 1–2 hours a day on leisure activities
- 16 per cent spent 3–4 hours on leisure activities
- 12 per cent spent 4–5 hours, and the rest spent more than 5 hours.

About one-third of people spend their leisure time reading and one-sixth watching TV. As China has developed and people become richer, increasingly more people are spending time online. About one-third of Chinese adults spend time on the Internet through their mobile phone or laptop. Other popular leisure-time activities include shopping, especially by women, and table tennis and badminton. Numerous parks throughout China have free table-tennis tables set up, and there are also free badminton courts. Kite-flying, tai chi, chess, mahjong, playing cards, public dancing and jogging are all common in Chinese parks.

Increasingly, the Chinese middle classes are taking part in sports and leisure activities such as cycling, swimming, camping and rock climbing.

However, for many Chinese they do not have the time to engage in these activities. Many migrant workers work extremely long hours, and may be too tired – physically or mentally – to engage in leisure activities. Moreover, they do not have much disposable income, especially if they have to send some of it to their family.

Leisure activities for Chinese children are also changing. Surveys of students show that the most popular activities were doing homework, doing extra reading, taking part in academic training programmes, playing with friends and watching TV. The amount of leisure time that students have increased after 1995, when Saturday school ceased to operate. Leisure activities in the vacation tend to be highly organized. Most children, especially in the more developed eastern part of the country, go to summer camps organized by schools or community organizations.

There are signs that leisure activities in eastern China are converging with leisure activities in the Western world. In 2016, China's largest private property developer, the Wanda Group, opened Wanda City in Nanchang, an entertainment complex that it is a home-grown (that is, Chinese) rival to Disney, and a theme park in Shanghai. Wanda City includes a Chinese-themed park, an indoor shopping mall with cinemas, restaurants and hotels, and the world's largest ocean park. Also in 2016, Disney opened its own resort in Shanghai, the largest Disneyland in the world. The Shanghai Disney Resort ("Mickey Mao") is expected to become the world's most visited theme park, attracting up to 50 million guests a year. In contrast, Walt Disney World in Florida attracted 19.3 million visitors in 2014. Some 330 million people live less than three hours by car from the Shanghai Disney Resort.

Photo E.5: Part of Wanda City: China's new theme park revolution

Table E.3: Biggest tourist spenders, 2014 ($m)

1	China	164.9
2	USA	145.7
3	Germany	106.6
4	UK	79.9
5	France	59.4
6	Russia	55.4
7	Canada	33.8
8	Australia	31.9
9	Brazil	30.0
10	Italy	28.9
11	Japan	28.6
12	Belgium	26.4
13	South Korea	25.9
14	Saudi Arabia	25.1
15	Singapore	23.9
16	Hong Kong	22.0
17	Netherlands	21.4
18	Switzerland	20.2
19	Norway	19.3
20	Sweden	18.5

Source: *The Economist*. 2015. *Pocket World in Figures*. London, UK. Profile Books.

Activity 5

Using information in this section, describe how participation in sports varies with (a) gender, (b) age, (c) ethnicity and (d) socio-economic conditions.

Suggest reasons to explain these variations.

Human factors

Human factors relate to economic, social and political issues. Most people who go on holiday travel a relatively large distance from their home, that is, they visit a place that they do not normally experience. Many sports take place in sporting venues such as tennis courts, football pitches and swimming pools. Thus, human factors might not be as important as physical factors.

There is a strong correlation between **economic wealth** and the origin of tourists (Table E.3) as well as the provision of sports facilities. For example, most golf courses are found in HICs and NICs. An obvious exception to this is the large number of golf courses that may be located in LICs for the benefit of tourists. The development of golf courses in Vietnam is a good example.

Political, social and cultural factors

There is also evidence that **political factors** influence participation in tourism and the provision of sporting infrastructure. Examples include the terrorist attacks in Paris and Brussels in 2015 and instability in the Middle East and North Africa (MENA) region.

Social factors are also important. Some people cannot afford the membership fees associated with certain sports. Golf clubs are often expensive. Boxing is a sport generally associated with a working-class population (although Oxford University and Cambridge University each have boxing clubs). Polo is another sport that is largely the preserve of the wealthy.

Cultural factors can also influence tourist destinations. Places such as Lourdes and Mecca attract many pilgrims each year. Culture also affects participation in sport. A good example is the low participation of Muslim women in athletics and swimming. The convention for Muslim women to remain robed means that successful Muslim athletes, such as the Moroccan middle-distance runner Hasna Benhassi, receive much criticism at home.

Socio-economic factors that affect participation in sport

Participation in sport varies according to socio-economic conditions, employment status and housing tenure. For example, people who own their house are more likely to participate in sport than those living in rented accommodation. Going to the gym is the most popular sporting activity for people living in rented accommodation. In contrast, swimming is the most popular sport for people in all other forms of housing tenure.

Access to a car

People with access to a car have higher rates of sports participation than those without access to a car. In contrast, those without access to a car walk more regularly.

Case study

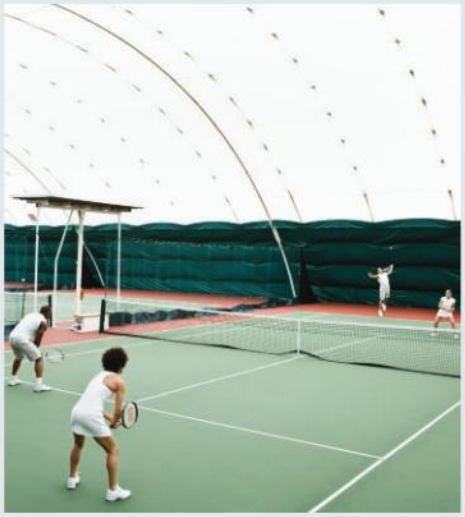
Sport participation in the UK

While men and women are equally likely to walk for health and recreational purposes, men are more likely to cycle or to take part in sport. Participation in sport is also greater among younger people, those with a car, students and those in higher income bands. People in managerial positions tend to take part in sport more frequently than those in other socio-economic groups, and people in full-time employment are more than twice as likely to cycle for health and recreation as retired people. The most popular sports vary by sex. Three of the top five sports for both men and women are swimming, health and fitness, and cycling. However, female participation is heavily concentrated in swimming and health and fitness, while male participation is more widely spread across a range of different activities. Time, expense and health problems are the most commonly cited reasons for not participating in sport. Participation in sport also varies according to personality – some people prefer high-risk sports such as mountaineering and rock climbing, whereas others may prefer more sedate sports such as bowls.

While non-participation does not vary by sex, it does by other demographic and socio-economic factors. Those most likely *not* to participate in any cultural or sporting activities are aged 75 and over; black and minority ethnic (BME); lone pensioners; local authority tenants; people with no qualifications; those in semi-routine or routine occupations; people who are permanently or temporarily sick, disabled or injured; and people who are on relatively low incomes. People who participated in sport as a child are more likely to participate as an adult. The analysis shows that the majority of adults who play sport also played sport as children.

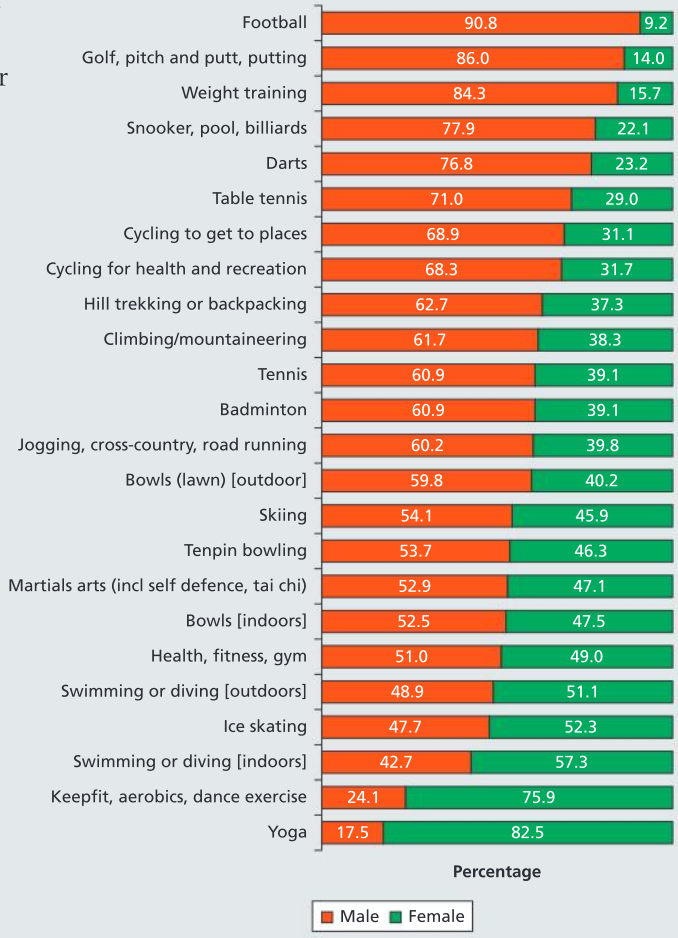
Specific sports have their own gender profiles. However, while, for example, nearly 85 per cent of those who take part in weight training are male, just over 5 per cent of men actually weight train. Women are more likely than men to take part in keep fit and aerobics, and over 75 per cent of

▼ **Photo E.6:** Tennis is a sport that is enjoyed by both genders



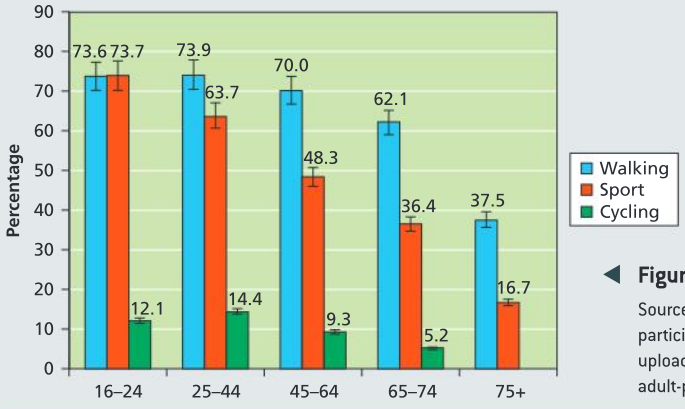
▼ **Figure E.5:** Sports participation in the UK by gender

Source: Department for media, culture and sport. 2011. "Adult participation in sport". https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137986/tp-adult-participation-sport-analysis.pdf



Case study (continued)

participants in those activities are female. Men are more likely than women to take part in cycling, and over two-thirds of cyclists are male. Women are more likely than men to go swimming, as also reflected in the proportions of participants.



The most popular sports also vary by age group. For example, 16–24-year-olds are most likely to play football outdoors (over 20 per cent), and football is the most popular sport among this age group. Health and fitness (that is, going to the gym) is a top 10 activity for all age groups and highest for those aged 16–24 (over 20 per cent) and 25–44-year-olds (18 per cent). The 16–44-year-olds are the most likely to swim, while people aged 75 and over are the least likely to. Golf is a top 10 activity for all age groups except 16–24-year-olds.

◀ **Figure E.6:** Sport and active recreation, by age

Source: Department for media, culture and sport. 2011. "Adult participation in sport". https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137986/tp-adult-participation-sport-analysis.pdf

Employment

▼ **Table E.4:** Sports participation by socio-economic status (%)

Socio-economic status	Walk	Cycle	Sport and active recreation
Managerial and professional	74.3	13.2	62.7
Intermediate occupations	67.4	10.0	51.7
Small employers and self-employed	64.2	9.6	55.9
Lower supervisory and technical occupations	66.7	9.9	49.4
Semi-routine and routine	62.0	10.3	53.6
Never worked and long-term unemployed	67.0	10.3	53.6

Concepts in context

The demand for leisure, recreation and tourism is affected by many **processes**. In short, people with a disposable income and free time are able to afford such activities. People lacking either factor have reduced leisure activity options. There are major differences in participation in leisure, sport and tourism. However, it is not just based on wealth and free time. There are major differences based on gender, ethnicity, marital status, age and composition of household (family life status). Leisure activities change as countries become wealthier. There has been some convergence of leisure activities. This is illustrated by the use of the Internet, enabling people around the world to follow similar interests wherever they are.

Check your understanding

1. Distinguish between leisure, sport and tourism.
2. Briefly explain three reasons why leisure time has inreased in HICs.
3. Explain how leisure time is affected by gender.
4. Briefly explain how a country's level of economic development affects participation in sport.
5. Briefly explain the variations in demand for tourist destinations.
6. Explain the concept of the "family life cycle".
7. Suggest how changes in family life cycle affect participation in sport and tourism.
8. Identify the social characteristics of people who are excluded from participating in sport in the UK.
9. Outline the differences in the number of hours that mothers and fathers spend watching TV as a leisure activity.
10. Distinguish between primary and secondary tourist/recreational resources.

2 Tourism and sport at the local and national scale

Rural and urban tourism hotspots

Hotspots are areas of intense sporting or leisure activity that attract above average numbers of visitors.

Tourists are attracted to these hotspots because they have primary and secondary resources and are accessible. They are also perceived to be free of tourist deterrents which may not be long-lasting but will put off visitors. Such deterrents would include:

- natural hazards, such as the earthquake in Haiti 2010
- political unrest and terrorism, such as the events in Paris in 2015
- disease, such as the ebola outbreak in West Africa in 2015.

In order to become a "successful" hotspot, an area needs to have both the infrastructure for tourists and the attractions. Tourist attractions include scenic landscapes, coastal resorts, heritage and historic buildings, different cultures, performing arts, and festivals. To cater for tourists, infrastructural developments include accommodation, transport and public utilities. Transport developments include external linkages (ports, airports, rail termini) to allow tourists to gain access to the location, and local linkages (roads, car parks, services). Accommodation development will reflect the demand, whether it is low–cost accommodation or exclusive accommodation. The expectations of many tourists means that local or national governments will have to provide public utilities such as water supply, sanitation and electricity. Finally, investment, labour and promotion is important. National governments typically play an important role in the promotion of destinations, in infrastructural improvements and employment training. By contrast private initiative is more prominent in the development of tourist accommodation and attractions.

Conceptual understanding

Key question

How do physical and human factors shape **places** into sites of leisure?

Key content

- Human and physical factors explaining the growth of rural and urban tourism hotspots including the role of primary and secondary touristic resources.
- Variations in sphere of influence for different kinds of sporting and touristic facility, including neighbourhood parks and gyms, city stadiums and national parks.
- Factors affecting the geography of a national sports league, including the location of its hierarchy of teams and the distribution of supporters.
- Large-scale sporting, musical, cultural or religious festivals as temporary sites of leisure, and their associated costs and benefits.

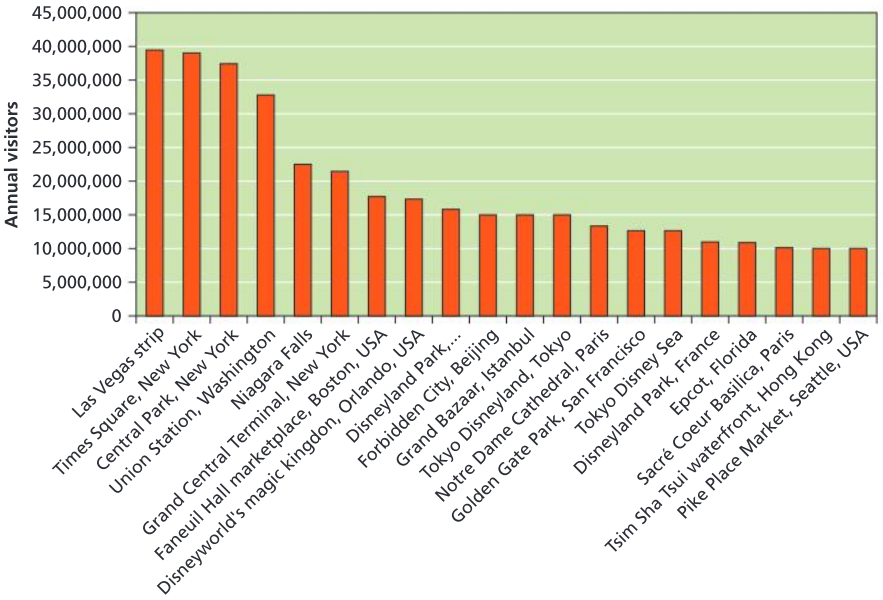
▼ **Table E.5:** Some factors affecting the growth of a tourist or leisure hotspot

Natural landscape	Mountains (Nepal); biodiversity (Monteverde cloud forest, Costa Rica); coasts (Mediterranean); forests (Amazon rainforest); deserts (Tunisia); polar areas (Iceland); rivers (Grand Canyon).
Climate	Hot, sunny, dry areas are very attractive to most tourists; seasonality of climate leads to seasonality of tourism.
Culture	Language, customs, clothing, food, architecture, and theme parks. Examples include recreation (Paris); religion (Mecca); education (Oxford).
Sporting events	Events such as the World Cup (Brazil, 2014) and the Olympic Games (London, 2012; Rio de Janeiro, 2016) lead to a short-term boom in tourism.
Government investment and planning	The creation of new resorts, improved infrastructure and new attractions, for example theme parks.

Activity 6

Figure E.7 shows the 20 most popular tourist attractions in the world by the number of annual visitors.

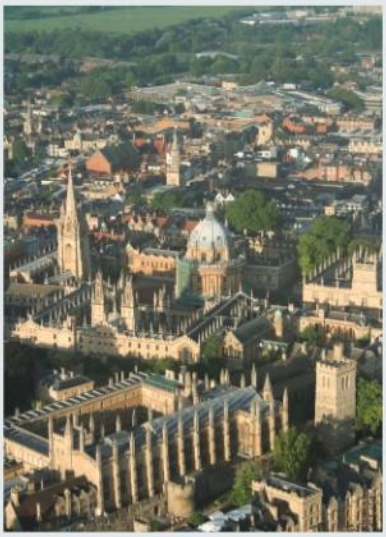
1. Describe the global concentration of these hotspots.
2. Explain the distribution shown.
3. Comment on the relative attraction of primary and secondary resources at these tourist hotspots.



▲ **Figure E.7:** The 20 most popular tourist hotspots in the world

Case study

Tourism in an urban hotspot: Oxford



▲ **Photo E.7:** Oxford at dawn

Oxford is world famous as a historic university city. Although Oxford is not heavily promoted as a tourist destination, it attracts a large number of tourists both from within the UK and from abroad. Outside London, Oxford is one of the most important visitor destinations in the UK, attracting over 5 million visitors each year. Tourism is a large source of employment in Oxford, providing over 5,000 full-time jobs.

Most of the people surveyed intended to visit one or more of Oxford's attractions during their visit. The most popular attractions included the Botanic Gardens, the Ashmolean Museum and a number of Oxford colleges. A number of other attractions included Blackwell's Bookshop, the Old Bodleian Library, the Sheldonian Theatre and the Carfax Tower. Nearly half of the visitors visited one or more of the university colleges, and the three most popular choices were Christ Church, Magdalene and New College.

Tourism generates around £200 million, spent directly into the tourist sector, and with linkages and the multiplier effects the value to the city's economy is nearly £300 million. The number of jobs sustained directly and indirectly by tourism is estimated at about 7,300 or 3–4 per cent of the economically active population in the Oxford travel-to-work area.

Most of the groups visiting Oxford were adult only (85 per cent), and a very high proportion were from the highest social groups. Eighty per cent of visitors were in social groups ABC1 (managerial and professional) compared to a national average of about 45 per cent for that group.

▲ **Photo E.8:** Tourist information board, Oxford

Case study (continued)

A survey of visitors revealed that the architecture (30 per cent), the history of the city (17 per cent), the colleges (14 per cent), as well as the nightlife and general atmosphere were the biggest attractions for tourists. However, traffic levels in the city, in particular the number of coaches and buses, the availability and cleanliness of toilets, pedestrian signposting, and the range, standard and value for money of accommodation were not viewed as favourably. In terms of improvements, most visitors said that there was too much traffic (22 per cent), that the city was overcrowded (9 per cent), and too expensive (5 per cent).

The Oxford Tourism Strategy

The Oxford Tourism Strategy aims to ensure visitor satisfaction, encourage an increase in tourist spending within the city, and minimize the environmental problems which result from tourism. In particular, the strategy intends to:

- provide a larger coach park and enforce on-street parking regulations
- increase the use of public transport and park and ride as a means of getting into the city; as part of the publicity material that Oxford City Council sends out there are maps which show the locations of the park and rides, the major coach routes and the main bus routes
- encourage walking tours, registered sightseeing buses and cycles
- provide comprehensive on-street information to encourage visits to lesser-known attractions and places of interest
- liaise with foreign language schools about the congestion and conflict their students cause
- increase the number of visitors off-season in order to spread the tourist load
- reinvest money generated by tourism into the fabric, infrastructure and facilities of the city, to support long-term **sustainability**.

There are also a number of economic benefits that could be increased. For example, Oxford City Council is targeting high-spending visitors who stay overnight. These bring more money to the city and create more jobs, for example in accommodation and catering, compared with coach visitors on route to Woodstock or Stratford upon Avon, who spend little time or money in the city. Nevertheless, the Council is also trying to attract independent day visitors, that is, not on coach journeys, and business visitors. The Oxford colleges are free of university students during the university vacation and this provides an ideal opportunity to use the accommodation for conference delegates.

Planning must also include the visitors. If the aim is just to take their money, tourism will soon fall off. Thus, the Oxford Tourist Strategy attempts to enhance the visitor experience. For example, the Oxford Information Centre attracts up to 500,000 people annually, making it one of the most visited attractions in Oxford! It is vital for visitor satisfaction that the Information Centre is able to meet demand and provide the information required.

Information is also provided on the on-street information boards and there has been improvement in the signposting of attractions.

In addition, attractions need to be more varied. At present Oxford is famous for its university buildings, churches and colleges. Many visitors have been attracted through TV and films made in Oxford, include *Inspector Morse*/*Lewis* and the use of Oxford in filming scenes from the *Harry Potter* films.

Particular groups of people, notably the disabled, are increasingly cared for. This includes interpretive facilities, loop systems for the hard of hearing, and ramps for people in wheelchairs.

Activity 7

1. Using examples, explain why tourism is important to Oxford.
2. Outline the main characteristics of (a) visitors to Oxford and (b) the attractions they visit.
3. What are the main issues related to tourism that need to be addressed in Oxford? Evaluate the ways in which these methods are being tackled.

▲ **Photo E.9:** The Gap of Dunloe, Killarney

Common mistake

✗ Many students believe that all national parks are managed in the same way.

✓ National parks have different rules and regulations in different countries. In some countries, including Ireland (Photo E.9) and the USA, national parks are owned by the state. In other countries, such as the UK, national parks have many owners, including private residents, the Forestry Commission, National Parks Authority, local councils, the Ministry of Defence, and farmers. This makes management of the parks very difficult.

▲ **Photo E.10:** Congested Killarney street

Managing tourism in Killarney National Park, Ireland

Killarney National Park is an excellent example of land-use management in an area renowned for its scenic beauty. However, the region relies heavily on tourism as a source of employment and revenue and as the amount of paid holidays, disposable income and transport infrastructure has increased, the number of tourists visiting Killarney has risen dramatically. Conflicts between environment and economy have intensified although management policy in Killarney National Park illustrates clearly the way in which tourism and conservation can be successfully managed: by placing the emphasis firmly on conservation.

The scenery of the Killarney area, including the National Park, is world renowned. It is a major attraction and the area is one of the most visited tourist venues in Ireland. Over a million visitors travel to Kerry each year bringing an estimated £160 million to the area. Of these the majority visit Killarney, a town with a resident population of 14,000 and over 4,000 tourist rooms! Under legislation in Ireland, where conflict arises between the need for tourism and the need for conservation, the protection of the natural heritage takes precedence over other considerations.

The scenic quality of Killarney is made up of a variety of physical and human landscapes. It includes the three lakes of Killarney; secluded lake shores, sometimes with low limestone cliffs; rocks and islands; waterfalls, tarns and rapidly flowing rivers; rugged sandstone mountains with moorland and some bare rock surfaces; glacially eroded valleys; native oak woodlands; the last herd of native red deer in Ireland; landscaped grasslands; historic buildings and bridges, cottages, and monastic and religious ruins.

The National Park

Killarney National Park is managed by the Office of Public Works (OPW) and has been designated a Biosphere Reserve by UNESCO. National Parks in Ireland are areas that "exist to conserve natural plant and animal communities and scenic landscapes which are both extensive and of national importance and, under conditions compatible with that purpose, to enable the public to visit and appreciate them".

The basic five objectives for the National Park are to:

- conserve nature
- conserve other significant features and qualities
- encourage public appreciation of the heritage and the need for conservation
- develop a harmonious relationship between the park and the community
- enable the park to contribute to science through environmental monitoring and research.

Of these, nature conservation takes precedence over the others should any conflict arise.

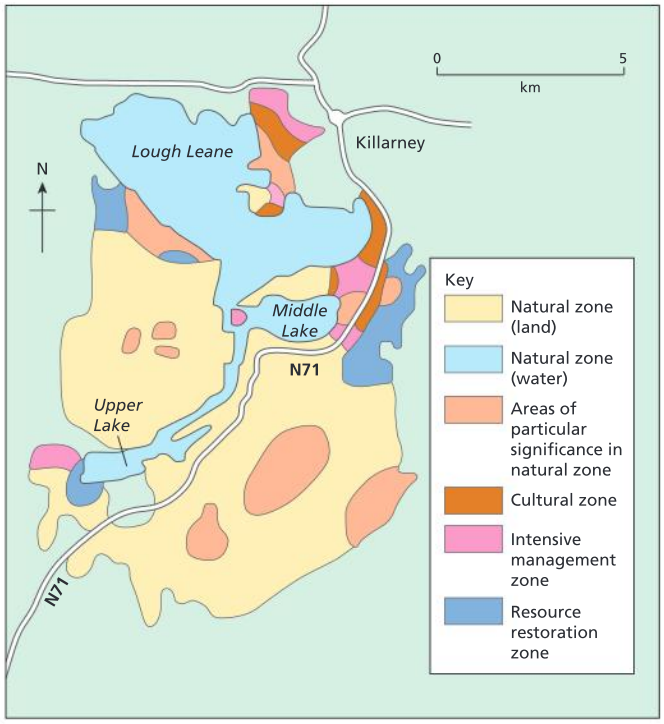
Management strategy

Nevertheless, Killarney National Park is not without its problems. It does not comprise a self-contained ecological unit, consequently it is

influenced by changes and developments that take place in the surrounding area. To successfully manage the interests of conservation and tourism Killarney National Park has developed a management plan, in which land use is controlled and potential conflicts reduced.

The Killarney National Park Management Plan identifies four main zones (Figure E.8):

- Natural zone: where nature conservation is the primary objective.
- Cultural zone: where the primary objective is the conservation of noteworthy features resulting from human activities including demesne landscapes, archaeological and historic sites, buildings and structures.
- Intensive management zone: where basic park objectives other than conservation are emphasized, provided park resources are not adversely affected.
- Resource restoration zone: comprising conifer plantations mainly in the Muckross area.



▲ **Figure E.8:** Zoning in Killarney National Park

In addition, the Management Plan identifies a potential buffer zone around the park within which development and change will be influenced in a positive manner. This has been developed in consultation with Kerry County Council, Killarney Urban District Council and other relevant bodies.

Within the National Park, there are a number of priorities which the park authorities have been tackling. Conservation and development plans have been drawn up. Control and eradication of the Rhododendron population is perhaps the biggest conservation challenge facing the National Park. Up to 900 ha of the park's 11,200 ha of native woodland are infested. Approximately 240 hectares have been cleared and the aim is to achieve the clearance of 75 per cent of the infested woodland and to maintain the cleared areas. Another priority is the removal of forestry plantations situated in the resource restoration zone. Here the aim is to replace most of these plantations with natural vegetation, and ultimately to integrate these areas into the other zones of the park, principally the natural zone.

Development plans have been established for much of the built fabric of the park. Muckross House is a late 19th-century mansion. It contains displays, folk-life exhibits and craft workshops. A folk farm has also been developed. The park entrance has been redesigned in conjunction with Kerry County Council's plans to widen the main access road (the N71) in this area. The former Kenmare Demesne, situated close to the town of Killarney, has plans which include a major tree planting programme, restoration of internal pathways, development of car parking areas, landscaping of the area and restoration of many formal features adjacent to the house and farmyard complex. Ross Castle has had restoration work. A development programme has also been undertaken, improving car

Activity 8

Study Figure E.8 which shows land-use zoning in Killarney National Park. Describe the pattern of zoning. How does this help conservation?

parking, toilet and boating facilities, landscaping and an information service for visitors. There are also plans to develop the long-distance footpaths in the area, such as the Kerry Way. In 2016, €250,000 was allocated to repair and improve roads within the National Park.

Killarney National Park illustrates the way in which tourists can be managed in an ecologically sensitive area. On the one hand they bring in much-needed money and generate employment in the area, whereas on the other hand they can cause serious problems such as traffic congestion, erosion of footpaths, destruction of vegetation and ruining of scenic views through the provision of tourist amenities. The Killarney National Park has developed a plan that reconciles these yet at the same time gives priority to the conservation of nature.

Variations in the sphere of influence

The **sphere of influence** refers to the area from which a facility or an attraction draws its support. A small playground may have a low **threshold** population and a very small **range**, hence it will have a small sphere of influence (catchment area). In contrast, the sports stadium of a top-league sports team is likely to derive its support from a much wider area. It will have a greater sphere of influence, a much larger range and threshold population.

The main purpose of a sports facility is to provide the opportunity to participate in sports for a number of people. Hence, many sports facilities are centrally located within their market areas. The greater the number of sports provided, the higher the order of the sports place. Low-order sports places provide sporting facilities that have a small catchment area, and a small threshold population. Higher-order sports facilities are fewer in number, more widely spaced, and have larger threshold populations.

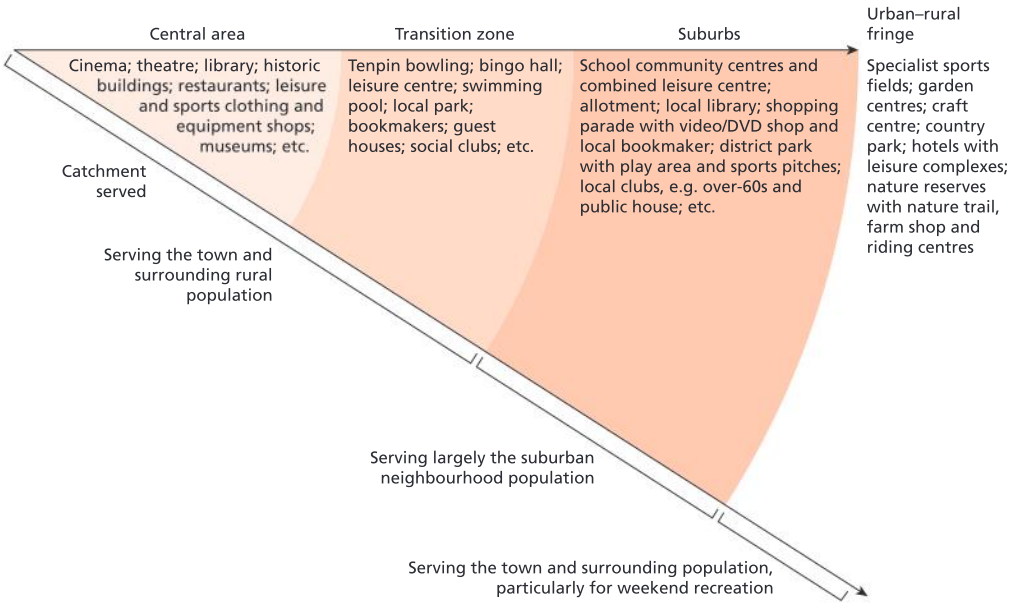
An example of a sports place at the bottom of the scale could be a playground, with a sphere of influence of about 1 km, providing facilities/activities for young children. At a higher level, there may be a sports facility with a variety of indoor and outdoor activities – a sports centre – providing for a range of up to 10 km. At the top end of the scale, there may be a top-level sports complex and athletics stadium/swimming pool, serving a larger population from a greater distance. In the UK, it has been suggested that the threshold population for an 18-hole golf course is about 30,000 people, and that about 3 ha of playing fields should be provided for every 1,000 people. In the USA, baseball pitches ("diamonds") and tennis courts have a threshold population of 6,000 and 1,000 respectively. In addition, it is possible to suggest threshold populations for which a sports team becomes viable. In the USA, a threshold population of one million fan visits per season is necessary for a baseball franchise.

In France and the USA, it has been shown that there is a clear positive correlation between the population size of a region and the number of clubs. For example, New York with a population of over 17 million had nine franchises, Pittsburgh with 2.4 million had three franchises, while Salt Lake City with 1 million people had one franchise.

A simple hierarchy is outlined below.

Table E.6: A hierarchy of sporting facilities in different settlements

Community size	Recommended facilities	Activities offered
Village 500–1,500	Community hall Community open space Mobile library	Badminton, keep fit, yoga, football, cricket
Small country town 2,500–6,000	As above plus: Tennis courts Sports hall Swimming pool	As above plus tennis, netball, gym, hockey
Town	As above plus: Specialist sports venues Golf courses, skateboard parks, bowling green	As above plus bowling, golf, skateboarding, judo, karate
City	Sports stadia Athletics grounds	As above plus home grounds of sports clubs (football, rugby, hockey, athletics grounds)
Capital city	National sports centre for selected sports	As above, but for national teams



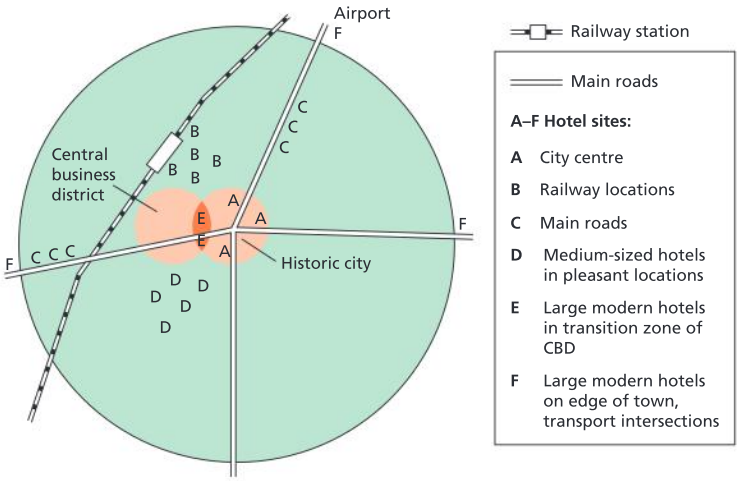


Figure E.9: Distribution of facilities in an urban area

Intra-urban spatial patterns

Figure E.9 shows the distribution of leisure facilities around a typical small or medium-sized town. In most small and medium-sized cities there is a concentration of leisure facilities and tourist attractions in the central area of the city, while on the periphery there are increasing numbers of sports and leisure centres, garden centres and country parks. The central area contains the main concentration of restaurants, cinemas, theatres and other facilities that do not require much space. Finally, some leisure facilities such as parks, recreation grounds and community centres may be dispersed into neighbourhoods.

Tourism facilities in urban areas

Urban areas are important for tourism because they are:

- destinations in their own right
- gateways for tourist entry
- centres of accommodation
- bases for excursions.

Factors affecting the geography of a national sports league

Most teams in the top league of their national sports derive support from a wide area. This is true for football teams such as Manchester United and Barcelona and baseball teams such as the New York Yankees and the Boston Red Sox. Some clubs have a global following, although many of the fans can only follow their "team" on television or the Internet. In contrast, lower league teams tend to have a much narrower sphere of influence. They do not have the success to generate international (or even national) interest. Hence, their support is more localized. In some towns and cities there are a number of clubs, such as Chelsea, Arsenal, Tottenham Hotspur and West Ham United in London, all of whom play in the English Premier League. Some of their fan base is very localized. However, many fans move to go to university or for a job, and so the fan base may become broader.

ATL Research and communication skills

For your home country (or another country that you are interested in), research the hierarchy of clubs in a league. Make a two-minute presentation to your class, telling them about your results.

Case study

National sports league

Rugby in South Africa

Rugby is one of South Africa's big three sports, alongside soccer and cricket. The country has traditionally fared extremely well on the world stage.

For the disadvantaged people of the old apartheid South Africa, rugby was the white person's game, and even more so the game of the Afrikaner. Traditionally, most black and coloured communities played soccer while, for white communities, rugby was the winter sport of choice.

Currie Cup

The Currie Cup is the premier provincial rugby competition in South Africa, and was first contested in 1892. The format of the Currie Cup varied from year to year, and finals were held intermittently until 1968, after which the final became an annual event.

Up to and including 2015, the most successful province in the history of the Currie Cup was Western Province (Western Cape) with 33 titles (four shared), followed by the Northern Transvaal/Blue Bulls with 23 titles (four shared). Since rugby became a professional sport in the early 1990s, no single team has dominated the Currie Cup.

Case study (continued)

For many years the biggest rivalry in South African rugby was between Western Province and the Blue Bulls. During the early to mid-1990s this was superseded by a three-way rivalry between Natal, the Lions and Western Province.

The Currie Cup takes place roughly between July and October. The format divides 14 teams into eight Premier Division and six First Division teams.

Vodacom Cup

The Vodacom Cup has become an important competition on the South African rugby calendar. It takes place at the same time as the Super 14 competition – starting in late February and finishing in mid-May – and thus creates a platform for talented young players who might otherwise not get a chance to make their mark.

It has also been a fertile breeding ground for strong players from previously disadvantaged backgrounds, thanks to the enforcement of quotas. Quotas, successfully implemented lower down, now extend through the higher levels of South African rugby, including the Super 14.

The Vodacom Cup is divided into two sections – North and South – with the top two teams advancing to the semi-finals and playing cross-section matches of one-versus-two for a place in the final.

The North is made up of the Golden Lions, Griffons, Leopards, Pumas, Falcons, Blue Bulls and Griquas. The South's teams are the Mighty Elephants, Boland Cavaliers, Border Bulldogs, Free State Cheetahs, Eagles, Western Province, and KZN Wildebeests (KwaZulu Natal).

Supporters are largely drawn from within the province, although some of the fan base may have moved away from their home for university, work or for marriage.

▲ **Figure E.10:** South Africa and its provinces

Case study

Gaelic Games in Ireland

In Ireland, the Gaelic Games (hurling, Gaelic football and camogie) are arranged at a county level. Teams from the Republic of Ireland (26 counties) and Northern Ireland (6 counties) compete in a national league and knock-out competition. The league is based on merit, whereas the knock-out competition is based on a provincial knock-out competition (there are four provinces), followed by the All-Ireland semi-finals and final. Support for the counties is largely from within each county, although some may have moved away from their county of birth/residence for work, university and so on.

ATL Research skills

Research the support base for a named sport in your home country (or a sport that you may know elsewhere). How does the support base vary between different clubs in different areas?

▲ **Photo E.11:** Competitors at the start of the Blenheim Triathlon

ATL Research skills

Sports leagues only form in countries where there is a certain level of development, and among people with a certain level of wealth and free time. Find out about sports leagues in the Democratic Republic of the Congo, South Sudan and Mali, for example.

Going down the hierarchy, many of the lower leagues are divided into regions and counties. This is partly for practical reasons – fans will not want to travel far to see two teams play in a lower league, whereas fans are prepared to travel a large distance to support a club that is in the top national league.

Costs and benefits of large-scale sporting, musical, cultural or religious festivals as temporary leisure sites

Large-scale sporting, musical, cultural or religious festivals may be temporary sites of leisure, but they provide many costs and benefits. Some events may take place in a location that is not normally used for leisure for the rest of the year, such as the Glastonbury Music Festival in the UK, whereas others may be temporary events in areas that are associated with leisure and tourism, such as the Triathlon at Blenheim Palace, Woodstock, the second largest triathlon in the UK.

The Glastonbury Festival

The Glastonbury Festival is the largest open-air music festival in Europe and is globally recognized. It comes under the heading of cultural tourism which embraces many activities including visiting heritage sites, exploring historical and religious buildings and attending music, fine arts and drama festivals. The music concerts and festivals industry is gaining popularity across the world. Festivalgoers are attracted by the opportunity to see a particular type of performance or a particular performer and to be part of the festival culture. This will present an opportunity to socialize with friends and maintain friendships as well as listen to music.

Development

Glastonbury began as the Pilton Pop Festival in 1970, and with the exception of 2001, it has been held every year since its inauguration. The festival is held in a huge open air arena which covers approximately 800 acres. This site now accommodates up to 250,000 people.

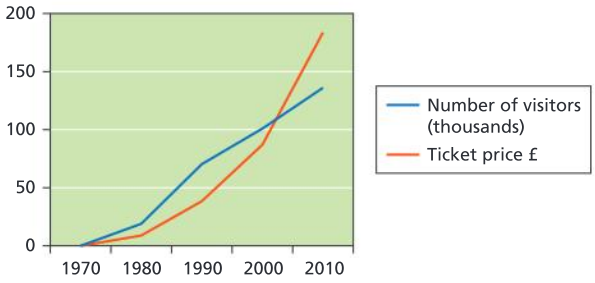
▲ **Photo E.12:** Glastonbury Festival, one of the world's largest annual music events

The impacts of the Glastonbury Festival

Economic impacts

Mendip local authority area, Shepton Mallet, Street and Wells and their rural hinterland, Bristol and Bath, the south-west region and the UK all benefit financially from the festival, but their financial support in the provision of services is essential.

Each visitor to the festival spends on average £293. The income from the festival makes substantial contributions to charities such as Water Aid, Greenpeace and Oxfam and may also be used to support local projects such as the provision of school and sporting facilities. On the other hand, Glastonbury has negative impacts including dealing with huge numbers of tourists, drug and substance abuse and crime such as theft.



▲ **Figure E.11:** The growth of visitor numbers and the increase in the price of attending the Glastonbury Festival

The growth of Glastonbury

▼ **Table E.7:** The growth of visitors and increase in price of attending the Glastonbury Festival

	1970	1980	1990	2000	2010
Number of visitors (thousands)	1.5	18	70	100	135
Ticket price (£)	1	8	38	87	185

The festival is not wholly welcomed by the local community because it is associated with rebellion and the hippie culture. During the weeks of June, the activities of local residents are severely restricted and the festival is a burden for them. Nevertheless, some civic pride is derived from hosting a global event. It also offers local people an employment opportunity.

▲ **Photo E.13:** Glastonbury Festival continues late into the night, sometimes to the anger of local residents

Environmental impacts

Air pollution

CO_2 emissions increase dramatically during June when the three-day festival is running. Car transport is still most popular because of its flexibility, but attempts have been made to encourage supporters to use public transport. Green coaches using environmentally acceptable fuels have been encouraged.

Waste disposal

The creation of waste is one of the greatest problems at the site. This consists mainly of human waste, empty plastic water bottles and tents. The tents present an enormous problem because many of the fans leave them behind at the end of the festival and their condition is not good enough for charity use.

In 2011 the Association of Independent Festivals found that one in six tents were left behind.

Noise pollution

Many of the performances continue through the night, which causes disturbance to local residents.

Provision of resources

Energy, water and food need to be supplied and residue has to be disposed of.

Activity 9

1. Referring to Table E.7, describe and explain the trends in ticket price and number of visitors.
2. Outline the potential conflicts between visitors and residents that result from the Glastonbury festival.

Concepts in context

There are many types of **places** that attract people for tourism and leisure activities. These are influenced by a range of physical and human factors including climate, access, size, investment, facilities and so on. Some areas will attract many more visitors and will develop into hotspots. Hotspots may draw in wealth, but they also generate many problems in relation to congestion and pollution. This may be long term (as in the case of Venice) or it may be short term, as in the case of Glastonbury. There are many possibilities as to how these areas may be managed.

Some leisure activities include watching sports. Larger clubs generally have a much greater sphere of influence than smaller clubs. Some leagues may be arranged on a country or provincial level.

As more people are able to afford to participate in leisure and tourism-related activities, the pressure on urban and rural areas to provide for them is likely to increase.

Check your understanding

1. Explain the interdependence of primary and secondary tourist resources.
2. Explain why and how the sphere of influence of different sporting facilities varies.
3. Briefly explain the term "range" in the context of sporting activities.
4. Why do tourist hotspots develop?
5. Describe the distribution of hotels in a model urban area.
6. Explain why Oxford has become a tourist hotspot.
7. Explain the purpose of a buffer zone around a national park.
8. Outline the main objectives of the Killarney National Park Management Plan.
9. Compare the leisure facilities likely to be found in the centre of a city with those likely to be found on the edge of a city.
10. Comment on the main methods used by the Oxford Tourism Strategy.

3 Tourism and sport at the international scale

Conceptual understanding

Key question

How do the variations in power of different countries affect their participation in global tourism and sport?

Key content

- Niche national tourism strategies with a global sphere of influence, including adventure tourism, movie location tourism and heritage tourism.
- The role of TNCs in expanding international tourism destinations, including the costs and benefits of TNC involvement for different stakeholders.
- Costs and benefits of tourism as a national development strategy, including economic and social/cultural effects.
- Political, economic and cultural factors affecting the hosting of international sporting events including the Olympics and football World Cup events.

Niche national tourism strategies

Niche tourism refers to special-interest tourism catering for relatively small numbers of tourists. There are many types of niche tourism, including heritage-tourism, ecotourism, agro-tourism, business, medical, adventure, wilderness, grey (or "silver"), tribal, and dark tourism. In contrast, mass tourism is typified by the package tour in which itineraries are fixed, stops are planned and guided, and all major decisions are made by the organizer. Familiarity is at a maximum and novelty at a minimum, and safety and companionship is gained from travelling in large crowds.

Adventure tourism

Adventure tourism is a form of niche tourism that involves travel to a remote area and some level of perceived (sometimes real) risk. Adventure tourism has increased in popularity in recent decades.

Adventure tourism attracts high-value customers. For example, to climb Mount Everest costs around $50,000 per person (see Option C, Extreme environments, pages 138–139 for a case study on tourism in Nepal). Not all adventure tourism is so expensive, but many people will pay around $3,000 for an eight-day holiday. Adventure tourism also supports local economies much more than mass tourism. The Adventure Tourism Trade Association (ATTA) suggests that about 66 per cent of revenue spent in the adventure tourism sector remains in the destination. Adventure tourism also encourages sustainable practices – it involves local

▲ **Photo E.14:** Mass tourism

Activity 10

1. Suggest examples of mass tourism and explain why it is likely to have adverse environmental impacts.
2. Discuss the ways in which cultural tourism might be beneficial to an indigenous community.
3. Discuss the benefits of mass tourism.
4. Identify the conflicts arising from pressure on tourist resources.

▲ **Photo E.15:** Hiking among the fjords of Greenland

Activity 11

1. Suggest another term for "other" in Table E.8.
2. Identify the type of adventure tourism in Photo E.15. Outline the reasons why the environment in Photo E.15 attracts adventure tourists.

communities, supports local businesses, and promotes environmental protection for future use (and ongoing economic benefits).

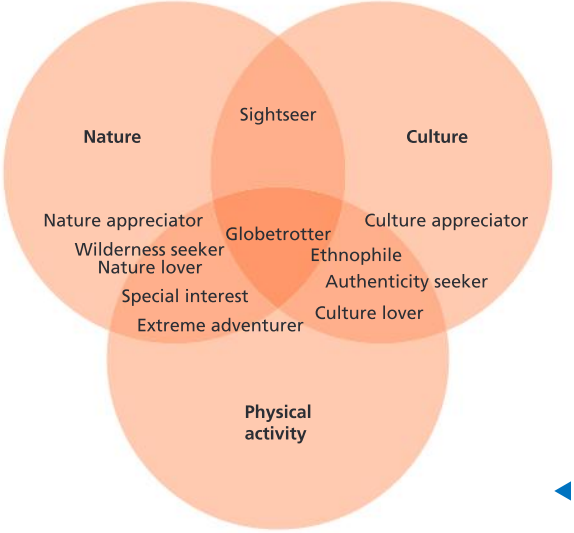
According to the UNWTO, in 2014 over half of all adventure tourists were women, over one-third had spent four or more years in higher education, and over 10 per cent had a professional qualification.

Adventure tourism in Greenland

Greenland has recently begun to develop its adventure tourism sector. Adventure tourism can be divided into three categories: soft, hard and other (Table E.8).

▼ **Table E.8:** Types of adventure tourism

Activity	Type	Activity	Type
Archaeological expedition	Soft	Hunting	Soft
Attending local festivals/fairs	Other	Kayaking – sea, white water	Soft
Backpacking	Soft	Learning a new language	Other
Birdwatching	Soft	Orienteering	Soft
Camping	Soft	Rafting	Soft
Canoeing	Soft	Research expeditions	Soft
Caving	Hard	Safaris	Soft
Climbing (rock, mountain, ice)	Hard	Sailing	Soft
Cruise	Soft	Scuba diving	Soft
Cultural activities	Other	Snorkelling	Soft
Ecotourism	Soft	Skiing/snowboarding	Soft
Educational programmes	Soft	Surfing	Soft
Environmentally sustainable programmes	Soft	Trekking	Hard
Fishing	Soft	Walking tours	Other
Getting to know locals	Other	Visiting family/friends	Soft
Hiking	Soft	Visiting historical sites	Soft
Horseback-riding	Soft	Volunteer tourism	Other



Greenland has targeted the North American market. This accounts for 25 per cent of visitors to the country. Between 2010 and 2014, adventure tourism grew by 195 per cent. Greenland offers a range of attractions for adventure tourists. These can broadly be put into three categories (Figure E.12).

For example:

- ethnophiles visit to gain a greater understanding of indigenous people and their culture
- cultural tourists may be attracted by museums, Viking ruins, Economusee workshops
- nature tourists are attracted by whale watching and bird watching in the Sermermiut Valley and Disko Bay

◀ **Figure E.12:** Types of adventure tourism in Greenland

- wilderness tourists are attracted by the opportunity to trek in wilderness areas (Photo E.15)
- extreme adventure tourists are able to cross the Greenland icesheet, climb ice cliffs and go heli-skiing
- sightseers may do so from the luxury of a cruise ship.

ATL **Research skills**

For an area of your choice, choose one form of adventure tourism outlined in Table E.8, and find out about its impacts.

Movie location tourism

There are a number of links between places used in TV and film and their attraction for fans. Films such as *Lord of the Rings* and *The Hobbit* have attracted many tourists to New Zealand, keen to visit sites used in the films. Skellig Michael (see Photo E.16) saw a surge in visitors after it appeared in a *Star Wars* film. Some television series attract large numbers of visitors. The UK programme *Coronation Street* attracts many visitors to Manchester, and Granada Studios had a Coronation Street tour. The TV detective Morse (and latterly Lewis and Endeavour) are said to have boosted tourism in Oxford, and Morse tours point out locations used in the series. Other popular TV series include *Game of Thrones*, leading to an increase in the number of tourists to Northern Ireland.

On a different scale, locations have been created to cater for people's desire to experience film/TV locations. Disneyland, Universal Studios and the Wizarding World of Harry Potter (Photo E.17) have created theme parks based around a film/concept.

▲ **Photo E.16:** Skellig Michael being transformed into a set for a *Star Wars* film

Heritage tourism

Heritage tourism relates to travel to experience the place, artefacts, historic sites and indigenous people of an area. It is sometimes referred to as cultural tourism.

Machu Picchu: heritage tourism costs and benefits

Machu Picchu along with Cuzco and other archaeological sites of the valley of the River Urubamba bear testimony to the unique Inca civilization. It was a centre of worship as well as a private retreat for the family of Inca ruler Pachacutec. It is split into two major areas: the agricultural zone, made up of terracing and food storehouses, and the urban zone featured as sacred temples, squares and royal tombs. It is a World Heritage Site and in 2007 it was selected as one of the new seven wonders of the world along with the Great Wall of China, the Coliseum and the Taj Mahal.

Standing 2,430 m above sea level in the midst of a tropical mountain forest, it was probably one of the most amazing creations of the empire at its height. It covers 32,500 hectares with its giant walls, terraces and ramps. It is situated on the eastern slopes of the Andes, which is also noted for its rich diversity of flora and fauna.

As the last stronghold of the Incas and of superb architectural and archaeological importance, Machu Picchu is one of the most attractive cultural sites in Latin America. Also culturally significant is that the local communities adopt a traditional lifestyle that closely resembles that of their ancestors. For example, their diet is based on potatoes, maize and llama meat.

ATL **Research and communication skills**

For a film or TV programme that you have enjoyed, investigate the impact it has had on the tourism industry in the relevant area where it was set. Make a short presentation to your class.

▲ **Photo E.17:** The Wizarding World of Harry Potter

Benefits	Costs
Social benefits • Encourages civic pride. • Provides cultural exchange between visitors and locals. • Benefits also spread to the country as a whole. • Encourages the celebration of particular customs and cultural events. • Encourages the learning of new languages and foreign customs. • Improvement of infrastructure (electricity, water supply, sewerage and communications) benefits local people.	***Social costs*** • Cultural conflicts and abandonment of traditional customs ad moral values. • Increase in local crime.
Economic benefits • It attracts affluent tourists. • It provides valuable foreign exchange, which can be invested in local services and projects, connected to development. • Extra tax revenue for the government derives from accommodation, restaurants, airports, sales, Inca Trail and Machu Picchu entrance fees at $20 per ticket. • It provides direct employment (accommodation, guides and visitor transport) and indirect employment (food production and housing construction). Tourism is a labour-intensive industry. • Tourism can produce a "multiplier effect" whereby money generated in one sector of the economy benefits another sector, and the amount of money circulating in the economy increases.	***Economic costs*** • It inflates local prices of goods and services. • Jobs in tourism are mainly seasonal. • Tourism is volatile and subject to downturns as a result of external influences such as world economic recession or terrorism. High dependence upon tourism either locally or nationally can be risky. • "Leakage" can easily occur. This means that money generated to tourism does not stay in the country but returns home. This occurs when local tour operators are not used.
Environmental benefits • Tourism has conserved natural and cultural resources that would have become derelict otherwise.	***Environmental costs*** • Visitor numbers are increasing by 6 per cent per year leading to footpath erosion because numbers are beyond **carrying capacity**. • Heavy rainfall, steep slopes, deforestation and trampling of vegetation can lead to landslides. • The local infrastructure cannot cope with recent urbanization, in particular hotel-building, e.g. Aguas Callentes. The Urubamba river is overloaded with untreated sewage and its banks are covered with garbage. • Helicopter flights introduce noise and disturbance.

The number of visitors to Machu Picchu has increased massively since its discovery in 1911. There are both positive and negative consequences of its development and tourist attraction.

Managing tourist pressure at Machu Picchu

Problems

UNESCO authorities are concerned about deforestation, the risk of landslides, uncontrolled urban development and illegal access to this sanctuary. UNESCO has considered adding the site to the endangered list but so far has not done so. The Ministry of Culture is thinking of limiting the day pass to three hours and limiting the time at each point. The officials are also considering offering alternative checkpoints to get into Machu Picchu to alleviate congestion at the entrance gates. Only 400 people per day are allowed to climb Huayna Picchu and there is a limit of 500 daily permits for the Inca Trail.

Until recently, Machu Picchu could only be accessed by railway or on foot. But there are plans to build a road from Cuzco and a cable car running from the valley to the top of Machu Picchu.

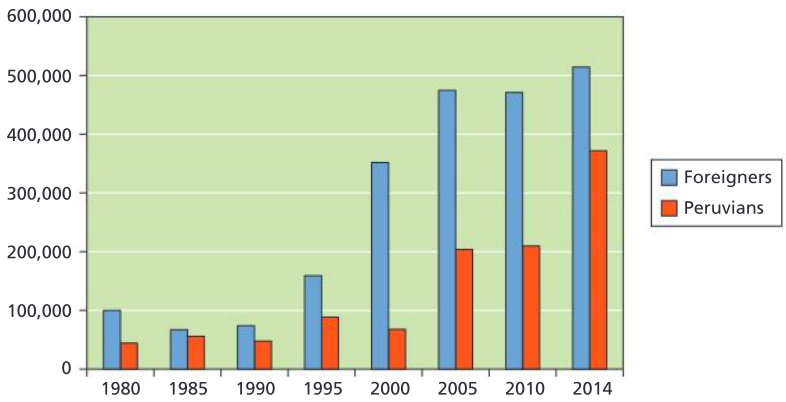
New regulations for visitors to Machu Picchu

Under new rules promulgated by the Ministry of Culture in Cusco, all foreign visitors to Machu Picchu have to hire an official guide to enter the Inca Citadel, follow one of three predetermined routes through the complex, and face time limits at specific points to keep the traffic flowing.

UNESCO has been urging Peru to finalize and adopt a public use plan.

- "The entrance for visitors into the Inca city of Machu Picchu will be conducted in an orderly manner and be based on previously organized groups of at most 20 people", the regulations state.
- Stricter procedures for guides will require them to wear uniforms and have clearly visible credentials.
- They will be limited to three established routes through the Inca Citadel and their clients will be "expressly prohibited" from "leaving an organized tourist group to join another and/or divert to a different guide or person".
- Time limits of 3–5 minutes to stop and appreciate some of Machu Picchu's most significant and sacred points of interest, including the Intihuatana, the Temple of the Condor, the Water Mirrors and the Temple of the Sun. The purpose is to prevent bottleneck traffic jams, the regulations say.
- "Keep Moving" signs and park guards blow shrill whistles when tourists stray unintentionally into increasingly restricted territory.

Supporters of the new rules believe that poor management and overcrowding at Machu Picchu is taking an undue toll on the iconic site. Tour operators are firmly against the new restrictions.



▲ **Figure E.13:** Visitors to Machu Picchu, 1980–2014

▼ **Figure E.14:** New restrictions for visitors to Machu Picchu

Article 19 – Prohibited Conduct

For all persons, national and foreign, who visit the Inca city of Machu Picchu, the following conduct is expressly PROHIBITED:

19.1 Carrying and consuming food and alcoholic beverages.

19.2 Climbing and touching the walls and other structures of the Inca citadel.

19.3 Leaning against or rubbing your hands or body against the walls and stone elements.

19.4 Igniting flames or building camp fires.

19.5 Carrying canes of any kind, except as needed for age, physical disability or injury.

19.6 Smoking tobacco, cigarettes or any other substance.

19.7 Disturbing the flora, fauna and biodiversity.

19.8 Polluting water sources.

19.9 Writing on the ground, walls, stones, as well as the elements of natural heritage under penalty of legal sanction.

▲ **Photo E.18:** Machu Picchu: Lost city of the Incas

19.10 Practicing nudity and obscene acts contrary to morals and good customs.

19.11 Disposing of solid and liquid waste.

19.12 Carrying backpacks with a capacity greater than 20 liters (5 gallons) or 6 kilos (13 pounds).

19.13 Offering and selling products within the Inca citadel and the immediate surroundings, including the receiving areas for visitors and vehicle access.

19.14 Conducting fashion shows, exhibitions of swimsuit or dancing and exotic musical instruments, which distort the sacredness of the Inca citadel.

19.15 Convening social events.

19.16 Bringing in pets.

19.17 Flying over the ruins in para-gliders, helicopters or any type of aircraft.

19.18 Launching drones or any type of aircraft to take photographs, videos or movies from the air, with the only exception to this prohibition being flights solely for scientific and cultural diffusion with prior express authorization of the Decentralized Directorate of Culture of Cusco.

19.19 Using aerosol sprays that release repellents, colognes, sunblocks, or anything else.

19.20 Changing attire, clothing and garments within the Inca citadel.

19.21 Bringing in or using large umbrellas during the rainy season.

19.22 Conducting explanations in spaces or sites not determined for that purpose.

19.23 Leaving an organized tourist group to join another and/or diverting to a different guide or person.

19.24 Going beyond the physical limits of the tour of the Inca citadel.

19.25 Filming footage for the purpose of marketing consumer products.

19.26 Any heavy filming equipment.

19.27 Any act that harms the conservation of the Inca citadel and its lithic elements will incur an administrative penalty and in addition may be the subject of criminal and judicial charges.

Since 2011, the average daily number of visitors at Machu Picchu has far exceeded the daily limit of 2,500 agreed to by Peru and UNESCO. The number of visitors to Machu Picchu surpassed 1 million tourists for the first time ever in 2012.

The role of transnational corporations (TNCs) in expanding international tourism destinations

In many LICs tourism has the potential to stimulate economic growth and development. It generates over 6 per cent of global GNP and 13 per cent of consumer spending. Many LICs possess primary resources (such as beaches, warm climates, forests, mountains, wildlife, heritage features, indigenous people) and secondary resources such as hotels which tourists wish to access. It would be difficult for the individual tourist to arrange their transport and accommodation independently. Moreover, LICs may not have all of the infrastructure in place to develop their own tourist industry. So they have been forced to rely upon the transnational corporations (TNCs) concerned with tourism to organize and market these resources and products. The TNCs are usually based in HICs. For example, the eight largest hotel chains in the world are all US-based companies. Although the LICs have become politically independent, the exploitation of their resources by the tourists of HICs has been unsustainable.

Hilton Worldwide is an example of a TNC involved in tourism. It was founded in 1919 by Conrad Hilton in the USA and now has over 4,600 hotels in 100 countries. It is the largest hotel chain in the world, by rooms and international presence, with over 750,000 rooms. Since 2005, the company has been a sponsor of the US Olympic Team.

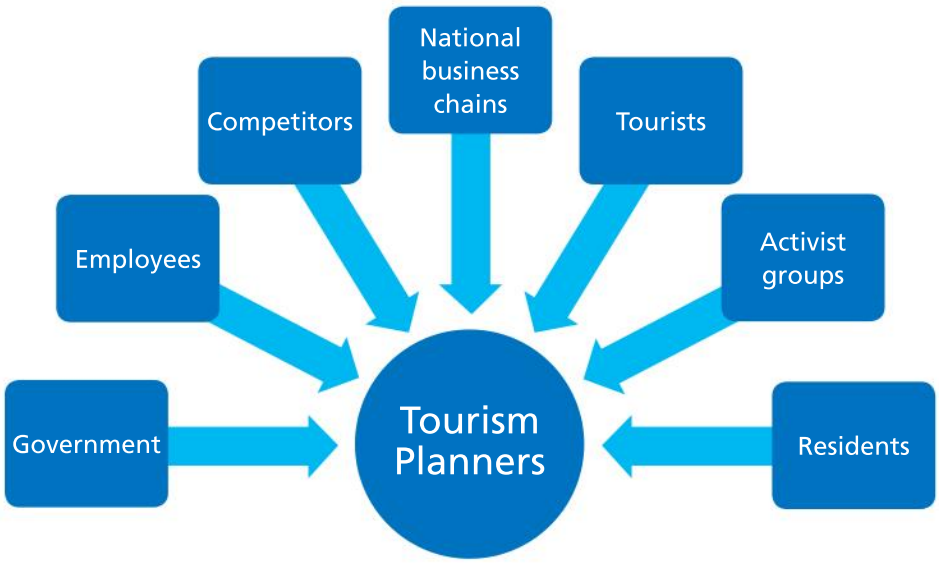
Hilton is credited with the development of the first airport hotel, in San Francisco in 1949. Hilton has concentrated on hotels. It has a number of brands including luxury hotels, such as the Conrad Hotels and Resorts and the Waldorf Astoria Hotels and Resorts, and full service hotels, such as the Hilton Hotels and Resorts. It employs over 160,000 people worldwide.

In contrast, the Thomas Cook Group is a tourism TNC that has diversified. Thomas Cook was originally founded in 1841 to take passengers between the cities of Leicester, Derby, Birmingham and Nottingham, in the UK. Its first tours to Europe took place in 1855 and to the USA in 1865. In 1974, Thomas Cook introduced "circular notes" which were later to become traveller's cheques. The company was also involved in military transport and the postal service. In fact, it was a late arrival into the package holiday market.

In the UK, Thomas Cook became a "vertically integrated" company providing air transport, hotels, resorts, cruise lines and a tour operator.

Activity 12

1. Define "heritage tourism" and give two rural and two urban sites.
2. Describe the tourist attractions of a site such as Machu Picchu.
3. To what extent do the economic benefits of tourism outweigh the environmental costs at this site?
4. Explain what is meant by the terms "multiplier effect" and "leakage".
5. Identify those in favour of regulating tourism at Machu Picchu and those against.
6. Evaluate the recent restrictions for visitors to Machu Picchu (E.14).
7. Describe and explain principal types of regulation that might be introduced to control the tourist impact at a heritage site.



▲ **Figure E.15:** The stakeholders in tourism planning

Thomas Cook Group employs over 20,000 people, has nearly 3,000 stores, 97 aircraft and around 20 million customers per year. Thomas Cook was a sponsor of the London 2012 Olympic Games, and was appointed to provide "affordable and accessible accommodation" throughout the Games.

Stakeholders in tourism can include individuals, groups and organizations with a business interest. Examples include agencies, private consultants, planners, leaders and local residents who are impacted by decision-making.

There are five main areas of TNC involvement in the tourism industry – airlines, hotels, cruise lines, tour operators and travel agents. All have been increasingly integrating their terms of business. For example, in the 1960s American Express moved beyond travellers cheques, buying shares, financing companies and computerizing ticketing. American Express is the largest travel agency in the USA and has offices in every important city around the globe. American Express now handles many other travel-related services including hotel, airline and cruise reservations, travellers cheques and credit cards, computer services, guidebooks and passports.

TOK

TNC involvement in tourism is an important feature of globalization, and also has many impacts associated with globalization, notably inequalities in wealth. Discuss this idea referring to a range of tourist activities and destinations.

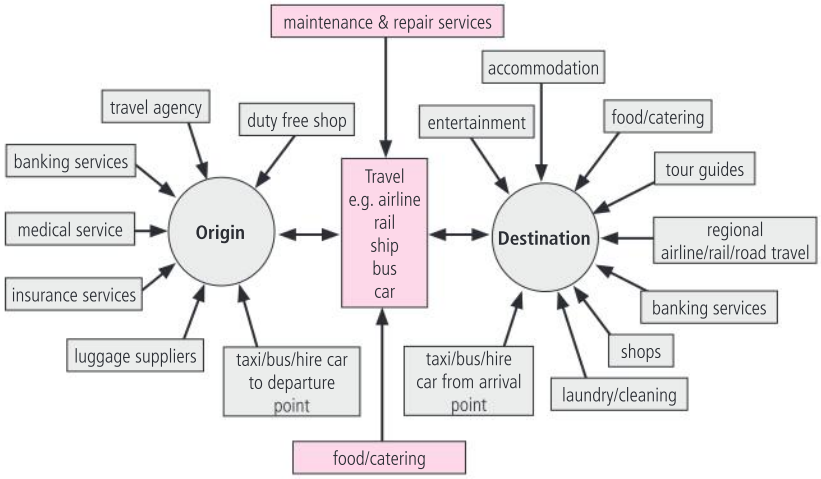
The costs and benefits of tourism as a national development strategy

Tourism as a development option has many attractions. Tourism is a positive route towards economic development for poor countries, especially when they lack the raw materials for manufacturing. Tourism can be regarded as an export, but goods and services are not subject to the price fluctuation of commodities sold on the world market. Tourism can be an effective way for a country to overcome its problems of balance of payments.

From the perspective of the host country and its population, tourism is labour intensive and can overcome the problem of unemployment both in rural and urban environments. The tourist economy provides jobs directly (tourist welfare, catering, transport, guiding and accommodation) or indirectly (construction, engineering and food production). Tourism also provides opportunities to acquire new skills, for example in languages, catering and entertainment.

TOK

There are many formal and informal activities that are beneficial for others in the tourism sector. Even though TNCs may control some tourist activities, there are many advantages for independent, local workers. Discuss this idea referring to specific activities and tourist destinations.



▲ **Figure E.16:** Tourist links

Tourism can create a multiplier effect, which means that income gained by local people is circulated through the economy by their purchasing of products within the host area. Tourism can redistribute wealth globally, nationally and locally provided that leakage is not allowed to drain the economy (as when foreign-owned companies manage the business, reap the profits and repatriate them).

Tourism adds diversity to the export base of the country and thereby helps to stabilize its foreign exchange earnings.

Tourism in Small Island Developing States (SIDS)

Small islands have relied on tourism as a means of economic development, and in many cases they have been successful. The islands of the Caribbean and Mediterranean are characterized by large-scale, high-density resort complexes, relatively short visitor stays and the gradual replacement of artificial attractions with natural and cultural amenities. Since the 1990s, tourist preference has shifted towards a more authentic experience on remote islands such as St Lucia in the Caribbean, the Maldives and Seychelles in the Indian Ocean, and French Polynesia in the South Pacific. As a development strategy for these islands, tourism brings both benefits and risks.

The benefits of tourism for SIDS

- A small land area and narrow resource base makes manufacturing an unlikely development strategy.
- Tropical islands are well endowed with many natural attractions such as coasts, mountains, ecosystems, heritage sites and indigenous tribes.
- As an exporting industry, tourism is not restricted by quotas or tariffs.
- Both direct and indirect employment in the tourist industry provides jobs for local people, many of whom are untrained.

The risks of tourism for SIDS

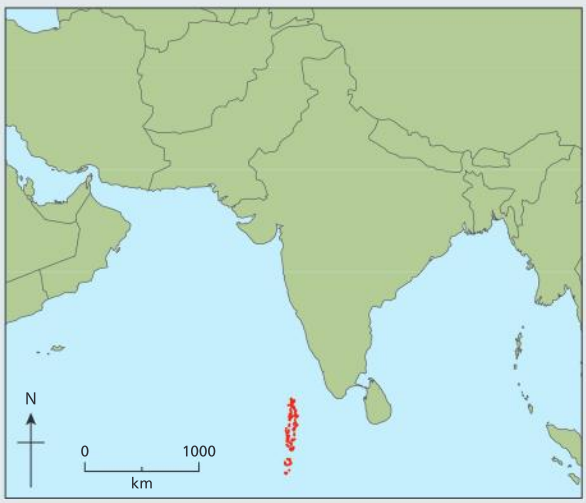
After decades of mass tourism, isolation and remoteness are two of the major tourist attractions, but transport costs are high and access to the core economies of Europe, North America and Japan is usually limited.

Online case study

South Africa

Case study

The Maldives – a Small Island Developing State



▲ **Figure E.17:** The location of the Maldives

▲ **Figure E.18:** International tourist arrivals and GDP in the Maldives, 2001–13

Background

The Maldives consist of an archipelago of 1,190 tiny islands, only 200 of which are inhabited by its population of 300,000. Located at latitude 3 degrees north, the islands experience a tropical monsoon climate with hot (26–31 °C) and humid conditions most of the year, and a dry season from October to April. For the majority of the

Case study (continued)

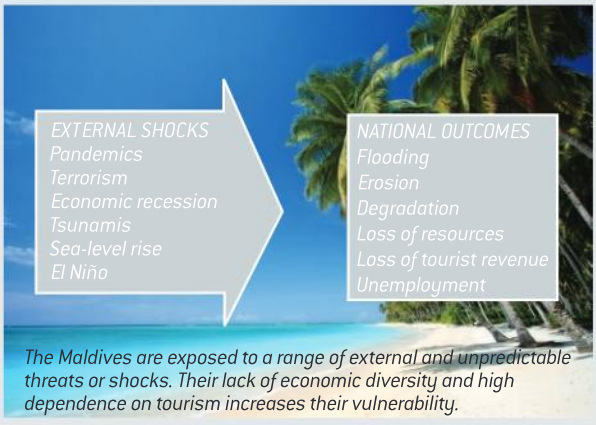
400,000 tourists who visit the islands annually, the sun-sea-sand combination makes this an ideal holiday destination.

Economic importance

Tourism accounts for 28 per cent of the Maldives' GDP and more than 60 per cent of its foreign exchange receipts. Over 90 per cent of government tax revenue comes from import duties. The development of tourism has fostered the overall growth of the country's economy. It has created direct and indirect employment and income generation opportunities in other related industries, the so-called multiplier effect. Fishing was once the prime industry here, but more recently tourism has assumed much greater importance. Agriculture and manufacturing continue to play a lesser role in the economy, constrained by the limited availability of cultivatable land and the shortage of domestic labour. Most staple foods must be imported. Industry, which consists mainly of garment production, boat building and handicrafts, accounted for only about 7 per cent of the Maldives' GDP in 2009.

Vulnerability to external shocks

Tourist demand and revenue grew rapidly between 1990 and 2009, at an annual rate of 5 per cent, but the rate has fallen and is predicted to average 2 per cent between 2010 and 2020. The Maldives, like many SIDS, are vulnerable to external shocks, whether from natural causes or human activity, and both are beyond their control.



The Maldives are exposed to a range of external and unpredictable threats or shocks. Their lack of economic diversity and high dependence on tourism increases their vulnerability.

▲ **Figure E.19:** The vulnerability of the Maldives

Sea-level rise is a real threat to the Maldives, where the average ground level is only 1.5 m above sea level; it is the lowest country on the planet. Since the early 1900s sea level has risen globally by about 20 cm, and current estimates suggest that it will rise by a further 59 cm by 2100.

Tsunamis are another threat. These islands are in a tectonically active zone and were badly affected by the Asian tsunami of December 2004, which left 100 dead, displaced 12,000 and caused $300 million of property damage. As a result of the tsunami tourist demand fell, and GDP contracted by 4.6 per cent in 2005. Although reconstruction was rapid and tourist numbers recovered, the trade deficit grew as a result of high oil prices and the import of construction materials required to rebuild resorts.

Since the world economic recession of 2008, growth has been stagnating for all sectors. The national economy has a narrow base that relies heavily on tourism, with a limited source area supplying 70 per cent of all tourists. Any threats to this limited market from changes in the world economy will be serious.

Vulnerability to internal limitations

Depletion of resources

The average tourist consumes more water and energy than the average Maldivian, and both are expensive to produce. Almost all water is provided by desalination. Groundwater supplies are running short and are often contaminated by sewage or saltwater incursion. All energy is produced by generator except on Male and Hulhulé Islands. The Maldives have no economic minerals and agricultural potential is very low.

Pollution

Solid and liquid waste production by tourists is also high, and matches their **consumption**. Solid waste is either dumped in poorly managed landfill sites, incinerated or dumped at sea. All three processes are unsustainable.

How the Maldives is responding to threats

The environment

All new tourism development sites must undergo an environmental impact assessment to measure potential **construction** carrying capacity for

Case study (continued)

the area. Developers must produce a mitigation plan against flooding. This must include a 40 m setback from the high-water mark, a maximum of 20 per cent land coverage by buildings, and building height restriction to tree-top level. Building materials such as sand and aggregates must be imported, mainly from India, but there is scope for recycling all demolition and building waste.

The problem of waste management is addressed through the compulsory installation of incinerators, bottle crushers and compactors in all resorts. Sewage disposal through soak-pits into the aquifer is discouraged, and all new resort developments must now have their own waste-water treatment plants. The installation of desalination plants for the provision of desalinated water in tourist resorts has also substantially reduced the stress on the natural aquifer.

President Mohamed Nasheed pledged to make the Maldives carbon neutral within a decade, which means encouraging the development of solar and wind energy. In 2009 he held an underwater cabinet meeting to emphasize his commitment to addressing the problem of climate change and consequent sea-level rise.

The economy

The Maldivian government aims to diversify the economy beyond tourism and fishing, and encourage linkage between tourism and other sectors such as construction, manufacturing and transport. Other aims include reforming public finance and encouraging foreign investment in the development of new resorts, broadening the tourism market by promoting domestic tourism, and attracting visitors from China and India. The goal is to increase employment, which is problematic given the limited resource base of the Maldives.

Hosting international sporting events

There are a number of political, economic and cultural factors that affect the hosting of an international event such as the Olympic Games or a World Cup. Most countries that bid to host such an event have to be in a position where they can guarantee that they can run the event successfully, hence the Olympic Games tend to be hosted in HICs and NICs/emerging economies. NICs that have hosted the events include China (Beijing Olympic Games, 2008), Brazil (2014 World Cup and 2016 Olympic Games) and South Africa (Football World Cup in 2010).

Hosting such an event requires stadia, transport infrastructure, hotels and other facilities for tourists/fans, and training facilities for the athletes/players taking part. Cultural factors may include the provision of sporting facilities – the Winter Olympic Games generally occurs in a country where winter sports is a tradition. Political factors involved in the allocation of the Games/World Cup include lobbying by national governments and alleged corruption of organizations such as the IOC and FIFA.

▼ **Table E.10:** The advantages and disadvantages of hosting the Olympic Games and World Cup

Advantages	Disadvantages
Prestige – it is considered an honour to host the event and if the games are a success the host city gains in reputation.	There may be financial problems – Montreal made a loss of over $1 billion in 1976 and the debt took years to pay off.
Economic spin-offs – trade and tourism in particular.	A large number of visitors puts a strain on hotels, transport, water supplies etc.

ATL Research skills

Find out about the controversy around the awarding of the 2022 Football World Cup to Qatar.

Activity 13

Study Figure E.18.

1. Describe and explain the relationship between PPP and international tourist arrivals.
2. Suggest reasons for the main fluctuations in the number of tourist arrivals in the Maldives.

ATL Research skills

Use the Internet to find out about the issues surrounding the Rio de Janeiro Olympic Games in 2016.

For example, what was the Occupy Golf movement and why was it formed?

Advantages	Disadvantages
It unites the country and gives a sense of pride.	Large events are security risks – due to the international television coverage they are now prime terrorist targets.
It gives a boost to sports facilities and other facilities. Cities build or improve their facilities to host events.	If an event does not do well, the host country's image suffers. The host will have difficulty attracting other events – if, indeed, it wants to.
The event may make a profit through sales of radio and TV rights, tickets and merchandise, as well as spending in hotels, restaurants etc.	

Activity 14

1. Consider the paragraphs above.
   a. List the positive and negative outcomes of the Olympic Games, ranking them in order from most positive to most negative.
   b. Were the London Games of 2012 a financial success?
   c. Are there any other outcomes that are difficult to measure?
2. Compare the outcomes and financial costs and benefits of two Olympic Games events held in countries at different levels of economic development.

Case study

The costs and benefits of hosting an international event: the London 2012 Olympic Games and Paralympic Games

The London 2012 Olympic Games and Paralympic Games were considered to be a great success for various reasons. The Games attracted a worldwide audience and helped to regenerate one of London's poorest areas. The Games created some 12,000 new jobs, up to £17 billion was spent on upgrading infrastructure and 2,800 new homes were built. The Games were a major factor in a 1.2 per cent reduction in London's unemployment rate in early 2012. More than 46,000 people worked at the Olympic Park and Olympic Village, more than 10 per cent of whom were previously registered unemployed.

The Games encouraged developments in the East End of London, such as Westfield shopping centre employing the unemployed from the East End. In the run-up to the games, women and black, Asian and minority ethnic (BAME) people found employment in construction jobs connected with the Games. The "Women into Construction" project funded by the London Development Agency and construction schools recruited and placed 266 women directly with Olympic Park contractors.

The UK government invested £30 million to transform the Olympic site into the "Queen Elizabeth Olympic Park" which includes housing, new schools, health centres, business space and sports venues. This involves converting the Olympic Village into more than 2,800 flats with additional new neighbourhoods containing 11,000 residences, a third of which will be affordable housing.

Transport for London invested £6.5 million in transport infrastructure in preparation for the 2012 games. Ten railway lines and 30 new bridges now connect London communities. There has been a £10 million investment to upgrade pedestrian cycling routes.

Sustainable efforts in this project were monitored by an independent commission that rated the global effort as "a great success". More than 90 per cent of demolition waste was recycled and 62 per cent of operational waste was reused,

Case study (continued)

▲ **Photo E.19:** Crowds at the Olympic Park

recycled or composted. To encourage biodiversity 300,000 plants were planted in the Olympic Park's wetlands area. In addition, over 1,000 new trees were planted in East London.

Nevertheless, there were many people who were not happy with the Games. They cost around £11 billion (plus the cost of infrastructure developments) and received lottery funding of £675 million, which could have gone elsewhere. Some people and businesses did not want to move but were forcibly relocated. There were regional development impacts too – London and the South East received the bulk of the funds, increasing inequalities between those areas and the rest of the country.

▼ **Table E.10:** Financial costs and benefits of the London Olympic Games, 2012

Costs	Benefits
Running the Games: £1.5 bn Olympic stadium: £560 m Athletes' village and park: £650 m Security: £200 m Redevelopment: £800 m Transport and infrastructure: £7 bn	**INCOME** Lottery £1.5 bn TV and marketing £560 m Sponsorship and official suppliers: £450 m Ticket revenues: £300 m Licensing: £50 m London Development Agency: £250 m Council tax levy: £625 m
Total £10.710 billion	Total £3.735 billion

The London 2012 Olympic Committee had four main aims for the Games:

- to regenerate and transform one of London's poorest areas
- to create a Games for the world, reflecting London's diversity
- to inspire young people into taking part in sport
- to create a legacy for east London which would last beyond 2012.

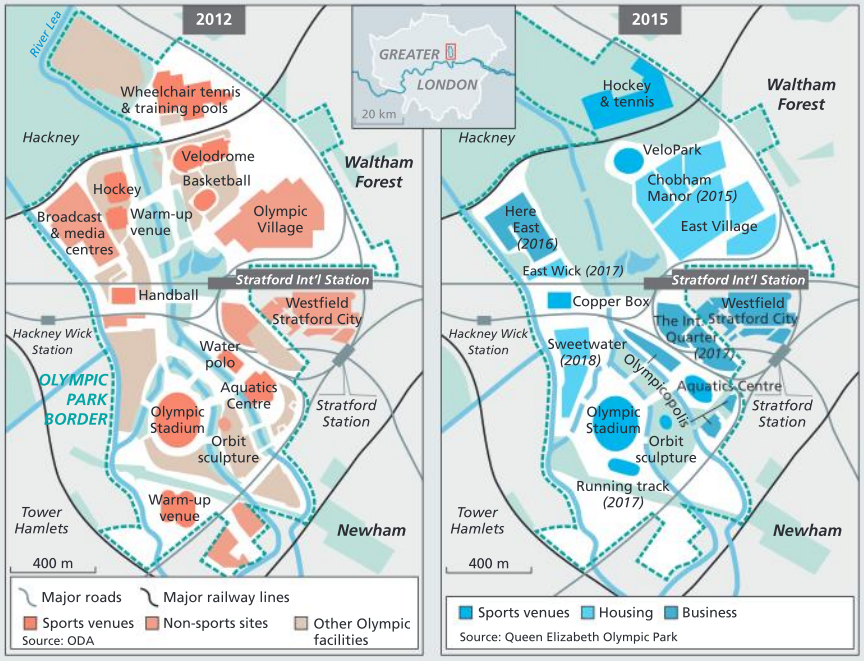
There were many changes that the Games brought about and continue to bring about. A new Olympic Park, the Queen Elizabeth Park, was opened on 1 January 2013 along the Lea river. Some 2,800 housing units were created from the Athletes Village and 50 per cent of these were affordable housing for local people. The first new residents moved into East Village in April 2013. In July 2013 the Copper Box opened as a local community leisure facility. In spring 2014 the Aquatic Centre opened as a local swimming pool. Transport infrastructure continues to be improved – in 2017 Crossrail will open at Stratford ready for the World Athletics Championships. Another 7,000 flats may be built by 2035. In 2016 the football club West Ham United moved into the Olympic Stadium, and in 2017 the media centre reopened as "Here East", a tech start-up hub.

Assessing the legacy

The main aims of hosting the Games were to build new sporting facilities and infrastructure, to host a successful Games and to make the facilities available for use after the games. Another aim was to get more young people involved in sport.

▲ **Photo E.20:** Restored River Lea and Athletes' Village

Case study (continued)



◀ **Figure E.20:** During and after: London's 2012 legacy

Source: *The Economist*. 2015. "What have the Olympics done for east London?" http://www.economist.com/news/britain/21659766-what-have-olympics-done-east-london-going-bronze

This aim has not been achieved: according to Sport England, the number of Britons exerting themselves at least once a week fell by 200,000 between 2012 and 2014. Partly this is down to government cuts to sports centres and the like.

After the 2012 Olympic Games the London 2012 organizers stated that they wanted an even better performance from British Athletes in the 2016 Olympic Games, and so the British government provided an extra £1 billion towards the development of elite sports, upgrading of existing infrastructure, the creation of new sports facilities and increased participation in sports, in particular sports related to the Olympic and Parlaympic Games. The focus on elite athletes might not translate into local participation.

The industrial and tourism sectors are expected to continue to grow in the coming years. However, the East London area, when compared to the rich West London area, is still very deprived. Much more long-term development is needed to change the relative inequalities in London. The waiting list for social housing in Tower Hamlets is around 22,000. Many of the housing developments are private – only 28 per cent are earmarked to be "affordable" (defined as 80 per cent of the market rent). Although the unemployment rate fell in Newham and Tower Hamlets, it is still higher than London's average.

▲ **Photo E.21:** Part of the Olympic Park

Concepts in context

Tourism and sport are two very important economic sectors. Both can create major economic benefits but both can cause major social, economic and environmental problems. Many countries attempt to develop tourism based around their particular resources – this can be very varied and can include adventure, movie and heritage tourism. TNCs have immense **power**, and have the ability to develop tourism and support sporting developments in many locations. They also manage much of the transport infrastructure. Nevertheless, many countries use tourism and major sporting events as a development strategy to earn income. Events such as the Olympic Games and the World Cup have the potential to redevelop important cities. However, the potential benefits that such events may bring might not materialize – and there has been much corruption linked to large sporting bodies.

Check your understanding

1. Define adventure tourism.
2. Define heritage tourism.
3. Outline the role of TNCs in the provision of tourist facilities and transport.
4. Suggest why tourists are attracted to South Africa.
5. Outline the advantages and disadvantages of tourism for the Maldives.
6. Comment on the costs and benefits of holding large-scale sporting events.
7. Explain why many Small Island Developing States rely on tourism.
8. Define "mass tourism" and outline its limitations.
9. Explain the disadvantages of heritage tourism.
10. Examine the role of tourism as a national development strategy or as an urban regeneration strategy.

4 Managing tourism and sport for the future

Conceptual understanding

Key question

What are the future possibilities for management of and participation in tourism and sport on varying scales?

Key content

- The consequences of unsustainable touristic growth in rural and urban tourism hotspots including the concept of carrying capacity and possible management options to increase site resilience.
- The concept of sustainable tourism, including the growth of ecotourism.
- Factors influencing future international tourism, including greater use of social media, international security and diaspora growth.
- The growing importance of political and cultural influences in international sport participation, including international agreements, inclusion via changing gender roles and the growing importance of the Paralympics.

Unsustainable touristic growth

The concept of **sustainable tourism** has often used the concept of carrying capacity. Carrying capacity can be thought of in three main ways:

- physical carrying capacity, which is the measure of absolute space, for example the number of spaces within a car park
- ecological capacity – the level of use that an environment can sustain before environmental damage occurs
- perceptual capacity – the level of crowding that a tourist will tolerate before deciding the location is too full.

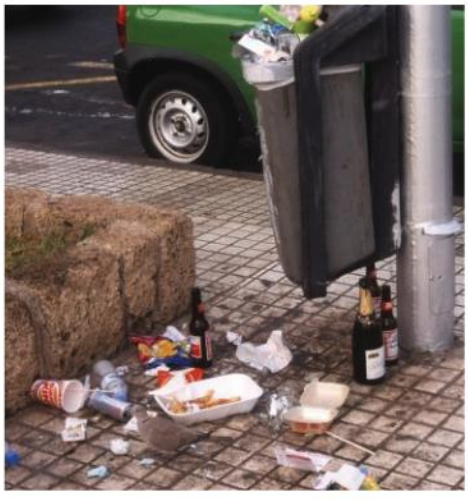
Tourism in Venice – an urban "hotspot"

The historic centre of Venice comprises 700 ha with buildings protected from alterations by government legislation. There is a conflict of interest between those employed in the tourist industry (and who seek to increase the number of tourists) and those not employed in the tourist industry (and who wish to keep visitor numbers down). The optimum carrying capacity for Venice is 9,780 tourists who use hotel accommodation, 1,460 tourists staying in non-hotel accommodation and 10,857 day trippers on a daily basis. This gives an annual total of over 8 million people. This is 25 per cent greater than the number of tourists actually arriving in Venice. However, the pattern of tourism is not even. There are clear seasonal variations with an increase in visitor numbers in summer and at weekends. Research has estimated that an average of 37,500 day trippers visit Venice every day in August. A ceiling of 25,000 visitors a day has been suggested as the maximum carrying capacity for Venice.

There are important implications for the environment and its long-term preservation if the carrying capacity is exceeded. The environmental and economic carrying capacity have different values (one concerned with preservation, the other with economic gain), but the 25,000 is a useful benchmark.

In 2000 the carrying capacity of 25,000 visitors was exceeded on over 200 days and on seven days the visitor numbers exceeded 100,000.

The large volume of visitors who travel to Venice creates a range of social and economic problems for planners. The negative externalities of over-population stagnate the centre's economy and society through congestion and competition for scarce resources. Day tripping is becoming increasingly important, while residential tourism is becoming less important. There have been complaints from local people of tourists sleeping on bridges, stealing gondolas for night-time rides, swimming in the canals, covering churches with graffiti, and even cooking in St Mark's Square. Thus the local benefits of tourism are declining.



▲ **Photo E.22:** Plastic pollution

The negative impact of tourism on Venice has resulted in a vicious circle of decline as day trippers, who contribute less to the local economy than resident visitors, replace the resident visitors as it becomes less attractive to stay in the city. A number of measures have been taken to control the flooding of Venice by day trippers such as:

- denying access to the city by unauthorized tour coaches via the main coach terminal
- building gates around the city and charging visitors to enter.

Nevertheless, the city continues to market the destination, thereby alienating the local population. Indeed, the local population has fallen from 120,000 in the 1960s to 55,000 in 2015.

Since 2000, Venice has seen an increasing number of cruise liners and passengers. In 2015, more than 650 boats docked, bringing over 2.2 million passengers. Over the same period, the value of tourism in Venice declined by €300 million. Cruise passengers do not stay in hotels, generally they do not eat large meals in Venice, and often they have their own guide.

The excessive number of day trippers has also led to a deterioration in the quality of the tourist experience. This is significant in that it highlights problems affecting many historic cities around the world, especially those in Europe.

▲ **Photo E.23:** St Mark's Square, Venice

▲ **Photo E.24:** Murano, Italy

Tourism in a rural area – the Brecon Beacons, Wales

The Brecon Beacons National Park is located in the south of Wales and is one of the closest national parks to people living in cities such as London, Birmingham and Bristol.

The Llanthony Valley is a microcosm of all that is bad about tourists. They bring little or no benefit to an area but they cause disruption, irritation and problems. Farmers find it difficult at times to move animals and large machinery, they find their gates blocked, and are disrupted by pony-trekkers and sightseers driving slowly. For the tourist, the trip is merely a pleasurable drive and they gain little or no understanding about the community, the landscape or the heritage that they have passed through.

Nevertheless, it is possible to integrate local communities into tourism. One attempt to involve the local community in tourism is the South Pembrokeshire Partnership for Action with Rural Communities (SPARC).

One SPARC action plan improved infrastructure, footpaths and routes that linked tourist sites. Residents become involved in tourism developments in many ways:

- local produce is used wherever possible
- the majority of visitors stay in locally owned and managed accommodation
- the service sector is locally owned
- local manufacturers are encouraged to tap the tourist market for gifts, souvenirs, crafts and other projects.

Table E.11: Environmental impacts of tourism

Stressor activities	Stress	Primary environmental response
Permanent environmental restructuring 1 Major construction activity: • urban expansion • transport network • tourist facilities • marinas, ski lifts 2 Changes in land use: • expansion of recreational lands	Restructuring of local environments Expansion of built environments Land taken out of primary production	Change in habitat Change in population of species Change in health and welfare of humans Changes in visual quality
Generation of waste: • tourism, recreation and leisure activities • transport	Pollution loadings: • emissions • effluent discharge • solid waste disposal • noise (traffic, aircraft)	Change in quality of environmental media: • air • water • soil Health of organisms Health of humans
Tourist activities: • skiing • walking • hunting • trail-bike riding	Trampling of vegetation and soils Destruction of species	Change in habitat Change in population of species
Effect on population dynamics: • population growth	Population density (seasonal)	Congestion Demand for natural resources: • land and water • energy

Sustainable tourism

Sustainable development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable tourism therefore needs to:

- ensure that renewable sources are not consumed at a rate that is faster than the rate of natural replacement
- maintain biological diversity (biodiversity)
- recognize and value the aesthetic appeal of environments
- respect local cultures, livelihoods and customs
- involve local people in development processes
- promote equity in the distribution of the costs and benefits of tourism.

Principles of sustainable tourism

Sustainable tourism is that which:

- operates within natural capacities for the regeneration and future productivity of natural resources

- recognizes the contribution of people in the communities, customs and lifestyles linked to the tourism experience
- accepts that people must have an equitable share in the economic benefits of tourism.

This entails:

- using resources sustainably – the sustainable use of natural, social and cultural resources is crucial and makes long-term business sense
- reducing over-consumption and waste – this avoids the cost of restoring long-term environmental damage and contributes to the quality of tourism
- maintains biodiversity – maintaining and promoting natural, social and cultural diversities is essential for long-term sustainable tourism and creates a resilient base for industry
- supporting local economies – tourism that supports a wide range of local economic activities and which takes environmental costs and values into account both protects these economies and avoids environmental damage
- involving local communities – the full involvement of local communities in the tourism sector not only benefits them and the environment in general but also improves the quality of the tourism experience
- training staff – staff training that integrates sustainable tourism into work practices along with recruitment of local personnel of all levels improves the quality of the tourism product
- marketing tourism responsibly – such as encouraging tourists to visit sites during off-peak periods to reduce visitor numbers and when ecosystems are most robust; marketing provides tourists with the full and responsible information, increases respect for the natural social and cultural environments of destination areas and enhances customer satisfaction
- undertaking research – ongoing monitoring by the industry using effective data collection analysis is essential to help solve problems and to bring benefits to destinations, the industry, tourists and the local community
- integrating tourism into planning – this entails tourism and development which are integrated into national and local planning policies, and management plans that undertake environmental impact assessments, projects, plans and policies to increase the long-term viability of tourism
- better information provision – providing tourists with information about tourist destinations in advance and in situ, such as through visitor centres.

The key objectives for sustainable tourism are:

- quality of the environment
- maximizing the economic benefit.

▲ **Photo E.25:** Well-watered golf course in a dry area

ATL Research skills

"Urban areas are more resilient to the impacts of tourism than rural areas." Discuss.

Either:

Present an argument supporting urban tourism in a named city.

Or:

Present an argument supporting tourism in a rural area.

Ecotourism

Ecotourism is a "green" or "alternative" form of sustainable tourism. It generally occurs in remote areas, with a low density of tourists. It operates at a fairly basic level. Ecotourism includes tourism that is related to ecology and ecosystems. These include game parks, nature reserves, coral reefs and forest parks. It aims to give people a firsthand experience of natural environments and to show them the importance of conservation. Its characteristics include:

- planning and control of tourist developments, which must fit in with local conditions
- increasing involvement and control by local or regional communities
- being appropriate to the local area
- a balance between conservation and development, between environment and economics.

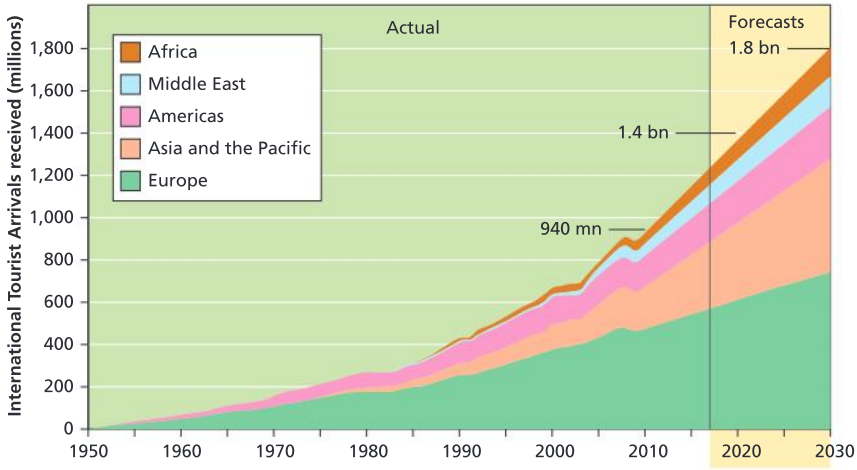
However, in areas where ecotourism occurs there is often a conflict between allowing total access to visitors and providing them with all the facilities they desire, and with conserving the landscape, plants and animals of the area. Another conflict arises when local people wish to use the resource for their own benefit rather than for the benefit of animals or conservation.

Ecotourism has also been described as egotourism. Critics argue that ecotourists are trying to get closer to the environment and are perhaps causing much more damage than mass tourism. Backpackers, for example, are thought to be the greatest threat. They put little into the local economy but want to go to all the best places. As backpackers go off the beaten track they destroy more of the natural environment. By contrast, mass tourists use the prepared routes such as the ones bus tours follow.

Future international tourism

International tourist arrivals worldwide are expected to increase by 3.3 per cent a year over the period 2010 to 2030 to reach 1.8 billion by 2030. By 2030, arrivals in emerging destinations are expected to increase at twice the rate of those in advanced economies. The market share of emerging economies increased from 30 per cent in 1980 to 45 per cent in 2014, and is expected to reach 57 per cent by 2030, equivalent to over 1 billion international tourist arrivals.

▼ **Figure E.21:** Trends and predicted growth for global tourism by region, 1950–2030



Forecasts

International tourist arrivals in the emerging economy destinations of Asia, Latin America, Central and Eastern Europe, Eastern Mediterranean Europe, the Middle East and Africa will grow at double the rate of growth in advanced economy destinations. Consequently,

arrivals in emerging economies are expected to exceed those in advanced economies before 2020.

The strongest growth by region will be seen in Asia and the Pacific. The global market shares of Asia and the Pacific will increase from 22 per cent in 2010 to 30 per cent in 2030, whereas Europe's share will decline from 51 per cent to 41 per cent.

Case study

The Monteverde cloud forest, Costa Rica

▲ **Photo E.26:** Monteverde zip wire

Costa Rica attracts about 1 million visitors each year. Well-organized government promotions and a reputation as the safest country in Central America attract a large number of North American and European visitors. Costa Rica's tourism is unusual in that a large part of it relates to special-interest groups, such as bird-watchers, and its dispersed small-scale nature is a form of sustainable ecotourism.

Monteverde's cloud forest is situated at a height of around 1,700 m. The Monteverde Cloud Forest Reserve was established in 1972. Initially, it covered 328 ha but now covers around 14,200 ha. There are over 100 species of mammals, 400 species of birds, 1,200 species of reptiles and amphibians, and several thousand species of insect. The Santa Elena Cloud Forest Reserve was established in 1989 and was one of the first reserves in the country to be directly controlled by the local community. It is 310 ha in size, and is home to spider monkeys. The observation tower offers spectacular views of the Arenal Volcano.

The Arenal Volcano and the Monteverde Cloud Forest are often part of a combined tour itinerary, and generally receive around 70,000 visitors a year.

Early tourists were mostly scientists and conservationists from the USA studying the area's rich biodiversity. In 1974 there were just 471 visitors. Since the early 1990s the numbers of tourists to Monteverde have stabilized at about 70,000 a year. The nature of the tourist has changed. At the beginning there were mainly specialists. Now most of the tourists have a more general interest in the forest, and seek a balance between entertainment, adventure and knowledge. Monteverde now accounts for about 18 per cent of Costa Rica's total tourist revenue. The growth and development of tourism came at a time when there was a long-term decline in agriculture in Costa Rica. At the same time, ecotourism was able to absorb some of the displaced agricultural workers in their own villages. Much of this development was small-scale. For example, 70 per cent of the hotels in Costa Rica have less than 20 rooms.

New businesses have been created in Monteverde, including hotels, bed and breakfasts, restaurants, craft stalls, supermarkets, bars, riding stables, private reserves, hiking trails, hummingbird galleries, frog ponds and a butterfly and botanical garden. The Butterfly Garden consists of a biodiversity centre, a medicinal garden, four climate-controlled butterfly gardens and a leafcutter-ant colony. Many of these are locally owned. Over 400 full-time and 140 part-time jobs have been created. In addition there are indirect employment and multiplier effects. There are also canopy walks and suspension bridges. Local farmers provide much of the food consumed by tourists to the area. Farmers' markets every Saturday also attract tourists. The Monteverde Coffee Tour provides a guided tour of the production of coffee from the field to the cup. All of the proceeds go towards supporting local farmers and families involved in the production of coffee.

Unlike many rural areas in developing countries, Monteverde is not experiencing **out migration**. Indeed, it has been quite the opposite. Because

Case study (continued)

of the developments in tourism there have been increased employment opportunities and this has attracted many young people. However, the growth in the resident and tourist population has placed a great strain on the existing infrastructure such as water supplies, refuse collection, electricity and telecommunications. In addition, the price of land has soared.

There have been benefits other than employment and income generation. Controlled access to the cloud forest, and the use of locals employed as guides means that not only are jobs created, but there is a reduction of visitor impact on parts of the forest. Local arts and crafts have been rejuvenated, and jobs in accommodation, transport, food and communications have been created. The increase in small businesses means that income should be more evenly distributed. Formal and informal education programmes have been strengthened, and the local community are even more aware of the value of their natural resources than they were when they were farmers. But the education is two-way: the villagers learn from the tourists just as the tourists learn from the villagers.

ATL Research skills

Visit the Monteverde Cloud Forest Information Centre at http://www.monteverdeinfo.com/ and the Arenal Volcano National Park at http://costa-rica-guide.com/nature/national-parks/arenal-volcano/

Find out about the activities and resources for both and produce a report on sustainable tourism in Monteverde and Arenal.

Online case study

The promotion of International sports participation

Political and cultural influences on international sport participation

Increasingly, sport has been used by nations for a variety of reasons. Some governments may wish to increase participation in sport for the health benefits that it could bring. Others may wish to host a mega event in order to help develop part of their economy, in particular tourism, or to regenerate urban areas and create a "feel good" factor among their citizens, as the country has the world's attention during the event.

The evidence is far from conclusive. The economic benefits from mega events are hard to quantify, and the link between government involvement in sport, and success or participation in sport, is unclear. The increase in sports participation for many sporting events is short term. In the UK, there is a seasonal rise in tennis following the Wimbledon All England Lawn Tennis championship. The fact that this occurs during the summer is likely to correlate with a time when more people are playing tennis anyway.

Qatar has been actively improving its position in the international sports scene. In 2010 Qatar was awarded the 2022 World Cup, and in 2011 it signed a deal to sponsor FC Barcelona, worth €150 million over five years. In addition, the Qatar Investment Authority became the majority shareholder in the French football club, Paris St Germain. Qatar Airways became the official sponsor of the Tour de France cycling event, and the Qatar-owned newspaper and television company Al Jazeera bought the rights to broadcast the Football World Cups in 2018 and 2022 to the Middle East and North Africa.

National pride might also affect success in sport. Match analysis has shown that Algeria, Libya, Morocco, Sudan and Tunisia all had greater success rates in football matches after the Arab Spring. One explanation that has been put forward is that players feel they are playing for their own nation rather than for a dictator.

Sport continues to be tainted by match fixing and the use of drugs. Match fixing has been identified in football, cricket and tennis in over 20 European countries, and has been linked to gambling syndicates in Asia.

The impact of social media

Social media has made a huge impact on tourism and travel. It has changed how people research trips, make decisions and share their experiences. Tourism relies on favourable opinions and recommendations. Social media sites such as TripAdvisor (50 million) and Facebook (800 million) allow customers to easily share tips and suggestions. In one survey 92 per cent of consumers said that they trusted social media more than any other form of advertising.

TripAdvisor, for example, was founded in 2000, and by 2015 it listed 890,000 hotels in 45 countries. It was claimed that if a hotel did not make the top five in its location, it would be losing business to competitors. Similarly, poor reviews have the ability to damage small businesses with limited resources. Many travellers trust the comments that are posted since they are generally written by fellow travellers.

Another study showed that over half of respondents changed their travel plans after using social media to research their trip. Some 85 per cent of travellers use their smartphones abroad, and over half of Facebook users said that their vacation choice was influenced by friends' holiday photos.

Activity 15

Visit http://visual.ly/impact-social-media-travel-and-hospitality-industry. Study the infographic which shows the importance of social media for the travel and tourism industry.

Outline how and why social media has influenced the growth of the travel and tourism sectors.

International security

The impact of terrorism on the travel and tourism industry can lead to long-term economic decline and associated social and economic impacts. Any terrorist threats in the industry are a cause of major concern for many governments and TNCs. The effect may be felt in associated industries including airlines, hotels, restaurants and shops that cater for tourists.

The success of travel and tourism does not shield it from the impact of terrorism. The 11 September 2001 (9/11) terrorist attacks in the USA highlighted the need for safe travel. The attacks had an immediate and important impact on worldwide travel. The initial drop in arrivals immediately following 9/11 reflected widespread concern about the safety of travel.

Terrorists target tourists in order to achieve ideological aims, punish people for supporting the government, and strengthen claims to political legitimacy by making the government look weak.

Terrorist attacks are not new. In 1972 during the Munich Olympic Games, Palestinian gunmen killed 11 Israeli athletes. During the mid-1980s there was a sharp decline in tourism to London due to the Irish Republican Army (IRA) bombing campaign in England. Similarly, tourism in Northern Ireland was very undeveloped for many years due to the country's negative image which was caused by terrorism.

Tourists and local people may differ in social and economic characteristics. When local people facing hardship are forced to co-exist with wealthy international tourists enjoying luxuries, friction is inevitable and may lead to conflict. Travel patterns may reflect ideological values, political views and cultural values of tourists and their countries. For example, certain tourist behaviours, such as the consumption of pork in an Islamic country, drinking alcohol, gambling

ATL Research and communication skills

Evaluate and discuss the methods used to reduce the impact of terrorism upon the tourist industry. Refer to the World Travel and Tourism Council website at http://www.wttc.org/.

ATL Research skills

Use some of the following websites (or find some for a country that you are interested in) to investigate diaspora tourism.

Tourism Ireland, Irish the world over at https://www.tourismireland.com/Press-Releases/2016/May/Tourism-Ireland-launches-new-online-film-Tracing-M.

Caribbean diaspora tourism at https://www.idrc.ca/en/article/familiar-faces-abroad-diaspora-tourism-caribbean.

Visit Scotland, "Discover your Scottish roots and start planning your ancestral journey to Scotland", www.ancestralscotland.com.

UNESCO's portal to the Africa Diaspora Heritage Trail http://portal.unesco.org/culture/en/ev.php-URL_ID=32295&URL_DO=DO_TOPIC&URL_SECTION=201.html.

Migration Museum Project http://migrationmuseum.org/

and Western dress styles can be at odds with local values. This theory may help explain Egyptian frustration with tourism in 1997 when gunmen killed 71 tourists outside the Egyptian resort of Luxor.

The rapid growth of the worldwide tourism industry is due to a number of interrelated factors including economic growth, a rise in disposable income, increased leisure time and promotion of tourism by governments, as well as development strategy.

At the national level, governments can also do much to implement tighter security. Despite tourism's economic strength, terrorism and political turmoil present major challenges to the industry. Many experts believe that certain parts of the Middle East, Pakistan, Afghanistan and sub-Saharan Africa are turning out to be the main power centres for terrorism, and so limit the potential for tourism there.

Diaspora tourism

Diaspora tourism is an increasingly important form of niche tourism, and it is one that has distinctive features and potential value. Diaspora tourists often require different forms of accommodation and activities compared with other travellers, and they may well spend their money in different ways. Diaspora tourism is an important sub set of VFR tourism (visiting friends and relatives). Diaspora tourists are "back home" when they are visiting their country of origin, and so may not need the same facilities that make foreign tourists comfortable.

Diaspora tourists are more likely than most international tourists to have or make connections with the local economy. They are more likely to stay with relatives, or in locally owned businesses (for example, bed and breakfast accommodation), to eat in local restaurants, go to local pubs and so on. Although they might not spend as much money as international tourists, it is more likely to go directly to local businesses. Thus, diaspora tourism can have a positive development potential. Moreover, diaspora tourism is not as seasonal as international tourism, and may be spread more evenly throughout the year.

Diaspora tourism may lead to the development or expansion of tourist facilities within a country. The Africa Diaspora Heritage Trail conference encourages public and private investment in diaspora tourism, as well as educational, sustainable and ecotourism.

Diaspora holiday visits to see family may well combine visits to family and friends with visits to other tourist attractions or leisure activities. Some tourism campaigns have targeted diaspora populations. For example, the Philippines, India, Taiwan and Cuba all have important medical tourism campaigns that have reached out to diaspora populations. In addition, business tourism by a diaspora population also has development potential.

Some forms of tourism deliberately target dispora populations. Genealogy tourism (or "cemetery tourism"!) focuses upon researching an individual's family tree. Increasingly, information is being made available on the Internet allowing people to do research into their family history before making a trip.

Governments may attract diaspora investment into the tourist industry by providing loans and grants. The restoration of historic buildings, such as kasbahs in Morocco and paradors in Spain, has involved some diaspora investment.

Diaspora tourism has been shown to be less affected by economic recession, and there are less disadvantages (for example, leakage, environmental disturbances) than with other forms of tourism.

▲ **Photo E.27:** Royal Brunei airlines – strong growth is forecast for the Asia-Pacific region

Gender and tourism/leisure

Gender

In 1966 42.2 per cent of women of working age were in employment. By 2013 this had increased to 67 per cent. Single professional women are more likely to:

- have an active social life
- regularly go to the theatre and cinema
- actively participate in sport (67 per cent compared with 50 per cent of married women)
- eat out regularly
- go to the pub regularly (41 per cent compared with 14 per cent of women with children).

The number of single professional and managerial women aged 25 to 44 is rapidly increasing and their work patterns and lifestyles will have an increasing impact on demands for leisure, retailing and housing.

Inclusion via changing gender roles

The world of sport is male dominated and women often face considerable challenges, sometimes just to participate in sport. For Muslim women there are additional challenges.

Islam promotes good health and fitness. However, Muslim women cannot participate in mixed-gender sports, and the environment in which they play and sports dress also need to be considered. In the UK, only 12.5 per cent of Asian women do enough sport each week to benefit their health, compared with 18.8 per cent of white women. In contrast, in traditional Muslim countries, for example countries in the Middle East, attitudes to physical exercise among Muslim women are much more positive than in the UK.

In Saudi Arabia, there has been an increase in the number of sporting facilities that are available for women only. For example, the Luthan Hotel and Spa is a women-only establishment in Riyadh. In the USA there are a number of swimming pools that offer women-only sessions, or sessions to serve both Jewish and Muslim women; for example, in St Louis Park, Minnesota and Williamsburg, Brooklyn.

ATL Research skills

Watch the movie *Bend it like Beckham*. Discuss the issues raised in this film about female participation in sport due to ethnicity.

Table E.12: Barriers to participation in sport for Muslim women in the UK

Dress code	Sport facilities/teams and clubs do not always appreciate the need for modest dress.
Facilities	Facilities need to be clean and water available to thoroughly wash after using the toilet. Provision of a prayer room or quiet area is required as most Muslim women will observe prayer during specified times in the day.
Lack of role models	The visibility of British BAME will help to break barriers and make the environment more inclusive.
Parental approval	This is especially important for young women whose parents need to understand the benefits of sport to allow them to encourage out-of-school activities and feel comfortable that the environment will be safe.
Transport	It is often more appropriate for women to access services locally as most will not have access to transport and will be reluctant to use public transport in the evening if they are on their own.
Social side	The traditional social side of sport does not link in with the religious requirements of Muslim women who do not drink alcohol and will not partake in activity that may be considered inappropriate and incompatible with their beliefs.
Communication	Language is often a barrier as being unable to communicate causes anxiety and uncertainty around how to approach and access services.
Lack of women-only sessions	Most Muslim women will only play in a female-only environment.
Childcare	Traditionally this is the sole responsibility of women. Although attitudes are changing, provision of crèche facilities will allow greater access for women with children.
Socio-economic difference	Statistically BAME people earn less than their white counterparts which limits access, particularly for women who often give financial priority to their families.
Time	Other commitments such as childcare and running the home take priority and sports organizers should consult with the community regarding the timetabling of events.
Employment	More needs to be done to encourage young women to access employment within the sector to help break down barriers and act as a resource to equip other staff with knowledge about the communities they serve. This includes the admin side of sport.
Environment	Safety, lighting and security are important to prevent racially motivated incidents.
Information	Information should be made available in other languages and services marketed in appropriate places, such as mosques and schools, to ensure women become aware of what is on offer.

ATL Research and communication skills

Use the Internet to find out about the Invictus Games. When were they initiated? What does the word "invictus" mean? How many countries compete in the Games? Who takes part in the Games?

Make a brief presentation of your findings.

Paralympic Games

The Paralympic Games is an international competition for athletes with a range of physical disabilities. It occurs immediately after the Olympic Games and takes place in the Olympic Stadium and other stadia. The Paralympic Games first took place in 1948, and consisted of British Second World War veterans.

Concepts in context

Tourism can bring many benefits, and it can also cause serious harm to the environment, society and the economy. Tourism needs to be managed carefully. One **possibility** is sustainable tourism, such as ecotourism. Ecotourism is being developed in many LICs but also features in HICs. It is likely that tourism in future will be influenced by greater use of social media, the Internet, security issues and the growth of diaspora. Tourism and sport are attempting to become more inclusive, as evident in the rise of the Paralympic Games.

Check your understanding

1. Explain what is meant by perceptual carrying capacity.
2. Describe the conditions that might exist when an urban tourist hotspot's carrying capacity has been exceeded.
3. Why is ecotourism sometimes referred to as "egotourism"?
4. Compare past and future international tourism trends for the world.
5. Examine the different rates of international tourism growth by world region.
6. Define diaspora tourism referring to at least two examples.
7. Explain how social media can influence tourist behaviour.
8. Explain what is meant by the "demonstration effect".
9. On what grounds have women been excluded from sport?
10. Explain the growing importance of the Paralympics.

Synthesis and evaluation

- The leisure activities of one place is influenced by its interactions with other places. Ecotourism activities in Monteverde, for example, are influenced by its promotion in rich countries as a tourist destination.
- People's freedom and ability to participate in leisure activities is subject to multiple influences from the local scale to the global scale. These include patterns of work, the growth of ICT, age, gender and wealth, for example.
- There are different perspectives on the costs and benefits of how places are used for leisure activities – these perspectives include individuals' views, those of TNC CEOs and their shareholders, city mayors, national governments – all of whom are engaged in the delivery of leisure, sport and tourism.
- Changes in visitor numbers suggest an exponential increase in tourism, especially from among NICs.

(a) (i) Suggest **two** ways in which these tourists may be affecting the environment due to their methods of transport. (2 marks)

(ii) Comment on the impact of these tourists on the carrying capacity of the beach. (2 marks)

(b) Explain **two** ways in which tourism on this beach could be managed. (3 + 3 marks)

(c) Either

"Participation in sport is as much a gender issue as it is a development issue". Discuss this statement. (10 marks)

Or

Examine the view that the potential for tourism and/or sport as a means of economic development is extremely limited. (10 marks)

OPTION F
THE GEOGRAPHY OF FOOD AND HEALTH

Key terms

Chronic hunger	Long-term hunger caused by a lack of food over a long timescale.
Periodic hunger	Temporary hunger that is caused by a short-term decline in food intake.
Malnutrition	Having a diet that lacks proper nutrition, caused by not having enough to eat or not enough good-quality food.
Epidemiology	The study of diseases.
Endemic	(Of a disease) prevalent in an area.
Epidemic	A fast-spreading outbreak of a disease.
Pandemic	A global epidemic.
HALE	Health-adjusted life expectancy – the length of time that an individual can expect to live based on adjustments made for years of ill health.
Food security	Food security for a population exists when all its people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food security for a household means access by all its members at all times to enough food for an active, healthy life. (UN Food and Agriculture Organization) Food security includes, at a minimum: (i) the ready availability of nutritionally adequate and safe foods; and (ii) an assured ability to acquire acceptable foods in socially acceptable ways (that is, without resorting to emergency food supplies, scavenging, stealing, or other coping strategies). (US Department of Agriculture)

This optional theme looks at the geography of food and health. Economic development is often accompanied by dietary change and an epidemiological transition, in which diseases of poverty become less common and diseases of affluence more common. However, this transition does not apply equally to all sectors of society.

Neither food nor health is easy to "measure", so alternative indicators of food and health are considered. There are many interactions between, and shared influences on, food and health. The role of gender, TNCs and national governments in both food and health provision is considered. This topic considers alternative ways of assessing agricultural sustainability alongside possibilities for improving food supplies and global health over the long term.

Through study of this optional theme, you will develop your understanding of processes, places, power and geographical possibilities. You will also gain an understanding of more specialized concepts such as **diffusion** and **barriers**, which are applicable to both food production systems and the spread of diseases. **Sustainability** is considered in relation to long-term food production.

Key questions

1. What are the ways of measuring disparities of food and health between **places**?
2. How do physical and human **processes** lead to changes in food production and consumption, and incidence and spread of disease?
3. What **power** do different stakeholders have to influence diets and health?
4. What are the future **possibilities** for sustainable agriculture and improved health?

1 Measuring food and health

Conceptual understanding

Key question

What are the ways of measuring disparities in food and health between **places**?

Key content

- Global patterns in food/nutrition indicators, including the Global Food Security Index, the Global Hunger Index, calories per person/capita, indicators of malnutrition.
- The nutrition transition, and associated regional variations in food consumption and nutrition choices.
- Global patterns in health indicators, including health-adjusted life expectancy (HALE), infant mortality, maternal mortality, access to sanitation, and the ratio between doctors/physicians and people.
- The epidemiological transition, the diseases continuum (diseases of poverty to diseases of affluence), and the implications of a global population for disease burden.

Global patterns in food and nutrition indicators

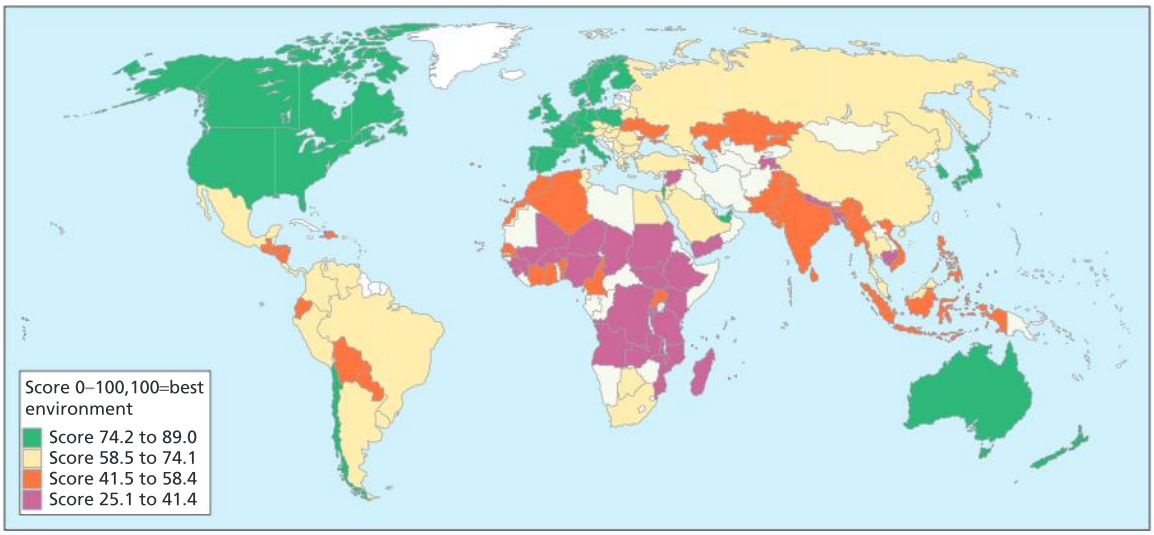
The Global Food Security Index

▼ **Table F.1:** The components of food security

Affordability	Food consumption as a share of household expenditure Proportion of population under the global poverty line Gross domestic product per person (PPP) Agricultural import tariffs Presence of food safety net programme Access to financing for farmers
Availability	Sufficiency of supply Public expenditure on agricultural research and development (R & D) Agricultural infrastructure Volatility of agricultural production Political stability risk Corruption Urban absorption capacity Food loss
Quality and safety	Diet diversification Micronutrient availability Protein quality Food safety

The Global Food Security Index considers the affordability, availability, and quality of food across 113 countries. The Index is based on 28 indicators that measure food security in high-, middle- and low-income countries. The Index looks beyond hunger to study the underlying factors affecting food security (Table F.1).

In 2015, food security improved in almost every region of the world. High-income countries still dominate the top of the rankings, but lower-middle-income countries made



▲ **Figure F.1:** Global Food Security Index scores, by country

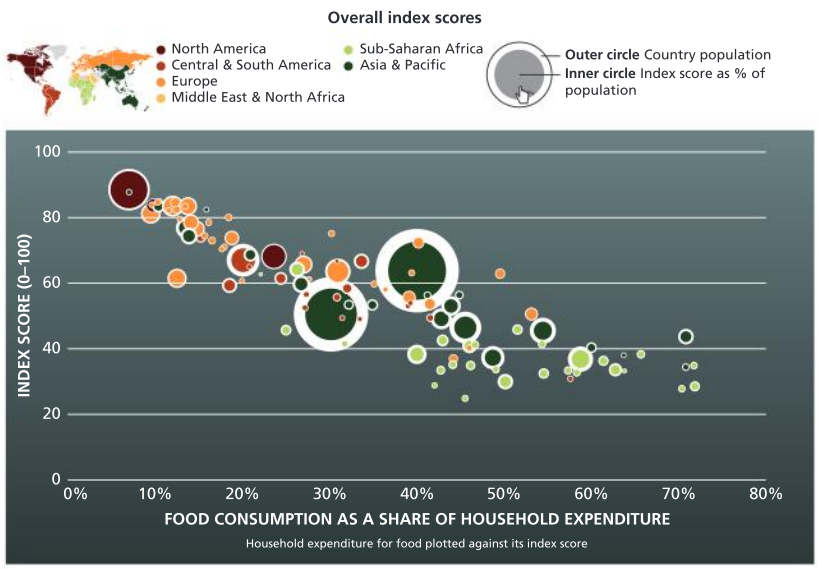
the biggest gains. The Middle East and North Africa (MENA) made the largest strides in food security. Europe is the only region where food security worsened, as the scores of 85 per cent of countries fell. Diet diversification and access to high-quality protein are increasing rapidly in low-income countries. Nutritional standards have improved substantially in almost every region.

The Global Hunger Index

The Global Hunger Index (GHI) ranks countries on a 100-point scale, with 0 being the best score (no hunger) and 100 being the worst, although neither of these extremes is reached in practice. Values

TOK

How useful is the national scale in the investigation of food security? For example, the map in Figure F.1 suggests that all people in the USA, Canada, western Europe and Australia, to name four areas, have food security. Which groups of people in these areas do you think lack food security? Give reasons for your answer.



▲ **Figure F.2:** The relationship between food consumption as a share of household income and food security (index score)
Source: http://foodsecurityindex.eiu.com/Index

▲ **Photo F.1:** Food aid is a feature of many low-income countries

ATL Research skills

Use the link http://foodsecurityindex.eiu.com/Index to access the data shown in Figure F.2 (see "Visual analysis"). Click on the options to show variations in affordability, availability, quality and safety. Choose a range of countries. Hover the computer mouse over the proportional circles to access the data on individual countries.

Use the interactive tool to explore food security in countries of your choice. Click on a country to find out about its strengths and challenges in terms of food security, affordability, availability, quality and safety (click on the pie charts to find out the factors they refer to). See also http://foodsecurityindex.eiu.com/Country for details on global food security by country.

Activity 1

Study Figure F.2.

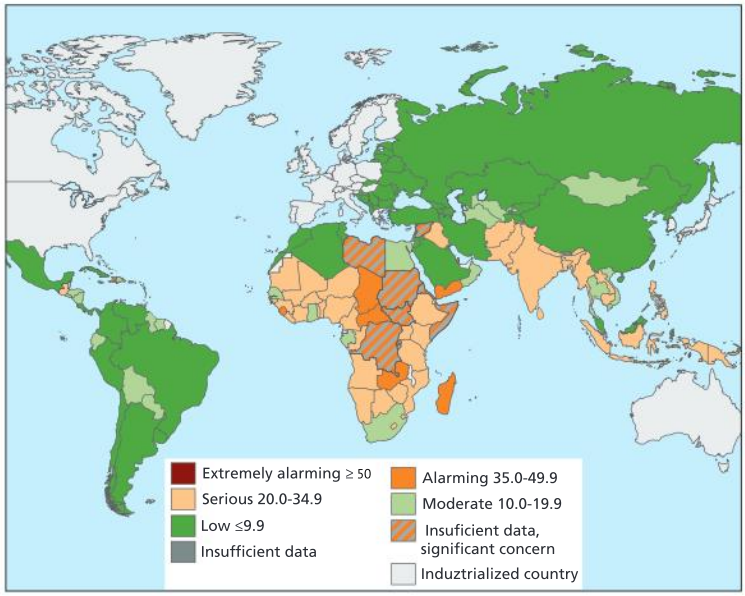
1. Describe the relationship between food consumption as a share of household income and food security (index score).
2. Use the website in the Research skills box to identify contrasting countries in Figure F.2. State their food security score and their food consumption as a percentage of household income.
3. Outline **two** or more reasons for the countries' position on the graph.

lower than 10.0 reflect "low hunger", 10.0 to 19.9 is described as "moderate hunger", 20.0 to 34.9 indicates "serious hunger", 35.0 to 49.9 is "alarming hunger", and 50.0 or more is described as "extremely alarming hunger".

The GHI is based on four component indicators:

1. Undernourishment – the proportion of undernourished people as a percentage of the population (the share of the population with insufficient caloric intake).
2. Child wasting – the proportion of children under the age of 5 who suffer from wasting (that is, low weight for their height, reflecting acute undernutrition).
3. Child stunting – the proportion of children under the age of 5 who suffer from stunting (that is, low height for their age, reflecting chronic undernutrition).
4. Child mortality – the mortality rate of children under the age of five (partially reflecting the fatal synergy of inadequate nutrition and unhealthy environments).

The data and projections used for the 2015 GHI are for the period 2010–16, reflecting the most recent available data for the four component indicators.



▲ **Figure F.3:** The Global Hunger Index
Source: http://ghi.ifpri.org/

Activity 2

Study Figure F.4.

1. Which region has made the greatest progress in reducing hunger since 1990?
2. Identify the regions that had the highest Hunger Index score in (a) 1990 and (b) 2015.
3. Describe how the composition of the Global Hunger Index score in the world changed between 1990 and 2015.

Table F.2: The components of the Global Hunger Index

Three dimensions	Four indicators	Weight	Reason for inclusion
Inadequate food supply FAO	Undernourishment	1/3	• Measures insufficient food supply, an important indicator of hunger • Refers to the entire population, both children and adults • Used as a lead indicator for international hunger targets
Child undernutrition UNICEF WHO World Bank	Wasting Stunting	1/6 1/6	• Goes beyond calorie availability, considers aspects of diet quality and utilization • Children are particularly vulnerable to nutritional deficiencies • Is sensitive to the uneven distribution of food within the household • Stunting and wasting are the suggested nutrition indicators for the Sustainable Development Goals (SDGs)
Child mortality IGME	Under-five mortality rate	1/3	• Death is the most serious consequence of hunger, and children are most vulnerable • Improves the GHI's ability to reflect micronutrient deficiencies • Wasting and stunting only partially capture the mortality risk of undernutrition

Source: Global Hunger Index, 2015

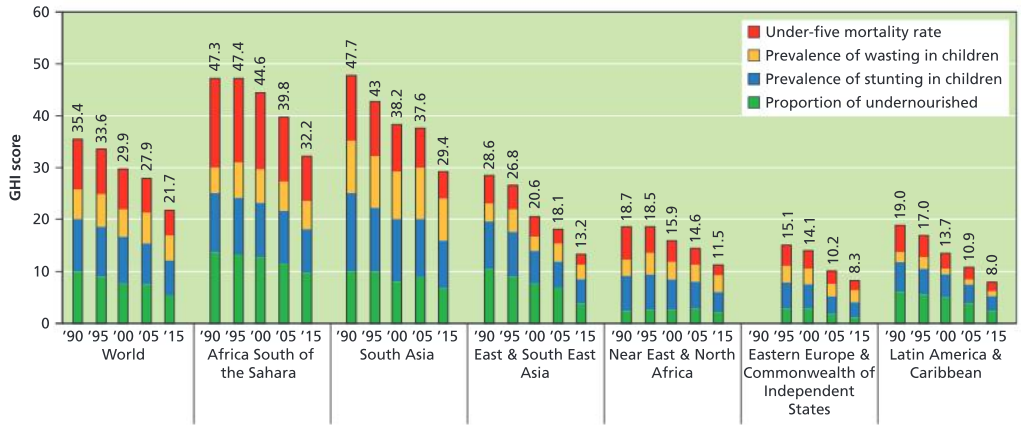


Figure F.4: Developing world, and developing world regions Global Hunger Index scores, with components, 1990, 1995, 2000, 2005 and 2015

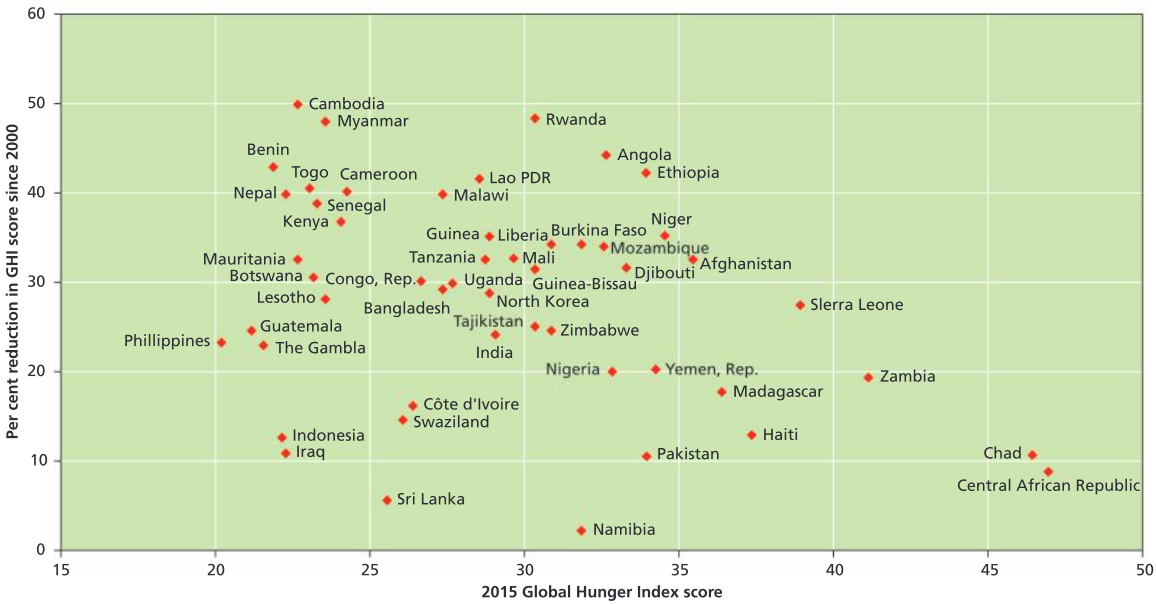


Figure F.5: The Global Hunger Index score 2015 and the reduction in score since 2000

Note: The countries included are those with 2015 GHI scores equal to or greater than 20, reflecting either serious or alarming hunger levels. This figure features countries where data were available to calculate GHI scores. Some likely poor performers may not appear, due to missing data.

ATL Research skills

Use the Global Hunger Index website http://ghi.ifpri.org/trends/ to access the data on the proportion of undernourished in a population, the prevalence of wasting in children under five years, the prevalence of stunting in children under five years and the under-five mortality rate.

Choose a range of countries and see how the GHI has changed in composition and in total, over time, for those countries.

Common mistake

✗ Many people believe that malnutrition only refers to hunger and starvation.

✓ Malnutrition is any diet that has an inadequate amount of quality or quantity of food, as well as those diets that consume too much food.

TOK

Are all forms of malnutrition equally serious? Which ones are self-inflicted and which ones do people have little control over? How long does temporary hunger last?

According to the 2015 GHI, among regions, hunger is highest in Africa south of the Sahara and South Asia. Africa south of the Sahara has a GHI of 32.2, while South Asia's is 29.4. Both regions' GHI scores reflect "serious hunger". The food and hunger situation in several countries (Central African Republic, Chad, Zambia, Timor-Leste, Sierra Leone, Haiti, Madagascar and Afghanistan) is still "alarming" according to the 2015 GHI.

Activity 3

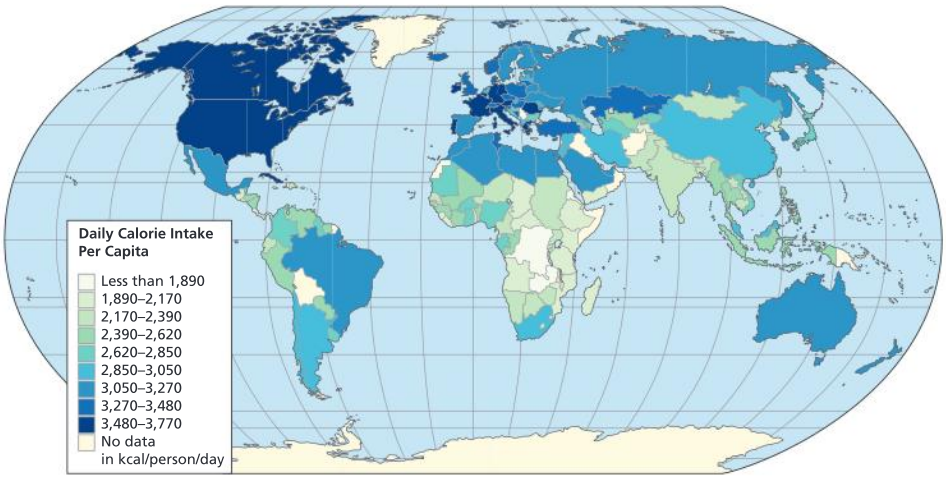
Study Figure F.5.

1. Describe the relationship between the GHI score 2015 and the reduction in score since 2000.
2. Identify two countries with a high GHI score and a low reduction score.
3. Suggest two or more reasons why some countries have made more progress at reducing their GHI score than others.
4. Using Spearman's Rank Correlation Coefficient, calculate the correlation between the GHI 2015 and percentage reduction in GHI since 2000.
   a. Assign a number, starting with 1, to all the countries.
   b. Select 12 countries at random by using a random number generator on your phone, Internet or book of statistical tables.
      - Test a null hypothesis that there is no relationship between the Z variables.
   c. Calculate the correlation between the two data sets.
   d. Test the level of significance of your n values.
      - Accept or reject the hypothesis.
      - Explain what is meant by statistical significance.
   e. Outline your conclusions about the relationship between the two variables.

Since 2000, Rwanda, Angola and Ethiopia have experienced the biggest absolute reductions in hunger, with GHI scores down by between 25 and 28 points in each country. The combination of high rates of hunger and only a small reduction in the GHI score since 2000 for the Central African Republic, Chad and Zambia is a cause for concern.

Calorie intake

Calorie intake is the amount of food (measured in calories) a person consumes. Figure F.6 shows average daily calorie intake per person by country. The world average is about 2,780 kcal/person/day, and the minimum recommended amount is around 1,800 kcal/person/day. However, this varies with age, gender, type of work, amount of physical activity and climate. Countries with the highest daily intake include Austria and the USA, with 3,800 and 3,750 kcal/person/day, respectively. In general, high-income countries have an intake of around 3,400 kcal/person/day. In contrast, people in low-income countries have an intake of around 2,600 kcal/person/day. However, in sub-Saharan Africa the intake is down to 2,240 kcal/person/day and in Central Africa it is just 1,820 kcal/person/day. In Burundi and Eritrea, daily calorie intakes are as low as 1,680 and 1,590 kcal, respectively.



▲ **Figure F.6:** Daily calorie intake per person by country
(Source: http://cdn3.chartsbin.com/chartimages/l_1150_b831d4f831204d4d2416d625e3064607

Indicators of malnutrition

Malnutrition means poor nourishment, and refers to a diet lacking (or with too many) nutrients. There are many types of malnutrition:

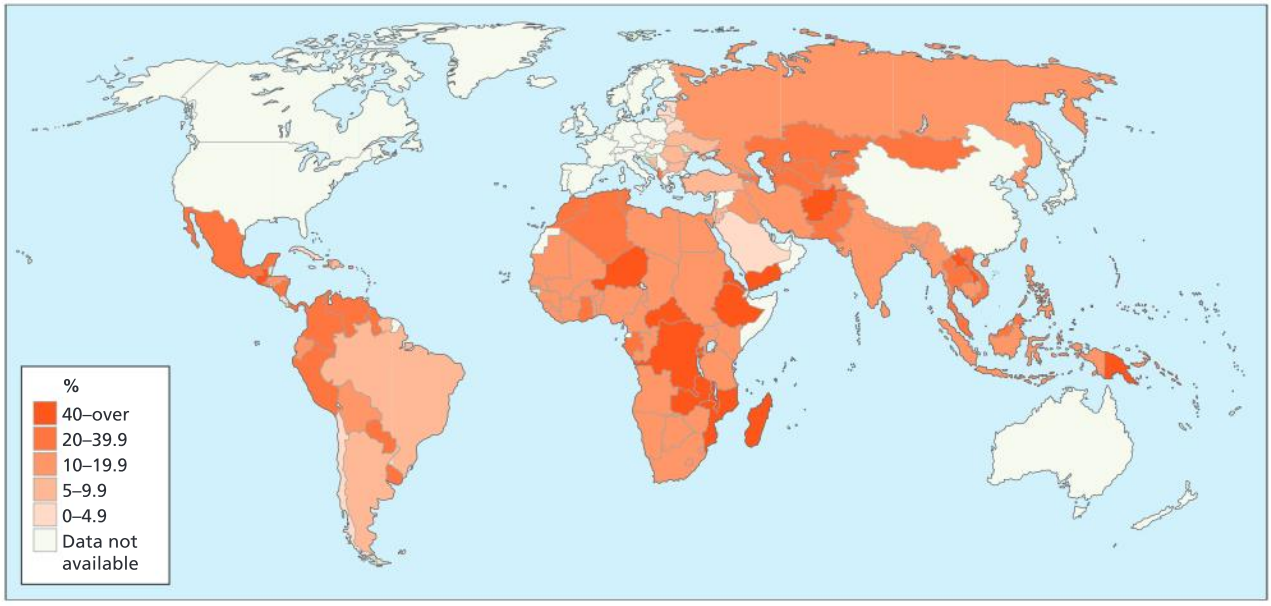
- Deficiency diseases such as pellagra result from a lack of specific vitamins or minerals.
- Kwashiorkor is a lack of protein in the diet.
- Marasmus is a lack of calories/energy.
- Obesity results from eating too many energy/protein foods.
- Starvation refers to a limited or non-existent intake of food.
- Temporary hunger is a short-term decline in the availability of food to a population in an area.
- Famine occurs when there is a long-term decline in the availability of food in a region.

Stunted growth/stunting

Stunted growth or stunting refers to long-term malnutrition and is usually identified in a child small in height for their age. Very high rates of stunting (over 50 per cent) are found in Timor-Leste, Burundi and Eritrea. There are also very high rates of stunting in a number of sub-Saharan African and South Asian countries. Rates for stunting tend to be much higher than for wasting (chronic or short-term malnutrition). In contrast, the lowest rates of stunting (below 5 per cent) are found in parts of the Middle East, Latin America and southern and eastern Europe, and also in Fiji, which has a stunting prevalence of 3.7 per cent.

Wasting

Wasting is defined as acute short-term malnutrition and is identified in a child with a low weight for their age. Very high rates of wasting (over 20 per cent) are found in South Sudan, Djibouti and Sri Lanka. There are also high rates of wasting in a number of countries throughout South Asia and sub-Saharan Africa. The lowest rates of

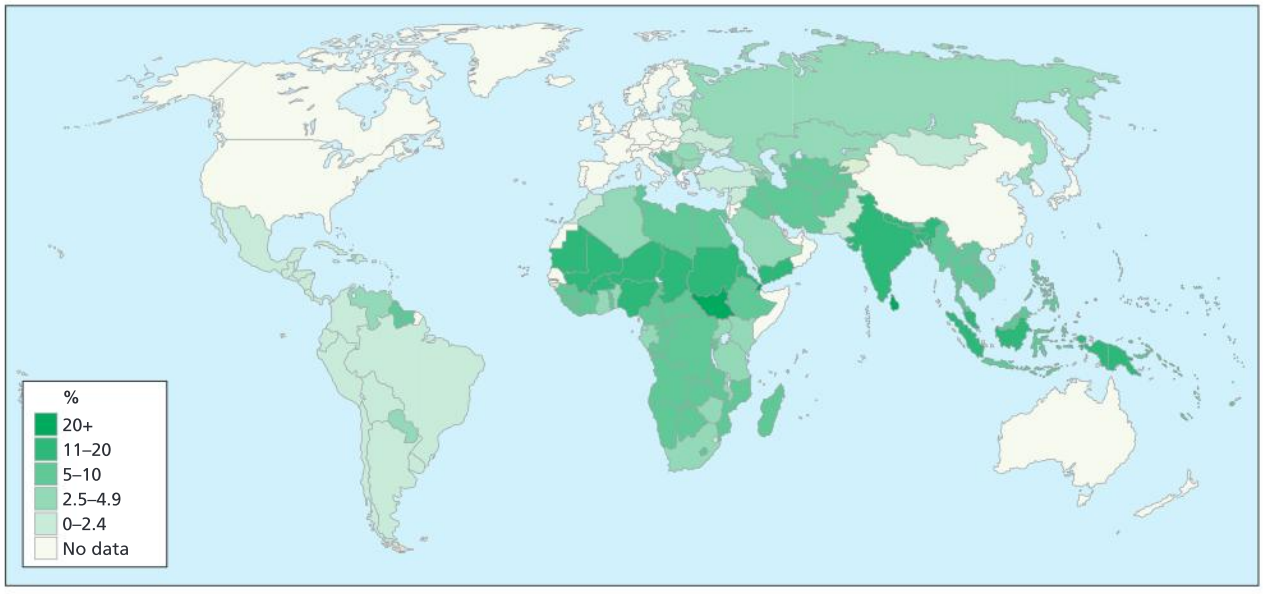


▲ **Figure F.7:** Global variations in under 5s stunting

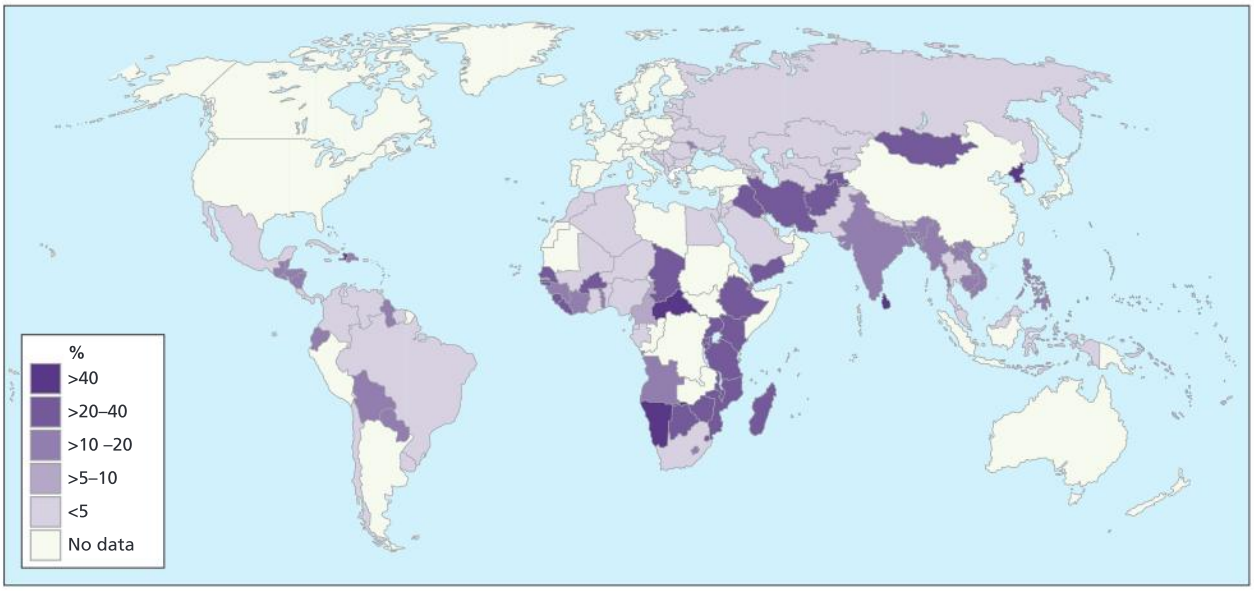
wasting (< 2 per cent) are generally found in high-income countries such as Australia and also much of Latin America. Anomalies include Pakistan and Mongolia (both less than 1 per cent) and Swaziland (2 per cent).

Undernourished

According to the Global Hunger Index, Haiti had the highest proportion of undernourished people of any country, with over 50 per cent. Zambia, the Central Africa Republic, Namibia and North Korea each had over 40 per cent of their population classified as undernourished. All the countries where between 30 and 40 per cent of their population were classified as undernourished were in sub-Saharan Africa (except Tajikistan). The same



▲ **Figure F.8:** Global variations in wasting in under-5s



▲ **Figure F.9:** Global variations in the undernourished population, 2016

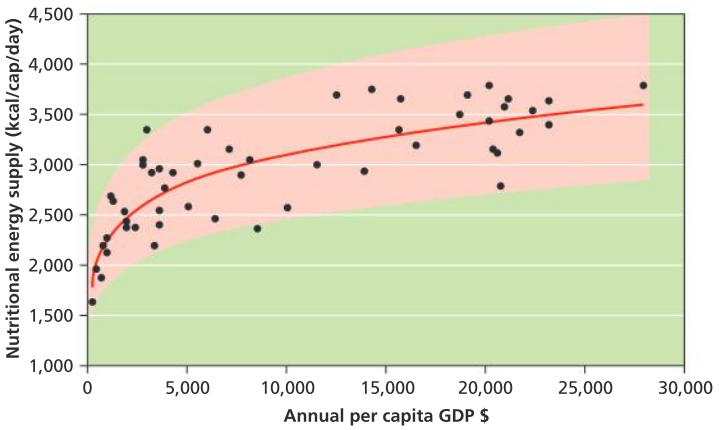
pattern occurs for countries with 20 to 30 per cent of their population undernourished (except Iran, Iraq and Afghanistan). The countries with the lowest proportion of undernourished people were generally European, South American or Middle Eastern. Anomalies include South Africa and Egypt, with 1.7 per cent and 1.9 per cent respectively classified as undernourished. This is surprising because South Africa had 22.9 per cent and Egypt 22.3 per cent of under-5 year olds classified as stunted.

The nutrition transition

As income increases in low-income countries (LICs), there is an increase and a change in food consumption patterns. People in LICs generally derive their food energy mainly from carbohydrates, while the contribution of fats is small and that of meat and dairy negligible. In Bangladesh, for example, the country with the lowest GDP in the analysis, people derive 80 per cent of their nutritional energy from carbohydrates and 11 per cent from fats. People in high-income countries (HICs) generally derive most of their food energy from carbohydrates and fat, with a substantial contribution from meat and dairy. The average consumer in the US, France and Denmark, for instance, derives 45–50 per cent of their food energy from carbohydrates and 40 per cent from fats.

Studies of human nutrition have shown that worldwide a nutrition transition is taking place, in which people are shifting towards more affluent food consumption patterns. The nutrition

▼ **Figure F.10:** The relationship between GDP/head and energy consumption (kcal/person/day)
Source: Gerbens-Leenes, P W, et al. 2010, "Food consumption patterns and economic growth. Increasing affluence and the use of natural resources". *Appetite*



Activity 4

Study Figure F.10.

1. Describe the relationship between annual per capita GDP and nutritional energy supply.
2. Suggest reasons for the relationship between the two variables.
3. Suggest two other nutritional indicators that would have a similar relationship to GDP.

Activity 5

Study Figures F.12 and F.13.

1. Describe what each graph shows.
2. Evaluate calorie consumption and protein consumption as indicators of health.
3. Describe the progress made in protein consumption in the developed and developing countries since 1961–73.

transition began in developed countries 300 years ago. It coincided with great economic growth. For LICs, a small increase in income may lead to a large increase in calorie intake, while for HICs increases in income may not lead to an increase in calorie intake (see Figure F.10).

Food consumption per capita has increased substantially since the period 1961–73 (both in energy and protein content). Growth rates are consistently higher in LICs, but their consumption levels per capita are still much lower than in HICs. The transition in diet is mainly influenced by higher income per capita – but food prices, individual and socio-cultural preferences, the development of the "cold chain", and other concerns also play a role.

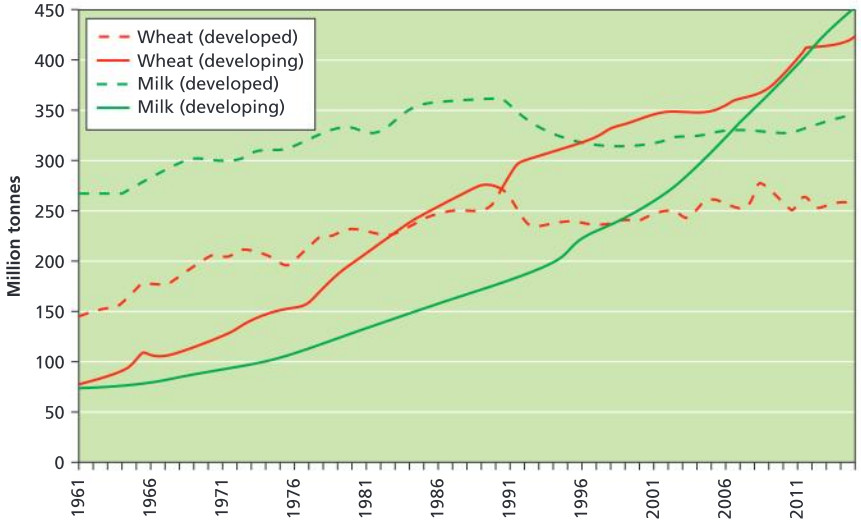
In HICs, the main dietary changes since the 1970s have been the reduction in cereals, while mainly vegetable oil and, to a smaller extent, meat intake increased (Figure F.12). Animal protein intake has been stabilizing: an increasing part of the population seems to be interested in reducing/replacing it for various reasons (ethical, health-related, environmental and economic).

In LICs the diet has diversified since the 1970s. Cereals, including rice, as well as vegetable oil, sugar, meat and dairy intake are higher compared to 1961–73, although in more recent periods cereal intake is stagnating and even declining. Their share of cereals also exceeds the share in HICs.

There is a strong positive relationship between level of income and consumption of animal protein (Figure F.13) and a negative relationship with staple foods. In LICs, dairy, fish and pulses are driving increases in total protein availability per capita. Sugar intake is also stabilizing. These numbers seem to suggest that the diet in LICs is slowly evolving in the direction of the HICs, with the exception of sugar.

Global patterns in health indicators

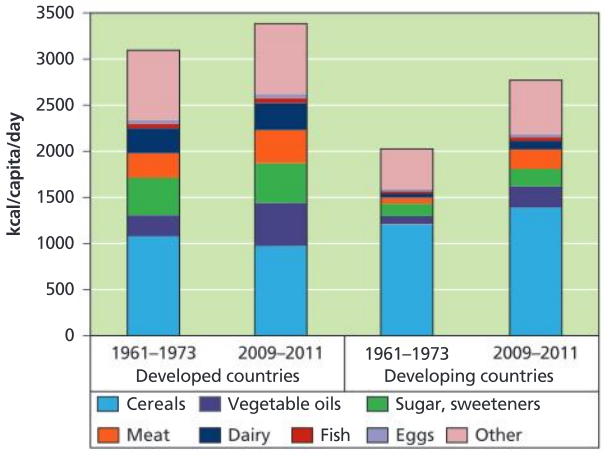
Health-adjusted life expectancy (HALE)



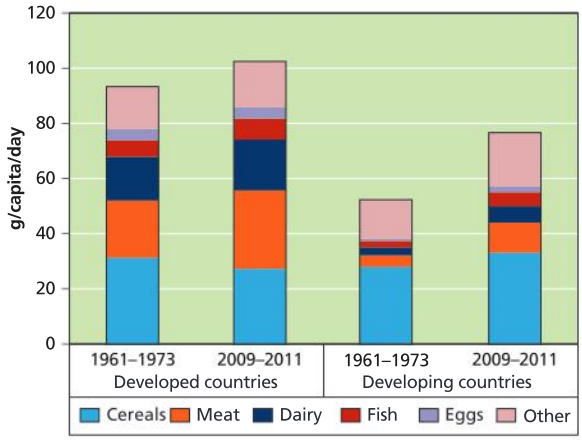
▲ **Figure F.11:** Changes in consumption of wheat and milk in high-income and low-income countries
Source: EU Agricultural briefs, 2015, No. 6, "World food consumption patterns – trends and drivers"

Health-adjusted life expectancy (HALE) is an indicator of the overall health of a population. It combines measures of both age- and sex-specific health data, and age- and sex-specific mortality data, into a single statistic. HALE indicates the number of expected years of life equivalent to years lived in full health, based on the average experience in a population. Thus, HALE is a measure not only of quantity of life but of quality of life. (See also Unit 1 for a discussion of life expectancy.)

Compared with conventisonal life expectancy, which considers all years as equal, to calculate



▲ **Figure F.12:** Changes in per capita calorie availability in high-income and low-income countries
Source: EU Agricultural briefs, 2015, No. 6, "World food consumption patterns – trends and drivers"



▲ **Figure F.13:** Changes in per capita protein availability in high-income and low-income countries
Source: EU Agricultural briefs, 2015, No. 6, "World food consumption patterns – trends and drivers"

HALE, years of life are weighted by health status. In a survey in Canada, a Health Utility Index obtained from 1994–5 National Population Health Survey data was used to measure health status. Traditional life expectancy and HALE figures were compared to estimate the burden of ill health.

The results showed a number of findings:

- The social burden of ill health is higher for women than for men.
- It is highest among those in "early" old age, not among the very elderly.
- Sensory problems and pain are the largest components of the burden of ill health.
- Higher socio-economic status confers a dual advantage – longer life expectancy and a lower burden of ill health.

Calculating HALE

The World Health Organization (WHO) uses life expectancy tables and Sullivan's Method (the number of remaining years, at a particular age, that an individual can expect to live in a healthy state) to compute the HALE for countries. The calculation method also includes a weight assigned to each type of disability adjusted for the severity of the disability.

Mortality data for calculation of life tables are obtained from death registration data reported annually to the WHO. For countries without such data, available survey and census sources containing information on child and adult mortality are analysed and used to estimate life-expectancy tables.

A major challenge with the HALE indicator is the lack of reliable data on mortality and morbidity, especially from low-income countries. Other problems with the indicator include the lack of comparability of self-reported data from health interviews.

Case study

HALE in Canada

According to the Public Health Agency of Canada, health-adjusted life expectancy is an indicator of the average number of years that an individual is expected to live in a healthy state. It is a summary measure that combines both quantity and quality of life. In other words, it combines mortality and morbidity experience into a single measure of population health. It can be used to measure the burden of disease and injury in the population, risk factors, and the performance of public health efforts.

A report published by the Public Health Agency of Canada provides estimates of health-adjusted life expectancy among Canadians with and without selected chronic diseases (diabetes and cancer) and chronic conditions (hypertension), and by socio-economic status (income). Estimates are provided for females and males and for people of different ages.

Low socio-economic status is associated with a loss in health-adjusted life expectancy. In 2001, Canadian women and men in the top one-third income group had a health-adjusted life expectancy at birth of 72.3 years and 70.5 years, respectively. Compared with the highest income group, being in the bottom one-third income group was associated with a loss of health-adjusted life expectancy at birth of 3.2 years for women and 4.7 years for men.

Chronic diseases and conditions also are associated with a significant loss in health-adjusted life expectancy. The estimates of health-adjusted life expectancy by chronic disease status in this report were based on the mortality and morbidity experience of people with and without diabetes and/or hypertension (high blood pressure) for the 2004–6 period and of people with and without cancer for the 2002–5 period. According to the results of this study, the diabetes cohort at age 55 had a loss in health-adjusted life expectancy of 5.8 years for women and 5.3 years for men. The cohort of people with high blood pressure at age 55 had a loss of 2.0 years and 2.7 years for females and males, respectively. The cancer cohort at age 65 had a loss in health-adjusted life expectancy of 10.3 years for women and 9.2 years for men.

▲ **Photo F.2:** Child graves, Eastern Cape, South Africa

Child and infant mortality rates

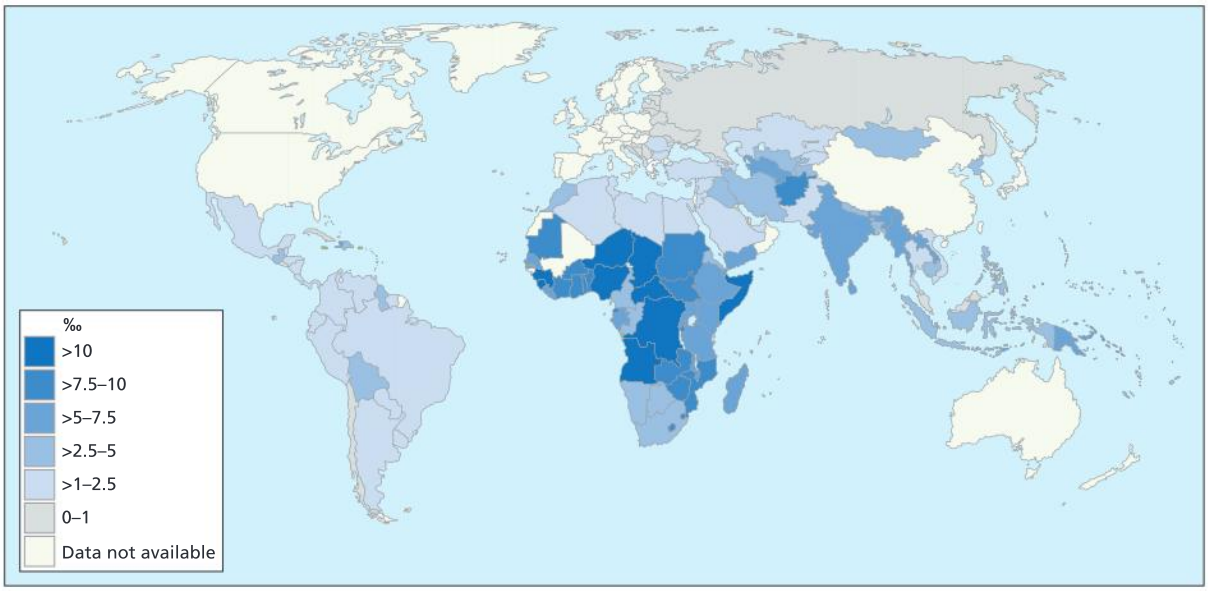
The **child mortality rate** or under-5 mortality rate is the probability per 1,000 births that a child will die before reaching the age of 5, if subject to age-specific mortality rates of the specified year.

It is calculated from:

$$\frac{\text{The number of deaths in children under the age of 5 years}}{\text{The number of children under the age of 5 years}} \times 1{,}000\ (‰)$$

It is an age-specific rate, so it compares like with like. However, the data are not as readily available as they are for the crude death rate. (See also Unit 1 for a discussion of crude death rates.) Generally, as children grow older, their chance of survival increases, so that, if they survive until their first birthday, their chances of survival to an older age increase.

Extremely high rates of child mortality are found in Angola, Sierra Leone, Chad and Somalia. All of the countries with over 10.1 per cent (101‰) child mortality rates are in sub-Saharan Africa (see Figure F.14). In fact, of all the countries with a child mortality rate of over 7.5 per cent (75‰), only two – Afghanistan and Sri Lanka – are not in sub-Saharan Africa. In contrast, countries with a very low child mortality rate (that is, 0–1 per cent) are mainly in southern and eastern Europe, although all regions have at least one country with a low child mortality rate; for example,



▲ **Figure F.14:** Child mortality rates of under-5s, 2016

Cuba and Costa Rica in Latin America, Qatar, Lebanon and Kuwait in the Middle East, and Malaysia in Asia.

The **infant mortality rate** (IMR) is the number of deaths in children under the age of 1 per 1,000 live births.

Infant mortality rate (IMR) =

$$\frac{\text{Total no. of deaths of children} < 1 \text{ year old}}{\text{Total no. of live births}} \times 1{,}000 \text{ per year (‰)}$$

It is an age-specific mortality rate, that is, it is comparing the death rates among the same ages, and so is more useful than the crude death rate.

Infant mortality rates vary from a low of under 2 per thousand in Monaco and 2‰ in Iceland, Japan and Singapore to over 100 per thousand in Afghanistan and Mali (Figure F.15). After Afghanistan (115‰), the 24 next highest IMRs are all from sub-Saharan Africa. There is a very strong correlation between types of country and IMR. Countries with a high human development index (HDI) have a low IMR, and those with a low HDI have a high IMR. The region with the highest IMRs is Central Africa, with on average an IMR of 96 per thousand in 2015. In contrast, the world average was 37 per thousand.

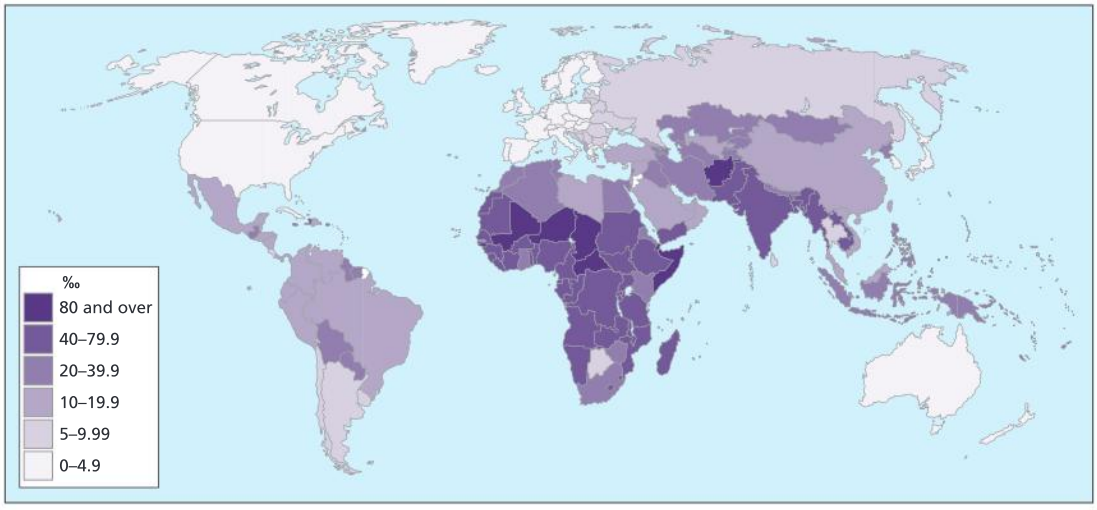
ATL Research skills

Use the World Bank website http://data.worldbank.org/indicator/SH.DYN.MORT to describe the changes in child mortality 1960–2015 in your chosen countries.

Use the timeline map sequence to describe how the pattern of child mortality has changed since 1960, see http://data.worldbank.org/indicator/SH.DYN.MORT/countries?display=map.

Maternal mortality rates

The maternal mortality rate (MMR) is the annual number of female deaths per 100,000 live births from any cause related to or aggravated by pregnancy or its management. As Figure F.16 shows, there is considerable variation in the maternal mortality rate. In 2016, South Sudan had the highest MMR with 2,054 deaths per 100,000 live births, followed by Chad (1,100) and Somalia (1,000). The highest MMRs are found in sub-Saharan Africa, parts of South Asia, Haiti and Guyana. In contrast, the lowest MMRs are found in high-income countries of Europe, Australia and Singapore. Estonia, Greece and Singapore all have MMRs of ≤3 per 100,000 live births.



▲ **Figure F.15:** Global variations in the infant mortality rate, 2016

ATL Research skills

Use the CIA World Factbook https://www.cia.gov/library/publications/the-world-factbook/ to discover the top five and lowest five infant mortality rates, and rates for your chosen countries.

Use the Population Reference Bureau to discover regional variations in the IMR: http://www.prb.org/pdf15/2015-world-population-data-sheet_eng.pdf.

The Millennium Development Goals (MDGs) 2000–2015 included the goal of reducing maternal mortality by three-quarters by 2015. As Figure F.17 shows, although there has been much progress, there is still high mortality in sub-Saharan Africa and moderate mortality in South-eastern and Eastern Asia and in Oceania.

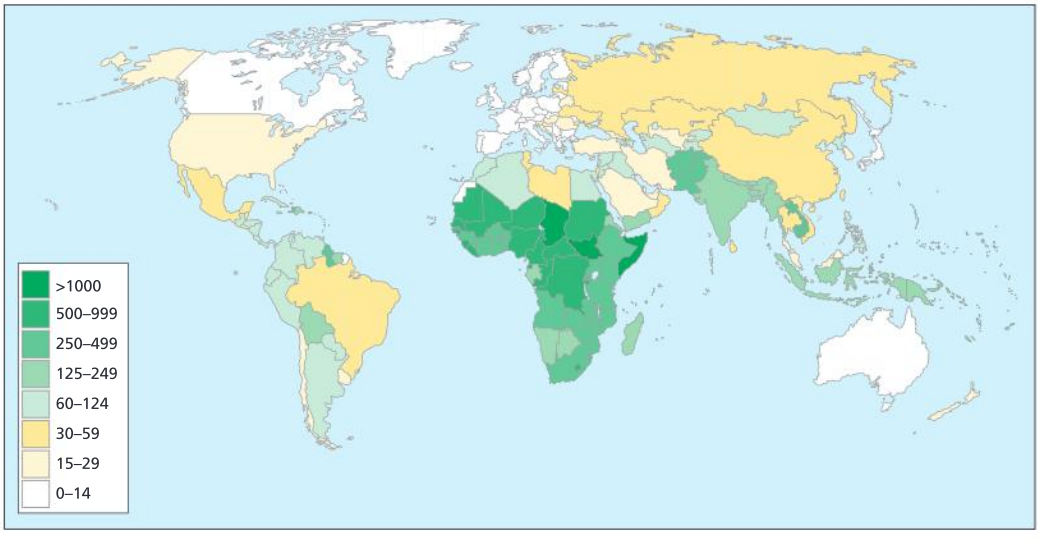
ATL Research skills

Use the CIA World Factbook https://www.cia.gov/library/publications/the-world-factbook/ to update the statistics for maternal mortality.

Use the United Nations MDG and Sustainable Development Goals (SDGs) sites to find out more about reducing MMR: http://www.un.org/millenniumgoals/maternal.shtml and http://www.un.org/sustainabledevelopment/health/.

Research changes in maternal deaths 1900–2013, using the PRB data sheet http://www.prb.org/pdf15/2015-world-population-data-sheet_eng.pdf. Select at least five contrasting countries.

▶ **Figure F.16:** Global variations in the maternal mortality rate (deaths/100,000 live births), 2016



Goals and Targets	Africa		Asia				Oceania	Latin America and the Caribbean	Caucasus and Central Asia
	Northern	Sub-Saharan	Eastern	South-Eastern	Southern	Western			
GOAL 5 | Improve maternal health									
Reduce maternal mortality by three quarters	low mortality	high mortality	low mortality	moderate mortality	moderate mortality	low mortality	moderate mortality	low mortality	low mortality

The progress chart operates on two levels. The text in each box indicates the present level of development. The colours show progress made towards the target according to the legend below:

- Target met or excellent progress.
- Good progress.
- Fair progress.
- Poor progress or deterioration.
- Missing or insufficient data.

▲ **Figure F.17:** MDG progress for maternal health

Access to sanitation

Activity 6

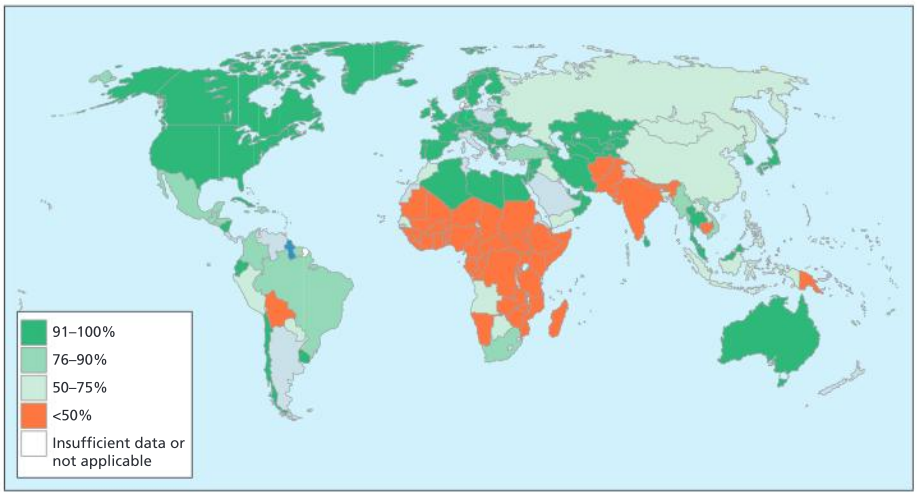
1. Identify the regions of the world with the best and worst access to sanitation.
2. Explain the meaning of "improved sanitation".
3. Suggest two physical factors and two human factors that make good sanitation difficult to achieve.

ATL Research skills

Make a sanitation fact file using http://www.un.org/millenniumgoals/endopendefecation.shtml and http://www.un.org/sustainabledevelopment/water-and-sanitation/.

According to the World Health Organization, 68 per cent of the world's population now uses an improved sanitation facility, 9 percentage points below the MDG target. In 2015 it was estimated that 2.4 billion people globally had no access to improved sanitation facilities. Of them, 946 million defecate in the open.

Some regions have done better than others. Due to a combination of population growth and slow progress, the number of people in sub-Saharan Africa without access to sanitation has increased since 1990. In addition, there are rural and urban disparities: while over 80 per cent of the urban population has access to improved sanitation facilities, only 51 per cent do in rural areas. The population without sanitation access lives primarily in Asia, sub-Saharan Africa, Latin America and the Caribbean. Figure F.19 shows the progress that has been made towards improved sanitation by region, 2000–2015.



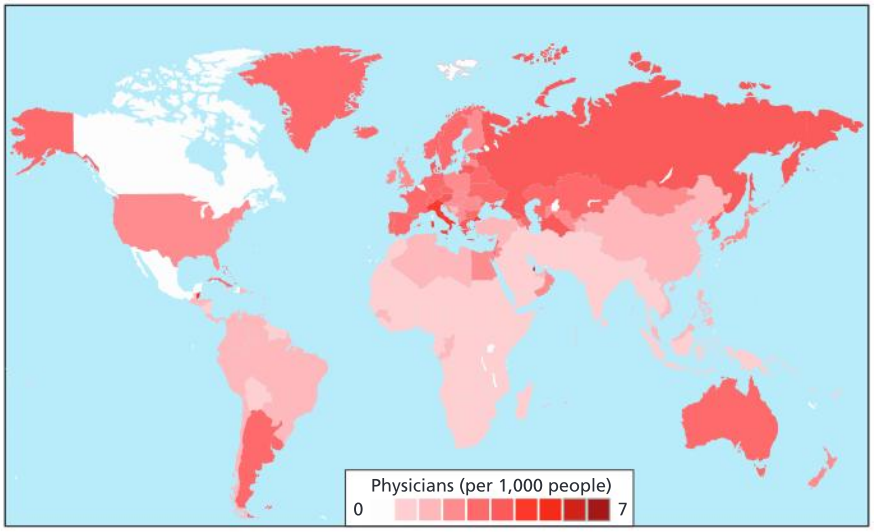
◀ **Figure F.18:** Global variations in access to sanitation

Goals and Targets	Africa		Asia				Oceania	Latin America and the Caribbean	Caucasus and Central Asia
	Northern	Sub-Saharan	Eastern	South-Eastern	Southern	Western			
Halt and begin to reverse the spread of HIV/AIDS	low incidence	high incidence	low incidence	low incidence	low incidence	low incidence	low incidence	low incidence	low incidence

The progress chart operates on two levels. The text in each box indicates the present level of development. The colours show progress made towards the target according to the legend below:

- Target met or excellent progress.
- Good progress.
- Fair progress.
- Poor progress or deterioration.
- Missing or insufficient data.

▲ **Figure F.19:** Progress towards halving the proportion of population without sanitation, 2000–2015



▲ **Figure F.20:** Global variations in doctors per 1,000 people, 2011
http://www.infoplease.com/ipa/A0934558.html

Access to health services

Access to health services is usually measured in the number of people per doctor or per hospital. Access to health services varies from one doctor per 100,000 in Burundi and one doctor per 50,000 people in Mozambique to one doctor per 280 people in Hungary and Iceland. In China there are 610 people per doctor and in India it is 1,960 per doctor. Figure F.20 shows global variations in the number of doctors per 1,000 people in 2011. However, inequalities in health services are not merely a question of the number of doctors or beds per person but also concern the facilities available in hospitals and clinics. And while it would be wrong to consider merely the quantity of resources per capita, it is impossible to assess their quality.

ATL Research skills

Use the CIA World Factbook to find data on physician density per 1,000 people and hospital bed density per 1,000 people for five or more contrasting countries.

TOK

There is a theory known as Hart's Inverse Care Law that states that those who need health care the most – the poor, the homeless and other vulnerable groups – have least access to it. Those who need health care the least – the well off – have most access to health care. To what extent do you think this is true or fair? How does the data in Figure F.20 support this view?

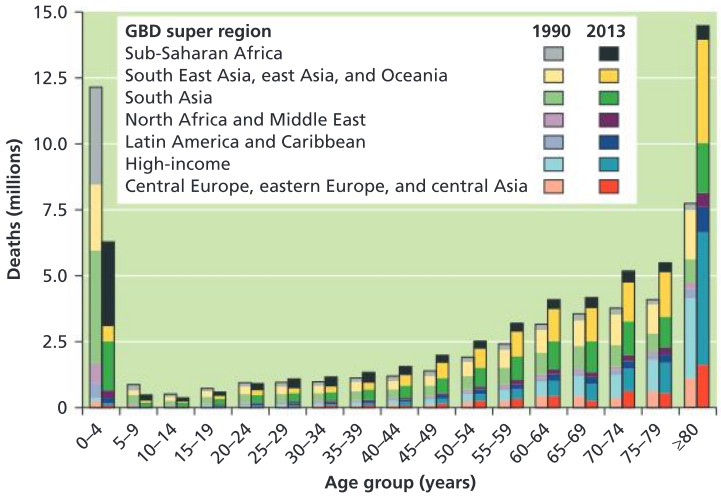
The epidemiological transition

One of the main changes in a country's health profile is the shift from infectious or contagious communicable diseases (**epidemics**) to non-communicable diseases that cause a gradual worsening in the health of an individual (**degenerative diseases**). This is known as the epidemiological transition. For example, a country in an early stage of development would be expected to have a large number of deaths and illnesses from infectious diseases such as respiratory diseases, measles and gastroenteritis (diarrhoea and vomiting). By contrast, we would expect an HIC to have more deaths and illnesses from heart attack, stroke and cancers – diseases that are not infectious or communicable. The exception to this is the rise in cases of AIDS, and with it TB, in HICs since the 1980s.

The Global Burden of Disease, 2013

The 2013 Global Burden of Disease study looked at 240 disease types for 72 countries. Its key findings were that life expectancy for both sexes increased from 65.3 years in 1990 to 71.5 years in 2013, while the number of deaths increased from 47.5 million to 54.9 million over the same period. There was a noticeable reduction in age-standardized

death rates for cardiovascular diseases and cancers in high-income regions, and reductions in child deaths from diarrhoea, lower respiratory infections and neonatal causes in low-income regions. HIV/AIDS reduced life expectancy in southern sub-Saharan Africa. For most communicable causes of death, both numbers of deaths and age-standardized death rates fell, whereas, for most non-communicable causes, demographic shifts have increased numbers of deaths but decreased age-standardized death rates. Diarrhoeal diseases, lower respiratory infections, neonatal causes and malaria are still the top five causes of death in children younger than five years. The most important pathogens are rotavirus for diarrhoea and pneumococcus for lower respiratory infections. Country-specific probabilities of death varied substantially between and within regions.

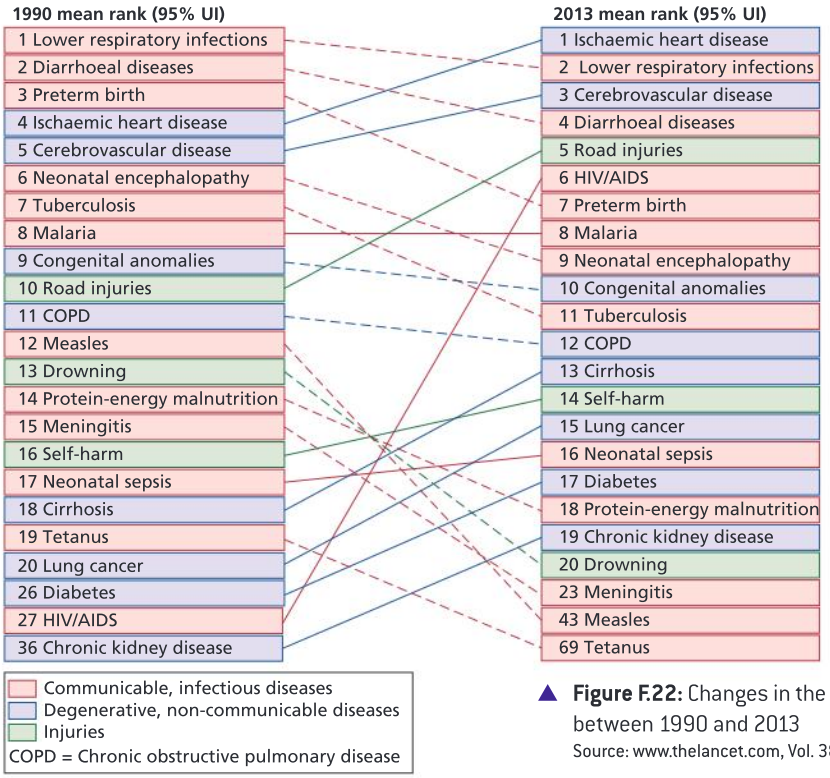


▲ **Figure F.21:** Global deaths by age and world region, 1990 and 2013

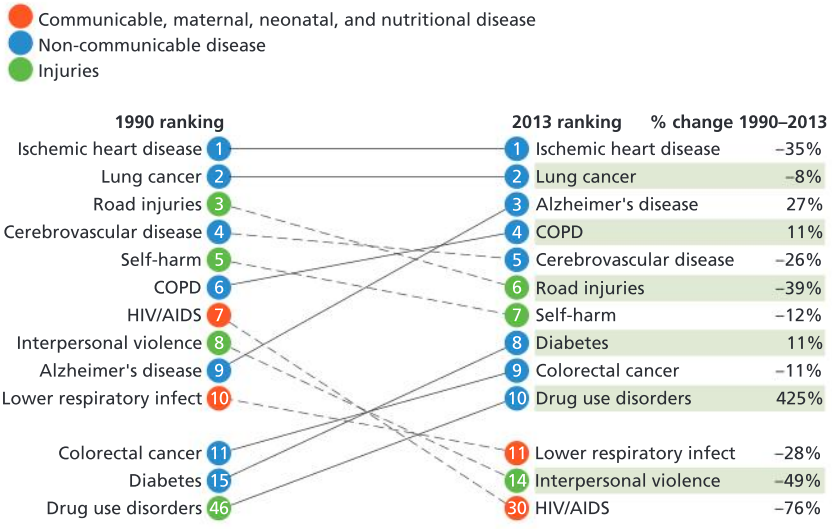
For most countries, the general pattern of reductions in age-sex-specific mortality has been associated with a progressive shift towards a larger share of the remaining deaths caused by non-communicable disease and injuries. Assessing epidemiological convergence across countries depends on whether an absolute or relative measure of inequality is used.

ATL Research skills

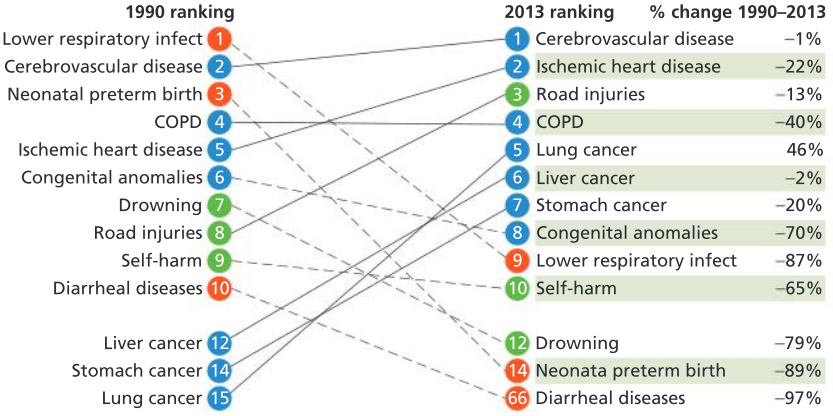
For an interactive version of this figure, showing the top 50 causes of death, 1990 and 2013, visit http://vizhub.healthdata.org/gbd-compare/.



▲ **Figure F.22:** Changes in the top 20 causes of death between 1990 and 2013
Source: www.thelancet.com, Vol. 385, Jan 10 2015, Fig. 10, p. 144



▲ **Figure F.23:** Leading causes of premature death in the USA, 1990 and 2013
Source: http://www.healthdata.org/united-states



▲ **Figure F.24:** Leading causes of premature death in China, 1990 and 2013
Source: http://www.healthdata.org/china

Activity 7

1. Name three causes of death with the highest increase and three with the highest decrease between 1990 and 2013.
2. Explain the changes in road injuries and protein/energy malnutrition between 1990 and 2013.
3. Evaluate this graphical technique in terms of displaying the data effectively.

Comparing changes in the USA, China and Afghanistan

In terms of premature death in the United States, ischaemic heart disease, lung cancer and Alzheimer's disease were the highest-ranking causes in 2013 (Figure F.23). The highest risk factors were poor diet, high body mass index and tobacco smoke. The greatest reduction in mortality rate from all causes was in males aged 5–9 years (49.2 per cent). In contrast, females aged 70+ years saw the largest increase in mortality rate (0.9 per cent).

By contrast, in China the main causes of premature death were cerebrovascular disease, ischaemic heart disease and road injuries (Figure F.24). Poor diet, high systolic blood pressure and air pollution were the leading risk factors in 2013. Females aged 28–36 years (84 per cent) experienced the greatest reduction in mortality rate from all causes.

In 2013, the main causes of premature death in Afghanistan were lower respiratory infection, neonatal preterm birth, and congenital anomalies (Figure F.25). Child and maternal malnutrition, air pollution, and poor diet were the leading risk factors. Females aged 1–4 years (61.2 per cent) experienced the greatest reduction in mortality rate from all causes. Females aged 70+ years saw the largest increase in mortality rate (10.6 per cent).

The implications of an aging population on the global disease burden

Of the total global burden of disease, 23 per cent is attributable to disorders in people aged 60 years and older. This accounts for about 50 per cent of the health burden in high-income countries and 20 per cent of the burden in low- and middle-income countries. The leading contributors to disease burden in older people are cardiovascular diseases (over 30 per cent of the total burden in people aged 60 years and older),

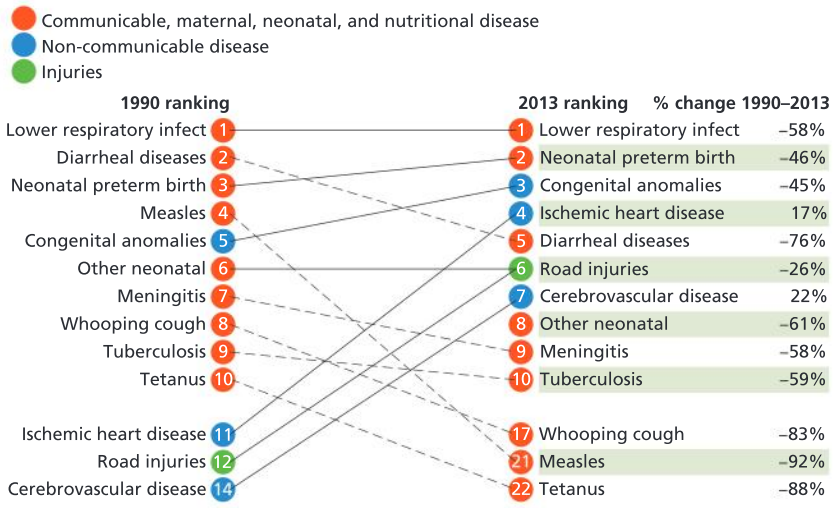


Figure F.25: Leading causes of premature death in Afghanistan, 1990 and 2013
Source: http://www.healthdata.org/afghanistan

Activity 8

1. Identify the three most common causes of death in the USA and Afghanistan.
2. Classify the conditions/diseases identified in (1).
3. Suggest reasons for the dominance of these causes of death in each country.

malignant neoplasms (15 per cent), chronic respiratory diseases (9 per cent), musculoskeletal diseases (7 per cent), and neurological and mental disorders (6 per cent). A substantial and increased proportion of morbidity and mortality due to chronic disease occurs in older people. Although population ageing is driving the worldwide epidemic of chronic diseases, substantial untapped potential exists to modify the relationship between chronological age and health. This objective is especially important for the most age-dependent disorders (dementia, stroke, chronic obstructive pulmonary disease, diabetes and vision impairment), for which the burden of disease arises more from disability than from mortality, and for which long-term care costs outweigh health expenditure. The societal cost of these disorders is enormous.

The worldwide epidemic of chronic diseases is strongly linked to population aging. In high-income countries, population aging persists as fertility continues to fall and life expectancy increases slowly. For many middle-income countries, mortality has decreased over much of the 20th century and decreasing fertility is leading to a rapidly ageing population. The doubling of the population aged over 65 years – from 7 to 14 per cent – took 46 years in the UK and 68 years in the USA, but will take just 26 years in China and 21 years in Brazil.

Cardiovascular diseases become more prevalent with the epidemiological transition. As mortality decreases, nutrition improves and infections are controlled, hypertension (high blood pressure), heart disease and strokes all become more common, with heart disease contributing most to mortality. However, as high-income countries advance into the age of "delayed degenerative diseases", age-adjusted mortality due to heart disease decreases as a result of better prevention and treatment. In low- and middle-income countries, heart disease episodes are occurring at younger ages than in high-income countries.

ATL Research skills

Learn more about the global burden of disease at http://www.healthdata.org/gbd and study the data visualization about the world's health levels and trends from 1990 to 2015 using the interactive tool. Comment on the main trends that you have found out about.

Concepts in context

The availability of food and access to health care services vary from **place** to place. As countries develop, changes occur in their dietary pattern and their disease pattern. There is no single indicator for access to food or health that covers all aspects of each – but many, each of which has its strengths.

Indicators for access to food are related not just to the quantity of food consumed but also to its quality. Indicators of health may take into account variations in access to health care. None of these indicators, in isolation, provides a complete picture of access but may suggest reasons for inequalities in access.

Check your understanding

1. Distinguish between hunger and malnutrition.
2. Referring to two or more examples, explain what is meant by the nutrition transition.
3. Suggest reasons why calories per day may not be a reliable indicator of nutrition.
4. Define health-adjusted life expectancy (HALE) and explain its value as an indicator of health.
5. Explain three limitations in assessing a nation's health by referring to the ratio of doctors and people.
6. Explain the difference between an epidemic and a pandemic.
7. Define the term "infant mortality rate" and explain its value as an indicator of a country's level of development.
8. Distinguish between diseases of affluence and diseases of poverty.
9. Describe how the leading causes of premature death in China changed between 1990 and 2013.
10. With reference to named examples, explain the epidemiological transition.

2 Food systems and the spread of disease

Conceptual understanding

Key question

How do physical and human **processes** lead to changes in food production and consumption, and to the incidence and spread of disease?

Key content

- A systems approach (inputs, stores, transfers, outputs) comparing energy efficiency and water footprints in food production, and relative sustainability in different places.
- Physical and human processes that lead to variations in food consumption.
- Diffusion (including adoption/acquisition, expansion, relocation) and its importance in the spread of agricultural innovations and also in the spread of diseases, and the role of geographic factors (including physical, economic and political barriers) in the rate of diffusion.
- How geographic factors contribute to the incidence, diffusion and impacts (demographic and socio-economic) of vector-borne and waterborne diseases.

A systems approach to food production

There are many types of farming (see the list of key definitions) and many factors that influence farming (Table F.3).

Activity 9

1. Referring to the key terms classifying types of farming activity, suggest the opposite type of activity to these three types: intensive, commercial, pastoral.
2. Identify three physical and three human factors affecting farming (listed below). Rank them in order of importance and explain how they affect farming.
3. To what extent are physical controls on farming less important now than they were in the past?

As a result of the many factors influencing farming and types of farming, farming systems are complex operations. In order to simplify farming types, a systems approach is used showing inputs, processes and outputs. This allows us to compare different aspects of the farming types. Figure F.26 shows a systems approach for shifting cultivation in Santa Rosa, Mexico and for intensive pig farming in Denmark.

Key terms

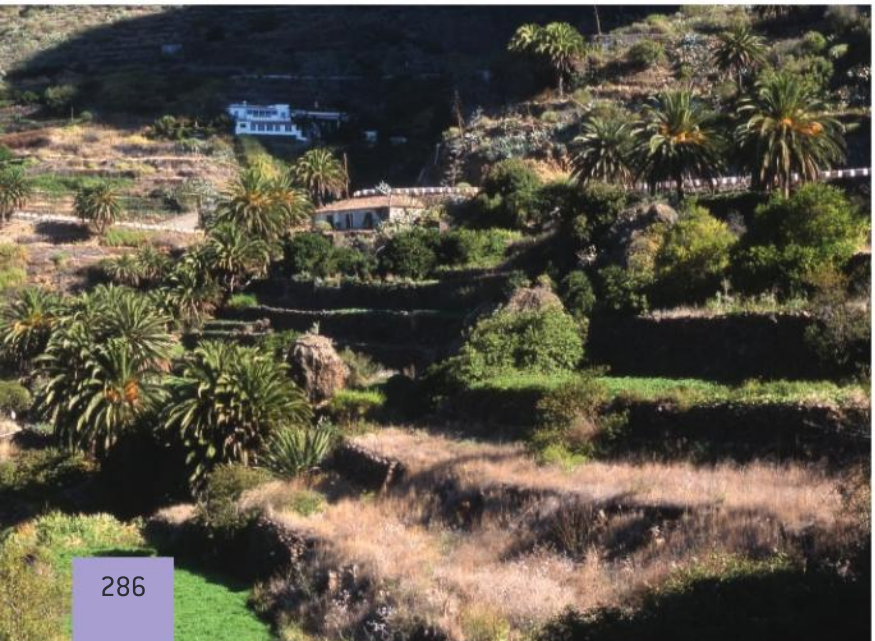
These are not exclusive categories but indicate a scale, along which all farming types can be placed.

Arable	The cultivation of crops such as wheat farming in the Great Plains of the USA.
Pastoral	Rearing animals, for example sheep farming in New Zealand.
Commercial	Products sold to make a profit such as market gardening in the Netherlands.
Subsistence (or peasant)	Products consumed by the cultivators, as in the case of shifting cultivation by Kayapo in the Amazonian rainforest.
Intensive	High inputs or yields per unit area, such as battery hen production.
Extensive	Low inputs or yields per unit area, as in free-range chicken production.
Nomadic	Farmers moving seasonally with their herds, such as the Pokot, pastoralists in Kenya.
Sedentary	Farmers remaining in the same place throughout the year, for example dairy farmers in Devon and Cornwall.

▼ **Table F.3:** Factors affecting farming activities

Physical
Climate:
Precipitation
• type
• frequency
• intensity
• amount
Temperature
• growing season (>6°C)
• ground frozen (0°C)
• range of temperatures
Soil:
Fertility
• pH
• cation exchange capacity
• nutrient status
Structure
Texture
Depth
Pests:
vermin, locusts, disease, etc.
Slope:
Gradient
Relief:
Altitude
Aspect
Ubac (shady) or adret (sunny)

Human
Political:
Land tenure/ownership
• ownership, rental, share-cropping, state-control
Organization
• collective, cooperative agribusiness, family farm
Government policies
• subsidies, guaranteed prices, ESAs, quotas, set-aside
War
• disease, famine
Economic:
Farm size
• field size and shape
Demand
• size and type of market
Capital
• equipment, machinery, seeds, money, 'inputs'
Technology
• high-yielding varieties (HYVs), fertilizers, irrigation
Infrastructure
• roads, communications, storage
Advertising
Social:
Cultural and traditional influences
Education and training
Behavioural influences
Chance



Another way to analyse agricultural systems is to consider them as modified ecosystems (Table F.4). Agricultural ecosystems can be compared with natural ecosystems in terms of productivity, biomass, nutrient cycling and energy efficiency. Average productivity from agricultural systems is 650 g/m^2/year, comparable with temperate grasslands or prairies. However, only about 0.25 per cent of incoming solar radiation is utilized by crops, and of that less than 1 per cent is used by humans as food.

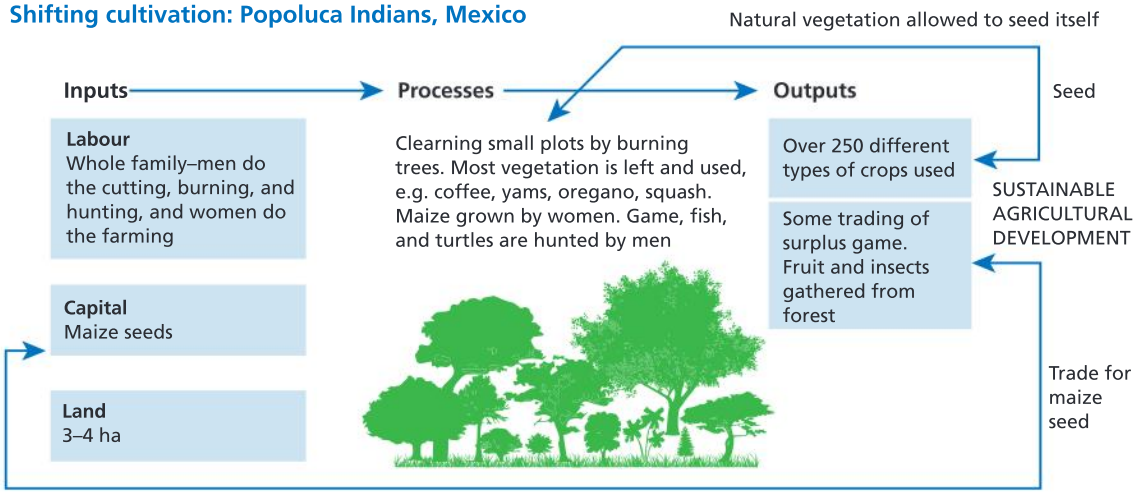
◀ **Photo F.3:** Terracing on steep slopes

▲ **Photo F.4:** Rice cultivation can support high population densities

▲ **Photo F.5:** Irrigation to increase food production in a dry area

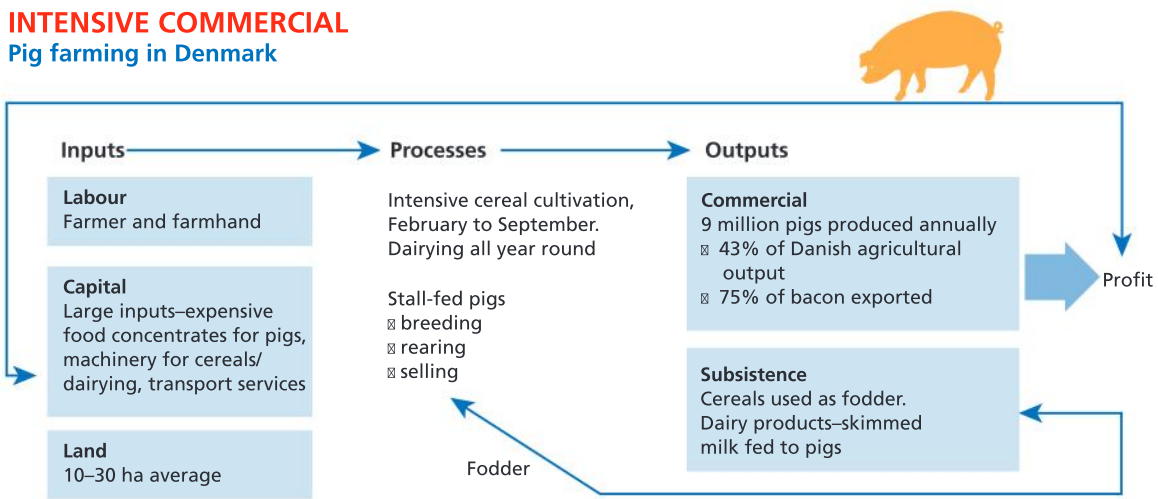
INTENSIVE SUBSISTENCE

Shifting cultivation: Popoluca Indians, Mexico



INTENSIVE COMMERCIAL

Pig farming in Denmark



▲ **Figure F.26:** A systems approach to two farming types

▼ **Table F.4:** A comparison of natural and agricultural ecosystems

Ecosystem	Natural	Agricultural
Food web	Complex – several layers	Simple – mostly one or two layers
Biomass	Large – mixed plant and animal	Small – mostly plant
Biodiversity	High	Low – often monoculture
Gene pool	High	Low, e.g. three species of cotton amount to 53 per cent of crop
Nutrient cycling	Slow; self-contained; unaffected by external supplies	Largely supported by external supplies
Productivity	High	Lower
Modification	Limited	Extensive – inputs of feed, seed, water, fertilizers, energy fuel; outputs of products, waste, etc.

Activity 10

1. Define the terms (a) productivity, (b) monoculture, and (c) energy subsidy.
2. Compare the inputs and outputs of intensive subsistence farming with intensive commercial farming.
3. Define the term "ecosystem".
4. Using examples, suggest how farming modifies the functioning and productivity of an ecosystem.

Photosynthetic efficiency

Agriculture seeks to improve the productivity of ecosystems by applying energy subsidies (to remove competitors, apply nutrients, add or take away water, and so on). However, these produce sustainable systems only when they are sympathetic to the local ecology. There is evidence that only in exceptional cases do crop efficiencies exceed 2 per cent – comparable to temperate forests.

▼ **Table F.5:** A comparison of photosynthetic efficiency for types of vegetation and selected crops

Crop or ecosystem	Location	Growth period (days)	Photosynthetic efficiency (%)
Natural ecosystem			
Tropical rainforest	Ivory Coast	365	0.32
Pine forest	UK	365	1.95
Deciduous forest	UK	180	1.07
Crops			
Sugar cane	Hawaii	365	1.95
Elephant grass	Puerto Rico	365	2.66
Maize (two crops)	Uganda	135 + 135	2.35
Maize (one crop)	Kenya (uplands)	240	1.37
Soya beans (two crops)	Uganda	135 + 135	0.95
Perennial ryegrass	UK	365	1.43
Rice	Japan	180	1.93
Winter wheat	The Netherlands	319	1.30
Spring barley	UK	152	1.49

Energy efficiency ratio (EER)

The energy efficiency ratio (EER) is a measure of the amount of energy inputs into a system compared with the outputs. In a traditional agro-forestry system the inputs are very low. However, the outputs from hunting and gathering may be quite high. In contrast, the inputs into intensive pastoral farming or greenhouse cultivation may be very great but the returns may be quite low.

▼ **Table F.6:** Energy efficiency ratios for selected farming systems (per unit of human/fossil fuel energy input)

Agro-forestry	65
Hunter-gatherers	7.8
UK cereal farm	1.9
UK allotment	1.3
UK dairy farm	0.38
Broiler hens	0.1
Greenhouse lettuces	0.002

Activity 11

1. Define "energy efficiency ratio".
2. Explain the energy efficiency ratios listed in Table F.6.
3. Estimate the energy ratios of activities such as prawn fishing and sheep farming.
4. Explain the protein outputs in F.7.

▼ **Table F.7:** Energy input and protein yields of four major agricultural systems

Agricultural system	Total energy input (10^6 kJ/ha)	Protein output (kg/ha)
Hill farming (sheep)	0.6	1–1.5
Mixed farming	12–15	500
Intensive crop production	15–20	2,000
Intensive animal production	40	300

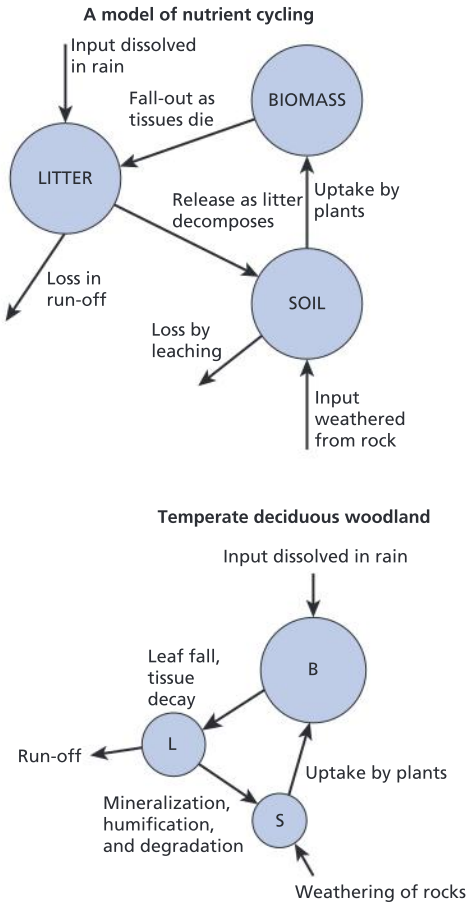
Nutrient cycling is often shown by the use of Gersmehl diagrams. Figure F.27 shows the differences between the nutrient cycling on a mixed farm and in temperate deciduous woodland with the same climate.

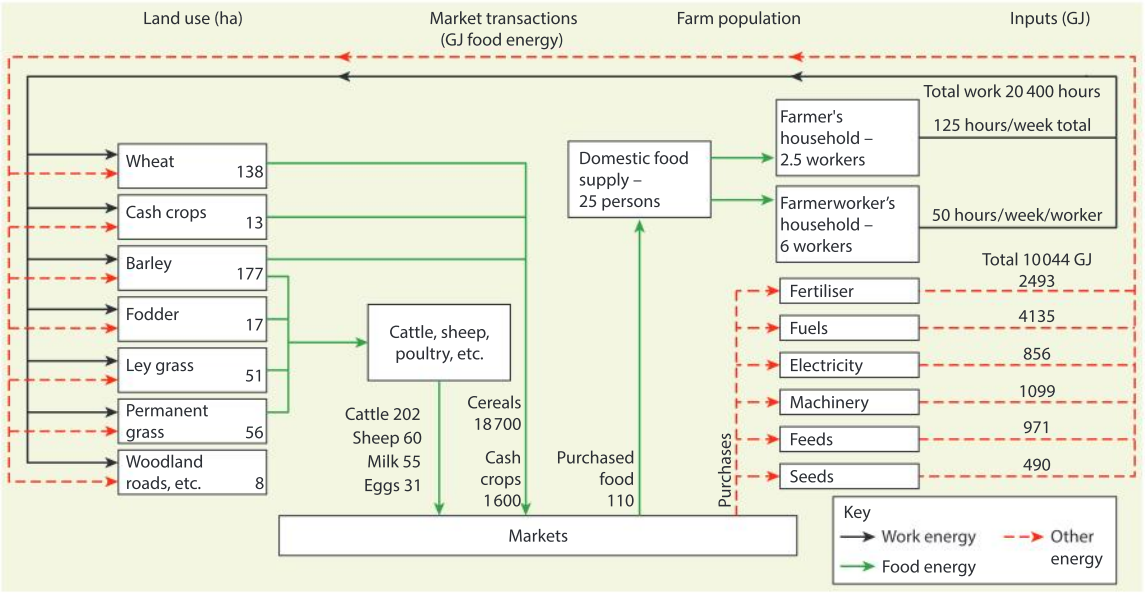
Ecosystems also have energy flows, in which sunlight energy is converted to food energy and passed along the food chain. Figure F.28 shows the energy flow of a farm.

Activity 12

1. Outline is the difference between intensive and extensive farming?
   a. What conditions are likely to cause intensive farming?
   b. How do these differ from the conditions that cause extensive farming?
2. Define the term "agricultural system". Comment on the usefulness of using agricultural systems as a way of studying farming.
3. Compare the nutrient cycling in a natural ecosystem with that of a mixed farming system.

▼ **Figure F.27:** Nutrient cycling in a temperate deciduous woodland and a mixed farm





▲ **Figure F.28:** The energy flow of a farm

Water footprints

Water footprints are a measure of how much water is used in human activities, such as for producing food. (See also Unit 3 for water embedded in food and manufactured goods.)

Activity 13

1. Identify the farming products that require (a) most water and (b) least water.
2. Identify (a) the crop that requires most water and (b) the animal that requires least water.
3. Study Figure F.29. How useful is this infographic as an indicator of the amount of water needed for different farming types?

Common mistake

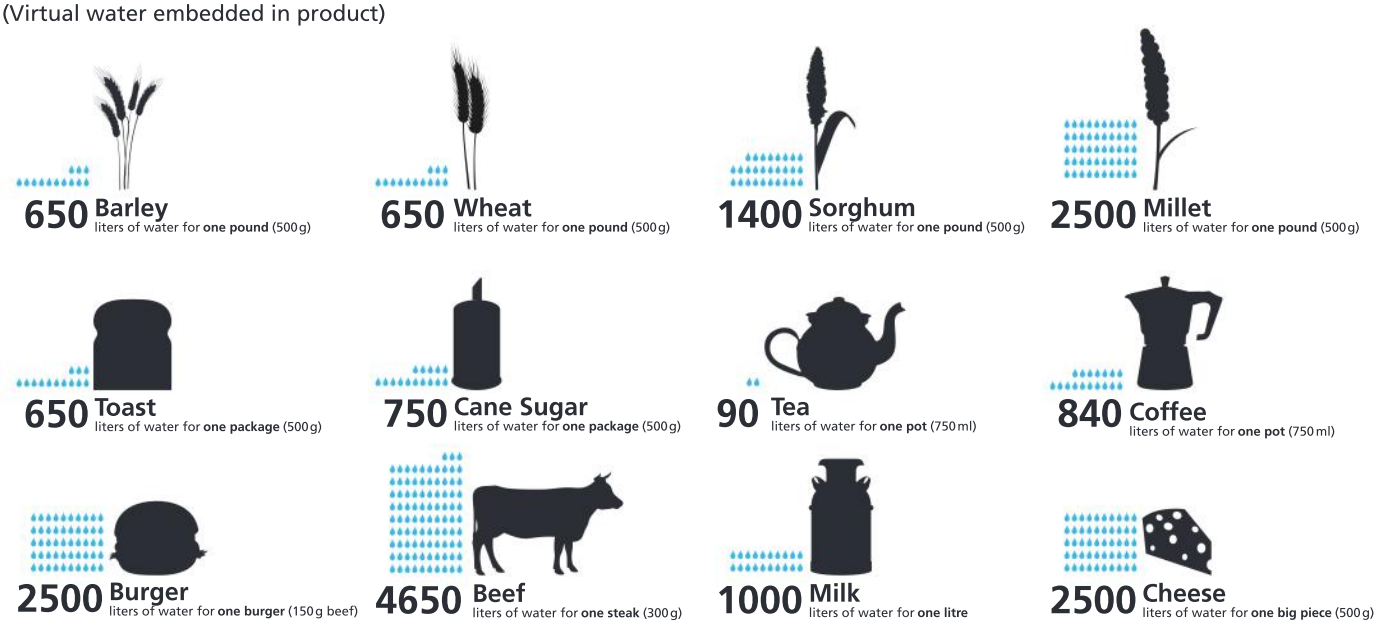
✗ Many people believe that the only reason people go hungry is because of a lack of food availability.

✓ There are many reasons why people can go hungry even when there is food available. They might not be able to afford it due to unemployment or low wages, they may be heavily in debt, they could be paying for medical fees and so cut back on purchasing food.

Physical and human processes that lead to variations in food consumption

Much early literature on famine and hunger was in the form of reports on climate and its effect on food supplies, and on the problems of transport, storage and relief organizations. Such studies often used the umbrella term **food availability deficit (FAD)**, which implied that food deficiencies were caused by local shortages as a result of physical factors.

More recently, the literature has been heavily influenced by political and economic factors. Sen (1981) observed that not all food shortages caused hunger, and that increased hunger occurred in areas where food production was, in fact, increasing. This has been seen in India, Ethiopia and Sudan. A shortage of available food could not therefore be the only cause of malnutrition, and nor could hunger be related



▲ **Figure F.29:** Water footprints for selected agricultural products
Source: http://virtualwater.eu/pics/poster_products_ani_600.gif

only to the distribution of resources and to poverty. In the analysis of the population "at risk" of malnutrition, it became clear that it was important to consider the political and economic system in which food is produced, distributed and consumed. This included not just the physical factors affecting yield, but also people's access to food and the conditions that alter their access, that is, **food entitlement deficit (FED)**. Sen's work has generally been accepted, although it is important also to think about physical factors, such as precipitation and environmental degradation, as a potential trigger of famines.

In a study of factors affecting food consumption in Bahrain, Abdulrahman Musaiger (1990) noted that, despite the problems of climate, soil and land availability, Bahrain was self-sufficient in fruit and vegetable production before the development of the oil industry in the 1930s. Many labourers left employment in agriculture, fishing and pearl diving. This lead to a decline in agricultural and fisheries production and an increased dependence on imported foods. With increased levels of wealth, and more electrical appliances such as fridges and freezers, more households get an increasing proportion of their energy needs from protein and fat, and less from carbohydrates. In addition, more of their protein comes from animal sources. He also noted the impact of migrants on the availability of new dishes in Bahrain (such as Indian samosas, chapattis, nashif and keema, and Iranian shish kebab). He also noted that the increase in working women led to increased demand for convenience foods. Television advertising of food products was found to have an important role in shaping the food consumption of poorer Bahraini households.

▲ **Photo F.6:** Food display – food availability in an HIC supermarket

Factors affecting food consumption

The social psychologist Kurt Lewin, writing in the 1940s, stated that "Food gets on to the table through 'channels' such as the grocery store, the garden and the refrigerator. The selection of channels and the food which flows through them is under the control of the gatekeeper." The "gatekeeper" refers to the role of women in the flow of food into the home. The type of food depended on expense, health, taste and status.

Income and level of education influence food choice via the resources available to purchase a higher-quality food. Diet may vary depending on the availability of income to purchase more healthy, nutrient-rich food. For a low-income family, price plays a larger role than taste and quality in whether the food will be purchased. The variety of foods carried in neighbourhood stores may also influence diet, and some people may live in a "food desert".

Case study

Food consumption in Khayelitsha, Cape Town, South Africa

Since 1994 (the end of the apartheid era in South Africa), there has been an increase in the number of black Africans living in urban areas, such as Khayelitsha, Cape Town. Urbanization is commonly accompanied by changes in diet. Consumption of traditional food is largely associated with poverty and, consequently, as people move to the city, they favour a typical westernized diet with a high fat and low carbohydrate content. This leads to an increase in levels of obesity and type II diabetes.

Researchers from the University of the Western Cape found that perceptions about food varied according to gender and age. They found that women's perceptions about food were centred on satisfying the family's needs. Women see themselves as food providers, so, even when food is scarce, they feel responsible for making sure that all family members have something to eat. In contrast, older men saw themselves as the person responsible for supporting the family. Some of the young women seemed to be conscious about body weight and therefore very selective about food, whereas many of the younger men felt that they could eat without restriction.

In addition to nourishing the body, food is seen as a sign of warmth, acceptance and friendship. People previously deprived of opportunities to eat a variety of foods, whether due to political, geographic or socio-economic factors, consider it necessary to enjoy as much as they can eat when they do have the opportunity, to show their improved socio-economic standing. For some, migration to urban areas may lead to debt and an inability to afford quality food. They may resort to cheap unhealthy food, such as tripe, chicken skins and pig's feet, which are readily accessible in Khayelitsha.

The daily consumption of meat is associated with high socio-economic status, while consumption of vegetables only is associated with low socio-economic status. Eating large portions of food is associated with affordability.

Food is used for celebrations, rituals and for welcoming guests. Food is also used during social occasions when people get together and meet socially. Sweets, ice cream and cakes are consumed on happy occasions. Fatty meat is a sign of generosity; lean meat and black tea are often eaten during mourning periods.

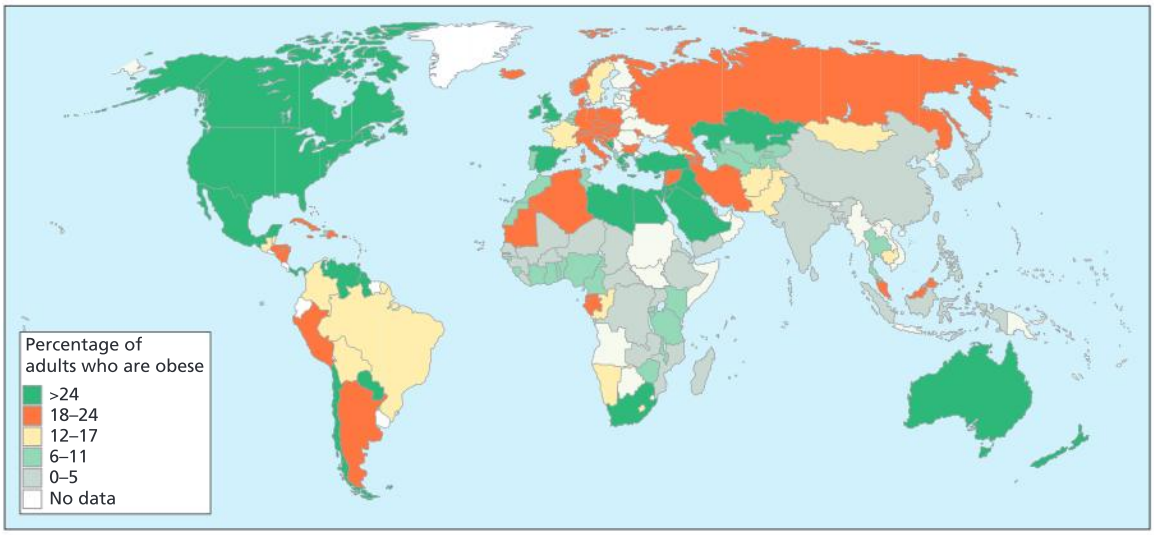
Activity 14

1. Distinguish between the food availability deficit (FAD) and food entitlement deficit (FED).
2. Explain how people can starve even when their food supply is adequate.
3. Define obesity.
4. Distinguish between being overweight and obese.

Case study

Food consumption in the Middle East

A number of factors have influenced food consumption in the Arab world. Food consumption patterns dramatically changed in some Arab countries as a result of the increase in income from oil revenues. Food subsidies adversely affected eating habits in the Gulf States by encouraging the intake of fat, sugar, rice, wheat flour and meat. Sociocultural factors such as religion, beliefs, food preferences, gender discrimination, education and women's employment have also had a noticeable influence on food consumption patterns in this region. Mass media, especially televised food advertisements, play an important role in modifying dietary habits. Migration movements, particularly those during the 1970s, have also had a big impact on the food practices in many Arab countries.



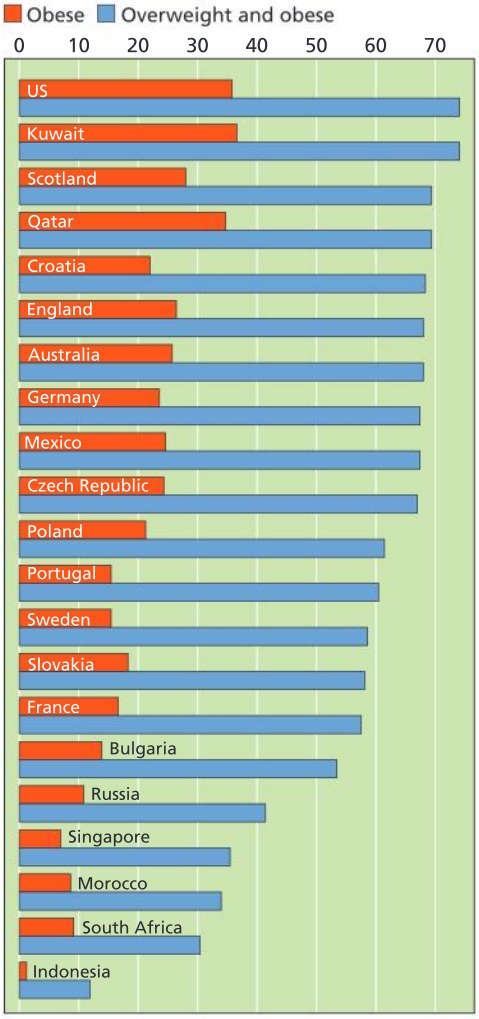
▲ **Figure F.30:** Global obesity prevalence
Boseley, S. "Obesity experts call for stricter rules on junk food ads targeted at children". *The Guardian*. 15 February 2015

Targeting obesity

Some of the world's leading obesity experts say that controls should be introduced worldwide to stop commercial companies marketing unhealthy foods and drinks that make children overweight and stunt their growth.

No country has yet reversed its obesity epidemic. Some childhood obesity rates have slowed in countries like the US and the UK, but not among poorer families where levels are still very high. This means that many thousands of overweight children will have health problems as adults. In England, a third of 10–11 year olds and more than a fifth of 4–5 year olds are overweight or obese. In the US, children are on average 5 kg heavier than children 30 years ago, and consume 200 kcal a day more than a child from the 1970s would have done – or 73,000 kcal more per year.

The average cost of food energy is about 56 cents per 100 kcal, say experts – so 200 kcal a day implies spending an extra $1.12 a day per child, or more than $400 a year. With about 50 million school-age children in the US, their excess food consumption each year



▲ **Figure F.31:** Obesity world rankings of men (%)
Boseley, S. "Obesity experts call for stricter rules on junk food ads targeted at children". *The Guardian*. 15 February 2015

approaches $20 billion. A high proportion of these children will continue over-consuming through adulthood, creating a market for the US food and beverage industry worth more than $60 billion annually. With such high sums at stake, the food industry is likely to resist controls in the same way that the tobacco and alcohol industries have.

Children's poor nutrition worldwide – including in the UK – leads to stunting as well as obesity. It is not only in poor countries that stunting – caused by poor nutrition – exists side by side with obesity. The national school measurement programme in England shows that children in poor households are not only likely to be fatter but also shorter than children from affluent families.

Obesity needs to be reassessed if we are to halt and reverse the global obesity epidemic. While individuals bear some responsibility for their health, we must also recognize that today's food environments exploit people's biological vulnerability (for example, innate preference for sweetened foods), psychological vulnerability (for example, marketing techniques), and social and economic vulnerability (for example, convenience and cost), making it more likely for them to eat unhealthy foods. It is therefore potentially possible to break the cycle of supply and demand for unhealthy foods with "smart food policies" by governments, alongside efforts from industry and civil society to create healthier food systems.

(Adapted from *The Guardian*, 19 February 2015)

ATL Research and communication skills

Visit the resources section of the World Obesity Federation's website, at http://www.worldobesity.org/resources/.

Find out about regional variations and trends in obesity. Choose one topic and give a two-minute talk to your class, or make a presentation about one way in which obesity varies by place, time, gender or education.

▲ **Photo F.7:** Large portions of fast food have been linked to rising obesity

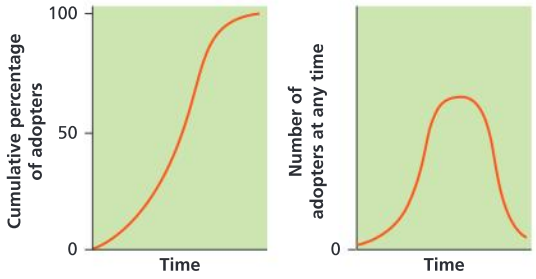
Diffusion

Hägerstrand's diffusion curve

The Swedish geographer Torsten Hägerstrand (1916–2004) was interested in the diffusion of innovations. He incorporated a chance element in his model and showed that the introduction of a new technique depended upon a number of factors, including information regarding innovations, financial security, the psychological make-up of the adopter, and the physical proximity to other adopters. Initially, very few people adopt an innovation (Figure F.32). As information becomes more widespread, and often the cost is reduced, increasingly more people adopt the idea. However, some people are reluctant to change and take a long time to accept a new technique, if they ever do, and so inequalities may develop (Figure F.33).

Disease diffusion

Disease diffusion refers to the spread of a disease into new locations. It occurs when incidences of a disease spread out from an initial source. The **frictional effect of distance**, or **distance decay**, suggests that areas closer to the source are more likely to be affected by it, and sooner, than areas further away from the source.



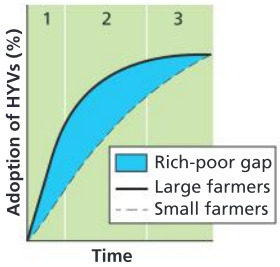
▲ **Figure F.32:** A diffusion curve

Hägerstrand is known for his pioneering work on "waves of innovation". This has formed the basis for many medical geographers, who attempted to map the spatial diffusion of disease. Four main patterns of disease diffusion have been identified, namely expansion diffusion, contagious diffusion, hierarchal diffusion and relocation diffusion. In addition, there is also network diffusion and mixed diffusion. The diffusion of infectious disease, for example, tends to occur in a "wave" fashion, spreading from a central source.

Some physical features act as a barrier to diffusion, including mountains and water bodies, while political boundaries and economic boundaries may also limit the spread of disease. The diffusion of disease can be identified as an S-shaped curve to show four phases: infusion (25th percentile), inflection (50th percentile), saturation (75th percentile), and waning to the upper limits.

There are several types of disease diffusion:

- **Expansion diffusion** occurs when the expanding disease has a source and diffuses outwards into new areas.
- **Relocation diffusion** occurs when the spreading disease moves into new areas, leaving behind its origin or source of the disease. An example could be a person infected with AIDS moving to a new location.
- **Contagious diffusion** is the spread of an infectious disease through the direct contact of individuals with those infected.
- **Hierarchical diffusion** occurs when a phenomenon spreads through an ordered sequence of classes or places, for example from cities to large urban areas to small urban areas.
- **Network diffusion** occurs when a disease spreads via transportation and social networks. Again, the spread of AIDS in Southern Africa along transport routes is an example.

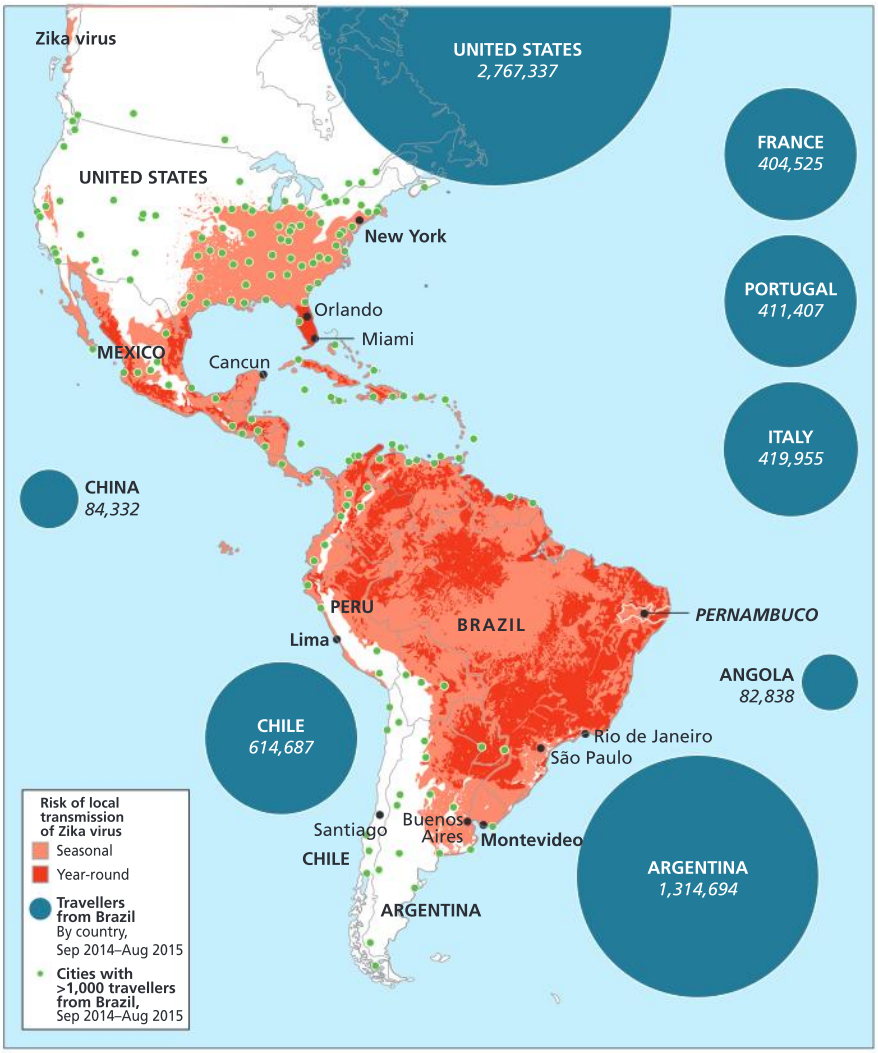


1 Rapid adoption by farmers with plentiful land and/or money. Land is used as security to buy seeds, irrigation pumps, fertilizers, pesticides, HYVs, etc. hence small farmers cannot benefit at first.
2 Adoption by smaller farmers caused by:
a. government backed agricultural development projects
b. new seeds targeted for more environments
c. continued population pressure creating extra demand for more food.
3 Diffusion of new techniques to most farmers. Widespread adoption.

▲ **Figure F.33:** The green revolution, diffusion and changing inequality over time

The Zika virus

Zika, a mosquito-borne virus that can also be transmitted through sexual contact, arrived in Brazil in May 2014. It has since spread to 21 other countries in the Americas. The mosquito is a poor flier (and can fly only about 400 m), but people are transporting the virus by travelling to and from areas with the disease (relocation diffusion). Initially, Zika was not thought to be much of a threat: only a fifth of infected people fall ill, usually with just mild fever, rash, joint aches and red eyes. However, the evidence is that it causes birth defects in children and neurological



▲ **Figure F.34:** The spread of the Zika virus
Source: Dr K Khan, St Michael's Hospital, Toronto

problems in adults. In 2015 El Salvador, Colombia and Ecuador recommended that women delay pregnancy until 2018.

In October 2015, doctors in north-eastern Brazil saw a huge increase in babies born with microcephaly – an abnormally small head – often with consequent brain damage. Over the next four months more than 3,500 cases of microcephaly were reported in Brazil. That compared with fewer than 200 a year in the five previous years.

Figure F.34 shows where Zika could become endemic. But places where air-conditioning, screened windows and mosquito control are the norm are unlikely to see outbreaks flare up. With Brazil hosting the Olympic Games in 2016, the increase in the number of tourists to the country brought a greater risk of the disease spreading to more countries.

Malaria

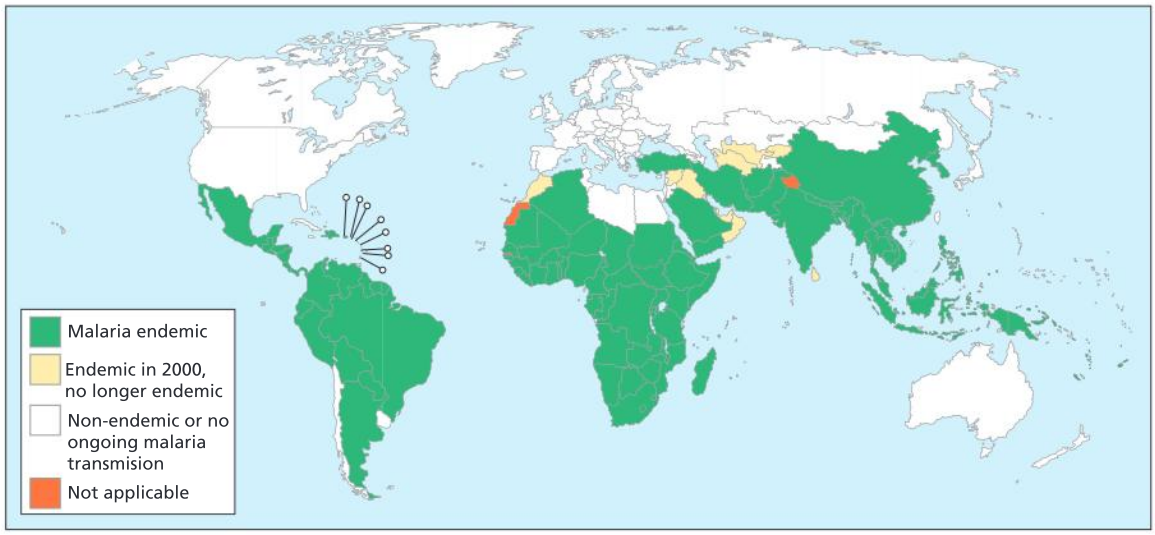
Malaria is a life-threatening disease for humans caused by the plasmodium parasite and transmitted to people via the bite of the female *Anopheles* mosquito. Here are some key facts about malaria:

- In 2015, 95 countries and territories had ongoing malaria transmission.
- About 3.2 billion people – almost half the world's population – are at risk of malaria.
- Malaria is preventable and curable and increased efforts are dramatically reducing the malaria burden in many places.
- Between 2000 and 2015, malaria incidence among populations at risk (the rate of new cases) fell by 37 per cent globally. At the same time, malaria death rates in populations at risk fell by 60 per cent globally among all age groups and by 65 per cent among children under five.
- Sub-Saharan Africa carries a disproportionately high share of the global malaria burden. In 2015 the region suffered 88 per cent of malaria cases and 90 per cent of malaria deaths.

ATL Research skills

Find the latest information on the Zika virus to see whether there was any increase in the prevalence of the disease following the Rio de Janeiro Olympic Games.

To show how the Ebola virus spread between March 2014 and March 2015, use the maps from the BBC website http://www.bbc.co.uk/news/world-africa-28755033.



▲ **Figure F.35:** The distribution of malaria
Source: WHO, *World Malaria Report, 2015*

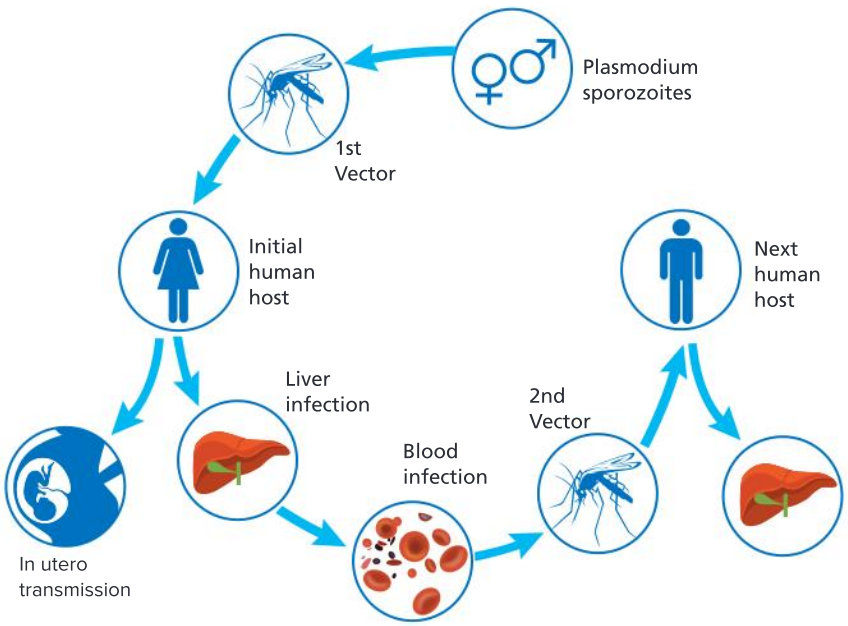
Environmental preferences

The malarial parasite (plasmodium) thrives in the humid tropics where a minimum temperature of 20°C allows it complete its life cycle. The mosquito is a primary host and the human is secondary. The mosquito's ideal environment is stagnant water, estuaries, deltas and irrigation channels. These are usually found in densely populated agricultural regions.

The disease is often triggered by natural events such as cyclones and flooding or by human conflicts such as war, which often results in refugees. They are likely to live in temporary camps with inadequate drainage (open sewers), which are ideal breeding grounds for the mosquito.

ATL Research skills

Using the WHO website and information given in this chapter, produce an information sheet for use in a village clinic. Do not assume that the readership has more than very basic reading skills.



▲ **Figure F.36:** The life cycle of the plasmodium parasite

▲ **Photo F.8:** A microscopic image of the malaria-carrying *Anapheles* mosquito

ATL Communication skills

Comment on the effectiveness of Photo F.8 in the drive to eradicate malaria. Suggest alternative images that could be as effective or more effective as a deterrent in the drive to eradicate malaria.

The cost of treating malaria

Global financing for malaria control increased from an estimated $960 million in 2005 to $2.5 billion in 2014. Malaria interventions led to health service savings of $900 million in sub-Saharan Africa between 2001 and 2014, owing to the reduced number of cases. The direct cost of malaria to individual households includes medication, doctors' fees and preventative measures such as bed nets, which help to reduce transmission. Infected individuals are unable to work, which can reduce family incomes during the attacks.

The symptoms of malaria

The first symptoms – fever, headache, chills and vomiting – appear seven days after the mosquito bite, and they may be mild at first and difficult to recognize as malaria. If not treated within 24 hours, malaria can progress to severe illness, often leading to death.

Children with severe malaria frequently develop one or more of the following symptoms: severe anaemia, respiratory distress in relation to metabolic acidosis, or cerebral malaria. In adults, multi-organ involvement is also frequent. In malaria-endemic areas, people may develop partial immunity, allowing asymptomatic infections to occur.

Who is at risk?

Some population groups are at considerably higher risk of contracting malaria and developing severe disease than others. These include infants, children under five years of age, pregnant women and patients with HIV/AIDS, as well as non-immune migrants, mobile populations and travellers. National malaria control programmes need to take special measures to protect these population groups from malaria infection, taking into consideration their specific circumstances.

Transmission

In most cases, malaria is transmitted through the bites of female *Anopheles* mosquitoes. There are more than 400 different species of *Anopheles* mosquito; around 30 are malaria vectors of major importance. All the important vector species bite between dusk and dawn. The intensity of transmission depends on factors related to the parasite, the vector, the human host and the environment.

Prevention

Vector control is the main way to prevent and reduce malaria transmission, as recommended by the WHO. Two forms of vector control – insecticide-treated mosquito nets and indoor residual spraying – are effective in a wide range of circumstances. If coverage of vector control interventions within a specific area is high enough, then a measure of protection will be conferred across the community.

Long-lasting insecticidal nets (LLINs) are the preferred form of insecticide-treated mosquito nets (ITNs) for public health programmes. In most settings, WHO recommends LLIN coverage for all people at risk of malaria. The most cost-effective way to achieve this is by providing LLINs free of charge, to ensure equal access for all. In parallel, effective behaviour change communication strategies are required to ensure that

all people at risk of malaria sleep under an LLIN every night, and that the net is properly maintained.

Indoor residual spraying (IRS) with insecticides, including DDT, is a powerful way to rapidly reduce malaria transmission. Its full potential is realized when at least 80 per cent of houses in targeted areas are sprayed. In some settings, multiple spray rounds are needed to protect the population for the entire malaria season.

Antimalarial medicines can also be used to prevent malaria. For travellers, malaria can be prevented through chemoprophylaxis, which suppresses the blood stage of malaria infections, thereby preventing malarial disease.

Insecticide resistance

Vector control is highly dependent on the use of pyrethroids, the only class of insecticides currently recommended for ITNs or LLINs. In recent years, mosquito resistance to pyrethroids has emerged in many countries. In some areas, resistance to all four classes of insecticides used for public health has been detected. Fortunately, this resistance has only rarely been associated with decreased efficacy of LLINs, which continue to provide a substantial level of protection in most settings. Rotational use of different classes of insecticides for IRS is recommended as one approach to manage insecticide resistance.

To ensure a timely and coordinated global response to the threat of insecticide resistance, the WHO worked with a wide range of stakeholders to develop the "Global Plan for Insecticide Resistance Management in Malaria Vectors (GPIRM)", which was released in May 2012.

Diagnosis and treatment

Early diagnosis and treatment of malaria reduces disease and prevents deaths. It also contributes to reducing malaria transmission. The best available treatment, particularly for *P. falciparum* malaria, is artemisinin-based combination therapy (ACT).

Antimalarial drug resistance

Resistance to antimalarial medicines is a recurring problem. Resistance of *P. falciparum* to previous generations of medicines, such as chloroquine and sulfadoxine-pyrimethamine (SP), became widespread in the 1970s and 1980s, undermining malaria control efforts and reversing gains in child survival.

The WHO recommends the routine monitoring of antimalarial drug resistance, and supports countries to strengthen their efforts in this important area of work.

Surveillance

Surveillance entails tracking the disease and taking action based on the data received. Malaria eradication is defined as the permanent reduction to zero of the worldwide incidence of malaria infection as a result of deliberate efforts. Once eradication has been achieved, intervention measures are no longer needed. In countries with high or moderate rates of malaria transmission, national malaria control programmes aim to maximize the reduction of malaria cases and deaths.

Common mistake

✗ Some students believe that malaria is a waterborne disease.

✓ Although stagnant water is important for the laying of mosquito eggs, the disease is a vector-borne disease, transmitted by mosquitoes.

Activity 15

1. Describe the distribution of malaria, as shown in Figure F.35.
2. Suggest reasons to explain this distribution.
3. Describe the life cycle of the plasmodium parasite, as shown in Figure F.36.

Vaccines against malaria

There are currently no licensed vaccines against malaria or any other human parasite. Clinical trials are currently being held, and it is expected that there will be a vaccine by 2020. In October 2015, two WHO advisory groups recommended pilot implementations of RTS, S/AS01 (a malaria vaccine) in a limited number of African countries.

The WHO strategy

The WHO Global Technical Strategy for Malaria 2016–30 – adopted by the World Health Assembly in May 2015 – provides a technical framework for all malaria-endemic countries. It is intended to guide and support regional and country programmes as they work towards malaria control and elimination. The strategy sets ambitious but achievable global targets, including:

- reducing malaria incidence by at least 90 per cent by 2030
- reducing malaria mortality rates by at least 90 per cent by 2030
- eliminating malaria in at least 35 countries by 2030
- preventing a resurgence of malaria in all countries that are malaria-free.

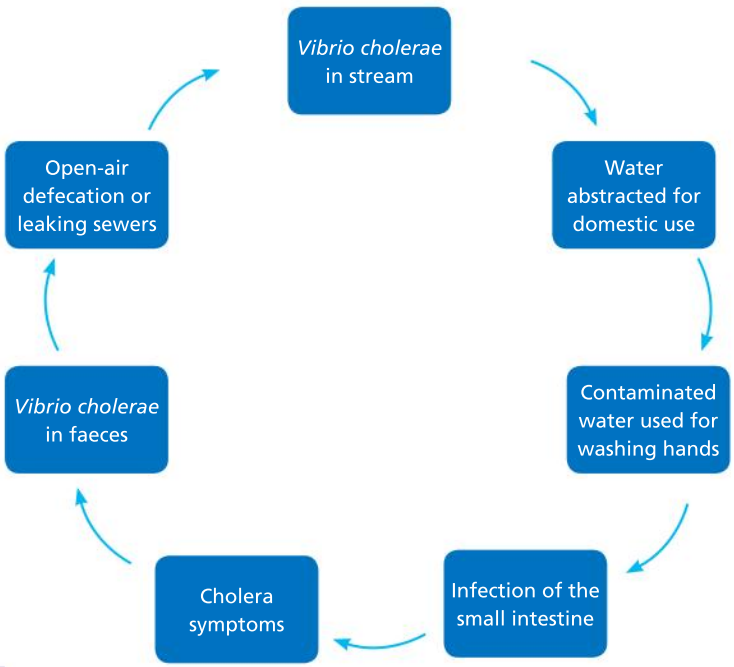
Cholera

Cholera is an infection of the small intestine caused by the bacterium *Vibrio cholerae*. There are several strains of the bacterium, some causing worse symptoms than others. It is a waterborne disease, although it can also be transmitted by contaminated food.

For cholera outbreaks to occur, there must be two conditions:

1. There must be significant breaches of water sanitation leading to contamination by the bacterium *Vibrio cholerae*.
2. Cholera must be present in the population.

Figure F.37: The transmission of *Vibrio cholerae*



This infection is mostly asymptomatic or causes mild gastroenteritis. However, about 5 per cent of infected persons develop severe dehydration and acute diarrhoea, which can kill within hours. There are 28,000–142,000 deaths from cholera every year. Even those who are symptom-free can carry the bacteria in their faeces and the disease is easily transmitted if sanitation arrangements are inadequate.

Risk factors

Transmission of *Vibrio cholerae* is relatively easy in areas of poor housing and inadequate sanitation. It is particularly the curse of displaced populations living in overcrowded camps. Children under five are particularly vulnerable.

Clinical treatment

- Prompt administration of oral rehydration therapy is sufficient to treat 80 per cent of patients.
- Very dehydrated cases need intravenous fluids.
- Antibiotics are useful while *V. cholerae* is still being excreted, but prolonged treatment can lead to antibiotic resistance – a serious problem in treating all infectious illness.
- Oral cholera vaccine (OCV) can be effective, but it is important to adopt prevention and control measures as well.

Domestic prevention and control measures

1. Drink and use safe water.
   - **a.** Drink safe water, but also use it for cleaning teeth and for making ice.
   - **b.** Always boil or disinfect untreated water.
   - **c.** Always put treated water in a clean and covered container.
2. Wash your hands.
   - **a.** Wash your hands often with soap (or ash or sand):
     - **i.** before you prepare seafood
     - **ii.** before feeding your children
     - **iii.** after using the latrine or toilet
     - **iv.** after taking care of someone ill with diarrhoea.
3. Dispose of faeces.
   - **a.** Do not defecate in any body of water.
   - **b.** Use latrines or chemical toilets to dispose of faeces.
   - **c.** Wash hands with soap and water (or ash or sand) after defecating.
   - **d.** If you do not have a latrine, defecate at least 30 m away from a body of water.
   - **e.** Dispose of faeces in plastic bags at collection points or bury in the ground.
4. Handle food hygienically.
   - **a.** Cook food well, eat it hot and peel fruit and vegetables.
   - **b.** Be sure to cook seafood, especially shellfish, until very hot all the way through.
5. Clean up.
   - **a.** Clean up thoroughly the places where the family eat and work.

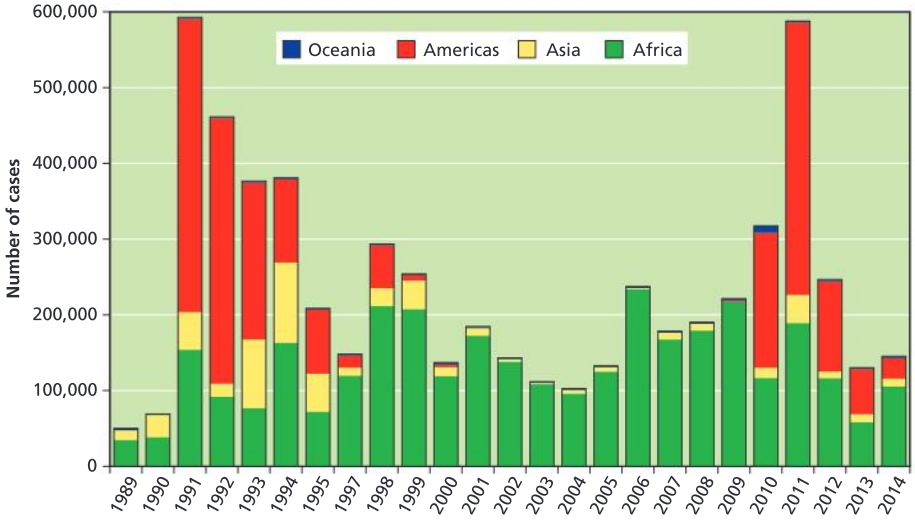
The role of the World Health Organization

The WHO Global Task Force on cholera control works to:

- support and implement global strategies to prevent and control cholera
- provide a forum for cooperation and to strengthen a country's capacity to prevent and control cholera

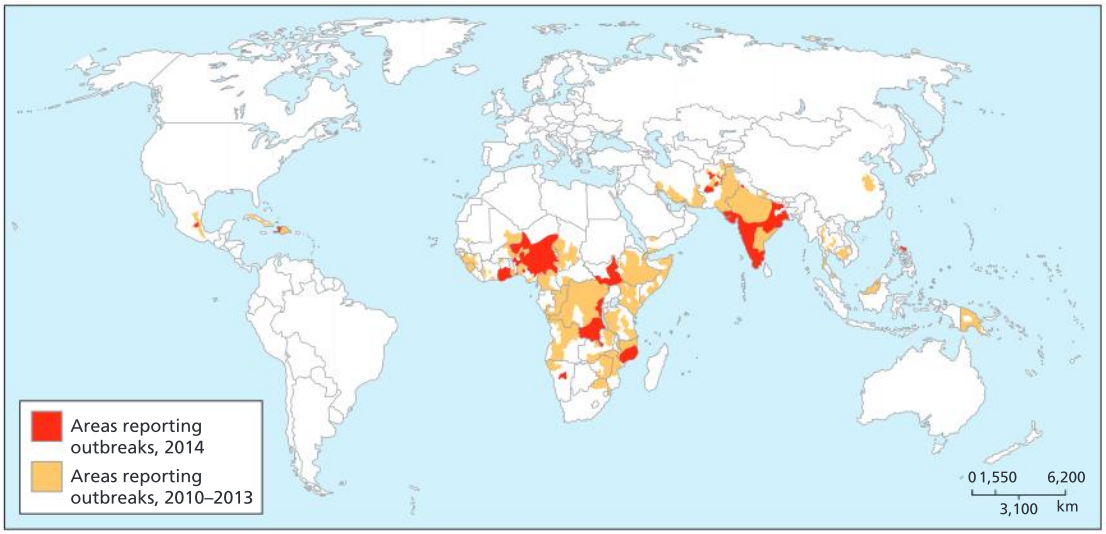
- support research
- increase the visibility of cholera as an important global health problem.

Figure F.38: Cholera cases reported to the WHO by year and continent, 1989–2014



Source: *Weekly Epidemiological Record*, 2015, 90(40), 517–44

Figure F.39: Areas of cholera outbreaks, 2010–13
Source: World Health Organization



ATL Research skills

To extend your understanding of cholera, carry out an investigation into the underlying problem of sanitation. Use as your source "Preventing diarrhoea through better water, sanitation and hygiene" by the WHO (http://apps.who.int/iris/bitstream/10665/150112/1/9789241564823_eng.pdf). Summarize sections 1–6, but keep it concise.

Activity 16

Study Figure F.38.

1. Describe the trends in the number of cholera cases occurring in the four regions of the world.
2. Suggest reasons for the trends described above.
3. Referring to Figure F.39, describe the global pattern of cholera outbreaks.
4. Identify the physical and human factors which influence this pattern.

Concepts in context

Farming production can be viewed as a type of system with inputs, stores and outputs. Farming systems have a number of **processes**, which vary from place to place and develop with technology over time. Inputs such as water, energy and fertilizers vary considerably with farming types. Agricultural practices may be spread from place to place, although not all farmers can afford the cost of new innovations.

Similarly, diseases may be spread between places, although physical and human barriers may limit their spread. Some diseases spread via organisms, such as mosquitoes that spread malaria, whereas other diseases spread through poor water quality. Thus, eradicating a disease may be possible by eliminating the vector/unclean water rather than by treating the disease itself.

Check your understanding

1. Define the term "water footprint".
2. Explain how farming inputs and outputs differ between an intensive subsistence and an intensive commercial system.
3. Compare the energy efficiency ratio of agro-forestry with that of greenhouse lettuces
4. Explain the process of diffusion with respect to agricultural innovations.
5. Describe how diet changes as standards of living increase.
6. Explain how diseases may be spread.
7. Describe the main impacts of malaria.
8. Suggest ways in which it is possible to manage malaria.
9. Give one example of each of the following disease types: (a) contagious, (b) infectious, (c) degenerative, and (d) non-communicative.
10. Explain the different approaches to the control and prevention of cholera.

3 Stakeholders in food and health

Conceptual understanding

Key question

What **power** do different stakeholders have to influence diets and health?

Key content

- The roles of international organizations (such as the World Food Programme, the Food and Agriculture Organization of the United Nations, and the World Health Organization), governments and NGOs in combating food insecurity and disease.
- The influence of TNCs (agribusinesses and the media) in shaping food consumption habits.
- Gender roles related to food and health, including food production/acquisition and disparities in health.
- Factors affecting the severity of famine, including governance, the power of the media and access to international aid.

The roles of organizations and governments in combating food insecurity and disease

Global food security is made difficult because:

- a significant share of the world's population is malnourished
- the global population continues to grow
- climate change and other environmental changes threaten future food production
- the food system itself is a major contributor to climate change and other environmental harms.

The UN has set out its goals for sustainable agriculture for 2030 (Table F.8).

The main aims of the United Nations Food and Agriculture Organization (FAO) are the eradication of hunger, food insecurity and malnutrition; the elimination of poverty and the driving forward of economic and social progress for all; and the sustainable management and utilization of natural resources, including land, water, air, climate and genetic resources for the benefit of present and future generations. In addition, it aims to increase the resilience of people to threats and crises.

For example, the FAO set up a project in rural Honduras to promote entrepreneurship among rural youth. Over 2,000 young people were trained in farming skills, marketing and developing business skills.

▼ **Table F.8:** SDG2: "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture"

2.1 By 2030 end hunger and ensure access by all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round.
2.2 By 2030 end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under five years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons.
2.3 By 2030 double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, and revolutionize the same and its activities, productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment.

The result was more than 1,500 successful microenterprises. In Khulna, Bangladesh, the FAO operated a project to improve food safety among urban street vendors. The aim was to minimize food contamination during preparation. Street foods are cheap and an essential source of food and nutrition to people on a low income, and also to schoolchildren. As a result of the success of this scheme, the project was extended to the city of Dhaka.

The World Food Programme (WFP) aims to end global hunger. The WFP focuses on food assistance for the poorest and most vulnerable people. Its plan has four objectives:

1. Save lives and protect livelihoods in emergencies.
2. Support food security and nutrition and (re)build livelihoods in fragile settings and following emergencies.
3. Reduce risk and enable people, communities and countries to meet their own food and nutrition needs.
4. Reduce undernutrition and break the intergenerational cycle of hunger.

Food security analysis provides information to:

- identify the most food-insecure people to ensure the most effective targeting
- identify the most appropriate type and scale of intervention, whether food distributions, school feeding or more innovative interventions such as cash or voucher programmes
- ensure the most efficient use of humanitarian resources by allocating funding according to needs.

The WFP undertakes food security analysis in close collaboration with partners worldwide, including governments, UN agencies such as the FAO, UNHCR, UNICEF, the WHO and local and international NGOs.

National and multi-government organizations

At the World Trade Organization's Doha Round in 2001, many developing nations – including Brazil, China and India – opposed agricultural subsidies in the US and EU. They argued that the high subsidies were artificially driving down global crop prices, unfairly undermining small farmers and maintaining poverty in many developing countries.

Subsidized agriculture in the developed world is one of the greatest obstacles to economic growth in the developing world. In 2002, industrialized countries in the Organization for Economic Cooperation and Development (OECD) spent a total of $300 billion on crop price supports, production payments and other farm programmes. These subsidies encourage overproduction. Markets are flooded with surplus crops that are sold below the cost of production, depressing world prices.

2.4 By 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality.

2.5 By 2020 maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge as internationally agreed.

2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development, and plant and livestock gene banks to enhance agricultural productive capacity in developing countries, in particular in least developed countries.

2.b Correct and prevent trade restrictions and distortions in world agricultural markets including by the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.

2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives, and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

See more at:

https://sustainabledevelopment.un.org/?page=view&nr=164&type=230&menu=2059#sthash.kXElTngm.dpuf

By 2013 many developing countries had established their own agricultural subsidies. The BRIIC countries (Brazil, Russia, India, Indonesia and China) have increased theirs the fastest. China's agricultural subsidies, estimated at $160 billion in 2012, now dwarf those in the US ($19 billion) and EU ($67 billion) combined. Brazil's agricultural subsidies doubled in just three years, and totalled about $10 billion in 2016.

Global subsidies may also lead producers to overuse fertilizers or pesticides, which can result in soil degradation, groundwater depletion and other negative environmental impacts.

The European Union Common Agricultural Policy (CAP)

There were three basic principles behind the formulation of the CAP in 1962:

1. It was to be a single agricultural market within which goods move freely.
2. Products grown in the EU were to be bought in preference to those from outside the EU.
3. EU member states finance the CAP.

The main priorities for agriculture were to:

- increase agricultural productivity and self-sufficiency
- ensure a fair standard of living for farmers
- stabilize markets
- ensure that food was available to consumers at a fair price.

Between 1958 and 1968 these aims were implemented: a single market existed in agriculture from 1962 and a common set of market rules and prices was introduced by 1968. At the centre of the CAP was the system of **guaranteed prices** for unlimited production. This encouraged farmers to maximize their production as it provided a **guaranteed market**. By 1973 the EU was practically self-sufficient in cereals, beef, dairy products, poultry and vegetables. Imports were subjected to duties or levies, and export subsidies were introduced to make EU products more competitive on the world market.

CAP led to intensification, concentration and specialization:

1. **Intensification** is the rising level of inputs and outputs from the land as farmers sought to maintain or increase their standards of living (or profit margins). The inputs included fertilizers, animal feed, fuel and machinery. Beef and butter "mountains" and "wine lakes" typified the increased outputs.
2. **Concentration** is the process whereby production of particular products becomes confined to particular areas, regions or farms.
3. **Specialization** is related to concentration and refers to the proportion of total output of a farm, region or country accounted for by a particular product. For example, wheat has become more concentrated in France and the UK as farmers have specialized in it.

The need for reform

By the 1990s, there was a need to reform the CAP because price guarantees and intervention storage created **surpluses** in cereals, beef, wine and milk. The EU was overproducing cereals by 20 per cent, while demand had dropped. In some sectors, **technological and scientific improvements** improved yields, further increasing surpluses. Consequently, a larger proportion of EU funding was used to store and sell off surpluses at subsidized prices on the world market. The EU also lost some of its traditional export markets in the former Soviet Union and parts of the Middle East, thereby reducing **demand**.

In 1992 the CAP was reformed. Five objectives were identified:

1. To increase Europe's competitive agricultural base.
2. To match production with demand.
3. To support farm incomes.
4. To stop the drift out of agriculture.
5. To protect and develop the potential of the natural environment.

In the years since the formation of the CAP, the EU has also to address the challenges of:

- food security – at the global level, food production will have to double in order to feed a world population of 9 billion people in 2050
- climate change and the sustainable management of natural resources
- looking after the countryside across the EU and keeping the rural economy alive.

Non-governmental organizations (NGOs)

A number of NGOs help deliver food to those with insufficient access to food. Many of these are in low-income and middle-income countries, such as Operation Hunger in South Africa, but others operate in high-income countries such as the food banks in the UK. There are many reasons why people in rich countries may lack food. Some of the reasons are shown in Figure F.40.

ATL Research and communication skills

Working in groups, find out whether there are any organizations providing food for people in your local area. How might you be able to help them provide more food and distribute it to those in need?

ATL Research and communication skills

Read the debate in the *Wall Street Journal* between Vincent H. Smith, who says farmers should stand on their own, and W. Robert Goodman, who believes that subsidies are important for food security: http://www.wsj.com/articles/should-washington-end-agriculture-subsidies-1436757020.

Arrange a class discussion of the question: "Should the USA end agriculture subsidies?"

Activity 17

1. Outline the main reasons why people in the UK use food banks.
2. Suggest possible reasons why there may be seasonal variations in the number of people using food banks.

TOK

From what you have learned so far from this chapter, suggest why the presence of food banks in the UK is unexpected.

▲ **Figure F.40:** Some of the reasons for food banks in the UK

The role of international organizations, governments and NGOs in tackling disease

Health has long been regarded as a basic human need and a basic human right. In 1948, the UN Declaration of Human Rights made it clear that health is a human right and a basic need. Goal 3 of the Sustainable Development Goals (SDGs) is called "Ensure healthy lives and promote well-being for all at all ages". The goals are shown in Table F.9.

The World Health Organization (WHO) is the part of the UN that deals with health issues. It has 7,000 people from more than 150 countries working in 150 country offices. The WHO has a number of objectives:

- Providing leadership on matters critical to health and engaging in partnerships where joint action is needed.
- Shaping the research agenda and stimulating the generation, translation and dissemination of valuable knowledge.
- Setting norms and standards and promoting and monitoring their implementation.
- Articulating ethical and evidence-based policy options.
- Providing technical support, catalysing change, and building sustainable institutional capacity.
- Monitoring the health situation and assessing health trends.

ATL Research skills

Find out about the reform of the WHO at http://www.who.int/about/who_reform/WHO_Reform_map_2015.pdf.

▼ **Table F.9:** SDG3: "Ensure healthy lives and promote well-being for all at all ages"

3.1	By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births
3.2	By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births
3.3	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases
3.4	By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being
3.5	Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol
3.6	By 2020, halve the number of global deaths and injuries from road traffic accidents
3.7	By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes
3.8	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all
3.9	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
3.a	Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate
3.b	Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all
3.c	Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing states
3.d	Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks

There are other initiatives. For example, the Global Fund to Fight AIDS, Tuberculosis and Malaria was launched in 2002. Based on the extra Overseas Development Aid provided by the Global Fund, many LICs have achieved huge improvements in the control of these diseases since 2002. The Global Alliance for Vaccines and Immunizations (GAVI) provides international financing for immunization coverage.

According to Jeffrey Sachs, Director of the Earth Institute, Colombia University, the following 10 factors could allow health for all by 2025:

1. HICs should donate 0.1 per cent of GNI to health assistance for LICs in order to close the financing gap of the primary health care system.
2. Half of that money should be channelled through the Global Fund to fight AIDS, TB and malaria, which would become a Global Health Fund.
3. LICs should allocate at least 15 per cent of their domestic revenue to the health sector. Total spending should be at least $60 per person per year in order to ensure basic health services.

4. The world should adopt a plan for comprehensive malaria control.
5. The G8 should fulfil the commitment to universal access to antiretroviral drugs (ARVs).
6. The world should fulfil the Global Plan to Stop TB, including closing the financing gap of $4 billion per year.
7. The world should fulfil the funding for access to sexual and reproductive health services, including emergency obstetrical care and contraception, partly through the Global Health Fund and partly through the United Nations Population Fund (UNFPA).
8. The Global Health Fund should establish finance for seven controllable neglected tropical diseases: hookworm, ascariasis, trichuriasis, onchocerciasis, schistosomiasis, lymphatic filariasis and trachoma.
9. The Global Health Fund should enable the mass training and deployment of one million community health workers for Africa.
10. The world should introduce primary health care (mass prevention and treatment) of non-communicable diseases, including oral health, eye care, mental health, cardiovascular disease and metabolic disorders.

National governments

There are a number of important differences in the delivery of health care in HICs and in LICs. Patterns of health care relate directly to the nature of a country's development and to the unequal distribution of and access to its resources.

Health care in many HICs clearly reflects the nature of society, in terms of **political developments** and **market forces**. In general, health care is based on **curative medicine** and the use of high-technology techniques. Much of this system has been privately run. By contrast, health care in many LICs is based on low-technology, preventative measures. Primary health care (PHC) is preventative rather than curative. The aims of PHC are low-cost health care, which promotes GOBIFFF, an acronym for:

- growth monitoring
- oral rehydration
- breast feeding
- immunizations
- food supplementation
- female education
- food fortification.

In theory, demand for health care should increase with more pregnant women, elderly and very young in a population, namely the vulnerable. It should also vary with the types of disease found and be available to those who need it most, but often this is not so.

Hart's inverse case law (1971) states that those who can afford it are those who least need it, whereas those who most need it cannot afford health care, and therefore do not get it. Moreover, health care

ATL Research skills

Choose any **two** of the countries where MSF has operations and find out why MSF is there, and what work the organization is doing there.

Have a look at an MSF annual review. Here is the link to the 2014 review (published in 2015): http://www.msf.org/sites/msf.org/files/msf_international_activity_report_2014_en.pdf.

For a video of the early years of MSF, visit http://www.msf.org.uk/founding-msf.

is increasingly beyond the reach of the poor in many countries as insurance schemes abound, medical salaries increase, and the cost of technological equipment continues to rise. Such a bias has arisen, in part, out of the **market orientation** of health care. Consequently health care is often inversely related to those in most need.

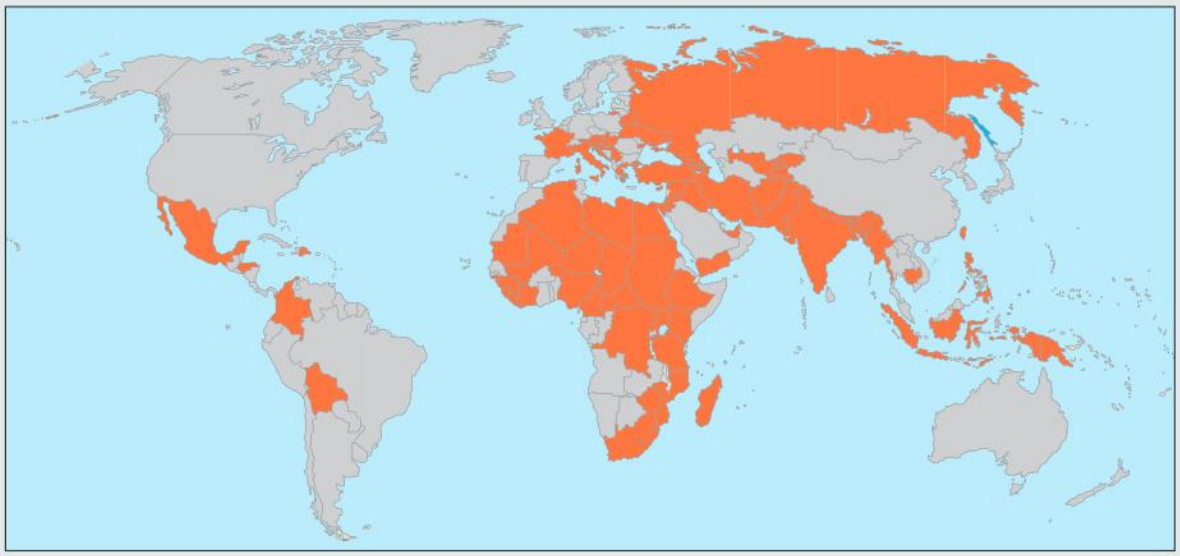
Case study

An NGO: Médecins Sans Frontières (Doctors Without Borders)

Médecins Sans Frontières (MSF) was founded in 1971 to provide emergency medical aid and as a new brand of humanitarianism independent of governments. MSF, which was awarded the Nobel Peace Prize in 1999, is a worldwide movement owned and run by its staff. In 2015 it provided medical aid in over 70 countries through more than 30,000, mostly local, doctors, nurses and other medical professionals, as well as logistical experts, water and sanitation engineers, and administrators. Private donors provide about 90 per cent of the organization's funding, while corporate donations provide the rest, giving MSF an annual budget of approximately $750 million.

Since 1979, MSF has been providing medical humanitarian assistance in Sudan. In March 2009, MSF employed 4,590 field staff there, tackling issues such as armed conflicts, epidemic diseases, health care and social exclusion. MSF's work in Sudan is one of the organization's largest interventions. MSF provides a range of health-care services including nutritional support, reproductive health care, counselling services and surgery to the people of Sudan.

In recent years MSF has also been involved in South Sudan, Yemen, Afghanistan, Haiti, Côte d'Ivoire (Ebola), Ukraine, Kenya and, for the first time, Europe. In 2016 it provided an emergency vaccination programme in Europe. Thousands of migrants were stranded and in desperate need, since Macedonia and other Balkan countries imposed strict border controls. The vaccinations were provided at Idomeni, a makeshift migrant camp on the Greece–Macedonia border.



▲ **Figure F.41:** Countries where MSF operates (shown in orange)

Case study (continued)

8,250,700
outpatient consultations

511,800
patients admitted

2,114,900
cases of malaria treated

217,900
severely malnourished children admitted to inpatient or outpatient feeding programmes

229,900
HIV patients registered under care at the end of 2014

218,400
patients on first-line antiretroviral treatment at the end of 2014

8,100
patients on second-line antiretroviral treatment at the end of 2014 (first-line treatment failure)

194,400
women delivered babies, including caesarean sections

81,700
major surgical interventions, including obstetric surgery, under general or spinal anaesthesia

11,200
patients medically treated for sexual violence

21,500
patients on tuberculosis first-line treatment

1,800
patients on MDR tuberculosis treatment, second-line drugs

185,700
individual mental health consultations

32,700
group counselling or mental health sessions

46,900
people treated for cholera

1,513,700
people vaccinated against measles in response to an outbreak

33,700
people treated for measles

75,100
people vaccinated against meningitis in response to an outbreak

7,400
people admitted to Ebola management centres in the three main West African countries, of which **4,700** were confirmed as having Ebola

2,200
people recovered from Ebola and discharged from management centres

▲ **Figure F.42:** MSF's activities, 2014

The impact of TNCs on food consumption

Throughout human history, traditional food systems and dietary patterns have been intrinsic to social, cultural and economic life, and to personal, community and national identity. However, the policies and practices of transnational companies (TNCs) are steadily displacing traditional food systems around the world. The term "big food" refers to the food and drink TNCs that increasingly control the production and distribution of ultra-processed food and drink throughout the world. The products are generally high in "refined" starches, sugars, fats and oils, preservatives and other additives. They are generally packaged as "fast foods" or "convenience foods".

Some processed foods, such as bread, have been part of the diet in many countries since before industrialization. Others, such as burgers, chips, sweets, biscuits, energy bars and energy drinks, have become popular since the 1970s. Since the 1980s, the transnational manufacture of packaged, long shelf-life snacks designed to replace meals – "big snacks" – has increased market share in HICs and, increasingly, LICs.

The main interest of a TNC and its shareholders is to make money. Their market penetration in HICs has largely plateaued, and TNCs have now developed "designer water" and "healthy drinks" to satisfy the demand for healthier diets in HICs. TNCs have increasingly looked to LICs to sell convenience foods, in countries such as China and India, where incomes are rising and many people are leaving rural areas for urban ones. The potential for food TNCs to achieve greater market share is therefore immense. The impact that this can have on nutrition, as well as on family life, remains to be seen.

Global value chains

Global value chain (GVC) analysis focuses on the role of "lead firms" in global industries (in this case global agri-food companies like Kraft, PepsiCo and McDonald's), and how they interact with local-level companies. GVC research has its foundation in world-system theory, which posits that countries are located in the core, periphery and semi-periphery of the global economy, with their position reflecting their potential to develop. World-system theory focuses on nation states, its fundamental principle being that power and trade relations are based on position in the global economy. GVC analysis embodies this core principle but shifts the focus to the powerful role of TNCs, which operate fluidly across borders.

Each stage of the food production system connects countries on a global scale, and these connections are driven by the practices of lead firms in developed countries. Within the global value chain are the global agri-business companies, food manufacturers, fast-food franchises and retailers. These segments of the chain are linked to each other at the global and local levels (Figure F.43).

Table F.10 gives some details about three major food TNCs that have a global impact.

Case study

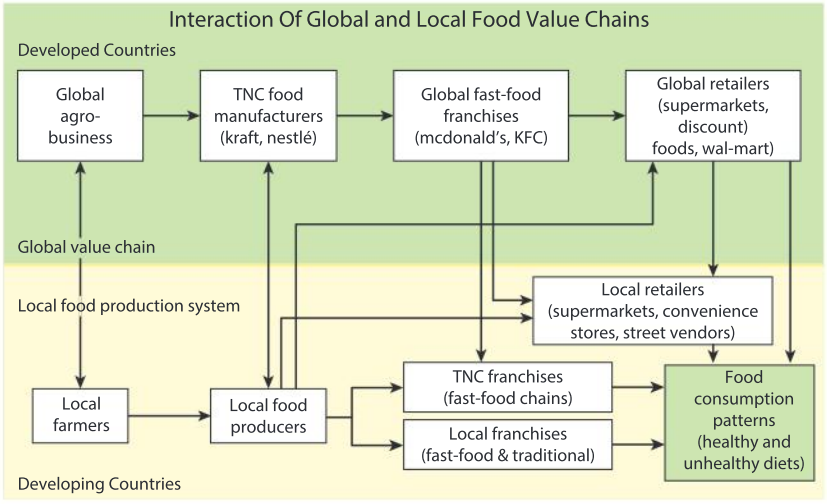
Changing dietary patterns in Brazil, an NIC

Traditionally, Brazil had a varied dietary pattern, showing the influence of native Amerindian populations, Portuguese, and African slaves and descendants. Rice, beans and cassava were common, with added oils, spices and herbs. The amount of meat and fish consumed depended on availability, price and income. Families would traditionally eat home-cooked meals together – but TV and Internet advertising, as well as changes in lifestyle (increasing urbanization, for example) have led to an increase in the consumption of convenience foods.

It would be simplistic to suggest that the traditional Brazilian diet was good whereas the modern one is bad. Salt was commonly used to preserve fish, but a high salt intake is related to high rates of hypertension and stroke. The traditional Brazilian diet is also high in sugar – the cheapest source of calories in Brazil. Nevertheless, food and drink TNCs are changing the diet in Brazil. In NICs and LICs, where the demand for convenience foods still has potential to rise, TNCs are marketing their products as best they can and there has been a huge increase in the availability of snack foods in Brazil.

▼ **Table F.10:** Selected global food TNCs

Company	Global sales	Employees	Main brands	No. of countries
Yum!	$13 billion	505,000	KFC, Taco Bell, Pizza Hut	Worldwide
McDonald's	$25.4 billion	420,000	McDonald's restaurants	119
PepsiCo	$63 billion	263,000	Pepsi, Frito-Lay, Tropicana	Worldwide



▲ **Figure F.43:** The interaction of global and local food value chains
Source: http://www.cggc.duke.edu/pdfs/GlobalHealth/Gereffi_Christian_TradeTNC_FoodConsumption_23Feb2009.pdf

For each of these companies, international sales are close to or over 40 per cent of their total sales. Each company adapts its products or its marketing to local preferences. For example, in 2000 McDonald's introduced salads, low-fat desserts, a wider range of fish and chicken dishes, and more regional dishes (that is, glocalization – the adaptation of a global product to a local market). In 2004 it discontinued the super-size option. In 2006, it began to put nutritional information on their packaging with icons for fat, protein, calories, carbohydrates and salt.

PepsiCo has two core brands – Pepsi Cola in the soft-drinks brand and Frito-Lay in the packaged fast-food industry. PepsiCo also adopted glocalization. In order to penetrate emerging markets, PepsiCo adapts its products to local tastes: Frito-Lay in Mexico sells chips (potato crisps) with chilli flavours, while Frito-Lay in China sells crab- or duck-flavoured chips. By using local suppliers, PepsiCo appeals to consumers' nationalist sentiments while also impacting local food-production systems. Sabritas in Mexico and Yazhou in China are both popular brands sold by PepsiCo with regional-sounding names. In 2004, PepsiCo launched its "Smart Spot" marketing campaign, which included the labelling of "healthy products" and exercise campaigns to promote a healthier lifestyle.

TNCs will often use the "five Ps" of marketing: price, packaging, product, promotion and public relations. For example, when Kraft Foods introduced Oreos in China, it was not a success. After research into local taste preferences, Kraft realized that the Chinese preferred smaller, less sweet biscuits, with fruit-flavoured cream. When Kraft introduced these in 2007, they were an instant success. There was also an extensive TV campaign and a grassroots campaign – Kraft paid students to cycle around Beijing, on bicycles decorated with Oreo wheel covers, distributing thousands of Oreos to passers-by. It also distributed them at popular sporting events. Oreo became the most popular biscuit, with 13 per cent of market share.

Gender, food security and nutrition

In developing countries, rural women and men play different roles in guaranteeing food security in their household and communities. While men grow mainly field crops, women are usually responsible for growing

and preparing most of the food and rearing small livestock, which provides protein. Rural women also carry out most food processing, which ensures a diverse diet, minimizes losses and can provide marketable products. Women represent about half the food-producing workforce in South East Asia and sub-Saharan Africa, but often as unpaid workers involved in subsistence farming.

▲ **Photo F.9:** Women working in a flooded field
Source: *The Guardian*

Inequality and discrimination against women

According to estimates, women and girls make up 60 per cent of the world's chronically hungry. Women face discrimination both in education and employment opportunities and within households, where their bargaining power is lower than men's. Women also face discrimination in access to land, training, technologies, finance and other services. Achieving gender equality is described as being instrumental in ending malnutrition. This is because women tend to be responsible for food preparation and childcare within the family and are more likely to spend their income on food and their children's needs. Research has shown that a child's chances of survival increase by 20 per cent when the mother controls the household budget. Women thus play a decisive role in future food security, dietary diversity and children's health.

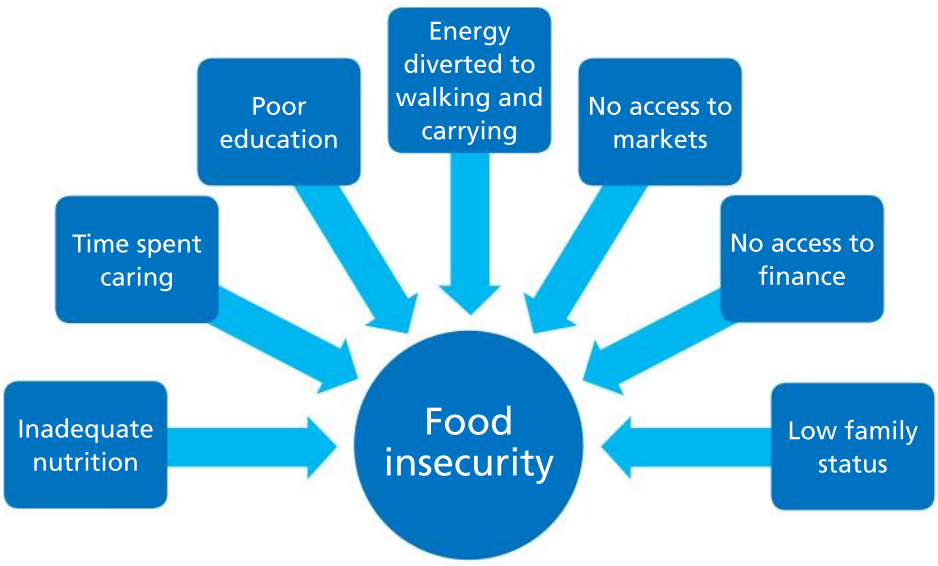
Gender and food production in the developing world

The positive impact of closing the gender gap in agricultural production cannot be overstated:

1. Studies suggest that if women had the same access to productive resources as men, they would increase yields by 20 to 30 per cent, raising overall agricultural production in developing countries by 2.5 to 4 per cent.
2. Women's access to education is a determining factor in levels of nutrition. Studies from Africa show that children of mothers who have spent five years in education are 40 per cent more likely to live beyond the age of 5.
3. Good nutrition and health depend on the safety of the food consumed. Contamination can lead to diarrhoea, a major cause of illness and death in children. Training women in hygiene and sanitation brings an immediate improvement in household health. Malnutrition in young children results from lack of dietary knowledge and leads to wasting and stunted growth.

Activity 18

Identify the positive and negative factors affecting women's role in food production from the seven points listed here.



▲ **Figure F.44:** Factors affecting food insecurity

4. Access to land and land ownership for women is very limited in most parts of the developing world. This means that they have little control over their land and the size of their holding is only large enough for subsistence farming.
5. A woman's time is spent fetching water, cooking, washing, cleaning and tending to the needs of children and livestock. For example, in Ghana and Tanzania, 77 per cent of their energy is expended on load-carrying activities involving wood, grain and water. Diseases such as HIV/AIDS in the family mean that women have to assume a greater caretaking role, leaving them less time and energy to grow and prepare food.
6. Access to most financial services such as credit and insurance is only available to men in rural areas. This greatly limits food security and farming innovation for women.
7. Women tend to be engaged in the production of traditional subsistence crops of inferior quality and are often denied the opportunity to sell their produce at the market and engage in the cash economy. They are also limited by lack of time and poor access through limited transport.

Activity 19

1. Briefly explain how gender inequality affects: (a) women's nutritional health, and (b) the survival of infants.
2. Design a diagram similar to Figure F.44, but identify the factors (either existing or planned) leading to improved food security in the future.

Female carers

Despite the fact that many women have joined the workforce in recent decades, their continued tasks in the domestic sphere mean that they increasingly confront a "double burden" of paid and unpaid work. Domestic roles include bearing and rearing children, and caring for other dependents such as the elderly, as well as day-to-day maintenance of the household. It has been noted that, even in HICs, gender equality has proceeded at a faster pace outside the domestic sphere than within it.

Women in developing countries continue to be the prime carers of children and the use of childcare facilities outside the family is limited. Moreover, having fewer children does not necessarily reduce women's caring role. Women's roles have expanded rather than changed.

The growth of an ageing population is one of the main characteristics of demographic change, not only in HICs but in newly industrialized countries (NICs) and, increasingly, LICs. In terms of absolute numbers, most elderly people live in LICs, and this majority is set to increase. Moreover, the pace at which populations are ageing is much more rapid in LICs and NICs than in HICs.

▲ **Figure F.45:** The savings made by the Irish government due to family carers

Ageing in LICs and NICs is occurring in contexts where the household continues to provide the bulk of financial, physical and emotional support for aged and infirm dependents. The impact of the growth of elderly dependents falls disproportionately on women, particularly wives and daughters-in-law. The trend towards delayed childbearing may mean that the care required by old or frail dependents

increasingly coincides with that demanded by children: what has been termed "the sandwich" generation is stuck in the middle of caring for both their own children and their own parents. In China, for example, children are legally bound to look after their parents. As a result of the one-child policy, two one-child children who marry could end up caring for five people, that is, their four parents and their one child. Rural-to-urban migration of family members may compound the effects of fertility decline and further diminish the number of people with whom caregiving responsibilities may be shared.

▲ **Figure F.46:** Some potential impacts on carers

Female carers in the USA

In the USA, up to two-thirds of older people with long-term care needs rely exclusively on family and friends to provide assistance. An estimated 66 per cent of caregivers are female, and the value of the informal care that they provide ranges from $148 billion to $188 billion annually. While women are the major providers of long-term care in the USA, they also have long-term care needs of their own. Women live longer than men, tend to outlive their spouses, and have less access to retirement savings such as pensions.

One national study on female caregivers highlighted the conflicting demands of work and caring for older relatives. The study found that:

- 33 per cent of working women reduced their work hours
- 29 per cent passed up a job promotion, training or assignment
- 22 per cent took a leave of absence
- 20 per cent switched from full-time to part-time employment
- 16 per cent quit their jobs
- 13 per cent retired early.

Women caregivers are likely to spend an average of 12 years out of the workforce raising children and caring for an older relative or friend. They are significantly less likely to receive a pension and, when they do, the pension is about half the amount that men receive. Moreover, the toll that caregiving takes is not just financial: higher levels of depression, anxiety and other mental health challenges are common among women caring for an older relative or friend.

TOK

To what extent should the state look after the elderly, or should the costs be borne by the family of the elderly?

ATL Communication skills

For an Institute of Development Studies animation on the toll of unpaid work on women, visit https://www.youtube.com/watch?v=VVW858gQHoE.

Comment on the message that you have seen.

Factors affecting the severity of famine

Famine refers to a long-term decline in the availability of food in a region. There are a number of interrelated factors affecting a famine's severity, including:

- the length and severity of drought – the longer and more severe the drought, the greater the impact of famine
- governance – where there is poor governance, populations are not protected and the risk of food scarcity increases
- the power of the media – the media has great power in bringing to the attention of the public the impacts of hazards, and the ability to raise funds for disaster relief

- access to international aid – aid needs to be directed to those who need it
- population growth – rapid population growth, particularly as a result of refugees and internationally displaced people (IDPs), increases the impact of famine in an area
- unemployment and entitlement to food – people unable to pay for food are just as vulnerable to famine as those who cannot grow food
- civil unrest, including war – this disrupts food production, food supply and decreases the number of young workers, thereby increasing the impacts of famine
- access to land and production of food.

Emergency aid can help those suffering the effects of famine in the short term, but long-term plans need to be put in place to mitigate the effects. Food assistance interventions must be designed to empower poor people to build productive assets such as water-harvesting tanks, dams and irrigation projects. Foreign companies should not be permitted to grow crops for export only.

ATL Research skills

For a programme about land grabs in Ethiopia, go to http://www.aljazeera.com/programmes/peopleandpower/2014/01/ethiopia-land-sale-20141289498158575.html.

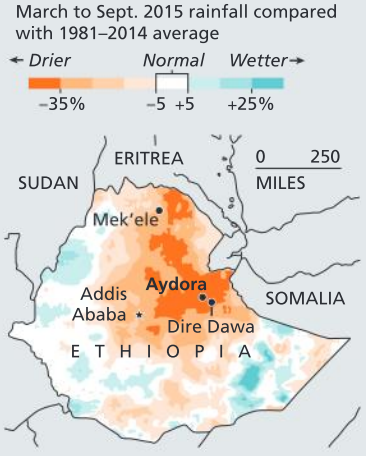
Case study

Famine in Ethiopia

Ethiopia has been plagued by famines since the 16th century. In recent times, famine struck the country in 1973 (40,000 starved in the north-east and around 55,000 died in the Ogaden region) and between 1983 and 1985, when areas of northern Ethiopia and Eritrea were affected in what is regarded as the country's worst famine in a century. Estimates of the number of deaths ranged from 400,000 to one million people. Millions of others were made destitute. The 1983–5 famine was widely reported in the media and received much publicity. It also led to the Band Aid and Live Aid concerts.

In 2015, the seasonal rains that usually fall between June and September in north-eastern, central and southern Ethiopia did not arrive. According to the UN, this was Ethiopia's worst drought in 30 years. Around 90 per cent of cereal production is harvested in autumn, after the summer long rainy season, and the rest at the end of spring after the end of the short rainy season.

These days, early-warning systems (Figure F.47) alert the government when famine threatens, and in 2015 the government was able to respond more quickly to the crisis than in 1983–5. There is evidence that in 2015–16 the Ethiopian government made provision to mitigate the impact of poor harvests, such as establishing a social security net so that poorer farmers can access funds for public works such as digging water holes. The Ethiopian government pledged $192 million for emergency food and other assistance, diverting money from projects such as road construction. The "international community" promised a further $163 million. Aid agencies suggested that $600 million was needed.



▲ **Figure F.47:** Famine early warning system: drought conditions in Ethiopia, March–September 2015

The drought was caused by the El Niño weather system, and resulted in a 90 per cent reduction in crop yields. (See pages 56–58 for a discussion of El Niño.) The famine, though, was brought about by factors including poor governance and state neglect. The key factors driving the famine,

Case study (continued)

then and now, include the selling off of land to international corporations for industrial farming – that is, "land grabs". Another criticism was that in 1983–5 much food relief was channelled towards the military. A further factor was the large number of refugees in Ethiopia: more than 650,000 refugees from Somalia, South Sudan, Sudan and Eritrea are in Ethiopia, and this places a large burden on water and land resources.

At first, some in the Ethiopian government claimed the country could handle the drought itself. In December, they said about 10.2 million people were in need of $1.4 billion in aid, with 400,000 children severely malnourished. This is in addition to 8 million people supported by the government safety net even before the drought. To date, less than 50 per cent of the appeal has been met, and the worst could be yet to come. In 2015–16 international donors were distracted by a string of humanitarian disasters around the world, such as in Syria and South Sudan. This meant that there was much less media coverage, and so less publicity compared with 1983–5. Events in Syria were more dramatic than the failure of the rains, although the failure of the rains probably caused more deaths.

Nevertheless, a number of organizations are working in Ethiopia, including the World Food Programme (WFP), Save the Children and the FAO. The WFP is helping to feed the refugees and also supporting the government's second five-year Growth and Transformation Plan (GTP), a school meals programme and a vulnerability and mapping unit (VAM). Save the Children Ethiopia reported substantial livestock losses in the Afar region. It had also mobilized $100 million, while the FAO announced a $50 million plan to assist agriculture- and livestock-dependent households.

Concepts in context

There are a number of stakeholders in food production and health-care provision. They vary in terms of **power** and range – from NGOs such as the FAO and the WHO to large TNCs such as Monsanto, national governments and members of a household/family. TNCs may influence consumption through advertising, sponsorship and marketing.

There are also important variations in the production of food by scale – ranging from type of country (HIC versus LIC) to individuals, with notable variations by gender. Women are very important providers of food and the main providers of health care.

Famines are associated with restricted access to food and increased mortality, and may be caused by a complex range of physical and human factors.

Check your understanding

1. Outline the main function of the FAO.
2. Comment on the main results of farm subsidies in the EU.
3. Define the term "agribusiness".
4. State three advantages and three disadvantages of TNC involvement in agriculture to the small farmer.
5. Briefly explain how TNCs have influenced national nutrition.
6. Describe the factors affecting food consumption.
7. Explain how food insecurity might be linked to the issue of gender.
8. Explain the main causes of Ethiopia's famines.
9. Suggest ways in which the media has influenced the responses to food crises?
10. To what extent is international aid helpful in the event of a famine?

4 Future health and food security and sustainability

Conceptual understanding

Key question

What are the future **possibilities** for sustainable agriculture and improved health?

Key content

- Possible solutions to food insecurity, including waste reduction, and attempts to tackle food insecurity.
- Advantages and disadvantages of contemporary approaches to food production, including genetically modified organisms (GMOs), vertical farming and *in vitro* meat.
- The merits of prevention and treatment in managing disease, including social marginalization issues, government priorities, means of infection and scientific intervention.
- Managing pandemics, including the epidemiology of the disease, prior local and global awareness, international action and the role of the media, and lessons learned for pandemic management in the future.

Common mistake

✗ Many students confuse free trade with fair trade.

✓ Free trade allows any country to trade with any other country. It benefits countries whose agriculture is heavily subsidized (often HICs) and therefore has a negative effect on LICs. In contrast, fair trade ensures that farmers are given a fair price and that farming conditions are good for the farmers and their families. It provides more benefits to LICs.

Possible solutions to food insecurity

There are a number of possibilities for reducing food insecurity. These include short-term, medium-term and long-term measures.

Short-term measures

- Increasing production and reducing set-aside: high market prices encourage more food production.
- Food aid: the World Food Programme (WFP) reaches only about 80 million of the most desperate people, mostly refugees from conflicts and natural disasters. There are 700 million more chronically hungry people scattered around the world.
- Seeds and fertilizer: as well as needing food to survive, the rural poor urgently need help planting next season's crops if there is to be an end to the food crisis. Millions have been forced to eat next season's seeds to survive, and the price of fertilizer (largely dependent on oil) has risen sixfold in some regions over the course of a year.
- Export bans: export bans drive prices higher and increase market variability.

Medium-term measures

- Free trade: trade liberalization, reducing farm subsidies in the USA and undoing some of the protectionism of the EU's Common Agricultural Policy should help poor farmers in the future, but the direct impact could be to increase food prices in the developing world, as producers focus on western markets.
- Biofuels: the food crisis has triggered a backlash against plant-derived fuels, which were originally hailed as an answer to global warming. With over 40 per cent of American maize being used to make ethanol, there is clearly a clash of interests.

Long-term measures

- Agricultural investment: experts believe yields in Africa can be increased up to fourfold with the right help – only 4 per cent of African agriculture is irrigated, compared with 40 per cent in Asia. The average Asian farmer uses 110 kg of fertilizer a year whereas the average African uses just 4 kg. At least a third of the crops in an average African season are lost after the harvest, largely because farmers cannot get them to markets on time.

- GM crops: agriculture experts at the UN and in developing countries do not expect GM crops on their own to radically improve yields. The main trouble, they argue, is that almost all the research has been devoted to developing crops for rich countries in the northern hemisphere.
- Sustainability: campaigners argue that the world cannot feed its population if China, India and other emerging economies want to eat like people in the West. The only long-term solution, they argue, is rethinking western lifestyles and expectations.

Case study

Addressing food insecurity in Bangladesh

Food insecurity in Bangladesh is affected by international trade, land scarcity, the need to increase production of nutritional food, natural hazards and climate change. Food security remains an issue at national, household and individual levels. Bangladesh has made significant progress in improving food security by increasing production of rice using irrigation water and high-yielding varieties. Increased emphasis on rice has necessitated increased imports of other foods. The government has also invested in storage facilities for rice, and cold-storage facilities for meat, fish, eggs and potatoes. Transport infrastructure has also been upgraded to enable faster and better distribution of food, including imports.

Bangladesh is now self-sufficient in rice, eggs, potatoes, vegetables, meat and fish. It is least self-sufficient in wheat, sugar and pulses. Food insecurity has declined considerably since the 1970s, although nearly 50 million people are still said to be food insecure, 26 million of whom are said to be extremely food insecure. Many of these are rural dwellers who are vulnerable to the annual monsoon floods.

Food waste

In HICs, consumerism, excess wealth and mass marketing lead to wastage. Approximately one-third of food is thrown away in the UK each year. In LICs, up to 80 per cent may be wasted before it reaches the market/shops. More efficient farming practices and better transport, storage and processing facilities ensure that a larger proportion of the food produced reaches markets and consumers. However, produce is often wasted through retail and customer behaviour. Major supermarkets, in meeting consumer expectations, often reject entire crops of perfectly edible fruit and vegetables at the farm because they do not meet exacting marketing standards for their physical characteristics, such as size and appearance. Globally, retailers generate 1.6 million tonnes of food waste annually in this way.

Overall, wastage rates for vegetables and fruit are considerably higher than for grains. In the UK, a recently published study has shown that, of the potato crop, 46 per cent is not delivered to the retail market. The details revealed that 6 per cent is lost in the field, 12 per cent is discarded on initial sorting, 5 per cent is lost in store, 1 per cent is lost in post-storage inspection, and 22 per cent is rejected after washing. A similar survey in India showed that at least 40 per cent of all its fruit and

Activity 20

Outline the ways in which the Bangladesh government has attempted to improve food security.

ATL Research skills

Using the Internet and/or other resources, suggest why achieving food security in Bangladesh may prove difficult.

ATL Thinking and communication skills

Think about ways in which you can reduce food waste. Discuss ideas within your class. Ideas for cutting food waste could include the following:

- planning your meals
- eating less-than-perfect looking fruit and vegetables
- eating local, in-season food
- cutting back on dairy and red meat – fruit, vegetables, fish and poultry have one-third the footprint of red meat and half that of dairy
- planning shopping trips and buying only what you need
- recycling packaging and composting organic scraps.

vegetables is lost between grower and consumer because of the lack of refrigerated transport, poor roads and poor weather.

Most of the waste is generated at the consumer stage. Estimates show that the value of the food that goes to waste amounts to approximately $250 billion globally. In LICs wastage tends to occur primarily at the farmer–producer end of the supply chain. Inefficient harvesting, inadequate local transportation and poor infrastructure mean that produce is frequently handled inappropriately and stored under unsuitable conditions. As a result, mould and pests (for example, rodents) destroy or at least degrade large quantities of food material. Substantial amounts of foodstuffs simply spill from badly maintained vehicles or are bruised as vehicles travel over poorly maintained roads. As the development level of a country increases, the food-loss problem generally moves further up the supply chain, with deficiencies in regional and national infrastructure having the largest impact. In South East Asian countries, for example, losses of rice range from 37 per cent to 80 per cent of the entire production, depending on development stage. The total loss is about 180 million tonnes annually.

Contemporary approaches to food production

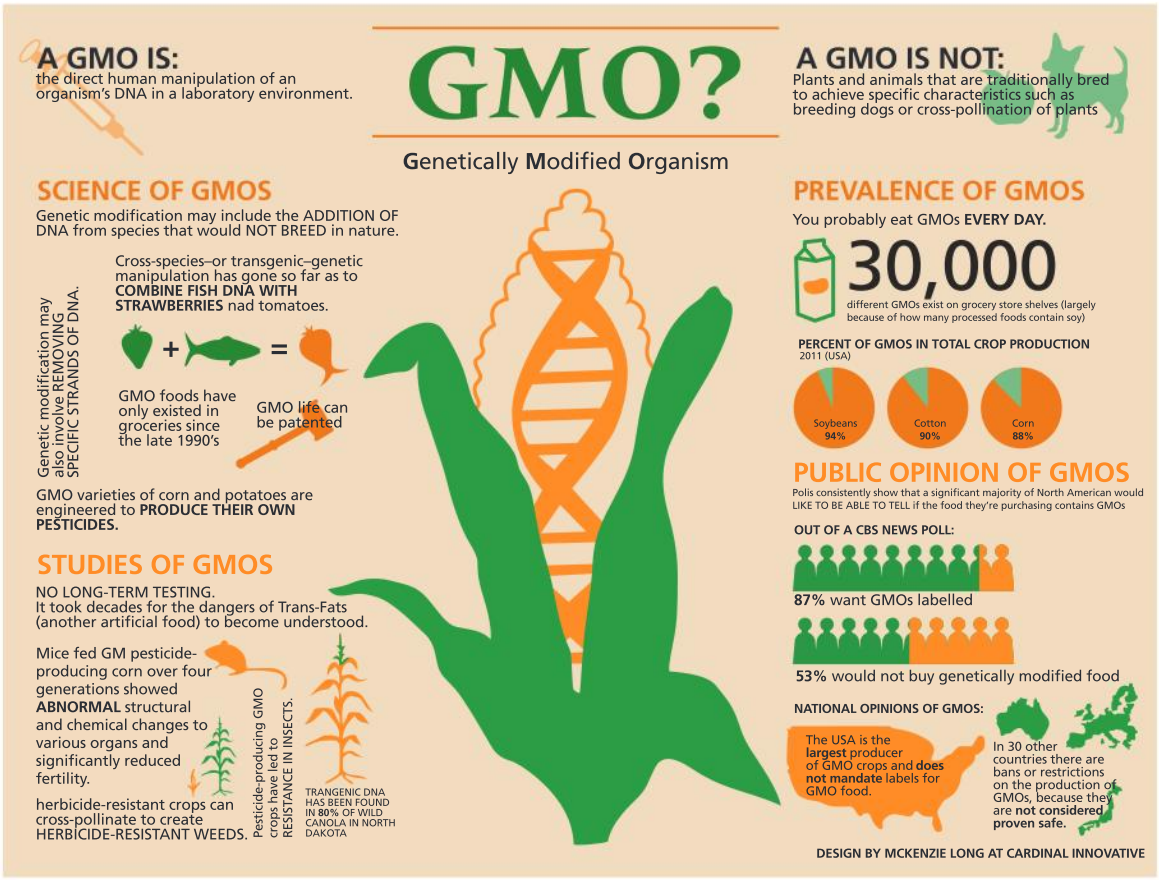
Genetically modified food

According to the National Academies of Sciences, Engineering and Medicine, genetically modified food is safe for human consumption. There is no conclusive evidence that it poses a risk to wildlife. GM technology has helped farmers to increase yields by protecting crops against pests and weeds.

Genetic engineering involves adding traits to a plant to make it more nutritious or more resistant to disease or pesticides. In 2015, a trial in the UK showed that Camelina, an oilseed plant, could be genetically modified to reproduce the nutrients in oily fish that are thought to protect against heart disease and help infant brain development.

The US Department of Agriculture has shown how genetically modified crops have taken over American farms since 2005. More than 93 per cent of corn, soy and cotton in the US is now genetically modified. In 2014, GMO crops made up 94 per cent of US soya bean acreage, 93 per cent of all corn planted, and 96 per cent of all cotton. Some 95 per cent of sugar beet in the United States is now genetically engineered to be herbicide-tolerant. Herbicide tolerance and insect tolerance are the most popular traits. Although herbicide tolerance technology does not appear to boost crop yields significantly or increase profitability, it does seem to save time and make weed management easier. The use of more herbicides raises the risk of creating herbicide-resistant weeds and may lead to the decline of some species, such as the monarch butterfly.

Globally, GMOs were planted on 175 million hectares in 2013 – or roughly 12 per cent of global farmland. GM crops are now planted in 27 countries. However, the vast majority of GM crops are grown in just five countries: the USA, Argentina, Brazil, Canada and India. Moreover, growth seems to be slowing – one reason is saturation – virtually all the corn, soya and cotton in the USA is now genetically engineered.



▲ **Figure F.48:** Genetically modified food
Source: http://visual.ly/gmo-genetically-modified-organism

Vertical farming

By 2050 the world's population will be over 9 billion and food production will need to increase by 70 per cent. Proponents of vertical farming see it as a way to feed this increasing population that is urbanizing rapidly. Vertical farms aim to grow year-round in high-rise urban buildings, reducing the need for the carbon-emitting transport of fruit and vegetables.

It could make food supplies more secure as well, because production can continue even in extreme weather. And as long as farmers are careful to protect their indoor "fields" from pests, vertical farming needs no herbicides or insecticides.

Following the nuclear accident in Fukushima, in 2011, Japan is leading innovation in vertical farming because much of the region's irradiated farmland can no longer be used. The plant racks in a vertical farm can be fed nutrients by water-conserving, soil-free hydroponic systems and are lit by LEDs that mimic sunlight. Control software can rotate racks of plants so each gets the same amount of light, and direct water pumps to ensure that nutrients are evenly distributed. Vertical farms are designed to recycle water, and they use 98 per cent less water per item of produce than traditional farming. Most vertical farms rely on natural light as much as possible. However, the electricity bills can add up quickly.

▲ **Photo F.10:** Vertical farming in Singapore

ATL Research and communication skills

Use this website to make a case for vertical farming: http://ifonlysingaporeans.blogspot.co.uk/2012/10/first-vertical-farm-to-boost-supply-of.html.

Write a report and make a presentation to the class about the potential benefits of vertical farming.

ATL Research and communication skills

Organize a class debate on the topic "New developments in farming have unknown ethical, environmental and socio-economic consequences".

ATL Research skills

View https://www.youtube.com/watch?v=hjd5DaxkLhQ for a short programme on robotics in agriculture.

The glasshouse industry has more than a century's experience of growing crops indoors in large quantities. It is now possible to tailor the temperature, humidity, lighting, airflow and nutrient conditions to get the best productivity out of plants year round, anywhere in the world. For example, in Antarctica the South Pole Food Growth Chamber, in operation since 2004, is a semi-automated hydroponic facility that provides each of the 65 staff of the Amundsen-Scott South Pole Station with at least one fresh salad a day during the winter months, when supply flights to the station are extremely limited.

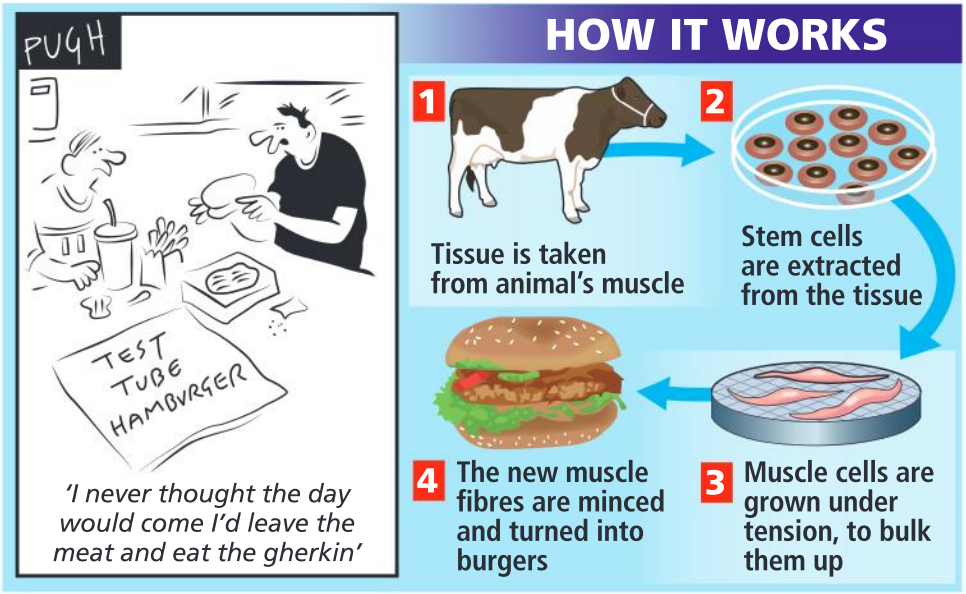
In vitro meat

In 1931, Winston Churchill is alleged to have said, "We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium."

In vitro meat, also known as cultured meat or synthetic meat, is a meat product that has never been part of a living animal. In November 2009, scientists from the Netherlands announced that they had managed to grow meat in the laboratory using the cells from a live pig. On 5 August 2013, the world's first lab-grown burger was cooked and eaten at a news conference in London. It cost €250,000 to produce.

It has been claimed that, conditions being ideal, two months of *in vitro* meat production could deliver up to 50,000 tonnes of meat from 10 pork muscle cells. Omega-3 fatty acids could be added to *in vitro* meat as a health bonus. However, difficulties of scale and cost need to be overcome before *in vitro* meat becomes commercially available.

Cultured meat has significantly fewer environmental impacts than normally slaughtered beef. For every hectare used for *in vitro* meat manufacturing, anywhere between 10 and 20 hectares of land may be converted from conventional agriculture usage back into its natural state. In theory, *in vitro* meat is potentially much more efficient and environmentally friendly, generating only 4 per cent greenhouse gas emissions, reducing the energy needs of meat generation by up to 45 per cent, and requiring only 2 per cent of the land that the global meat/livestock industry does. In contrast, cattle farming is responsible for 18 per cent of greenhouse gases. Along with vertical farming, *in vitro* meat could eliminate the need to create extra farmland in rural areas.



▲ **Figure F.49:** *In vitro* meat

The prevention and treatment of disease

Preventative treatment means adopting policies and lifestyles that will reduce the risk of disease. This may range from people having a healthy diet to not smoking or drinking to excess to reduce the risk of cancer, heart attacks and strokes. However, many people fail to change their lifestyle until something serious happens to their health. Thus, curative treatment is required to treat cancers, heart disease and stroke. This is much more expensive that preventative health care and may involve lengthy hospitalization.

Many of the world's poor are at increased risk of disease. Many lack information, money or access to health facilities for adequate health care. The poor may be socially marginalized, and may have to make difficult choices. In addition, they may have to care for relatives in their own homes rather than make use of hospital facilities.

In many cases, primary health care is available for poor communities whereas curative hospitalized care is available for wealthier individuals (see national governments on page 310). Some of this hospital care is private but much of it is public. Government funding may need to change in order to redress the rich–poor imbalance. Critics would argue that investment in clean water and sanitation would have a greater impact on health among poor communities than health care, as most of the diseases are those of poverty. Scientific, curative medicine is more suited to degenerative diseases.

Pandemics are global epidemics. Their large scale makes them difficult to manage and they may also involve new diseases, or relatively unknown diseases, such as Ebola and the Zika virus. If the disease is new, there may not be any recognized vaccinations. Even for well-established diseases, there is a risk of the disease spreading rapidly due to the frequency and volume of people moving between countries, and the ability of some vectors to spread between countries.

It is likely that the spread of diseases due to lifestyle will increase as more of the world's countries enjoy a higher standard of living.

TOK

Artificial meat stops cruelty to animals, is better for the environment, and it could be safer and more efficient, and even healthier. Animal welfare groups are generally in favour of the production of *in vitro* meat because it does not have a nervous system and therefore cannot feel pain.

Is *in vitro* meat less objectionable than traditionally obtained meat – as it does not involve killing and reduces the risk of animal cruelty – or is it unnatural and are scientists interfering with nature?

Case study

The diabetes pandemic

The number of people worldwide with diabetes is around 422 million, a figure likely to double in the next 20 years. Diabetes affects people of all ages and races; in 1980, 4.7 per cent of adults were affected; in 2014 it was 8.5 per cent. Diabetes is a chronic, lifelong condition and a major cause of blindness, kidney failure, heart attacks, stroke and lower limb amputation. The disease reduces both a person's quality of life and life expectancy.

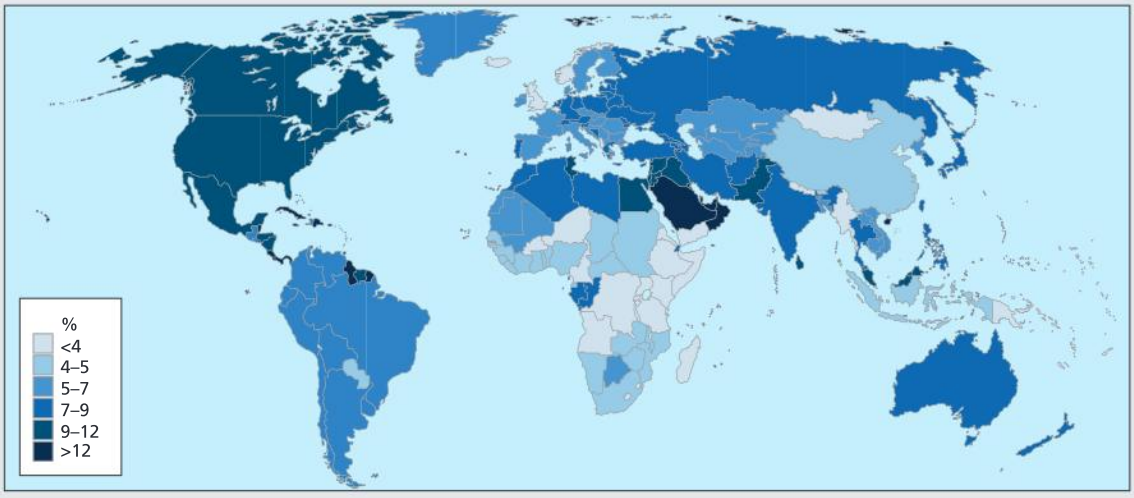
In 2012 1.5 million people died as a result of having the disease. The death rate of men with diabetes is 1.9 times the rate for men without diabetes, and the rate for women with diabetes is 2.6 times that for women without diabetes.

There are three types of diabetes.

Type I occurs when the pancreas produces insufficient insulin. It requires daily administration of insulin by injection. The cause is unknown but it may be genetic.

Type II, the most common type, is non-insulin-dependent and results from the body's ineffective use of insulin.

Case study (continued)



▲ **Figure F.50:** The distribution of Type I and Type II diabetes in 2014

Type III is found in some women who become diabetic during pregnancy; their children are at increased risk of developing type II in early adulthood.

The illness

Normally, the hormone insulin controls blood sugar levels, so lack of insulin in the blood leads to hyperglycemia (high blood sugar). If diabetes is not well managed, over time this can damage blood vessels and may lead to the conditions listed above, reducing quality of life and causing permanent disability.

Hypoglycemia (a "hypo") is low blood sugar – the opposite of hyperglycemia – and symptoms include sweating, tremors and confusion. A hypo can happen if a diabetic eats less carbohydrate than usual or takes strenuous exercise, so that their insulin levels become too high causing a drop in blood sugar to below normal levels. To remedy the situation, the patient must take glucose, either orally or by injection. Recovery is usually quick and the patient remembers nothing of the event. If the blood sugar level is very low the patient may become unconscious and in extreme circumstances may die.

Treatment and care

Some problems with diabetic care can be solved without great expenditure and these solutions are suitable for LICs. They include blood sugar control, blood pressure control, foot care and preconception care for women. More sophisticated types of care, found in HICs where funding is greater, include the drug metformin for those needing to boost their own insulin supply, annual eye examinations and cholesterol control. Insulin can be supplied to those requiring it.

Sophisticated treatments are ineffective without lifestyle changes and good self-management of the condition. Daily blood testing is an essential requirement. Regular blood sugar monitoring is standard practice in HICs. It records the readings over several months, which can be used to track the status of the disease.

Risk factors for diabetes (causes)

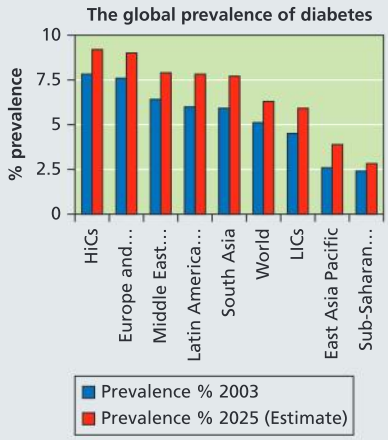
The causes of type I are unknown and it is not possible to prevent it, but it is possible to reduce to risk of developing type II by making lifestyle changes.

Environmental factors that can lead to type II include the following:

- Obesity – The strongest and most consistent risk factors for diabetes and insulin resistance among different populations are obesity and weight gain: for each unit increase in body mass index, the risk of diabetes increases by 12 per cent. The distribution of fat around the trunk region, or central obesity, is also a strong risk factor.
- Physical inactivity – A sedentary lifestyle and physical inactivity are also associated with increased risks of developing diabetes.

Case study (continued)

- Diet – Some studies report a positive relationship between dietary fat and diabetes, but specific types of fats and carbohydrates may be more important than total fat or carbohydrate intake. Saturated fats and trans fatty acids may increase the risk of diabetes, as may sugar-sweetened beverages. Conversely, high intakes of dietary fibre and of vegetables may reduce the risk.



▲ **Figure F.51:** The global prevalence of diabetes

- Increased affluence – The adoption of western lifestyles has been associated with an increase in the prevalence of diabetes in many indigenous populations.

The economic burden of diabetes

Diabetes imposes large economic burdens on national health care systems and affects national economies, families and individuals. Direct medical costs include resources used to treat the disease. Indirect costs include lost productivity caused by morbidity, disability and premature mortality. Intangible costs are the reduced quality of life for people with diabetes brought about by stress, pain and anxiety.

Preventing type II diabetes

Four major trials – in China, Finland, Sweden and the USA – have demonstrated that intensive lifestyle interventions involving changes to diet and physical activity can delay or prevent type II diabetes among people at high risk. The results of the trials showed a reduced incidence of diabetes of 58 per cent.

ATL Research skills

1. Track the spread of a disease epidemic and examine the role of the media in raising awareness.
2. Choose one national newspaper and record the frequency, length and focus of all reports tracking the international diffusion of an infectious disease.
3. Using the FAO website, select one country and record its attempts to tackle food insecurity.

To manage pandemics there must be a coordinated effort among global communities. For example, following the outbreak of Ebola in West Africa, the Nigerian government established a massive public health campaign. Containment was the key to ending Ebola. Everyone who had been exposed to the virus was found and monitored, and isolated if they developed the symptoms. Nigeria set up a centralized emergency operations centre, staffed with public health experts who had earlier worked on a polio eradication programme. TV broadcasts and social media were used to reassure people. In Sierra Leone, gatherings were banned. Markets and schools were closed, and school lessons were given over the radio. Although Ebola had the potential to become a pandemic it did not due to the speedy response of health officials not only in West Africa but in other countries such as the USA, UK, Spain and Italy.

Activity 21

1. Describe the pattern of diabetic prevalence shown in Figure F.50.
2. To what extent is it influenced by economic factors?
3. Referring to Figure F.50, identify the world regions that in 2013 had a higher diabetic prevalence than the world average.
4. Referring to Figure F.50, identify the regions that will experience the fastest rate of increase in diabetic prevalence between 2013 and 2025.
5. Suggest reasons for the large increase in some regions and the smaller increase in others.

Concepts in context

There are a number of **possibilities** for the future of food security and the provision of health care. Possibilities for producing more food include intensification, extensification, genetically modified organisms, vertical farming, and *in vitro* farming. However, issues such as cost and ethical considerations may limit some of these possibilities. Approaches to disease treatment include preventative methods, such as primary health care. In addition, there are global programmes to tackle malaria and AIDS. These are costly, but illustrate the point that the technology exists to find solutions as long as rich companies help out poorer ones.

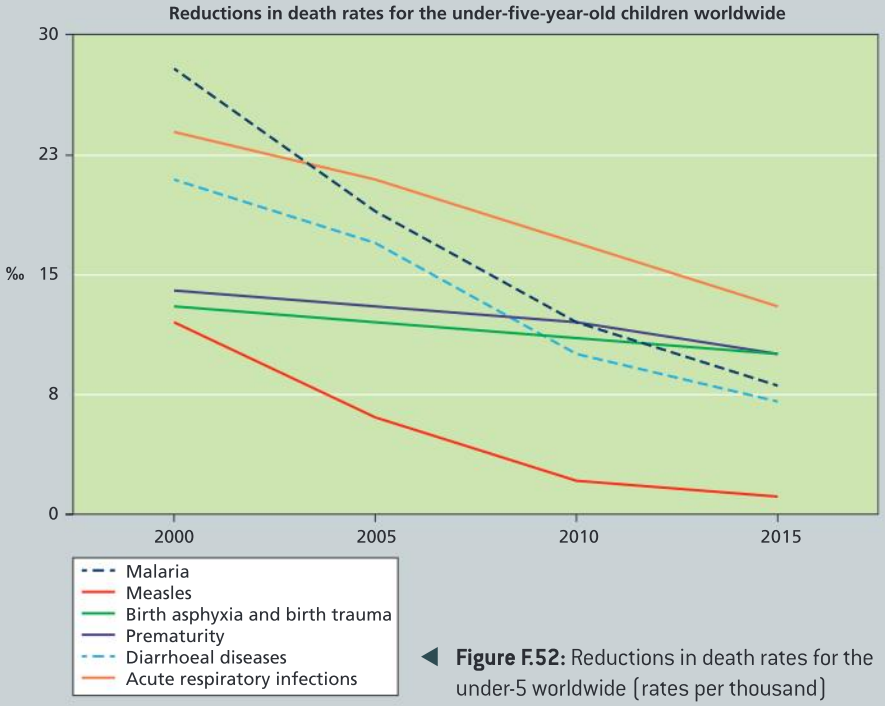
Check your understanding

1. Explain the increase in food waste as countries go through the nutrition transition.
2. Outline the possible solutions to food insecurity.
3. Explain how waste reduction may prevent food insecurity.
4. Examine the ways in which food production may be increased.
5. Outline the advantages and disadvantages of vertical farming.
6. Compare the relative merits of *in vitro* meat production with conventional livestock farming.
7. Examine the political issues involved in GM food production.
8. Explain the merits of disease prevention as opposed to treatment. Refer to at least one disease.
9. Explain the political difficulties in managing a pandemic.
10. "The diseases of affluence are out of control." Discuss this statement with reference to at least one example.

Synthesis and evaluation

- There are many overlaps between the geography of food and the geography of health. In general, societies with high levels of food consumption experience many degenerative diseases, such as heart attacks, strokes and cancers. In contrast, societies with limited access to food experience many diseases of poverty, including infectious/contagious diseases such as diarrhoea and measles. This change of disease from infectious/contagious to degenerative disease is known as the epidemiological transition.
- The scale of the food problem and associated solutions also varies from small scale and short term to large scale and long term, such as famine in some LICs. Some nutritional problems may be short term, such as wasting, whereas others are long term, such as stunting. Solutions include preventative as well as curative measures. The latter are more costly but more frequently used.
- There are many competing stakeholders in the provision of food and health – TNCs, NGOs, MGOs, national governments, workers (farmers, nurses, doctors) and household members. Each may have different goals and different ways of achieving their goals.
- Patterns of health can be shown in many types of maps and graphs, including choropleth maps, bar charts and maps showing change over time (diffusion) using proportional symbols.

The graph shows changes in the death rates for under-five year old children worldwide.



◀ **Figure F.52:** Reductions in death rates for the under-5 worldwide (rates per thousand)

(a) Compare the trends for the decline in under-5 mortality rates for malaria and diarrhoeal diseases. (4 marks)

(b) Briefly explain three reasons for the changes in death rates between 2000 and 2015. (6 marks)

(c) Either

Evaluate the efforts made to contain one infectious disease. (10 marks)

Or

Examine the challenges faced by contemporary approaches to food production. (10 marks)

OPTION G
URBAN ENVIRONMENTS

Key terms

Urban area	A built up area that forms part of a city or town.
Informal/formal activities	Informal activities are untaxed, unregulated jobs whereas the formal economy refers to taxed, regulated activities such as people working in offices and factories.
Suburbanization	The outward growth of towns and cities to engulf surrounding villages and rural areas.
Gentrification	Improvement of residential areas by immigrants and the residents themselves, with an economic dimension such as the development of retailing and other services.
Counter-urbanization	A process involving the movement of population away from larger urban areas to smaller urban areas, new towns, new estates, commuter towns, or villages on the edge or just beyond the city limits or the rural–urban fringe.
Re-urbanization/ urban renewal	The development of activities to increase residential population densities within the existing built-up area of a city.
Urban circular system	A sustainable city in which there are recycling, reuse and reduction of resources, renewable forms of energy, and measures taken to reduce the ecological footprint.
Urban ecological footprint	The amount of land required to sustain a population with the resources they need, and to assimilate their waste.

More than half the world's population now lives in urban environments – many of them in megacities. This optional theme considers the hierarchy of cities and other urban places as sites of intense social interaction and as focal points of production, wealth generation and consumption. Urban environments exhibit diverse patterns of wealth and deprivation, which can result in conflict. They may share common characteristics and processes, irrespective of the national level of economic development.

Transport improvements have led to rapid growth and shifts in population and economic activities, producing stresses and challenges for urban planners. The theme also considers issues of sustainability, wherein cities need to be managed to minimize harmful social and environmental impacts.

Through study of this optional theme, you will develop your understanding of processes, places, power and geographical possibilities. You will also gain an understanding of more specialized concepts, including **hierarchies** (of settlements), **systems** (in relation to movements of people and the management of transport and waste flows) and **sustainability**.

Key questions

1. How do the characteristics and distribution of urban **places**, populations and economic activities vary?
2. How are economic and demographic **processes** bringing change over time to urban systems?
3. What are the varying **powers** of different stakeholders in relation to the experience and management of urban stresses?
4. What are the **possibilities** for the future of urban environments?

1 The variety of urban environments

The characteristics of urban places

A number of criteria are used to specify what an urban place is and it is not possible to give a single definition. However, an urban place is characterized by:

- population size
- specific features, such as a CBD and residential zones
- predominant economic activities, such as manufacturing and services
- an administrative function.

Site

The **site** of a settlement is the actual land on which a settlement is built, whereas its **situation** or position refers to its relationship with its surrounding area. In the past, geographers emphasized the importance of physical conditions on the pattern of settlement, land tenure and type of agriculture practised. Increasingly, social and economic factors are important, especially in explaining recent changes in rural settlements.

Early settlers took into account the advantages and disadvantages of alternative sites for agriculture and housing. Desirable factors included:

- readily available water
- freedom from flooding
- level sites to build on (but less easy to defend)
- local timber for construction and fuel
- sunny, south-facing slopes
- proximity to rich soils for cultivation and lush pasture for grazing
- the potential for trade and commerce, such as proximity to bridges or weirs, a confluence site, the head of an estuary, a point of navigation and upland gaps.

As industrialization occurred, areas with good access to resources developed and became cities. For example, Johannesburg and Bloemfontein grew on account of their mineral resources. Places near great rivers, such as New York, on the mouth of the River Hudson, developed, in part, as a result of their excellent ability to trade.

Function and land use

Most urban places have an industrial role (manufacturing and/or high-tech industry) and/or a service role (health care, education, retail,

Conceptual understanding

Key question

How do the characteristics and distribution of urban places, populations and economic activities vary?

Key content

- The characteristics of urban places, including site, function, land use, hierarchy of settlement (including megacities), and growth process (planned or spontaneous).
- Factors affecting the pattern of urban economic activities (retail, commercial, industrial), including physical factors, land values, proximity to a central business district (CBD) and planning.
- Factors affecting the pattern of residential areas within urban areas, including physical factors, land values, ethnicity and planning.
- The incidence of poverty, deprivation and informal activity (housing and industry) in urban areas at varying stages of development.

leisure, entertainment, local government). Urban places also have a very important residential role. There may be some agriculture in urban areas, such as allotments, urban farms and vertical farms, but this uses only a small proportion of the land in the area. In contrast, many rural areas have an agricultural focus and few residents.

The proportion of each land use varies from city to city and over time. For example, in much of Europe, North America and Japan, the amount of industrial land has declined, as many countries have entered the post-industrial era and now provide more jobs in services than in industry.

Nevertheless, some urban areas are still associated with particular functions. For example, there are fishing settlements, mining settlements, tourist settlements and planned political settlements such as Brasilia in Brazil and Canberra in Australia. Many former rural settlements have expanded and become important dormitory towns, offering a residential function and relatively little else.

Land is used in a number of ways in urban areas. It may be:

- residential – where people live
- industrial – manufacturing industries that process raw materials
- for services – education, health care, retail, entertainment
- open space – parks, gardens, sports facilities, rivers
- for recreation – including open space, sports centres, playgrounds, sports stadia
- transport routes.

Vertical zoning, where the same building is used for one function on one floor and another function on another floor, is common in urban areas. For example, there may be retailing on the ground floor and offices or flats/apartments on the upper floors.

Case study

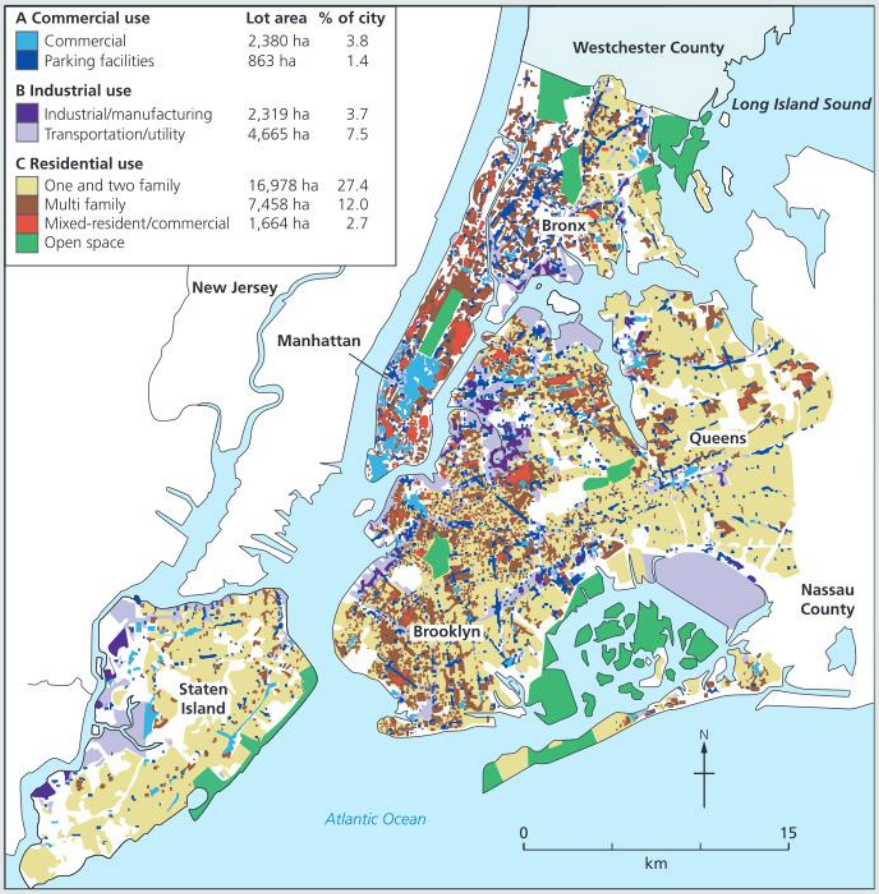
Land use in New York

New York City's land area covers about 825 km^2. Commercial land use is focused on two areas, midtown Manhattan and downtown (lower) Manhattan (Figure G.1). Lower Manhattan is the centre for finance and banking, containing Wall Street and the Stock Exchange. In contrast, midtown Manhattan has the main shops (Fifth Avenue), theatres (Broadway), hotels, and landmark buildings such as the Rockefeller Center and the Empire State Building. Commercial areas occupy less than 4 per cent of the city's land, but they use space intensively. Most of the city's 3.6 million jobs are in commercial areas, from the office towers of Manhattan and the regional business districts of downtown Brooklyn, to the local shopping corridors throughout the city.

Industrial uses, the warehouses and factories, occupy 4 per cent of the city's total lot area, and are found primarily in the South Bronx, along either side of Newtown Creek in Brooklyn and Queens, and along the western shores of Brooklyn and Staten Island. Riverfront locations are highly valued.

Low-density residences, the largest use of city land, are found mostly in Staten Island, eastern Queens, southern Brooklyn, and north-eastern and eastern Bronx. In contrast, medium- to high-density residential buildings (three or more dwelling units)

Case study (continued)



▲ **Figure G.1:** Land use in New York

contain more than two-thirds of the city's housing units but occupy only 12 per cent of the city's total lot area. The highest-density residences are found mainly in Manhattan, and four- to twelve-storey apartment houses are common in many parts of the Bronx, Brooklyn and Queens.

Public facilities and institutions – including schools, hospitals and nursing homes, museums and performance centres, places of worship, police stations and fire houses, courts and detention centres – are spread throughout the city and occupy 7 per cent of the city's land.

Approximately a quarter of the city's open space is occupied by public parks, playgrounds and nature reserves, cemeteries, amusement areas, beaches, stadia and golf courses. Approximately 8 per cent of the city's land is classified as vacant. Staten Island has the most vacant land, with more than 2,100 hectares, and Manhattan the least, with less than 162 hectares.

▼ **Table G.1:** Land use (%) in New York City by borough

	1	2	3	4	5	6	7	8	9	10	11	12
Bronx	18.1	15.5	2.7	4.3	3.8	2.8	11.6	31.1	2.0	4.3	3.8	100
Brooklyn	22.7	16.0	3.4	3.1	4.9	4.2	6.0	33.9	1.8	3.1	0.9	100
Manhattan	1.3	23.9	12.2	10.2	2.4	6.6	11.7	25.1	1.7	3.0	1.9	100
Queens	36.2	10.6	1.5	3.2	3.7	11.8	4.5	19.7	1.3	5.2	2.3	100
Staten Island	33.6	3.1	0.5	3.4	2.9	7.8	9.6	20.7	0.5	17.5	0.5	100
New York City	27.4	12.0	2.7	3.8	3.7	7.5	7.3	25.4	1.4	6.9	1.8	100

Key

1. Low-density residential
2. High-density residential
3. High-density apartments/commercial
4. Commercial/office
5. Industrial/manufacturing
6. Transport/utility
7. Public facilities and institutions
8. Open space
9. Parking facilities
10. Vacant land
11. Miscellaneous
12. Total

Activity 1

Study Figure G.1 and Table G.1.

1. Describe the distribution of commercial land in New York City.
2. Comment on the distribution of industrial land.
3. Compare the distribution of low-density residential areas with that of high-density residential areas. How do these compare with the distribution of apartments?
4. Compare and contrast the main land uses in Manhattan with those of Queens.

The hierarchy of settlements

The term "hierarchy" means "order" or "importance". Settlement size is normally used as a measure of settlement hierarchy, although other measures used include number of jobs provided and/or amount of wealth generated.

A number of terms are used to explain settlement hierarchies. These include:

- **range** – the maximum distance that people are prepared to travel for a good or service
- **threshold** – the minimum number of people required for a good or service to stay in business
- **low-order goods** – necessity goods or convenience goods bought frequently, such as bread, newspapers
- **high-order goods** – luxury or shopping goods bought or used infrequently, for example watches, cars
- **sphere of influence** – the area served by a settlement, also called a hinterland.

Dispersed, individual households are at the base of the settlement hierarchy. At the next level are hamlets. A hamlet is a small collection of farms and houses, generally lacking all but the most basic services and facilities. The trade generated by the population, which is often less than 100 people, will only support **low-order services** such as a general store, a sub-post office or a pub. By contrast, a village has a larger population, so it can support a wider range of services such as a school, church or chapel, community centre and a small range of shops.

The different-order centres can be distinguished by their (a) type, (b) number of functions, (c) market area, (d) employment, and (e) population size.

Only basic or **low-order** functions are found in a hamlet, while larger settlements (villages and market towns) support the same functions and services, together with more specialized ones – **high-order** functions. Market towns draw custom from surrounding villages and hamlets as well as serving their own population. The demarcation between hamlet, village and town is not always very clear-cut and they all share features on a sliding scale (**continuum**) rather than being completely separate categories.

Larger urban areas, such as cities, offer a wider range of services and goods, and more of them. When two or more cities merge, it is referred to as a **conurbation**. A **millionaire city** is a city with over one million inhabitants. A **megacity** is a city with over 10 million inhabitants. The term **metacity** describes large-scale city regions (such as China's Pearl River Delta), where a number of large cities merge. This is similar to the idea of a **megalopolis**, where cities sprawl and merge into one. One example is Bosneywash, the sprawling and near-merging of Boston, New York and Washington, DC on the east coast of the USA. The metacity differs in that it is denser and has less defined areas between individual cities.

A number of generalizations can be made about the hierarchy of settlements:

- There are many more small settlements than there are large settlements.
- Towards the bottom of the hierarchy, villages provide a limited range of low-order goods to a small number of people (threshold) living in the village and surrounding hamlets (sphere of influence).
- Small urban areas provide a wider range of high-order goods and low-order goods to a larger population drawn from the town, surrounding villages and hamlets.
- Towards the top of the hierarchy, large urban areas provide a large number of high-order goods and low-order goods to a very large number of people, drawn from a wide area.

▲ **Photo G.1:** The Empire State Building – a landmark of Manhattan's CBD

Megacities

Megacities are cities with a population of over 10 million people. Megacities grow as a result of economic growth, rural–urban migration and high rates of natural increase. As a result of people migrating to the city in search of jobs, megacities develop an age structure that is dominated by young adults. Thus, the city grows not only through migration but also because of the high birth rates associated with a younger population. As the cities grow, they swallow up rural areas and nearby towns and cities. They become multi-nuclei centres. The world has never had so many very large settlements. Some of these cities have populations that are bigger than the population of entire countries – Mumbai, for example, has more people than Sweden and Norway combined.

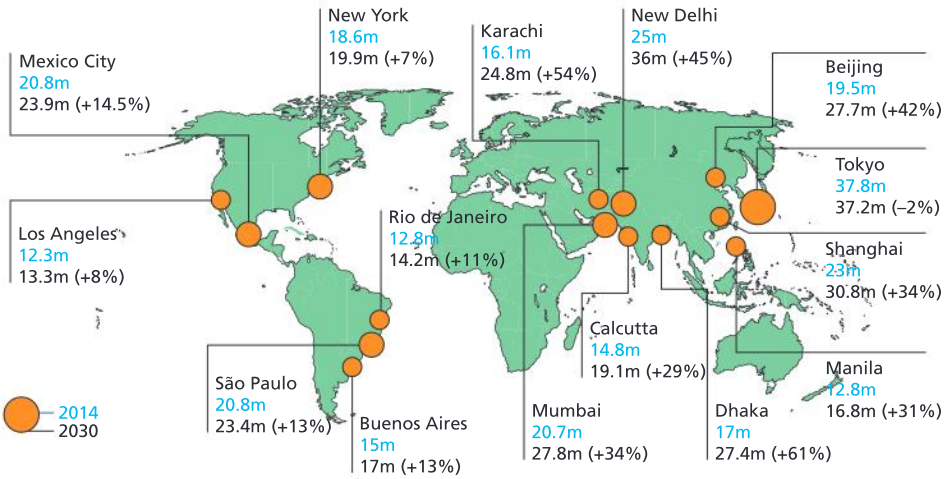
Common mistake

✗ Some students wrongly claim that a megacity is a city with a population of over one million people.

✓ Those cities are in fact called millionaire cities. A megacity has a population of over 10 million people.

Nevertheless, megacities still contain only between 4 and 7 per cent of the world's total population, and usually grow at relatively slow rates, perhaps 1.5 per cent per year – more slowly than medium-sized cities. The first megacity was Tokyo, which now has a population of about 35 million (larger than Canada's entire population). By 2017, other megacities will include Mumbai, Delhi, Mexico City, São Paulo, New York, Dhaka, Jakarta and Lagos. Lagos has been growing at a very fast rate – 5 per cent per annum – and is expected to increase at this rate until after 2020.

By 2020, all but four of the world's megacities will be in developing regions, 12 of them in Asia alone. The impact of megacities on their region is huge. They are



▲ **Figure G.2:** Population growth in the world's megacities, 2014–2030 (millions)

Activity 2

Study Figure G.2.

1. State how many megacities are located in high-income countries.
2. Identify the largest megacity in 2014. By how much is it projected to increase by 2030?
3. Identify the fastest-growing megacity shown in Figure G.2. What will its population be in 2030?
4. Comment on the location of megacities, as shown in Figure G.2.
5. Suggest why so many people migrate to megacities.

likely to require new forms of planning and management to cope with such large sizes. The scale of environmental impacts is likely to be great. Rapid economic growth and urbanization in China has had a negative impact on the urban environment. China now has 16 of the 20 most polluted cities in the world and, after the USA, is the largest producer of greenhouse gases.

Megacities are important for the generation of wealth. In HICs, urban areas generate over 80 per cent of national economic output; in LICs, the figure is over 40 per cent. On the other hand, some aspects of megacities, such as crime and environmental issues, are less attractive.

Urban growth and economic development

There is a clear correlation between urban growth and economic development. Levels of development have normally been measured in terms of GNP per head (although this is not necessarily the best measure of development). However, to suggest that one causes the other is not necessarily correct. For example, does a high proportion of people living in urban areas lead to increased wealth, or does increased wealth lead to a high proportion of people living in urban areas? There is certainly a connection, but one does not necessarily cause the other.

Urban places perform a number of important functions in the process of development:

1. **Commercially**, towns provide the market and exchange centres necessary for the conversion from subsistence to cash crops.
2. **Industrially**, towns may provide a stimulus for development – the larger the town the better it is for skilled and unskilled labour.
3. **Politically**, towns may provide a focus for nationalist feeling and also allow for ethnic, tribal and religious intermixing.
4. **Administratively**, towns provide economies of scale for health and education.
5. **Socially**, the intermixing may help weaken ties to traditional rural beliefs and customs.

Although cities make significant contributions to the economic wealth of a nation, they also lead to huge problems such as pollution, destruction of ecosystems, and poor living conditions. The deterioration is manifested in:

- high rates of unemployment and underemployment, as urban labour markets are unable to absorb the growing number of job seekers
- insufficient housing and shelter, coupled with the growth of slums and squatter settlements
- overloaded and overcrowded transport systems
- air, water and noise pollution
- deteriorating infrastructure (basic services) and shortfalls in service delivery (public transport, waste disposal and health care)
- growing inequalities between areas or districts within a city in terms of access to infrastructure and services

- inadequate sanitation and water supplies and associated health problems
- increasing prevalence of social problems, such as rising crime rates, suicide rates, drug and alcohol abuse, family breakdown and homelessness
- a general deterioration in the perceived quality of life.

According to UN Habitat, the environmental problems resulting from urbanization are best considered at five different but closely related levels. These range from the household and its immediate surroundings – for ill health, disablement and premature death arising from contaminated water and inadequate sanitation – to the global level, where city-based production and consumption place large burdens on dwindling resources. Table G.2 shows the range of impacts.

▼ **Table G.2:** Potential impacts of megacities

	Household/workplace	Community	Metropolitan area	Region	Continent/ planet
Key infrastructure and services	Shelter, water storage, on-site sanitation, garbage storage, stove, ventilation	Piped water, sewerage, garbage collection, drainage	Industrial parks, roads, treatment plants, outfalls, landfills	Highways, water sources, power plants	Atmosphere, oceans
Characteristic problems	Substandard housing, lack of water, lack of sanitation, disease vectors, indoor air pollution	Excreta-laden water/soils, rubbish dumping, flooding, noise stress, natural disasters	Traffic congestion, accidents, air pollution, toxic dumps	Water pollution, natural environments lost	Acidification, global warming, ozone destruction

The function of urban settlements

Trade and communications have always been important. Cairo grew as a result of being located at the meeting point of the African, Asian and European trade routes. It also benefited from being the seat of government and the royal family, and having a university and all kinds of linked industries such as food and drink, and textiles. Similarly, Paris grew because of its excellent location on the Seine. Not only could the river be crossed at this point but it could also be used for trade and communications.

Other centres had good raw materials. In South Africa, the gold deposits near Johannesburg and the diamonds at Kimberley and Bloemfontein caused these settlements to grow as important mining and industrial areas.

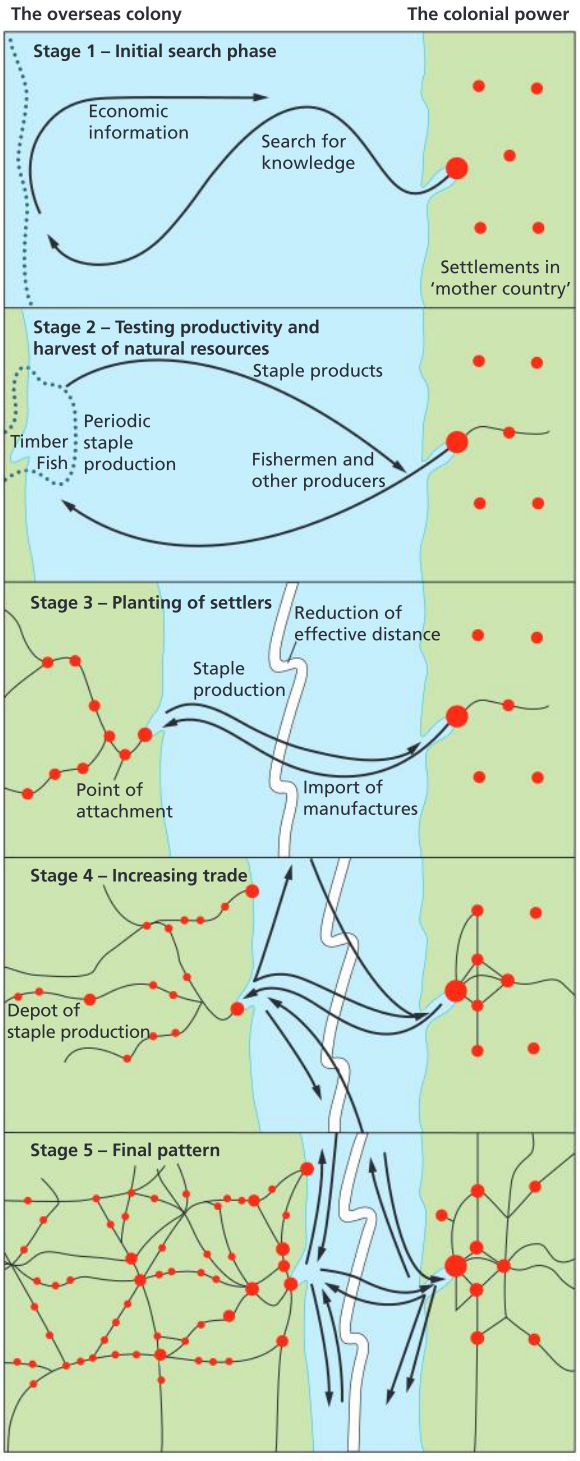
Functions change over time. Many settlements that were formerly fishing villages have evolved into important tourist resorts. The Spanish Costas and many Caribbean settlements, such as Soufrière in St Lucia, are good examples of this. South Korea has rapidly industrialized and urbanized since the 1950s, and now over 85 per cent of the population live in urban areas. Other centres have become important due to political factors. New capital cities – such as Brasilia, Canberra and Ottawa – have developed important administrative roles. Other planned cities, such as Putrajaya in Malaysia and Incheon in South Korea, have become important centres for government services and high-tech industries, respectively.

Growth processes

A number of factors affect the size, growth and function of a settlement. In extreme environments – whether too hot or cold, wet or dry – settlements are generally small and isolated because the environment is too harsh to provide much food. In contrast, in areas favouring food production, settlements have managed to grow. If more food is produced than the farmers need, non-farming services can be supported. At first these would have included builders, craftsmen, teachers, traders, administrators, and so on. Thus, settlements in more favoured areas have greater potential for growth and for a greater range of services and functions.

Environments naturally favouring urban growth include those in the north-eastern USA, where settlements on the lowland coastal plain were able to farm and trade. Those with links inland as well, such as New York, were doubly favoured.

All urban areas change over time. Some increase in size and importance, whereas other decline. The pattern of settlement may also change over time. In a study of north-eastern USA, James Vance showed how the development of settlements occurred as a result of colonial mercantile (trade) interaction between the colony and the empire (Figure G.3).



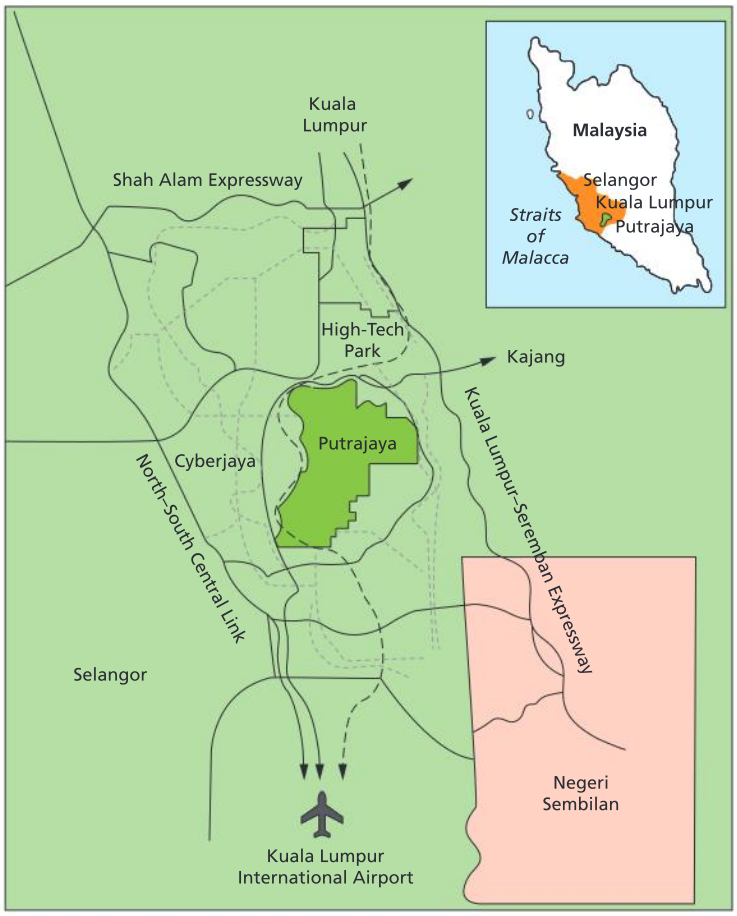
▲ **Figure G.3:** The development of trading centres (**Vance's model**)

▶ **Figure G.4:** The location of Gongju-Yongi

It adds a historical-geographical dimension to the study and emergence of settlements.

Vance's model stresses the importance of external influences. The hierarchy evolves from the top down, with large cities acting as centres of innovation for external commercial forces. Boston was the focal point for change, according to Vance. The model can also be applied to Australia, although the nature of the Australian landscape has not favoured infilling to such an extent.

Other geographers stress other factors. The American geographer August Losch emphasized the importance of transport accessibility. He suggested that cities grow more where there are good transport links and less where accessibility is limited. These transport links produce corridors of urban areas, such as the M4 Corridor in the UK, which has become a region for high-tech industry.



▲ **Figure G.5:** The location of Putrajaya

There have been many attempts to reduce the importance of very large cities, including London, Rio de Janeiro and Seoul. Developers and governments have attempted to build new towns and new capital cities to deflect growth away from these main cities. For example, Cairo's new towns, such as Sadat City and 10th of Ramadan, were new settlements designed to accommodate the overspill population from Cairo. Similarly, Tai Po and Yeun Long were planned to accommodate people living in overcrowded conditions in Hong Kong Island and Kowloon.

New, planned capital cities include Brasilia, Canberra and, in Korea, Gongju-Yongi. Originally, Gongju-Yongi was planned to replace Seoul as Korea's capital by 2020. Construction of the £26 billion scheme began in 2007. However, Seoul will now remain the capital although relocation of many people to Gongju-Yongi is still necessary to ease chronic overcrowding in Seoul, to redistribute the state's wealth, and to reduce the impact of a military attack from North Korea. Previous developments had concentrated huge amounts of money, power and up to half of Korea's population in Seoul.

Another impressive scheme is Putrajaya in Malaysia, a totally new, planned city 25 kilometres south of the capital city of Kuala Lumpur. Covering an area of 4,931 hectares, Putrajaya was established in 1995. It is being built according to a series of comprehensive policies and guidelines for land use, transportation systems, utilities, infrastructure, housing, public amenities, information technology, parks and gardens.

The **mission** of the Putrajaya Corporation is to provide:

- an efficient and effective administration
- quality services to ensure customer satisfaction
- infrastructure and amenities towards creating an ideal environment for living and working.

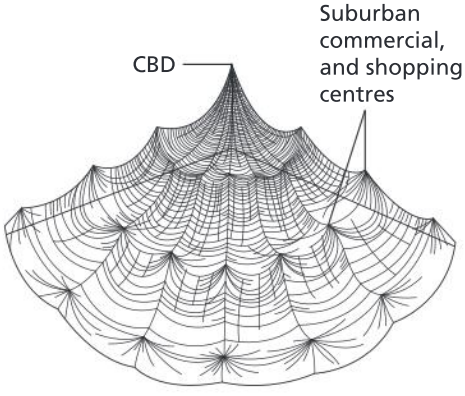
The Corporation's **functions** include:

- local government in the Putrajaya area
- promoting, stimulating, facilitating and undertaking commercial, infrastructure and residential development in the area
- promoting, stimulating and undertaking economic and social development in the area
- controlling and coordinating the performance of their activities in the area.

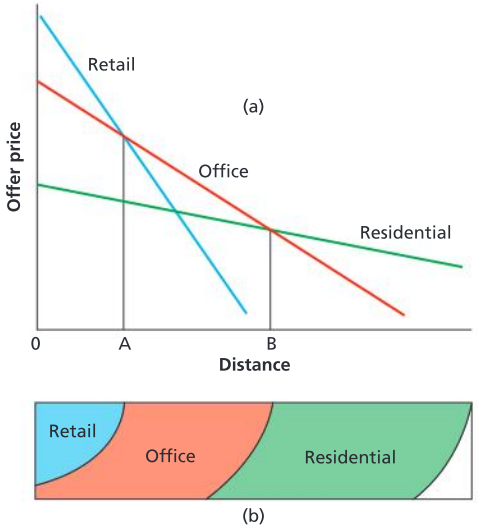
▲ **Photo G.2:** Part of Tokyo's CBD

Factors affecting the pattern of urban economic activity in cities

The value of land varies for different purposes, such as commercial, manufacturing and residential (Figure G.6). This is known as the **bid rent** of land. Land at the centre of a city is most expensive for two main reasons: it is (or was) the most accessible land to public transport, and there is only a small amount of it available. Land prices generally decrease away from the most central area, although there are secondary peaks at the intersections of main roads and ring roads (Figure G.7). It is the change in levels of accessibility, caused by the use of private transport as opposed to public transport, which explains why areas on the edge of town are often now more accessible than inner areas.



▲ **Figure G.6:** Variations in land value with accessibility



Offer prices of retail, office and residential uses with distance from the city centre:
(a) Section across the urban value surface.
(b) Plan of the urban value surface.

▲ **Figure G.7:** The principles of bid rent

Retail land use

Traditionally, geographic accounts of retailing concentrated on the location and type of retailing outlet. A central place-type hierarchy was seen:

1. Low-order goods concentrated in neighbourhood stores and shopping parades.
2. High-order goods in high street shops, department stores.
3. Out-of-town superstores and retail parks.

▲ **Photo G.3:** An edge-of-town supermarket

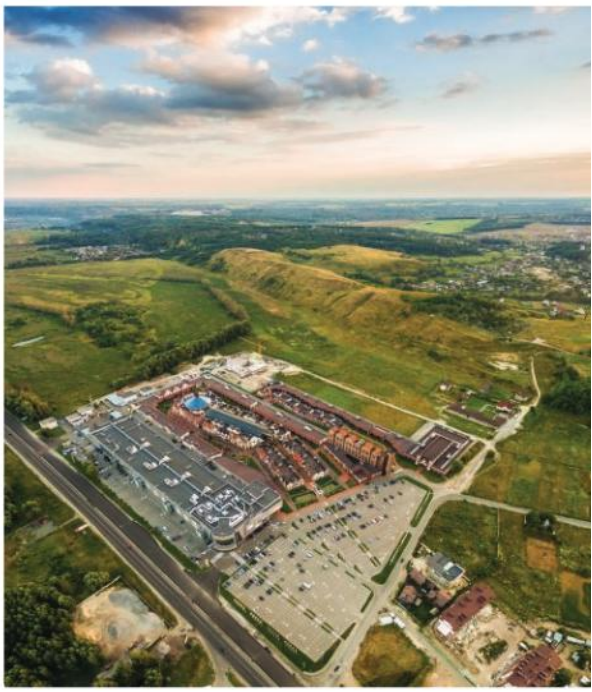
Central shopping areas or high streets are characterized by department stores, chain stores, specialist shops and, increasingly, by pedestrianized malls. Outlets sell mainly high-order goods with a large range and threshold. The sphere of influence of central shopping areas is generally large. By contrast, **shopping parades** are clusters of shops. These usually include a small supermarket, an off-licence, a newsagent and other low-order outlets serving nearby residential areas. At the bottom of the hierarchy are small, independent outlets, selling a variety of convenience goods such as food, newspapers and confectionery. They are "convenient" on account of their long opening hours and the wide variety of products they carry.

However, modern retailing has recently changed rapidly with the growth in the number of superstores and retail parks, built on greenfield suburban sites with good accessibility and plenty of space for future expansion. **Superstores** are large outlets close to residential areas with >2,500 square metres of shopping space, ample parking and good road access (Photo G.3). Hardware, electrical and furniture superstores may cluster to form a **retail park** (Photo G.4).

This retailing revolution has focused on superstores, hypermarkets and out-of-town shopping precincts, and people shopping less frequently.

A number of factors explain this change in shopping habits, including:

1. demographic change, such as falling population growth, smaller households, and more elderly people
2. suburbanization and counter-urbanization of more affluent households
3. technological change, as more families own deep freezers and do not need to shop daily
4. economic change, with increased standards of living, especially car ownership
5. congestion and inflated land prices in city centres



▲ **Photo G.4:** An edge-of-town retail park

1 Multi-storey development

- High land values force buildings to grow upwards, hence the floor space of the CBD is much greater than the ground space.

2 Concentration of retailing

- High levels of accessibility attract shops with high range and threshold characteristics, such as department stores in the most central areas and specialist shops in less accessible areas.

3 Public transport is concentrated in the CBD

- There is a convergence of bus routes on the CBD.

4 Offices are concentrated in the CBD

- Centrality favours office development.

5 Vertical zoning is apparent

- Shops occupy ground floors whereas offices occupy upper floors.

6 Functional segregation occurs

- Different types of land use occupy different parts of the CBD.

7 Few people live in the CBD

- These are limited to a few luxury flats as well as some artisans.

8 Pedestrian flows are highest

- This is due to the attractions of a variety of commercial outlets and service facilities.

9 Traffic restrictions are greatest

- Pedestrianization has reduced access for cars since the 1960s.

10 The CBD changes over time

- There is an assimilation zone (the direction in which the CBD is moving) and there is a discard zone (the direction from which it is moving away).

▲ Characteristics of the CBD

6. the increased accessibility of suburban sites, especially those close to ring-road intersections
7. social changes, such as more women in paid work.

The effect of this change on smaller high-street shops, which depended on frequent convenience trade, has often been considerable and has led to the closure of many of them. As a result, government policies increasingly favour a return to central shopping areas and neighbourhood schemes over more out-of-town developments. Attempts to maintain or revitalize retailing in central areas is of increasing importance and in some places has coincided with inner-city redevelopment.

Renovation may entail:

- full-scale development, as in the case of Princes Square in Glasgow and Newcastle
- the creation of traffic-free zones, as in Bruges and Cologne
- large-scale redevelopment schemes, such as Les Halles in Paris and Part-Dieu in Lyon.

There has been some decentralization of other commercial activity to suburban sites/edge-of-town sites. The development of business parks is related to the cheaper land values, better access to private transport, free parking and room for expansion.

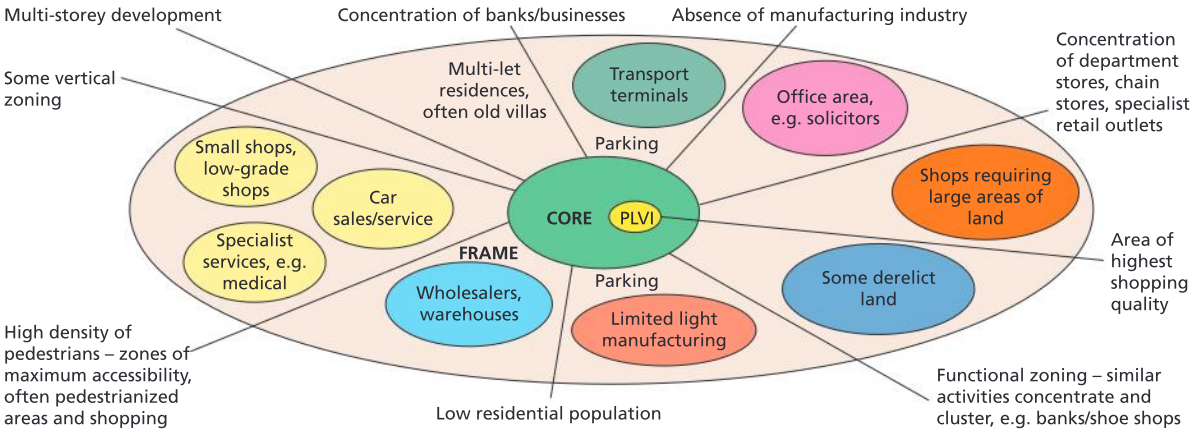
Commercial land use – the CBD

The central business district (CBD) is the commercial and economic core of a city. It is the heart of the city, the area most accessible to public transport, and the location with the highest land values. It has a number of characteristic features and internal zoning (clustering of similar types of business).

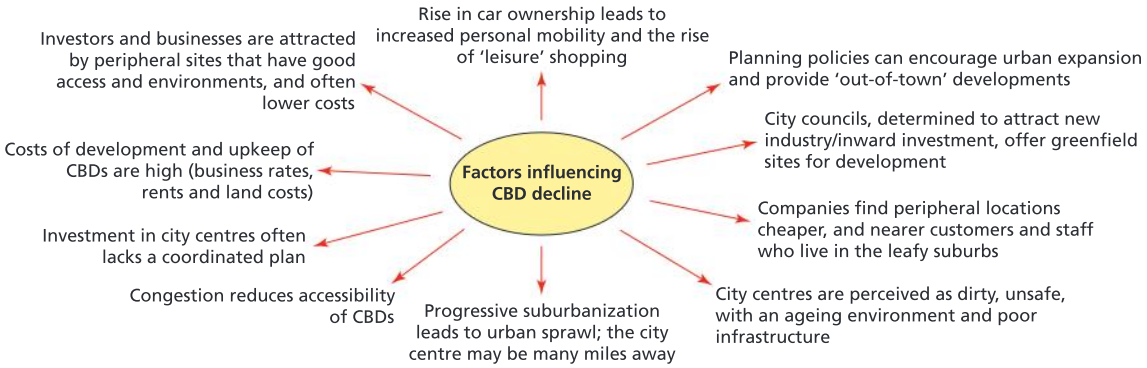
Industrial activity

There are a number of locations for industrial zones in most cities. These include:

- inner-city areas close to railways and/or canals, for example dock-related industries such as imports and exports
- brownfield suburban sites close to airports



PLVI = peak land value intersection: the highest rated, busiest, most accessible part of CBD



▲ **Figure G.8:** Examples of a typical HIC CBD

- sites away from residential locations, for polluting industries that may be required to locate outside the urban area.

Industries found in cities include:

- those needing skilled labour, such as medical instruments
- those needing access to the CBD, such as fashion accessories and clothes
- those needing the whole urban market for distribution, such as newspapers.
- These industries all have a central location.

Large cities are attractive for industries for a number of reasons:

- Capital cities such as Paris or Moscow are often the largest manufacturing centres of a nation.
- Cities are large markets.
- Port cities have excellent access to international markets.
- Cities are major centres of innovation, ideas and fashion.
- A variety of labour is readily available, including skilled and unskilled workers, decision-makers and innovators.

▲ **Photo G.5:** Port-based industries centred on the import of goods

Planning urban economic activity

Increasingly, there is evidence of planning with respect to urban economic activities. Putrajaya is a planned settlement with designated economic areas, as are many planned settlements such as the new towns of the UK, Hong Kong, the Netherlands and Egypt. In other cases, industrial zones may be placed downwind or downstream of urban areas so that they do not pollute the main city. Ahead of the Beijing Olympic Games in 2008, the Chinese authorities closed down a number of factories and relocated an iron and steel plant so that it was away from the city and by the coast.

Government assistance may be provided in order to regenerate a declining area. The 1992 Olympic Games in Barcelona were used to regenerate Barcelona's waterfront industries, and the redevelopment of London Docklands was a joint partnership between central government and private investors. On a smaller scale, local planning laws may prevent the development of certain areas for particular activities. The UK's green belt, for example, allows low-density service developments but generally restricts the development of heavy manufacturing industry.

Factors affecting the location of urban residential areas

Physical factors

In some urban areas, wealthier people live near rivers or canals. This is partly because of the pleasant views they provide and partly because of the recreational opportunities they offer. In contrast, in some poor countries it is the poor who live close to rivers and areas at risk of flooding. Similarly, high ground in some urban areas in HICs may be attractive for housing for wealthy households, whereas in LICs it is the poor who are forced to live in areas of steep relief, where mass movements may be a risk. In rich countries, building standards generally take into account the risks associated with the site of housing. In areas of rapid population growth and informal housing, individuals may have to use any available site and may not be able to protect against the risk of hazards.

Land values

In most HIC cities, there is often a pattern of residential location, with the highest residential densities in inner-city areas. Usually, residential density in the city centre is low because of high land values (see Figure G.7, Bid rent, on page 340). In the inner city, high-density terraced housing may date from the 19th century. However, with increasing distance from the city centre, residential density decreases. This reflects the greater availability of land in the suburbs. Traditionally, poorer households were located in the inner city, close to jobs, whereas high-quality housing is located further out. However, densities in suburban areas have increased since the 1980s as a result of decentralization and the development of edge-of-town estates.

The paradox of the poorest people being located on expensive inner-city land reflects their need to be close to sources of employment. Landlords achieved their profits by cramming as many tenants as they could into

these zones. By contrast, wealthier people live in the outer areas, in lower-density housing, where they are able to commute to work. However, land value is just one factor affecting the location of residential areas. Certain land uses may deter each other and high-class residential and low-class residential areas may be separated by physical or built barriers.

Ethnicity

Some ethnic groups may choose to live close together, and so end up forming neighbourhoods. For example, the majority of the South Korean population in London lives in New Malden, a suburb with good rail links to central London, and it now has a number of Korean restaurants and supermarkets. This is a form of **positive segregation**, whereby the ethnic group gains advantages by being located in one place: there are enough of them to support services. On the other hand, **negative segregation** is where certain groups are excluded from particular areas. This might be because of either cost or "red-lining", an illegal process whereby people and authorities prevent particular groups from locating in an area. Sometimes, this red-lining is legally enforced, for example during the apartheid era in South Africa (Photo G.6), when blacks, whites, coloureds and Indians, in theory, had to live in their own designated areas. In contrast, some governments may have a multiracial policy of locating all racial groups, including the indigenous population, together on housing estates.

▲ **Photo G.6:** Housing inequalities in Grahamstown, South Africa – the area in the foreground was a "white" area and the areas in the background were "black" and "coloured" townships

Urban residential planning

Planning is increasingly important in many cities, where authorities try to achieve a balanced social mix by having a mixture of housing types dispersed around the city. However, in many cities this does not occur. "Edge cities" – such as Barra da Tijuca, on the edge of Rio de Janeiro – are often gated communities of wealthy people. Similary, people in rich neighbourhoods may resist the development of socially affordable housing in their neighbourhoods. In the USA, for example, following the movement of Afro-Caribbeans into some formerly "white" areas, a process of "white flight" occurred, when many whites moved to the outer suburbs or other settlements. In many cases, private developments favour the wealthy, as they are more able to afford to choose where they live, whereas poorer people rely on local government housing, informal housing, public housing, or housing association housing.

There are a number of key points regarding cities in poor countries:

- The rich generally live close to the city centre, whereas the poor are more likely to be found in the periphery, on poor-quality land, and on land that may be at risk from hazards, such as landslides and floods.

Case study

Cities in Latin America

Many cities in Latin America have a pattern of development different from that in other parts of the world. In Latin America the CBD developed around the colonial core, and a commercial avenue extended from it. This then became the spine of a sector containing open areas and parks, and homes for the upper and middle classes. Middle-class suburbs surround the CBD. These have good-quality streets, schools and public services.

Further out are the more recent suburbs, with more haphazard housing and fewer services. Squatter housing is found at the edge of the city and there are also some sectors of older, more established shanty housing that extend in towards the city centre. Conditions in shanties near the city centre are better than in the more recent shanties at the edge. In addition, those living in the central shanty towns are closer to centres of employment and are more likely to find work. Industrial areas are scattered along major transport routes, with the latest developments at the edge.

- Higher-quality land is occupied by the wealthy.
- Segregation by wealth, race and ethnicity is evident.
- Manufacturing is scattered throughout the city.

Urban poverty, deprivation and informal activity in urban areas

Activity 3

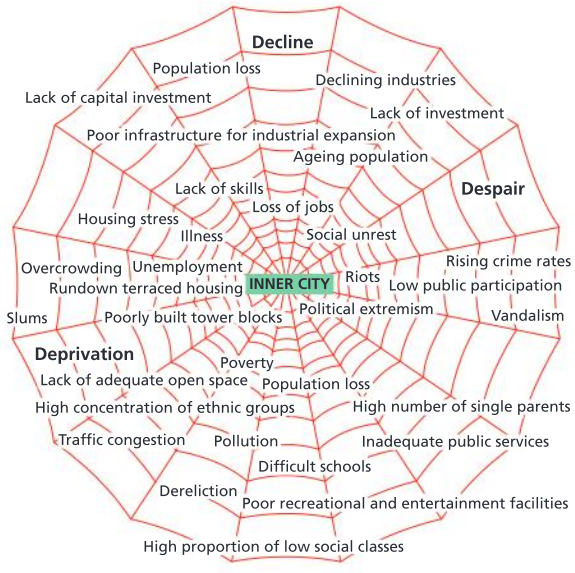
Briefly explain the high value of land in (a) central areas of cities and (b) on the edges of cities.

In most cities there is considerable variation in the quality of life. This raises questions about equality of opportunity and social justice. The areas labelled "poor" are zones of deprivation, poverty and exclusion. In the developed world these are often inner-city areas, or ghettos, whereas in developing countries it is frequently shanty towns that exhibit the worst conditions. The factors associated with deprivation are varied, but they result in a cycle of urban deprivation and a poor quality of life.

Measuring deprivation

A number of indices are used to measure deprivation. These include:

- physical indicators – such as quality of housing, levels of pollution, incidence of crime, vandalism, graffiti
- social indicators – including crime (reported and fear of); levels of health and access to health care; standards of education; proportion of population on benefits (unemployment, disability, free school meals); proportion of lone-parent families
- economic indices – access to employment; unemployment and underemployment; levels of income
- political indices – opportunities to vote and to take part in community organization.



▲ **Figure G.9:** The web of deprivation for a high-income country inner city or edge-of-town estate

Slums and squatter settlements

The total number of slum dwellers in the world stood at about 980 million people in 2015. This represents about 32 per cent of the world's urban population, but 78.2 per cent of the urban population is in LICs. Slums are typically located on land that planners do not want: steep slopes, floodplains, edge-of-town locations and/or close to major industrial complexes.

The UN defines a slum household as one or a group of individuals living under the same roof in an urban area, lacking one or more of the following five amenities:

1. durable housing – a permanent structure providing protection from extreme climatic conditions
2. sufficient living space – no more than three people sharing a room
3. access to improved water – water that is sufficient, affordable and can be obtained without extreme effort

4. access to improved sanitation facilities – a private toilet or a public one shared with a reasonable number of people
5. secure tenure – protection against forced eviction.

Despite the success of MDG 1, "Reduce extreme poverty by half", more than 200 million people in sub-Saharan Africa still live in slums, and more than 190 million in South and East Asia live in slums.

▼ **Table G.3:** The positives and negatives of living in a slum

Positive aspects
They are points of assimilation for immigrants
Informal entrepreneurs can work here and have clienteles extending to the rest of the city
Informal employment, based at home, avoids commuting
There is a strong sense of kinship and family support
Crime rates are relatively low
Negative aspects
Security of tenure is often lacking
Basic services are absent, especially water and sanitation
Overcrowding is common
Sites are often hazardous
Levels of hygiene and sanitation are poor, and disease is common

Informal economic activity (housing and industry)

The **dual economy** of the developing world city consists of a formal economy, complete with offices, factories and commercial buildings, and an informal economy, consisting of servants, gardeners, maids, cleaners, taxi drivers, prostitutes and a variety of other occupations. Much of the formal economy (the "upper economic circuit") is foreign owned and produces goods and services for an elite population. In addition, the civil service employs a large number of people including teachers, nurses, soldiers and clerical officers. By contrast, the informal economy (sometimes called the "lower economic circuit") is small scale, locally owned and labour intensive. However, the same person could work in both sectors; for example, a teacher who works in a school may also offer private tuition.

▲ **Photo G.7:** An informal garbage picker

The informal sector is often divided into two: a traditional **bazaar economy** and a **street economy**.

The bazaar economy consists of small trade and service establishments, and craft workshops. Many bazaars are family enterprises employing children as well as the elderly. In this respect, it is a transfer of the way in which farming is organized to urban, service-based or industrial activity. Bazaars generally account for up to 45 per cent of employment in a city, producing cheap goods and services for low-income households. Intense competition between rivals keeps prices low and the activities normally support a low standard of living.

The street economy includes street hawkers, shoe-shiners, beggars, thieves and prostitutes. These may account for up to 40 per cent of the labour force. Earnings and standards of living are low.

Some geographers see the informal sector as a valuable way of relieving the economic problems of the poor by using

▼ **Table G.4:** Characteristics of the formal and informal economic sectors

Informal sector	Formal sector
Ease of entry	Difficult entry
Indigenous inputs predominate	Overseas inputs
Family property predominates	Corporate property
Small scale of activity	Large scale of activity
Labour intensive	Capital intensive
Adapted technology	Imported technology
Skills from outside the school system	Formally acquired skills
Unregulated/competitive market	Protected markets, e.g. tariffs, quotas, licensing

▼ **Table G.5:** Income opportunities in LIC cities

1 Formal income opportunities
Public sector wages
Private sector wages
Transfer payments, for example pensions, unemployment benefits
2 Informal income opportunities: legitimate
Primary and secondary activities, e.g. farming, market gardening, building, self-employed craftspeople, shoemakers, brewing and distilling
Tertiary (service) enterprises with relatively large capital inputs such as housing and transport
Small-scale distribution, e.g. market traders, street hawkers, food and drink sellers, bar attendants
Other services, such as musicians, launderers, shoe-shiners, barbers, photographers, car repairers
Private transfer payments such as gifts and similar movements of money between people, borrowing and begging
3 Informal income opportunities: illegitimate
Services such as receiving stolen goods, usury (lending money at an exorbitant rate of interest), pawnbroking, drug pushing, prostitution, smuggling, bribery, political corruption, protection rackets
Transfers, such as petty theft (pickpockets, larceny), burglary and armed robbery, speculation and embezzlement, gambling

Activity 4

1. Describe the nature of employment in the informal economy.
2. Explain why informal activities are important in the economy of developing world cities.

their energy, together with small-scale assistance or training, to try to help them improve their circumstances (Table G.5). This approach led to the basic needs strategy. These are the self-help programmes that flourished in the 1980s and 1990s in an attempt to overcome the problems of housing, employment and general standards of living in many cities.

Exploitation of the informal sector

Some geographers argue that the informal economy allows even more exploitation of the poor by the rich. Exploitation takes place in a large number of ways. For example, the entrepreneurs who own the equipment or the capital necessary for the operation of a business are often quite wealthy people who work in the formal sector. In addition, the informal sector benefits those in the formal sector, since it keeps prices down. Hence it reduces the price that those in regular employment (the formal sector) have to pay for their goods.

Concepts in context

Urban **places** vary in terms of site, function, land use, position in the hierarchy and nature of development. Land uses, including economic and residential uses, are affected by a variety of physical and human factors, including planning regulations. In many large cities, there are major inequalities in wealth. Some urban populations are wealthy but many more are caught up in a cycle of deprivation. Ironically, the rich need the poor just as the poor need the rich in order to earn a livelihood, and so very often the two groups are found in relatively close proximity to each other.

Check your understanding

1. State four characteristics used to classify settlements.
2. Define and describe a named and located example of a settlement hierarchy.
3. Explain how spheres of influence may vary in space and time.
4. Identify and locate the industrial functions of a city.
5. Briefly explain the meaning of the term "bid rent".
6. Explain the factors determining the location of the commercial zone in a city.
7. Outline the main characteristics of the "cycle of deprivation".
8. Comment on the nature and characteristics of the informal sector.
9. Outline the main characteristics of slum housing.
10. Briefly explain why some modern retailing is attracted to out-of-town locations.

2 Changing urban systems

Conceptual understanding

Key question

How are economic and demographic processes bringing change over time to urban systems?

Key content

- Urbanization, natural increase and centripetal population movements, including rural–urban migration in industrializing cities, and inner-city gentrification in post-industrial cities.
- Centrifugal population movements, including suburbanization and counter-urbanization.
- Urban system growth, including infrastructure improvements over time, such as transport, sanitation, water, waste disposal and telecommunications.
- The causes of urban deindustrialization and its economic, social and demographic consequences.

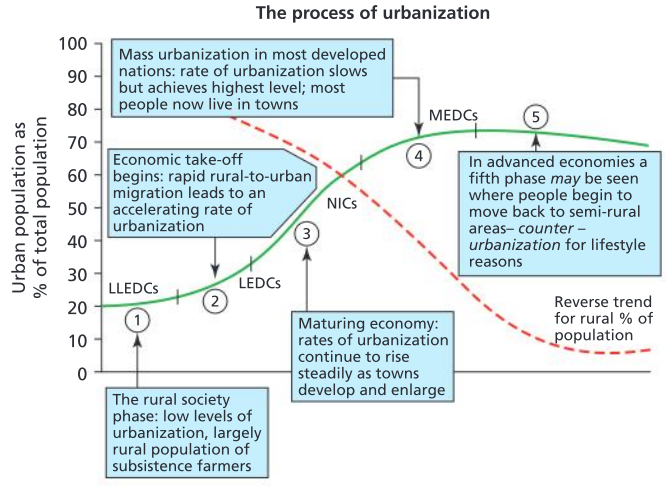
Urbanization, natural increase and population movements

Urbanization

Urbanization is defined as an increase in the proportion of people living in urban areas. It can be caused by rural-to-urban migration, higher rates of natural increase in urban areas, or the reclassification of rural areas as urban areas, as for example with urban sprawl. In many rich countries, the process of urbanization is almost at an end and the proportion of urban dwellers is beginning to fall. The process has followed an S-shaped curve and it seems to have tailed off at 80 per cent of the total population (Figure G.10). For many HICs, there appears to be a cycle of urbanization, suburbanization, counter-urbanization and re-urbanization.

Natural increase

When the birth rate is higher than the death rate in a country or place, it is called the natural increase. Natural increase often occurs in cities because of its youthful age structure. Urban areas attract many young migrants and this makes the age structure younger. In contrast, the rural areas that they leave behind develop more of an ageing population, which means that rural birth rates are likely to decrease. On the other hand, the social and cultural pressures on women to have children are less in urban areas than in more traditional rural areas. Thus, in



▲ **Figure G.10:** A model of urbanization

some urban areas, despite the more youthful age structure, birth rates and fertility rates remain low. This could be partly due to the career choices of women and partly due to the high cost of raising a child. (See Unit 1 for a discussion of factors affecting birth rates.)

Rural–urban migration

Rural–urban migration refers to the movement of people away from the countryside to towns and cities. This is a very important process, especially in LICs and NICs. It occurs because people believe they will be better off in urban areas than in the rural areas. Reasons for this movement have been described using the concept of push and pull factors:

- **Push factors** are the negative features that cause a person to move away from a place (for example unemployment, low wages, natural hazards).
- **Pull factors** are the attractions (whether real or imagined) that exist at another place (for example, better wages, more jobs, good schools).

Gentrification

Gentrification is the reinvestment of capital into inner-city areas. It refers mostly to an improvement of residential areas, although there is an economic dimension, too. It is common in areas where there may be **brownfield sites** (abandoned, derelict or underused industrial buildings and land, which may be contaminated but has potential for redevelopment). Thus, as well as residential rehabilitation and upgrading, there is also commercial redevelopment. Gentrification may lead to the social displacement of poor people: as an area becomes gentrified, house prices rise and the poor are unable to afford the increased prices. As they move out, young, upwardly mobile populations take their place.

Gentrification has occurred in many large old cities throughout the world, such as in New York (Greenwich Village and Brooklyn Heights), Toronto (Riverdale) and London (Fulham and Chelsea). It has also been observed in cities as diverse as Johannesburg, Tokyo and São Paulo.

Re-urbanization/urban renewal

Re-urbanization is a revitalization of urban areas and a movement of people back into these areas. A good example is the re-urbanization of Barcelona and the use of the 1992 Olympic Games to re-establish the city. "Urban renewal" refers to the rehabilitation of city areas that have fallen into decline (urban decay). A good example is the renewal of Manhattan in New York and Woodstock in Cape Town.

Centrifugal population movements

Suburbanization

Suburbanization is the outward expansion of towns and cities, mainly in Europe, North America and Australia, largely thanks to improvements in transport systems. By the early 20th century, railways, electric tramways and buses were critical to the growth of middle-class, residential suburbs. Town extensions were really a form of suburban development following the lines of trams and trains. In addition, the price of farmland had declined dramatically and there was scope for urban expansion on a great scale.

The early 20th century was a period of optimism. Rising wages and living standards were matched by rising expectations. Housing was now available, affordable and of a quality unimaginable only a few decades earlier.

There were a number of reasons for this boom in private housebuilding:

- lower costs of living
- very low interest rates
- expansion of building societies
- willingness of local authorities to provide utilities, such as sewers, electricity, gas and water
- improved public transport.

Counter-urbanization

Counter-urbanization is a process involving the movement of population away from larger urban areas to smaller urban areas, new towns, new estates, commuter towns or villages on the edge or just beyond the city limits/the rural–urban fringe. There are several reasons why people may wish to leave large urban areas and move to towns and villages in rural areas. These include:

- high land prices
- congestion

Case study

Gentrification and relocation in Cape Town, South Africa

In South Africa, the phenomenon of gentrification is commonly associated with the rebirth of downtown Johannesburg and Woodstock, an inner-city suburb of Cape Town.

Woodstock is located between the docks of Table Bay and the lower slopes of Devil's Peak, about 1 km east of the city centre. It covers an area of less than 5 km^2 and has a population of over 11,500. In the middle of the 19th century, notably after the arrival of the railway line, Woodstock became a fashionable seaside suburb with a beach that stretched to the Castle of Good Hope. However, in the 1870s and 1880s Woodstock grew rapidly due to its ease of access to the harbour, improved transport and increased industrialization. The first glass manufactured in South Africa was made at the Woodstock Glass Factory in 1879.

By the 1950s Woodstock had ceased to be a seaside resort, but it managed to remain integrated during the apartheid era and survived being declared a "whites only" area. As a "grey" (mixed-race) area, many coloured and black people started to move into Woodstock during the 1970s and 1980s, creating the foundation for the urban renewal that would start in the late 1990s.

Urban renewal

Many of the lower parts of Woodstock became run down in the second half of the 20th century, with litter, crime and drugs becoming a serious issue. Young professionals have taken advantage of affordable Victorian semi-detached homes, many of which have been renovated and restored. Fashionable restaurants, ICT, businesses and offices have sprung up in converted warehouses, abandoned buildings and even a disused Castle brewery. The Old Biscuit Mill hosts a neighbourhood goods market every week, where visitors can enjoy fresh local produce and organic foods. The Old Castle Brewery has been restored to its former glory.

Activity 5

Describe the changes in (a) the number and (b) the distribution of cities with more than a million inhabitants ("millionaire cities") between 1900 and 2000.

▲ **Photo G.8:** Suburban development

▲ **Photo G.9:** Suburban housing

- pollution
- high crime rates
- a lack of community
- declining services.

In contrast, there is a perception that smaller settlements have a closer sense of community, better environments and a safer location.

Urban sprawl

Urban sprawl, the uncontrolled growth of urban areas at their edges, suggests that urban areas grow in an unchecked fashion. However, the existence of green belts prevents urban sprawl because there are limits on how far the urban area can grow. Many of the world's largest cities, such as Tokyo, Seoul and Mexico City, have been characterized by urban sprawl.

Urban system growth

As urban areas grow, there is increased need to provide access to clean water, sanitation and waste disposal. If these are not provided, the risk of disease increases, placing further burdens on the city authorities. In addition, if urban areas are to be successful, they need to expand their transport facilities and their telecommunications networks. Without these, the ability to attract new economic activity is limited. For many rapidly growing cities, traffic jams, air pollution, unclean water and inadequate telecommunications reflect a failure to match population growth with infrastructure growth. The case study on Shanghai below examines the growth of population and infrastructure as the city consolidates its position as one of the world's great cities.

Case study

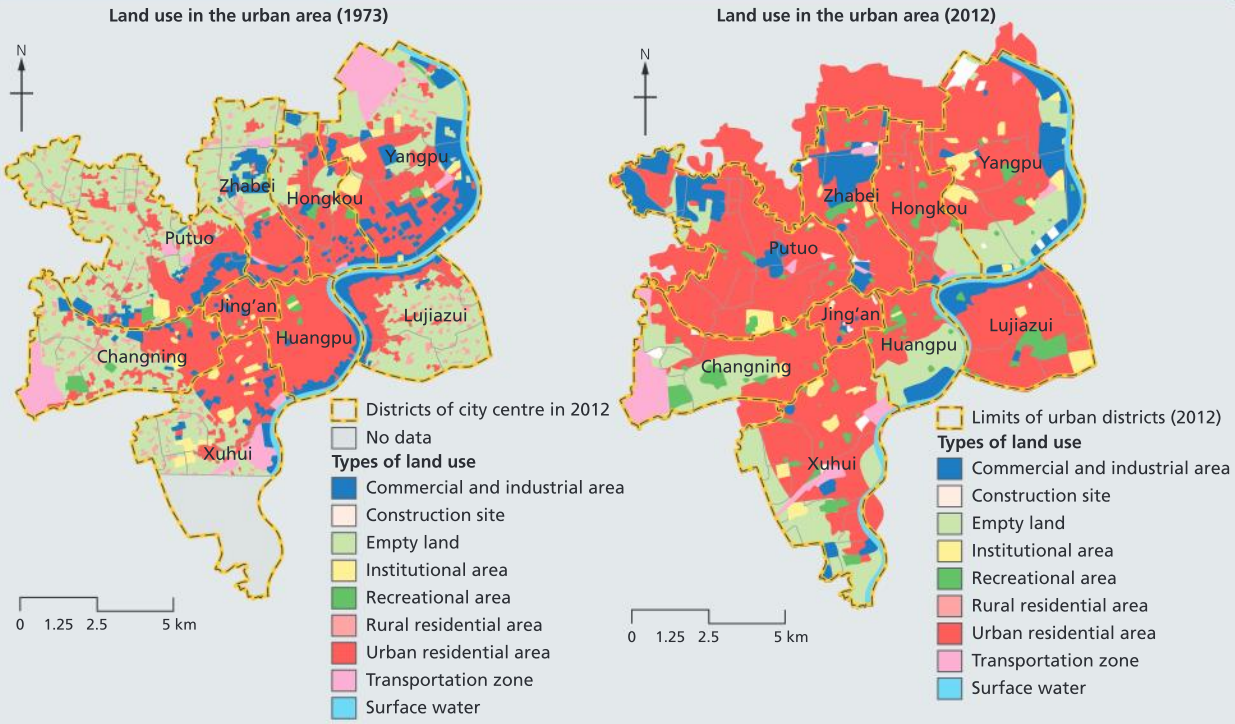
A changing urban environment: Shanghai

Shanghai has been growing at a rate of about 10 per cent a year since 1992 and now has a population of about 23 million, double what it was in 1987. The central city is the political, economic and cultural centre of Shanghai. By 2020 its population is set to reach over 16 million. The plan is to turn Shanghai into an international economic hub – "a seaport, an airport and an information port". The CBD, including Pudong, has a variety of functions including finance, trade, retailing, recreation, tourism, media, information services and business. There is a small amount of residential land use within the CBD.

The main civic centre surrounds the Peoples' Square, and its function includes administration, government buildings, retailing, cultural recreation and tourism. There are four secondary civic centres: Xajuahui, Huamu, Jiangwan-Wujiaochang and Zhenru.

In an attempt to ease pressure on the city, 11 satellite towns have been built and these act as growth points around the city. Each satellite

Case study (continued)



▲ **Figure G.11:** The distribution of selected land uses in Shanghai, 1973 and 2012

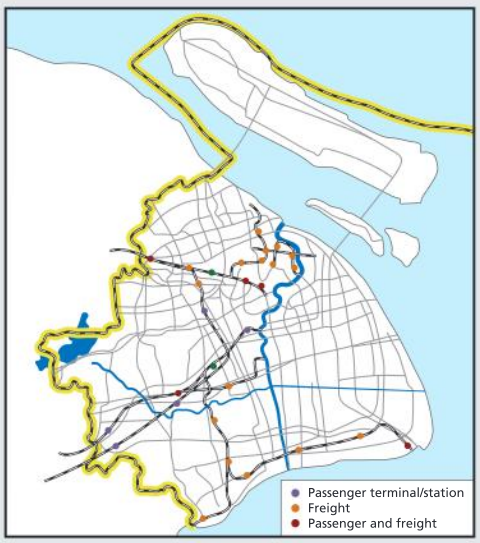
town has a different emphasis; for example, Jiading New Town will be the first "wireless zone" in China; and Anting New Town is closely linked to the automobile industry (Volkswagon has a factory close to the F1 circuit).

Changes in transport infrastructure in Shanghai

As a result of population growth and the expansion of the built-up area of Shanghai, there is a need to develop transport systems. Shanghai's integrated transport system is developing a transport infrastructure that will deal with increased traffic volumes. The transport system focuses on two ports, two highways and three transport networks.

Shanghai has completed the north port area of the Yangshan Deep-Water Port. It is the busiest port in the world, with an annual cargo of 590 million tonnes. Shanghai has two international airports and four airport terminals. It receives over 70 million passengers each year. Pudong International Airport is the world's third largest in terms of cargo.

Rail transport is the key feature of Shanghai's public transport. The urban rail network (Figure G.12), developed in less than 20 years, is over 400 km long and has 13 metro lines, which together carry over 5 million passengers daily. Approximately 25 per cent of the city centre is covered by railway stations, serving 40 per cent of the city centre's population. Journey times have been shortened; for example, to Hangzhou journey time fell from 90 to 30 minutes and to Nanjing from 180 to just over 70 minutes.



▲ **Figure G.12:** Shanghai's rail network

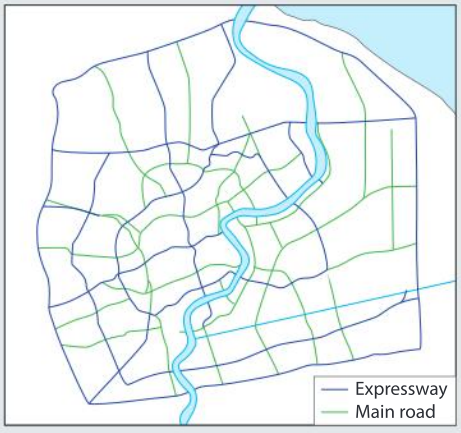
Case study (continued)

▲ **Figure G.13:** Shanghai's trunk road network, including highways and main roads

In addition, there are over 1,000 bus lines and 17,000 buses.

Shanghai has over 12,000 km of roads, including nearly 800 km of expressways. The target for planners has been referred to as "15, 30 and 60", that is, motorists in suburban areas can reach an expressway within 15 minutes, then travel to the city centre in 30 minutes, and travel between any two suburban areas in less than 60 minutes.

The Urban Expressway Network is over 4,000 km long, with over 3,000 km of road in the city centre and nearly 200 km of expressway. There are some 23 crossing facilities for the Huangpu River, including four bridges and 12 tunnels.



▲ **Figure G.14:** Central Shanghai's main road network

The practical targets of Shanghai's transport strategy are that:

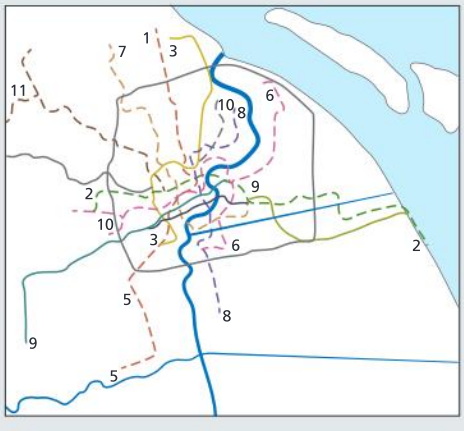
- public transport between any two parts of the city centre should take less than 60 minutes
- public transport between any two parts of the city centre should take just one bus ride.

With increasing globalization, population growth (Shanghai is growing by about 350,000 each year) and increased car ownership, there will be increasing pressure on Shanghai's roads.

Access to water and sanitation in Shanghai

The Huangpu River and the Yangtze River are the main surface water sources for Shanghai's water supply. Part of the upper reaches of the Huangpu River pass through suburban Shanghai, with its intensive farming activities, while the lower course passes through urban areas with intensive industrial activities.

In urban areas throughout China, the proportion of the population with access to piped water rose from 40 per cent in 1990 to nearly 95 per cent in 2007. Nearly 80 per cent of Shanghai's waste water is treated, and this is set to rise to 90 per cent by 2020. Over 70 per cent of households have access to sewerage services. Although water is abundant in Shanghai, there are high levels of water stress. Increasing demand, pollution and saltwater intrusion all threaten the city's water security. For example, agricultural practices have led to fertilizers and insecticides getting into the



▲ **Figure G.15:** Shanghai's metro network (Numbers refer to the subway line)
Source: Development of Shanghai integrated transport, 2010–2015

Case study (continued)

Pigs in the water supply

Over a two-week period, over 16,000 dead pigs have been recovered from the rivers that supply Shanghai. Contaminated water is now one of the greatest causes of illness in China. A study carried out by the Chinese government in 2011 found that nearly half of all cities had "seriously contaminated" groundwater supplies. The government has invested comparatively little in water saving, industry has been allowed to pollute on a massive scale, farmers are left to take too much, and consumers have been able to waste water.

Adapted from *The Guardian*, 22 March 2013

urban water system. The relatively low capacity of the sewage treatment system has led to some industrial and residential waste being discharged directly into rivers. Due to organic pollution, the Huangpu River has lower water quality than the Yangtze River. In addition, saltwater intrusion is a seasonal problem in the winter and the early spring dry season. To combat the need for more fresh water, Shanghai built the Qingcaosha Reservoir, designed to provide water for up to 68 days (the theoretical maximum extent of saltwater intrusion in Shanghai).

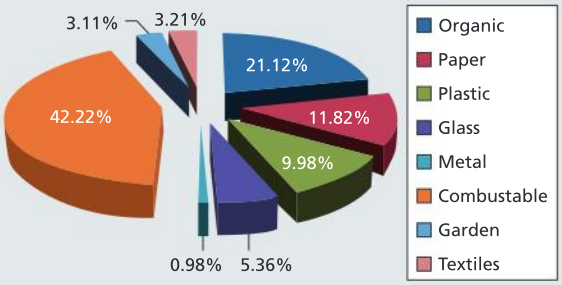
Waste treatment in Shanghai

In the past, most of Shanghai's rubbish ended up in landfill sites or in unregulated heaps on the edge of the city. At such sites, there was much informal recycling of materials, but there was also contamination of the land and groundwater by methane. Plastics were carried into the rivers, and from them into the ocean.

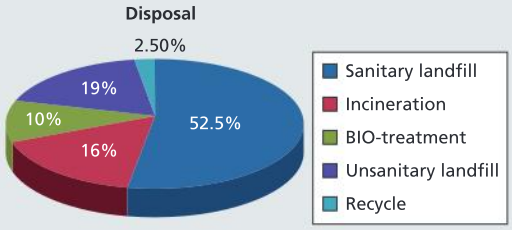
As Shanghai increases in size, it is producing more rubbish and landfill sites are filling up. Increasingly, Shanghai is turning to incineration and generating electricity at "waste to energy" plants, such as the one at Hangzhou. The demand for such incinerators is increasing at a much more rapid pace than elsewhere in the world. (*The Economist*, 25 April 2015)

▲ **Photo G.10:** A landfill site in Laogang, Shanghai

Shanghai currently produces the most household rubbish in China – 22,000 tonnes/day. China's largest landfill site, Laogang, is located near the city at the coast. However, there is now an incinerator next to the landfill and this takes in around 3,000 tonnes a day. The waste is burned at high temperatures (850°C or higher) to destroy toxins. This heats water to produce steam that in turn drives turbines to generate electricity. The new incinerators at Laogang will burn 9,000 tonnes a day. The aim is to increase the proportion of domestic waste incinerated from 35 per cent to 75 per cent.



▲ **Figure G.16:** Properties of waste
Numbers may not add up to 100 per cent due to rounding.



▲ **Figure G.17:** Municipal solid waste disposal, 2007

Case study (continued)

Access to telecommunications

Shanghai was one of the first centres in China to develop telecommunications services. In 1871 an underwater telegraph cable was laid between Hong Kong and Shanghai, and in 1907 a local telephone service was introduced, followed by a long-distance one in 1923. By 1949 Shanghai had around 30 per cent of all the phone lines in China.

Following the economic reforms of the 1980s, Chinese leaders realized that telecommunications would be an important aspect of developing Shanghai's economy. Although the national government encouraged foreign investment in communications equipment manufacture, it prohibited foreign or even private Chinese companies from taking part in operating the domestic phone companies. It feared for domestic security, and so companies such as China Telecom, China Mobile and China Unicom were prevented from forming joint partnerships with foreign companies.

China's entry into the World Trade Organization (WTO) meant that it had to allow greater foreign involvement and ownership of fixed-line, mobile phone and Internet networks. However, government nurturing and protectionism has provided Shanghai with a strong telecommunications base, and this was critical in attracting high-technology investment to Shanghai.

Activity 6

1. Describe the main characteristics/features of domestic waste, as shown in Figure G.16.
2. Comment on the methods of waste disposal (Figure G.17).

Activity 7

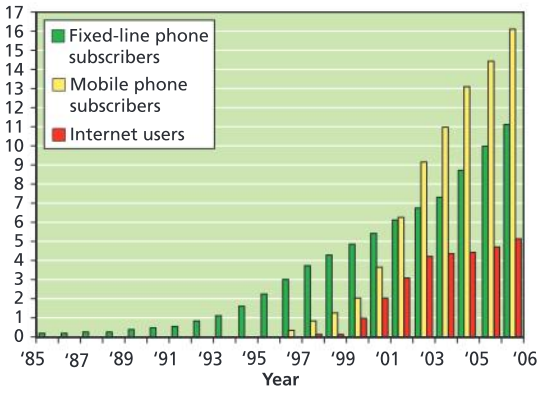
1. Describe the trends in fixed-line telephone subscribers, mobile phone subscribers and Internet users in Shanghai between 1985 and 2006.
2. Update the data using the more recent *Shanghai Statistical Yearbook*.

ATL Research and communication skills

To investigate waste to energy in selected parts of Asia visit https://waste-management-world.com/a/1-the-far-east-embraces-waste-to-energy.

Activity 8

1. Study Figure G.11.
   a. Describe the growth of Shanghai between 1973 and 2012.
   b. Describe how land use has changed in Shanghai between 1973 and 2012.
2. Study Photos G.11 and G.12. The photos were taken from the same location, and looking in the same direction. Identify the differences in the pictures, and comment on them.



▲ **Figure G.18:** Numbers of Shanghai fixed-line and mobile telephone subscribers, and Internet users, 1985–2006 (millions)

The causes and consequences of urban deindustrialization

Deindustrialization is the long-term, absolute decline in employment in the manufacturing sectors of an economy. It refers to a loss of jobs rather than a decline in productivity. The decline of certain industries or areas is due to a number of factors, including:

- the exhaustion of resources
- the increasing costs of raw materials
- automation and new technology
- the introduction of a rival product
- fall in demand
- overseas competition from NICs
- rationalization
- a rise in costs
- the removal of a subsidy
- lack of capital.

Since the 1950s there has been a decline in manufacturing employment (deindustrialization), especially in the older industrialized countries. In contrast, there have been gains in the service sector, especially in banking, finance and insurance. However, these have failed to compensate for the manufacturing losses and many of the new jobs are filled by commuters from outside the city areas.

▲ **Photo G.11:** Shanghai in 1987

▲ **Photo G.12:** Shanghai in 2013

Women took many of the new jobs in the service sector, but these were often part-time and low paid. Firms that survived in the inner cities were frequently older, less competitive and less innovative enterprises demanding low skills. Inner cities had many of the oldest and least profitable industries, so these were areas of **disinvestment** characterized by massive **outflows** of capital and labour.

There are two types of deindustrialization, positive and negative:

- Positive deindustrialization occurs when industries reduce their workforce to increase productivity through mechanization and rationalization. This makes the industry more competitive.
- Negative deindustrialization occurs when particular industries decline without any compensating rise in productivity or mechanization.

In contrast, reindustrialization is the growth of high-technology industries, small firms and services industries (tertiarization). The highest rates of increase in small firms are found in the less industrialized, rural, peripheral areas rather than large urban areas with derelict sites.

Case study

Urban deindustrialization: decline in Detroit

Detroit was once the USA's fourth-largest city. Indeed, in 1960 it had the highest per-capita income in the USA. Now up to a quarter of the city has been reclaimed by nature. Up to 40,000 buildings and parcels of land are vacant. Property prices have fallen by 80 per cent or more. In 2013 a three-bedroomed house on Albany Street was for sale for $1!

Detroit is the largest US city to declare bankruptcy. Its long-term debts are estimated at over $18 billion, or $27,000 for every resident.

Between 1900 and 1950 Detroit prospered because General Motors (GM), Ford and Chrysler, which made most of the cars sold in the USA, were based there. Detroit's population increased from about 300,000 in 1900 to 1.8 million in 1950, but fell to just 700,000 in 2013.

Many of Detroit's people are poor and relatively poorly educated – over 80 per cent have no more than a high school diploma. Delivering services to sparsely populated neighbourhoods in the city, which sprawls over 340 km^2, would be difficult even if the city could afford it.

The causes of Detroit's troubles include:

- falling car sales and therefore less tax revenue from the city's large firms
- a shrinking population – many of the richer people have moved away
- high pension and social welfare costs – the city has an ageing population.

Detroit has paid the price for being over-reliant on a single industry – the motor car. It attracted many black workers from the American south to work in the factories. However, inequalities in working conditions and living conditions led to race riots in 1943 and 1967. Many white people abandoned the city during the "white flight" of the 1950s, 1960s and 1970s.

Only 30 per cent of the jobs available in the city are taken by Detroit residents and over 60 per cent of Detroit's population who work do so outside the city. Unemployment had reached 30 per cent by 2013. Over a third of Detroit's population and nearly half its children live below the poverty line. Nearly half of Detroit's adults are functionally illiterate and 29 of the city's schools closed down in 2009 alone. Detroit's population is now 81.6 per cent Afro-American.

According to a report in *The Economist*, law and order has completely broken down in the inner city, and drugs and prostitution are commonplace. Detroit's murder rate is at a 40-year high. Of the city's 85,000 street lights, half are usually out of service because thieves have stripped them for copper. Only one-third of its ambulances are in working order.

However, there is some growth. Urban farms are appearing. Young people – especially artists and musicians – are moving into Detroit to make use of the abandoned and affordable urban spaces. Low rents, good universities and tax breaks are attempting to attract businesses back to the city.

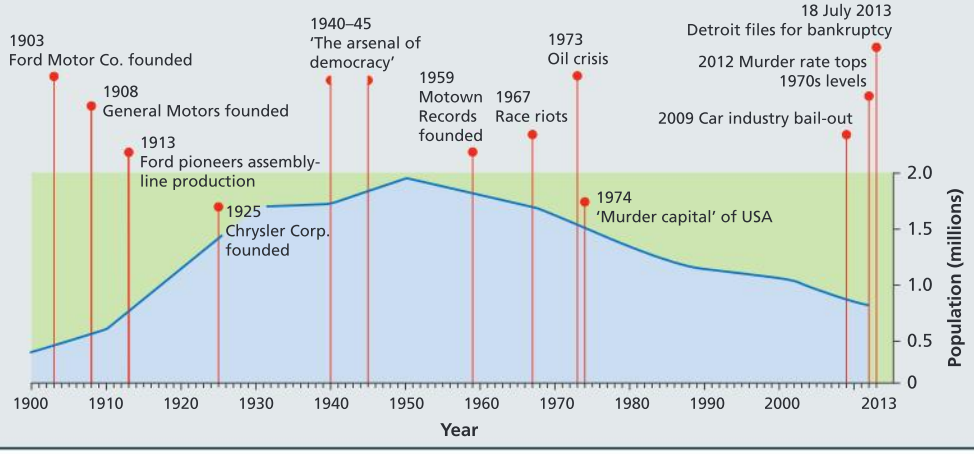


Figure G.19: Population change in Detroit (millions)

▲ **Figure G.20:** Manufacturing employment in Detroit, 1990–2010

▲ **Photo G.13:** Decaying vacant buildings in Detroit, 2011

Activity 9

1. Suggest reasons for Detroit's growth between 1900 and 1950.
2. Suggest why Detroit's population declined after 1950.
3. Suggest the likely impacts of a falling population size.
4. Describe the trend in manufacturing employment in Detroit between 1990 and 2010. Suggest the likely impacts of the changes that you have described.
5. Watch "Death of Detroit" at http://www.youtube.com/watch?v=-aUUuTBVypk and "Grown in Detroit" at http://www.youtube.com/watch?v=XH6sI7BqXLo and the "Grown in Detroit" documentary trailer, http://documentaryheaven.com/requiem-for-detroit/.

Concepts in context

Many **processes** operate in urban areas. Some are causing urban areas to increase, such as rural-to-urban migration and natural increase, leading to urbanization. Some are causing urban areas to decline, such as counter-urbanization. Urban areas may therefore grow over time, and develop complex networks of transport, water, sanitation, energy provision, and telecommunications. However, some urban areas decline. This may be due to the decline in industry. However, some former run-down areas may appear attractive to certain populations, and may regenerate as a result of gentrification.

Check your understanding

1. Explain how centrifugal movement of population affects a city and its hinterland (surrounding area).
2. Explain the advantages and disadvantages of counter-urbanization.
3. Explain the process of deindustrialization.
4. Describe the process of urbanization.
5. Suggest why most of the world's growing megacities are found in LICs.
6. Outline the potential impacts of megacities.
7. Describe the growth in telecommunications in Shanghai.
8. Briefly outline the problems associated with the growth of Shanghai.
9. Suggest reasons for the growth of Detroit.
10. Explain the causes and consequences of the decline of population in Detroit.

3 Urban environmental and social stresses

Conceptual understanding

Key question

What are the varying **powers** of different stakeholders in relation to the experience of, and management of, urban stresses?

Key content

- Urban microclimate modification and management, including the urban heat island effect, and air pollution patterns and impacts and their management.
- Traffic congestion patterns, trends and impacts and their management.
- Contested land use changes, including slum clearances, urban redevelopment and the depletion of green space, and their effect on neighbourhoods and their populations.
- Managing the impacts of urban social deprivation, including the cycle of deprivation and geographic patterns of crime.

Urban microclimates

The climate of an urban area is affected by two main factors:

- The structure of the air above the urban area – more dust in the air means a greater concentration of hygroscopic particles, less water vapour, but more CO_2 and higher proportions of noxious fumes from the combustion of fuel and discharge of waste gases by industry.
- The structure of the urban surface – more heat-retaining materials are used, with lower albedo and better radiation-absorbing properties. There are rougher surfaces with a great variety of perpendicular slopes facing different aspects. Tall buildings can be very exposed, while the deep streets are sheltered and shaded.

The resultant processes are as follows:

1. Radiation and sunshine
    a. Greater scattering of shorter-wave radiation by dust, but much higher absorption of longer waves owing to surfaces and CO_2, hence more diffuse sky radiation with considerable local contrasts owing to variable screening by tall buildings in shaded narrow streets.
    b. Reduced visibility arising from industrial haze.
2. Clouds and fogs
    a. Higher incidence of thicker cloud cover in summer and radiation fogs or smogs in winter because of increased convection and air pollution, respectively.

b. Concentration of hygroscopic particles, accelerating the onset of condensation (see 5 below).

c. Day temperatures on average 0.6°C warmer.

3. Temperatures

a. Stronger heat energy retention and release, including fuel combustion, giving significant temperature increases from the suburbs into the centre of built-up areas, creating heat "islands".

b. Up to 1.5°C warmer during winter nights (snow in rural areas increases their albedo, thereby increasing the differences).

c. Heating from below, increasing air mass instability overhead, notably during summer afternoons and evenings.

d. Big local contrasts between sunny and shaded surfaces, especially in spring.

4. Pressure and winds

a. Severe gusting and turbulence around tall buildings causing strong local pressure gradients from windward to leeward walls.

b. Deep, narrow streets much calmer unless aligned with prevailing winds to funnel flows along them – the "canyon effect".

5. Humidity

a. Decreases in relative humidity owing to lack of available moisture and higher temperatures.

b. Partly countered in very cold, stable conditions by early onset of condensation in low-lying districts and industrial zones (see 2 above).

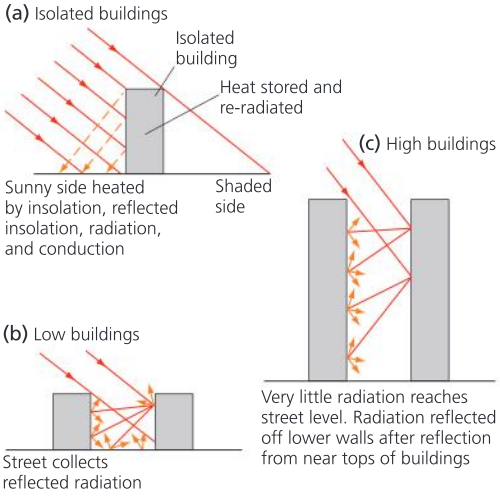
6. Precipitation

a. Perceptibly more intense storms, particularly during hot summer evenings and nights owing to greater instability and stronger convection above built-up areas.

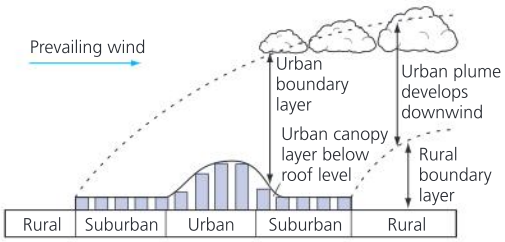
b. Probably higher incidence of thunder in appropriate locations.

c. Less snowfall and briefer covers, even when uncleared.

The effect of city morphology on radiation received at the surface

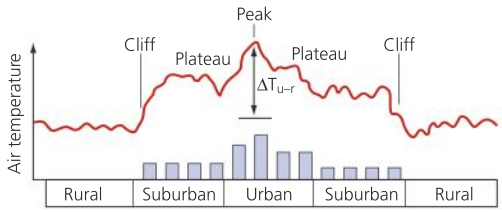


The structure of the urban climatic dome

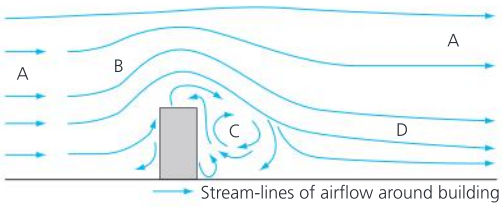


The morphology of the urban heat island

ΔT_{u-r} is the urban heat island intensity, i.e. the temperature difference between the peak and the rural air



Airflow modified by a single building



▲ **Figure G.21:** Urban microclimates

The urban heat island

Urban areas are generally warmer than those of the surrounding countryside; temperatures are on average 2–4°C higher. This creates an urban heat island. It can be explained by heat and pollution release:

- Wind speeds are lower due to the height of buildings and urban surface roughness.

▼ **Table G.6:** Average changes in climate caused by urbanization

Factor		Comparison with rural environments
Radiation	Global	2–10% less
	Ultraviolet, winter	30% less
	Ultraviolet, summer	5% less
	Sunshine duration	5–15% less
Temperature	Annual mean	1°C more
	Sunshine days	2–6°C more
	Greatest difference at night	11°C more
	Winter maximum	1.5°C more
	Frost-free season	2–3 weeks more
Wind speed	Annual mean	10–20% less
	Gusts	10–20% less
	Calms	5–20% more
Relative humidity	Winter	2% less
	Summer	8–10% less
Precipitation	Total	5–30% more
	Number of rain days	10% more
	Snow days	14% less
Cloudiness	Cover	5–10% more
	Fog, winter	100% more
	Fog, summer	30% more
	Condensation nuclei	10 times more
	Gases	5–25 times more

- Urban pollution and photochemical smog trap outgoing radiant energy.
- Burning of fossil fuels for domestic and commercial use can exceed energy inputs from the sun.
- Buildings have a higher capacity to retain and conduct heat and a lower albedo.
- The reduction in thermal energy required for evaporation and evapotranspiration is due to the surface character, rapid drainage and generally lower wind speeds.
- The reduction of heat diffusion is due to changes in airflow patterns as the result of urban surface roughness.

The heat island effect

The contrast between urban and rural areas is greatest under calm, high-pressure conditions. The typical heat profile of an urban heat island shows a maximum at the city centre, a plateau across the suburbs and a temperature cliff between the suburban and rural areas (Figure G.21). Small-scale variations within the urban heat island occur with the distribution of industries, open spaces, rivers, canals and so on.

The heat island is a feature that is delimited by isotherms (lines of equal temperature) normally in an urban area. This shows that the urban area is warmer than the surrounding rural area, especially by dawn during anticyclonic conditions. The heat island effect is caused by a number of factors, including:

- heat produced by human activity: a low level of radiant heat can be up to 50 per cent of incoming energy in winter
- changes of energy balance: buildings have a high thermal capacity in comparison to rural areas – up to six times greater than agricultural land
- the effect on air flow: turbulence of air may be reduced overall, although buildings may cause funnelling effects
- the reduced number of open water bodies: this means less evaporation and fewer plants, therefore less transpiration
- the composition of the atmosphere: the blanketing effect of smog, smoke or haze
- the reduction in thermal energy required for evaporation and evapotranspiration: this is due to the surface character, rapid drainage, and generally lower wind speeds
- the reduction of heat diffusion: this is due to changes in airflow patterns as a result of urban surface roughness.

Urban areas may also develop a pollution dome. Highest temperatures are generally found over the city centre – or downwind of the city centre if there is a breeze present. Pollutants may be trapped under the dome. Cooler air above the dome prevents the pollutants from dispersing. These pollutants may prevent some incoming radiation from passing through, thereby reducing the impact of the heat island. By night, the pollutants may prevent some long-wave radiation from escaping, thereby keeping urban areas warmer than surrounding rural areas.

Air pollution patterns

Poor air quality affects half the world's urban population. Each year several hundred thousand people die because of poor air quality, and many more are seriously affected. The problem is increasing as population growth increases in urban areas, with industrial development and the increase in the number of vehicles worldwide.

The world's population is growing by about 95 million people each year. This increases the demand for energy, transport, heating and so on. Increasingly, more and more people are living in urban areas. In LICs population growth is very rapid, and cities have fewer resources to cope than cities in HICs. Overcrowding is widespread in many cities but reaches alarming proportions in cities in LICs and NICs. For example, in London, population densities reach as high as 4,000 people per square kilometre. By contrast, densities per square km reach 24,000 in Cairo, 34,000 in Mexico City and 88,000 in Calcutta. In many developing countries indoor air pollution is high due to the burning of fuelwood and paraffin for cooking and heating. Up to 700 million people in LICs and NICs are thought to be at risk of high levels of indoor air pollution, especially those living in slums.

LICs and NICs have weaker economies and so investment in pollution control is minimal. Instead, such countries favour industrialization and the use of cheap, inefficient energy resources, such as lignite and low-grade coal, as a source of energy. By contrast, HICs – which may have gone through the process of deindustrialization – have the capital and the technology to tackle air pollution.

One of the major sources of pollution is motor vehicles. At present, LICs/NICs account for about 10 per cent of the world's motor vehicles and about 20 per cent of the world's cars but some countries, such as India and China, are expanding their car industries as a key part of their economic development. Cars and other vehicles in LICs tend to be less fuel-efficient and produce more pollution because they are older, poorly serviced and lacking in clean, environmentally friendly technology. In addition, roads are often in a poor state and

Case study

Cheong Gye Cheon, Seoul, South Korea – the impact of river restoration on an urban microclimate

The urban microclimate can be reversed, as has happened in Seoul. The heat island phenomenon used to be observed in the Cheong Gye Cheon Stream area under the impact of heavy traffic on an elevated highway, concentrated commercial facilities, and the impermeable soil surface over the waterway. The area was showing a temperature about 5 degrees higher than the average temperature of the city.

The project to restore the stream and the areas alongside it has turned the location into a linear green oasis.

The water flowing in the stream has decreased the air temperature by up to 10–13 per cent, that is, by 3–4°C during the hottest days, when the temperature goes up to 30°C or higher. The removal of the elevated highway has allowed wind speeds to increase – to up to 7.8 per cent faster than before – pushing the temperature down even further. The decrease in the number of vehicles passing by has also contributed to the drop in the temperature.

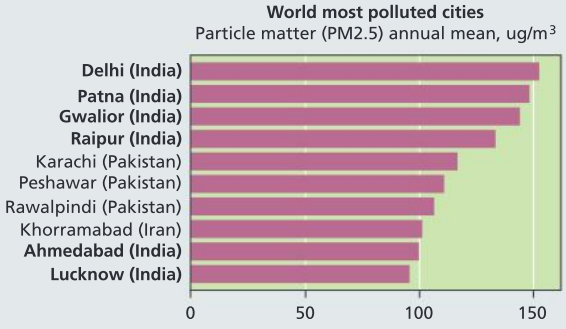
this reduces the quality of vehicles quickly. In many cities there are limited funds to tackle urban air pollution. City planners have to balance the demands against the needs for housing, education, employment, health and so on. Environmental issues are rarely top of the agenda.

Case study

Air pollution in Delhi

New Delhi, the capital of India, has the reputation for being the most polluted city in the world. This is due to its combination of diesel exhausts, construction dust, industrial emissions and the widespread burning of biofuels for cooking. Smaller Indian cities such as Gwalior, Patna and Raipur, each with populations of between 1 and 2 million people, also have dangerously high levels of PM2.5, which increases the risk of cancer. In a WHO survey of 1,600 urban centres, India had 13 out of the 20 most polluted cities. In 2013 alone, there were over 586,000 premature deaths in India due to poor air quality (up from 365,000 in 1990). This compares with 9,500 premature deaths in London in 2014. The number of cars, trucks and motorbikes in India increased dramatically between 2004 and 2014. In 2014, vehicle sales were up by 7.2 per cent, and the number of trucks increased by 16.2 per cent.

India's construction boom is another contributor. Dust management rules are rarely enforced. Emissions from informal industries, such as brick kilns, are unregulated. About half of India's population cook their food and keep warm in winter by burning wood, coal and even cow dung – all of which release high levels of particulates. Each winter, Delhi is shrouded in a haze caused by the burning of an estimated 500 megatonnes of post-harvest stubble in the fields of Punjab and Haryana.



▲ **Figure G.22:** The world's most polluted cities

India has two emissions standards – Bharat IV, the equivalent of Europe's 2005 clean air emissions in 33 cities, and Bharat III, equivalent to what Europe abandoned in 2005, in the rest of the country.

Pollution management strategies

Reducing emissions

There are a number of ways to reduce air pollution from transport emissions, including:

- burning less fossil fuel and using more energy-efficient technologies such as hybrid/electric cars
- using public transport rather than private cars
- using a car pooling scheme, for example liftshare.com
- cycling or walking more, for example the "Living Streets" walk to school campaign in the UK
- using catalytic convertors to reduce emissions of NOx
- increasing enforcement of emissions standards, for example the Zero Emissions network in east London.

In general, reducing fossil fuel emissions will be cheaper and more effective than trying to clean up the pollution after it has happened.

Urban trees and green spaces

Green spaces and trees are vital to the health of a city and its people because they help to reduce the effects of the urban heat island, reduce noise levels and filter and clean the air.

With an extensive and healthy urban forest, air quality can be drastically improved. Trees help to lower air temperatures in urban areas by increasing evapotranspiration. This reduction of temperature not only lowers energy use but also improves air quality, as the formation of ozone is dependent on temperature. Large shade trees such as the London plane tree (Table G.7) can reduce local ambient temperatures by 3–5°C. Maximum midday temperature reductions due to trees range from 0.04°C to 0.2°C per 1 per cent canopy cover increase.

Although street trees provide the greatest cooling potential per unit area, light surfaces provide the greatest overall cooling potential when available area is taken into account, because there is more available area in which to implement this strategy compared to the other strategies. Living roofs offer even greater cooling per unit area than light surfaces, but less cooling per unit area than curbside planting.

▼ **Table G.7:** Managing air pollution using the London plane tree

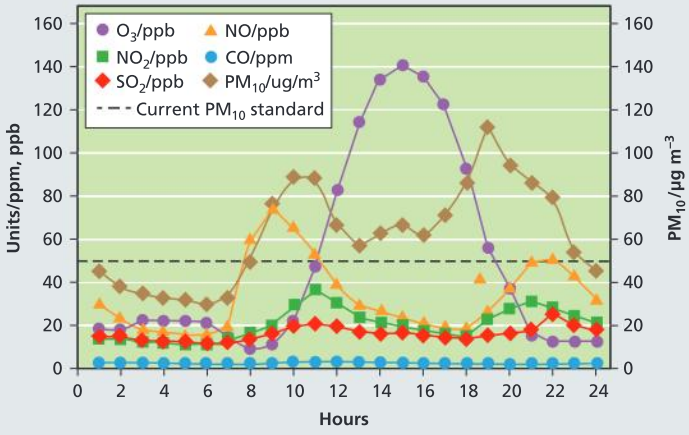
Advantages	Disadvantages
• Very tolerant of air pollution: hairs on young shoots and leaves help to trap particulate pollution • Rarely affected by disease and pests (although some shoots are killed each year by fungal infection) • Very tolerant of poor soil conditions including compacted soil (although some stunting of growth is caused by road salt) • Grows vigorously and tolerates pruning • Trees rarely blow over or shed branches • Open canopy produces light shade. Will intercept some rain, especially when in leaf • Provides valuable nesting sites for birds • Sufficient light below canopy to allow significant plant growth	• Leaves, fruit and bark need clearing from streets and pavements • Its enormous ultimate size makes it too large for some locations • Due to their water uptake, roots can cause problems in foundations of buildings on clay soils • Fine hairs on young shoots, leaves and fruit may cause irritation and even allergies in some people • Estimates suggest that its VOC emissions are relatively high

Source: Adapted from the Field Studies Council's Urban Ecosystems website www.field-studies-council.org/urbaneco

Case study

Managing air pollution in Mexico City

In Mexico City, average visibility has decreased from 100 km in the 1940s to about 1.5 km in the 2000s. Levels of nitrogen dioxide regularly exceed international standards by two to three times, and levels of ozone are twice as high as the maximum allowed limit for one hour a year. This occurs several times every day.



▲ **Figure G.23:** Air quality in Mexico City

The average altitude of Mexico City is 2,240 metres above sea level. Consequently, average atmospheric pressure is roughly 25 per cent lower than at sea level. The lowered partial pressure of oxygen (PO_2) has a significant effect on transport – fuel combustion in vehicle engines is incomplete and results in higher emissions of carbon monoxide and other compounds such as hydrocarbons and VOCs.

The most important air pollutants in Mexico City include PM10, ozone (O_3), sulphur dioxide (SO_2), nitrogen oxides (NOx), hydrocarbons, and carbon monoxide (CO). Intense sunlight turns these into photochemical smog (Photo G.14). In turn, the smog prevents the sun from heating the atmosphere enough to penetrate the inversion layer blanketing the city.

In the late 1990s, ozone levels exceeded standards on almost 90 per cent of days and PM10 exceeded standards on 30–50 per cent of days. Research suggests that reducing PM10 would yield the greatest health and financial benefits. Reducing both ozone and PM10 by 10 per cent would save $760 million a year. In human terms, this would result in over 33,000 fewer emergency visits and over 4,000 fewer hospital admissions for respiratory distress in 2010. In addition, it would lead to more than 260 fewer infant deaths each year.

▲ **Photo G.14:** Photochemical smog over Mexico City

The main programmes to combat air pollution in the Mexico City Metropolitan Area are as follows:

1. Reduce the use of private vehicles: the government has implemented a one-day-stop programme called *Hoy no curcula* (Today my car doesn't move). Anyone found driving when they shouldn't be has their plates taken away and must pay a fine of 20 days' pay based on the Mexico City minimum wage.

   Stopping days are randomly distributed to encourage car owners to use public transport and/or adopt car-pooling.
2. Enforce engine maintenance standards to keep vehicles in good condition.
3. Improve fuel quality by reducing its lead and sulphur content.
4. Make catalytic converters compulsory.

Other initiatives to improve the city's air quality since 1990 – such as moving refineries beyond its boundaries and introducing cleaner buses – are having some effect. Between 1990 and 2012, levels of ozone fell from 43 parts per billion to 27 parts per billion; sulphur dioxide from 55

Case study (continued)

parts per billion to 5 parts per billion; and carbon monoxide from 84 parts per billion to 10 parts per billion.

Most people (74 per cent) travel around Mexico City using public transport. Although only about a quarter of the population uses private transport, this represents about three-quarters of total energy consumption. More than 3 million vehicles – 30 per cent of them more than 20 years old – use Mexico City's roads. By expanding the city's metro system and investing in the Ecobici bike hire scheme – which is used for about 26,000 journeys a day – the city hopes to reduce people's dependence on cars.

Azoteas verdes in Mexico City

A growing number of *azoteas verdes* – or green roofs – are springing up around Mexico City as part of the city's attempts to clean its air. The *azotea verde* of the botanic garden's office, for example, is planted with stonecrop (of the sedum family). This can withstand the Mexico City summer, but it also produces oxygen and filters out some of the carbon dioxide and heavy metal particles in the air. The roof also helps regulate the temperature of the offices below it and soaks up rainwater to keep the building dry.

The *azoteas verdes* project increased the total area of green roofs in hospitals, schools and government buildings to over 20,000 square metres in 2014. The green roofs do far more than simply purify the air: they reduce the heat island effect, help educate children about nature and speed up the recovery of hospital patients by creating a more pleasant environment.

However, despite the measures taken so far, the combination of Mexico City's size (20 million), the number of cars and industries, its topography and its altitude mean that photochemical smog is likely to remain a problem. The national debt and widespread poverty mean that a number of more costly policies, for example to improve the environment, cannot be implemented.

Traffic congestion patterns, trends and impacts

Urban traffic congestion varies with days of the week, time of day, weather and the seasons. Traffic in urban areas is an important issue affecting people's livelihoods as well as economic development.

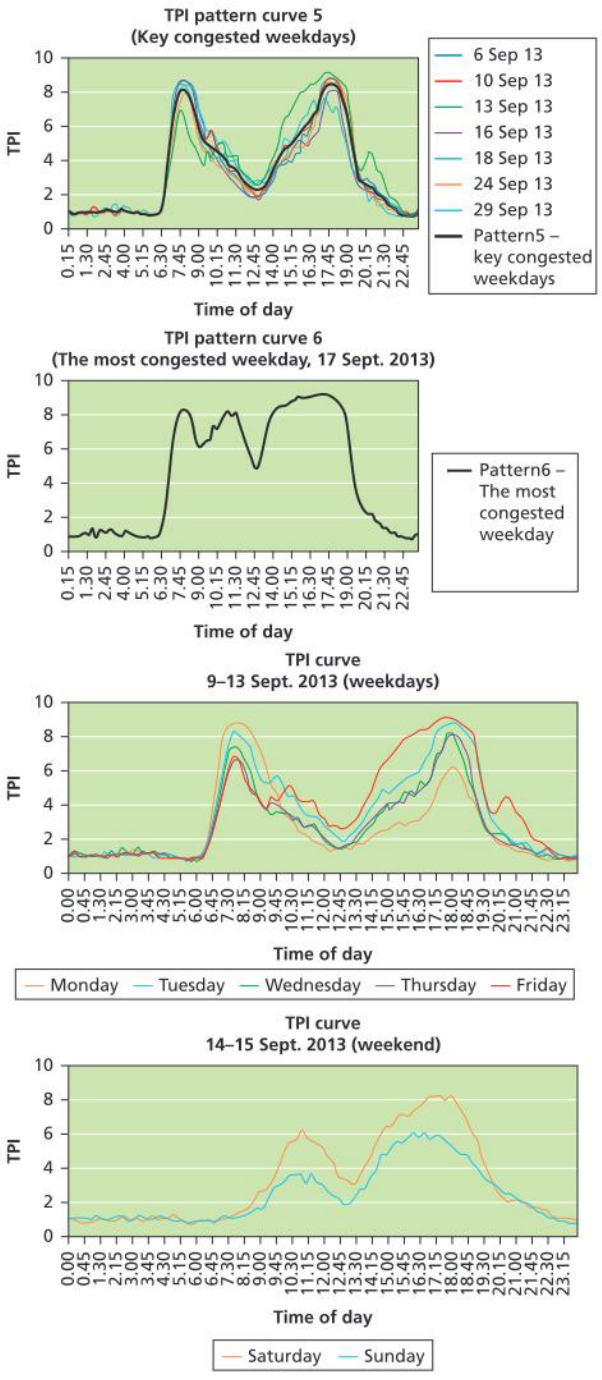
A city's transport performance index (TPI) may vary from 0 (excellent traffic flow) to 10 (serious congestion). Travel is more congested on weekdays, especially during the peak flow times in the morning (7.00–9.00) and evening (17.00–19.00). The most congested morning is Monday and the most congested evening is Friday.

Congestion is worse when the new school year starts, and festivals and national holidays also tend to increase the amount of traffic on the roads. By contrast, during the summer vacation, urban congestion is less of an issue.

Normal traffic flow on weekdays has an obvious morning and evening peak and the all-day congestion period may be prolonged (Figure G.24). In contrast, at weekends the TPI pattern curve has smaller but more prolonged peaks, with the morning peak occurring between 7.00 and 1.00 and an evening peak between 14.15 and 19.45.

Impacts of traffic congestion: noise pollution

Road traffic noise is related to traffic volume, traffic composition, speed, noise screens, distance from the source of the noise, reflection



▲ **Figure G.24:** TPI pattern curves

of noise from barriers, retaining walls or mitigation techniques, weather conditions, terrain and road surface. Noise disturbance may cause people in urban areas to move or consider moving from cities of high population density to quieter environments. Noise from road traffic and other sources has been associated with raised blood pressure, coronary heart disease, psychological stress and annoyance, and sleep disturbance.

In the USA, some 30 million workers are exposed to excessive occupational noise annually. Street noise exposure is believed to account for 4 per cent of the average individual's annual noise dose. A study of mean street noise in New York City found that the mean level was 73.4 dB, with a range between 55.8 dB and 95.0 dB. Density of traffic was considered to be the most important factor. Manhattan had the highest noise levels. A study in London found that, despite a reduction in air pollution, there was little change in noise levels close to main roads even after the introduction of congestion charging in 2003 and a low emission zone in 2008. These were designed to limit the number of cars allowed to enter an area (by price or by number plate).

The USA's EPA has established 70 dB as a safe average for a 24-hour day. In Amman, capital of Jordan, noise levels are between 34 dB and 80 dB. The main factor is traffic volume, with volumes of between 40 and 60 vehicles per minute causing the most noise. Other factors include speed, distance from an intersection, percentage of heavy vehicles and the nature of pavements. Jordan's recommended noise levels are for day and night 60 dB and 50 dB in residential areas. A study in Lagos, Nigeria, found that the highest levels of noise occurred during the morning rush hour and that traffic was a large contributory factor.

Contested land

Slum clearance in Rio

The 2016 Rio de Janeiro Olympic Games caused a property boom in some of the more central favelas. For example, the Vidigal favela had been dominated by drug gangs but was transformed by the potential of the Olympic Games. The value of land rose threefold in three years, and land speculators bought properties. Outsiders and real-estate agents moved in. The police made the area safe and the average house price increased by 165 per cent between 2012 and 2016. Values rose faster in favelas where the drug gangs were eliminated.

Activists claim that the developers have displaced more than 170,000 people, forced out of their homes for games-related purposes. For example, the Favela do Metro, home to 1,000 residents, was destroyed, arguably to make way for parking facilities.

The Occupy movement

Occupy Wall Street (OWS), New York, was an anti-capitalist protest focusing on inequality. Protesters used the slogan "We are the 99 per cent" to bring attention to the huge profits and inequalities generated by the financial services.

Occupy St Paul's in 2012 was a similar anti-capitalist protest in London. The protesters had originally intended to camp outside the London Stock Exchange in solidarity with Occupy Wall Street protesters in New York. Instead, they formed a camp outside St Paul's Cathedral in October 2012 and remained there until they were evicted in February 2013, with 20 arrests being made. Following eviction, the protesters moved to Salvation Army offices near the Millennium Bridge, until police moved them on.

▲ **Photo G.15:** Occupy St Paul's protest, 2012

Contested land in Dharavi

The Dharavi slum in Mumbai is a classic example of an area in a prime site for development, but where development would affect the lives of thousands, or even millions. Dharavi is connected by all three of the city's railways and the Indian property developer Mukesh Mehta wants to develop Dharavi into an international business destination.

However, Dharavi is home to thousands of micro-industries, which account for $650 million annually. As such, Dharavi should not be considered a slum sink but as a means of escaping poverty. Dharavi has been described as an "informal city" that attracts labour: people can work there and sleep in their workshops. Experts suggest that the informal economy accounts for the overwhelming majority of India's economic growth and as much as 90 per cent of employment.

The space is contested because developers such as Mukesh Mehta could make a huge fortune from developing the area as a financial or service district. But to do this would displace up to 1 million people to the edge of the city in places such as Mankhurd, which offer few economic prospects.

One successful development was the building of the Four Seasons Hotel (Photo G.16). There are good business reasons for the development of the hotel: there is a shortage of hotel rooms in India. The hotel cost $100 million to build and rooms start at $500 per night.

ATL Research skills

Use the Internet to find out more details about Occupy Wall Street and other Occupy movements.

1. When was Occupy Wall Street?
2. What were the protesters protesting about?
3. What is meant by the phrase "We are the 99 per cent"?
4. What impact did the Occupy Movement have?

▲ **Photo G.16:** The Four Seasons Hotel and Dharavi, Mumbai

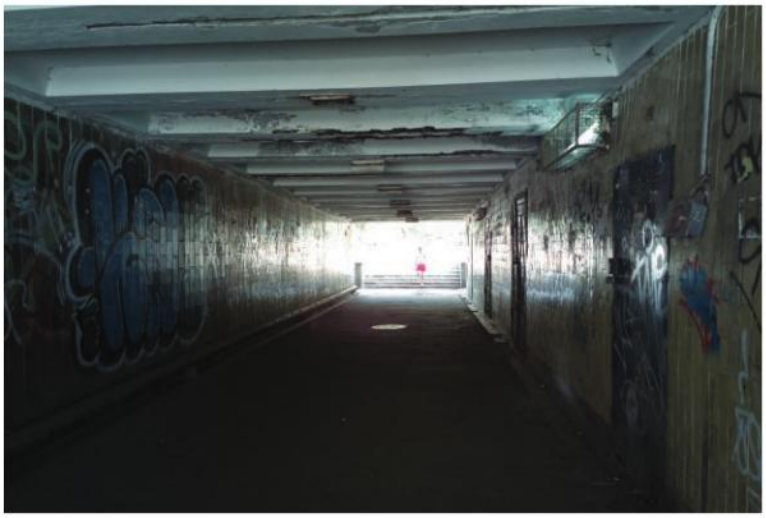
Activity 11

Investigate the contested space of Dharavi, using the websites for the Four Seasons Hotel: http://www.fourseasons.com/mumbai/Private-Residences-Mumbai.jpg and Mumbai Vision 2020: http://www.visionmumbai.org/aboutusdocs/McKinseyReport.pdf.

Depletion of urban green space

Open spaces are important for physical and mental well-being, but the amount of open space in urban areas varies enormously. For example, London has 50 m^2 of open space for each resident, whereas Mumbai has less than 2 m^2 of open space per resident. India's national building code recommends at least 4 acres of open space per 1,000 residents, but Mumbai has just 0.3 acres of open space per 1,000 residents. Mumbai now has the second-highest childhood obesity rate in India, and some 68 per cent of the city's children are said to have sedentary lifestyles.

It is not just green spaces that are important. In the 1960s in Bangalore, there were over 280 lakes but now there are fewer than 70, and many of these are biologically dead. The government turned many of them into vehicle parking spaces, a bus station and a sports stadium; others have been surrounded by slums. In addition, between 2010 and 2014, over 50,000 trees in Bangalore were cut down to make way for road widening. Some critics have suggested that compensatory afforestation projects should be set up to counter the loss of trees in Bangalore. However, the creation of forests elsewhere will not affect the lives of citizens in Bangalore, who are affected by air and noise pollution.



▲ **Photo G.17:** A potential site of criminal activity in a poor urban area

Space is at a premium in many urban areas. However, occasionally open space is created in cities. This has happened in Seoul, South Korea, in London with the creation of Queen Elizabeth Park, following the 2012 Olympic Games (see page 248), and in Hiroshima where the devastated central area was converted into the Hiroshima Peace Memorial Park.

Urban crime

The majority of criminal activity is concentrated in the most urbanized and industrialized areas and, within these, the poorest working-class neighbourhoods. Some crimes, such as fraud and sexual offences, are relatively more common in lower-density neighbourhoods with plenty of open spaces and a limited police presence.

According to the British Crime Survey, the risk of being a victim of household crime in the UK was higher in more deprived areas than in the least deprived areas. Rates of vandalism, burglary and vehicle-related theft are also higher in more deprived areas compared with less deprived areas. Rates of recorded crime in London and other cities are worse when the daytime population is greater than the resident population. Conversely, commuter areas where the daytime population is lower than the resident population may have lower than expected rates of crime.

▼ **Table G.8:** The typical common attributes of known offenders

Category	Indicator	Subgroup at risk
Demographic	Age	Young
	Sex	Male
	Marital status	Single
	Ethnic status	Minority group
	Family status	Broken home
Socio-economic	Family size	Large
	Income	Low
	Occupation	Unskilled
	Employment	Unemployed
Living conditions	Housing	Substandard
	Density	Overcrowded
	Tenure	Rented
	Permanence	Low

▲ **Photo G.18:** A burnt-out car on an estate at the edge of a city

A number of factors influence the development of a crime hotspot, an area where the offence rate is particularly high. These include:

- the presence of crime targets for an offence to happen
- site features such as easy access and lack of security
- the presence of a higher number of offenders and sufficient incentive and ability to commit crime
- a high level of residential land use
- a lack of health centres, schools and recreational areas in a settlement
- lack of a police station.

Case study

Urban crime in Zanjan, Iran, and Kaduna, Nigeria

Islamabad is a large informal settlement in the city of Zanjan in northern Iran, with a high proportion of residential land use but few services and facilities. Islamabad is one of the most densely populated parts of Zanjan, with densities about six times greater than the city average. It contains 11 per cent of the city's population but less than 2 per cent of its land.

Patterns of crime in Zanjan are highly centralized and clustered, and Islamabad has been described as a "crime hotspot". The main crimes there include violence, drug abuse and drug trafficking.

A crime hotspot can be just a small area (such as within Islamabad) or an individual home or building.

A study in Kaduna, northern Nigeria, also found that crime patterns were clustered. In the Badarawa-Malali district in Kaduna, where population densities were highest, notably in areas of poor housing, there was more burglary and stealing, whereas in the areas of lower-density, higher-quality housing and wealthier residents, there was more car theft and damage to cars.

Case study

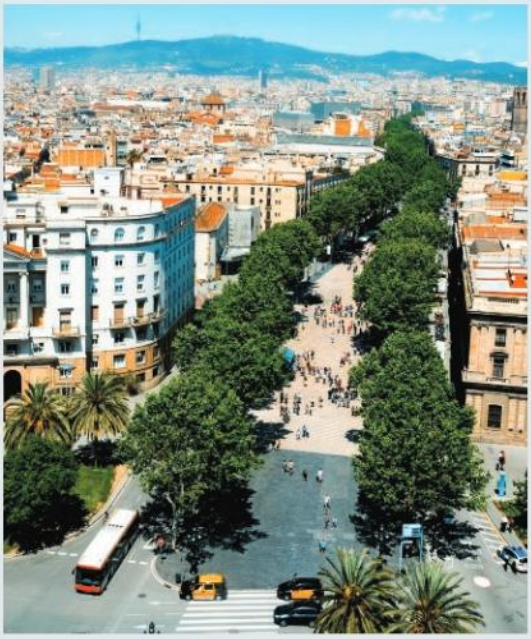
Urban deprivation and regeneration in Barcelona

Deprivation takes many forms – including low incomes, a lack of employment opportunities, ill health, poor educational achievement, limited access to housing and services, high rates of crime and a poor living environment.

In the city of Barcelona, which has a population of about 1.6 million people – and around 5 million in the wider metropolitan area – the greatest level of deprivation is in two main areas. One is the inner-city district of El Ravel, associated with poor-quality housing built during the industrial era, and the edge-of-town locations of Can Peguara and La Mina, where social housing was built to accommodate migrants to the city during the 1960s.

During the 1970s and 1980s Barcelona deindustrialized rapidly. In the 1980s, unemployment in the city was 20 per cent, and many locations became derelict. However, Spain's entry to the European Union in 1985 and the creation of the European Single Market in 1993 gave Barcelona an opportunity to tackle deprivation and regenerate its economy.

Since then, a major economic transformation has taken place, with processes such as deindustrialization, tertiarization (the growth of services), deconcentration (movement away from inner-city areas) and globalization all affecting the city. Barcelona's strategy has been to halt economic decline, create visible signs of growth and foster renewed confidence. The 1992 Olympic Games and the 2004 Universal Forum of Cultures were used to develop the infrastructure that the city needed – its port, airport, road and rail infrastructure. Between 1992 and 2007, Barcelona's vision changed from physical regeneration to high-value economic diversification and the promotion of Barcelona as an important European city.



▲ **Photo G.19:** Regeneration of Barcelona's inner-city area to reduce levels of deprivation

Managing urban crime

Crime can be tackled in a number of ways, including having:

- more police officers on patrol
- greater use of CCTV/security cameras
- improved street lighting
- buildings designed to reduce dark/unlit areas
- greater availability of taxi services around the closing time of clubs and bars
- more women-only taxis
- adopting zero-tolerance policies towards crime, as in New York City.

Managing urban deprivation (Barcelona)

The reasons for Barcelona's success are varied, and include:

- entrepreneurial and political leadership
- a public–private partnership with active citizen involvement
- diversification of the economy to include tourism, biomedicine, culture and ICT.

Employment in Barcelona increased by over 50 per cent between 1995 and 2008, with 900,000 new jobs. More than 70 per cent of the jobs were in the service sector. During this period, employment in manufacturing rose by a quarter and employment in services by 60 per cent. Many of the traditional manufacturing industries (cars, chemicals, textiles and food processing) moved to the suburbs, mainly because of the lower land prices than those near the city centre.

Not only did Barcelona create many new jobs and upgrade its infrastructure, but it also provided new housing – such as the Athletes' Village from the 1992 Olympic Games in the Poblenou coastal district, which was built on an abandoned factory site. The combination of employment, housing and infrastructure was crucial for the regeneration of the city and for tackling deprivation. There is still relative deprivation but it is not as marked as it was during the 1970s and 1980s.

Barcelona also continues to develop – regeneration is not a one-off programme but has to be linked with a continuous process of growth and development (Photo G.20). Alongside the port is Zona Franca, Spain's largest and most dynamic industrial estate. The development of technical parks for high-tech industry has contributed to the growth of Europe's so-called "sunrise belt".

TOK

Read the Option E case study on the impact of the 2012 Olympic Games on the East End of London. Compare and contrast the aims and methods of regeneration of London's East End with the regeneration plans of Barcelona.

▲ **Photo G.20:** Continuing development of Barcelona's port area

Concepts in context

Urban stresses can result from unequal **power** among urban stakeholders. Urban microclimates, in part, relate to industrial emissions, as well as to density and type of buildings. As urban economies expand, urban dwellers are increasingly contributing to urban microclimate and to pollution. Traffic congestion is a symptom of urban stress. Workers in urban areas are generally better off than those in rural areas, and are more likely to own a car. As cities grow, congestion becomes a greater problem. Cities experience many problems, such as competition for land, crime, social inequalities and lack of green space. There have been many attempts to manage urban problems such as social deprivation, and there is a need to tackle causes (for example, unemployment) as well as symptoms (for example, poor living conditions and poor educational standards).

Check your understanding

1. Explain how urban atmosphere differs from that in its surrounding area.
2. Explain how urban structures modify radiation activity.
3. Describe the features of urban climate.
4. Explain the intra-urban variation in microclimate that exists in some cities.
5. Explain the regional variation in the "urban heat island effect".
6. Define "anthropogenic heat sources" in the city.
7. Why is crime associated with cities?
8. Suggest why Dharavi in Mumbai is an example of contested land use.
9. Explain the causes and consequences of urban noise.
10. Outline the causes and consequences of urban air pollution.

4 Building sustainable urban systems for the future

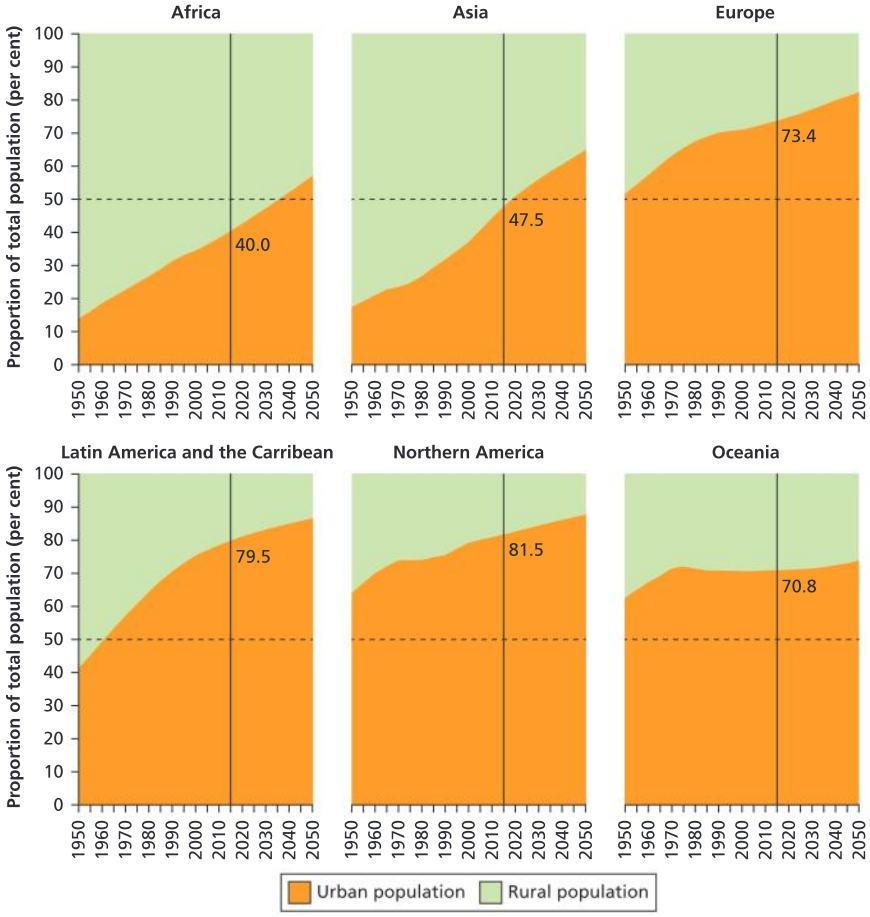
Conceptual understanding

Key question

What are the future possibilities for the sustainable management of urban systems?

Key content

- Urban growth projections for 2050, including regional/continental patterns and trends of rural–urban migration and changing urban population sizes and structures.
- Resilient city design, including strategies to manage escalating climatic and geopolitical risks to urban areas.
- Eco-city design, including strategies to manage the urban ecological footprint.
- Smart city design and the use of new technology to run city services and systems, including purpose-built settlements and retrofitting technology to older settlements.



Urban growth projections for 2050

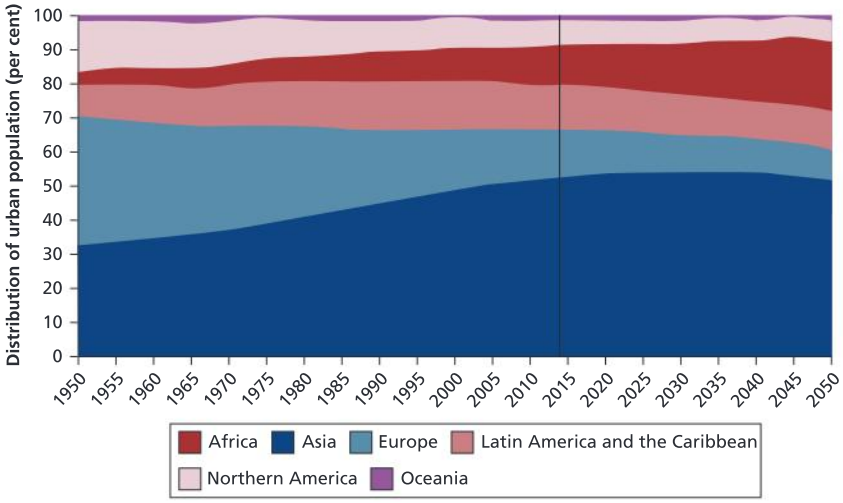
In 1950, 30 per cent of the world's population lived in urban areas. By 2014 this had risen to 54 per cent and, by 2050, it is expected that 66 per cent of the world's population will live in urban areas. Currently, North America is the most urbanized region, with 82 per cent of the population living in urban areas, followed by Latin America and the Caribbean (80 per cent) and Europe (73 per cent).

The world's urban population has grown rapidly, from 746 million in 1950 to 3.9 billion

Figure G.25: Urban and rural populations by world regions, 1950–2050

in 2014. By 2050, a further 2.5 billion people will live in urban areas. Asia contains the largest number of people living in urban areas, while India, China and Nigeria are expected to account for over 33 per cent of the urban growth by 2050. India alone is expected to have over 400 million more urban dwellers by then.

Currently, almost half of the world's urban population lives in cities of fewer than 500,000, while about 12 per cent live in megacities. Some cities in low-fertility countries in Europe and Asia have experienced decline. Figure G.27 shows the past trend and future projections for cities of different sizes. Cities of all sizes are growing, and megacities and large cities are growing slightly faster than medium-sized cities and cities of 500,000 to 1 million.

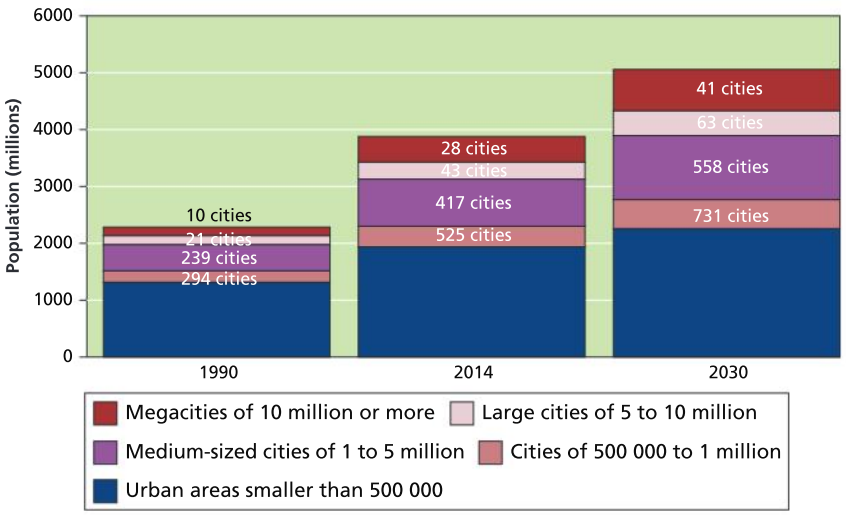


▲ **Figure G.26:** The origin/location of the world's urban population

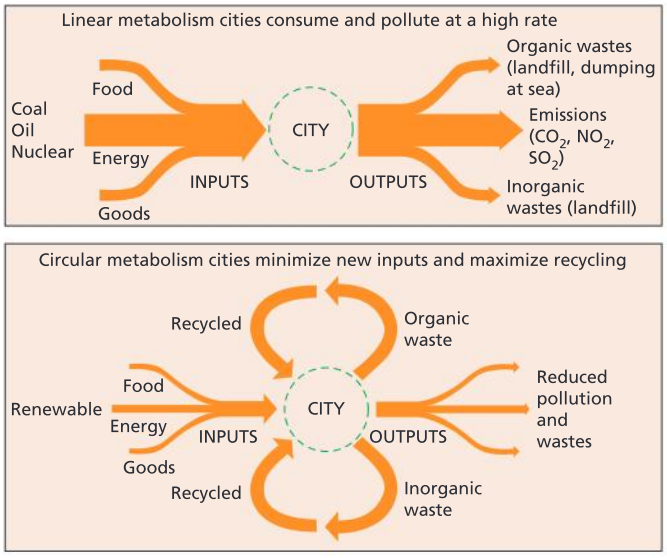
Resilient city design

There are many characteristics of cities which make them important, related to the high concentration of people and the type of economic activities they contain. Cities are usually:

- productive parts of a nation's economy
- centres of innovation
- trading centres
- experiencing rapid population growth
- manifesting major inequalities
- able to benefit from economies of scale
- having to deal with air and water pollution, congestion and inflated land prices.



◀ **Figure G.27:** The growth of global urban populations in cities of all sizes
Source: UN World urbanization prospects: the 2014 Revision Highlights



▲ **Figure G.28:** The Rogers model of city systems

Resilient cities are economically productive, socially inclusive and environmentally friendly. To function effectively and be economically productive, cities need a properly functioning transport network and energy, water and waste infrastructure. Urban areas need to allow for social mobility; otherwise protest, unrest and conflict may result. The high population densities associated with most cities increase their vulnerability to air and water pollution and contamination of land. Cities can reduce their ecological footprint by burning less fossil fuel and increasing the number of resources that can be recycled, reused and reduced (Figure G.28).

Cities can adapt to environmental change, which may involve building expensive infrastructure such as tidal barriers and sea walls. Nevertheless, densely populated cities have certain advantages over less dense cities: they tend to produce less CO_2 per capita and the potential for better public transport increases. There are also savings in the heating and cooling of buildings. Emissions per person in apartments and terraced housing tend to be lower than emissions from a detached house.

As urbanization proceeds, some cities are able to develop new transport systems, for example the metro systems in Beijing and Shanghai. Bogotá, in Colombia, has a rapid-transit bus system, as does Curitiba in Brazil. Some cities have been expanding their bus lanes, cycle lanes and footpaths, which should lead to a reduction in the amount of fossil fuel used. Bike-sharing schemes have been established in Paris (the Velib scheme), Barcelona and London.

China has over 100 cities with more than 1 million people living in them. China faces an uphill battle to provide alternative transport to private cars – the country has become the largest single market for new car sales each year.

Urban water supplies

Cities need to provide water for their citizens, their industries, for ecosystems and for agriculture. Providing a reliable supply of clean water at an affordable and acceptable level may prove challenging in some areas. New York obtains its water from upstate locations, in particular the Catskill and Croton drainage basins. In about 2000, these supplies were contaminated with agricultural and industrial waste products. New York City came up with a financial incentive to stop farmers and industrialists polluting the area. Both parties were happy with the solution, as New York did not have to pay to build new water purification schemes.

Urban waste management schemes

Traditionally, much urban waste has been put into landfill or left in giant waste heaps. Landfills are a wasted opportunity as much of the material can be recycled , and there is a now great potential for generating energy from waste (EfW). Ankara in Turkey has a major recycling, composting and EfW scheme, which sells electricity back to the urban grid. This is an example of "smart infrastructure".

Managing hazard risk

Many cities are at risk from environmental hazards. For example, New York City was affected by Superstorm Sandy in 2012, and there are predictions that such storms, and their associated storm surges, will become more frequent in the future. Cities need to prepare for such events.

Cities have the option to be more efficient and have low carbon emissons per person. This will help reduce the impact of hazard events. For example, London and New York suffered from major smog events in the 1950s. In 1955 the UK introduced the Clean Air Act that limited the burning of coal in residential areas. Once the change to cleaner energy was made, the smog largely disappeared. Beijing and Delhi both suffer from poor air quality, but have a potential solution.

Some cities are vulnerable to seismic events, including Los Angeles, Istanbul, Manila, Tokyo and Port-au-Prince (Haiti). Buildings can be made safer. Zoning can be used to prevent building in unsafe areas, for example on steep slopes with the risk of landslides. Building codes and regulations can be enforced.

In cities where there is a flood risk, levees and sea walls can be built and maintained. In New York, following the flooding associated with Superstorm Sandy, electricity generators were removed from basements and transferred to the upper floors of buildings. In the Netherlands, where polders (reclaimed land) were created to provide more land for the growing population, the tidal barriers are left open ordinarily, to allow normal ocean flow and ecosystem functioning, but they are closed during storm surges. (See also the Thames Barrier, Chapter 2, page 82.)

▲ **Figure G.29:** New York's PlaNYC

Sustainable cities are generally resilient to hazards. They also have lots of green open space. In the USA, Portland and Seattle were the first cities to adopt sustainability plans. On a much larger scale, New York has adopted a sustainability plan (Figures G.29 and G.30). New York's CO_2 emissions are about one-third of the USA's average. It expects the population to increase by 1 million by 2030, and is preparing for such an outcome by providing more affordable housing. It also plans to create more open space and clean up derelict sites.

Online case study
Urban areas and geopolitical risk

New York is developing:

- energy-efficient buildings – through a reduction of CO_2 emissions in heating, cooling and ventilation of buildings
- cleaner sources of energy including renewables such as HEP from Canada and off-shore wind power
- leaner transport systems, for example electrification, hybrid vehicles, mass transit, walking and bicycling
- leaner transport-management system, with recycling and energy-from-waste (EfW) schemes.

Figure G.30: Report extract from New York's PlaNYC

CATEGORY	METRIC	2030 TARGET	FIGURE FOR MOST RECENT YEAR	TREND SINCE BASE YEAR
HOUSING AND NEIGHBORHOODS	**Create homes for almost a million more New Yorkers while making housing and neighborhoods more affordable and sustainable**			
	Increase in new housing units from 2007	314,000	98,924 [2]	↗
	Total units of housing in NYC	INCREASE	3,328,395 [4]	↗
	% of housing affordable to median-income NYC household	INCREASE	64.1% [4]	↘
	Vacancy rate of least expensive rental apartments	INCREASE	0.98% [4]	↘
	% of new units within a 1/2 mile of transit	>70%	78% [2]	↗
	Residential building energy use per capita (MMBTU) (3 yr rolling avg)	DECREASE	2.13 [5]	NEUTRAL
PARKS AND PUBLIC SPACE	**Ensure all New Yorkers live within a 10-minute walk of a park**			
	% of New Yorkers that live within a 1/4 mile of a park	85%	74% [1]	↗
BROWNFIELDS	**Clean up all contamined land in New York City**			
	Number of vacant tax lots presumed to be contaminated	DECREASE	1,500 – 2,000 [2]	NEUTRAL
	Number of tax lots remediated in NYC annually	INCREASE	0 [2]	NEUTRAL
WATERWAYS	**Improve the quality of our waterways to increase opportunities for recreation and restore coastal ecosystems**			
	Fecal coliform rates in New York Harbor (Cells/100mL) (5 yr rolling avg)	DECREASE	21.1 [3]	↘
	Dissolved oxygen rates New York Harbor (mg/L) (5 yr rolling avg)	INCREASE	6.71 [3]	↗
WATER SUPPLY	**Ensure the high quality and reliability of our water supply system**			
	Number of drinking water analyses below maximum contaminant level	INCREASE	99.995% [6]	NEUTRAL
	Water usage per capita (gallons per day) (3 yr rolling avg)	DECREASE	124.67 [7]	↘
TRANSPORTATION	**Expand sustainable transportation choices and ensure the reliability and high quality of our transportation network**			
	Sustainable transportation mode share (Manhattan CBD bound commute)	INCREASE	73.5% [3]	NEUTRAL
	Change in transit volume minus change in auto traffic volume	POSITIVE	-2.8% [3]	↗
	Vehicle revenue miles (Miles transit vehicles travel in revenue service)	INCREASE	945,912,801 [3]	↗
	% of bridges meeting a state of good repair (FY)	100%	41% [3]	NEUTRAL
	% of roads meeting a state of good repair (FY)	100%	72% [2]	↗
	% of transit station components meeting a state of good repair	100%	72% [2]	NEUTRAL
ENERGY	**Reduce energy consumption and make our energy systems cleaner and more reliable**			
	GHG emissions per unit of electrical power (lbs CO_2e/MWh)	DECREASE	692.25 [3]	↘
	System reliability SAIFI (System Average Interruption Frequency Index)	DECREASE	69.72 [3]	↘
	Energy use per capita (MMBTU) (3 yr rolling avg)	DECREASE	102.55 [3]	NEUTRAL
AIR QUALITY	**Achieve the cleanest air quality of any big U.S. city**			
	City ranking in average PM 2.5 (3 yr rolling avg)	#1 (LEAST)	7 [3]	↘
	Change in average PM 2.5 (3 yr rolling avg)	DECREASE	-3.5% [4]	↘
SOLID WASTE	**Divert 75% of our solid waste from landfills**			
	Percentage of waste diverted from landfills	75%	51% [2]	NEUTRAL
CLIMATE CHANGE	**Reduce greenhouse gas emissions by more than 30%**			
	Increase the resilience of our communities, natural systems, and infrastructure to climate risks			
	Greenhouse gas emissions ($MTCO_2e$)	DECREASE 30%	49,301,948 [3]	↘
	Greenhouse gas emissions, (100% = 2005 GHG emissions)	70%	87.06% [3]	↘
	Greenhouse gas emissions ($MTCO_2e$) per GCP ($M)	DECREASE	91.07 [4]	↘
	Greenhouse gas emissions ($MTCO_2e$) per capita	DECREASE 30%	5.87 [3]	↘

Case study

Protecting Lagos: Eko Atlantic

Lagos is a coastal megacity and the largest city in Africa. Its population of about 21 million people is expected to grow to 25 million by 2020. It is considered to be the financial capital of West Africa and is the main port of the region. However, it is at great risk from coastal erosion. In 2003 a sea wall (named the "Great Wall of Lagos") was designed to stop the erosion resulting from sea-level rise and human activities further along the coastline.

Developers claim that the Great Wall will be 8 km long when complete. However, a new development is taking place behind the Great Wall, called Eko Atlantic. This planned new city, which has been called the "African Dubai", will have a population of 250,000 with a further 150,000 commuters. The eco-friendly city will contain businesses, residential districts, hotels, leisure facilities, banks and TNCs. All the finance for the Eko Atlantic project has been raised by private companies.

However, two-thirds of Lagos's population live in slums and critics believe that the Lagos State Government should do more to improve the lives of slum dwellers rather than encourage developments that will benefit the wealthy. Moreover, many of the nearby slum population claim that the Great Wall and Eko Atlantic project will lead to an increase in coastal erosion as a result of coastal scouring.

ATL Research and communication skills

To what extent can the London 2012 Olympic Games be said to have created a resilient city? Give examples to support your views.

Eco-city design

If a city covers too large an area, it becomes congested, overcrowded, overpriced and polluted. It then becomes unsustainable. Compact cities minimize travel distances, use less space, require less infrastructure (pipes, cables, roads, etc.), are easier to provide a public transport network for, and reduce urban sprawl. This makes them more likely to be sustainable.

An eco-city or sustainable city is a city designed to have minimal environmental impact. To achieve sustainability, a number of options are available:

- reducing the use of fossil fuel, for example by promoting public transport

- keeping waste production to levels that can be treated locally
- providing sufficient green spaces
- reusing and reclaiming land, for example brownfield sites
- encouraging active involvement of the local community
- conserving non-renewable resources
- using renewable resources.

The Beddington Zero Energy Development (BedZED)

BedZED is an environmentally friendly housing development built in 2000–2002 near Wallington, south London. The 99 homes and 1,405 square metres of workspace have a number of features, including 777 m^2 of solar panels; south-facing houses that are triple-glazed and have high thermal insulation; building materials selected from renewable or recycled sources within 35 miles of the site, to minimize the energy required for transportation; and a location close to a tram line, a train line and bus routes.

The BedZED development has achieved a number of successes compared with UK averages:

- Space-heating requirements are 88 per cent less.
- Hot-water consumption is 57 per cent less.
- The electric power used is 25 per cent less than the UK average, 11 per cent of it produced by solar panels.
- Mains water consumption has been reduced by 50 per cent.
- The residents' car mileage is 65 per cent less.

However, the project cost around £15 million, which equates to approximately £150,000 per home, which is very expensive.

The urban ecological footprint

The urban ecological footprint is a measurement of the land area required to provide a population with the resources it needs and to dispose of all its waste. Since all the resources people use for their daily needs – such as food, water and electricity – must be produced using raw natural resources, the ecological footprint measures the amount of arable land and aquatic resources needed to sustain a population, based on consumption levels at a given point in time. To the fullest extent possible, this measurement incorporates water and energy use, uses of land for infrastructure and different forms of agriculture, forests, and all other forms of energy and material "inputs" that people require in their day-to-day lives. It also accounts for the land area required for waste assimilation.

Case study

Masdar City

Masdar City is a planned city project in the UAE. Work began in 2006 and the whole project will not be completed until around 2030, at a cost of about $22 billion. It is hoped that some 50,000 people will live there, at a cost of around $400,000 per resident. Eventually, it is hoped that 60,000 workers will commute daily to Masdar City, but by 2016 only 2,000 people were employed there.

The city is planned to be the world's most sustainable eco-city. It is powered by around 88,000 solar panels in a 20 hectare field. It is also connected to the public transport system: cars are not permitted in Masdar City – consequently, the roads are narrow and never longer than 70 m, allowing cool breezes to flow along them. Building at the ends of these roads causes turbulence, pushing the air upwards and enhancing circulation. The International Renewable Energy Agency has its headquarters in Masdar City, and Siemens has a regional headquarters there too. Siemens' headquarters is believed to be the most energy-efficient building in Abu Dhabi. The project is supported by the US government, the WWF and Greenpeace. Greenpeace has, however, stated that there should be greater emphasis on retrofitting existing cities rather than creating new eco-cities.

TOK

To what extent are sustainable cities expensive to develop? Is it true that the only way of developing cheap, sustainable cities is by building them – however expensive that might be – and hoping that the cost of technology will come down in future, as it becomes more efficient?

Case study

Tokyo's ecological footprint

According to the Earth Council, each person needs a biologically productive area of 1.7 hectares for basic living. This means that, for sustainable living, the people in Tokyo alone need an area of 45,220,000 ha – 1.2 times the land area of the whole of Japan. If mountains and other regions are discarded and only habitable land is included, then this becomes 3.6 times the land area of Japan.

The difference between very high-density cities (compact cities like Tokyo with much vertical development) and extended cities (cities with suburban sprawl, like those in Australia and the USA, for example) is that extended cities use three or four times more land area. Tokyo is a city where the land is used several times at several levels: its large population lives in a very small and dense area of land, freeing land area for other purposes. This also reduces the amount of infrastructure needed to service the population, and the resources needed for everyday living, because they are not spread out over a vast area.

Case study

Environmental measures in Chicago

The roof of City Hall in Chicago consists of 18,500 square metres of shrubs, vines and small trees. It was planted in 2000, and reduces the amount of energy needed to cool the building in the summer; it captures water when it is raining, thus reducing the amount of water flowing into Chicago's sewers; and reduces the urban heat island. On average, air temperatures above City Hall are 5–7°C degrees lower than those above the adjacent black-tar roof of the Cook County Building. On hot summer days the difference can be over 20°C. City Hall's roof accounts for a small proportion of Chicago's total green-roof space.

In September 2008, Chicago launched its Climate Action Plan (CCAP) (http://www.chicagoclimateaction.org/). CCAP aims to reduce Chicago's greenhouse-gas emissions to 75 per cent of their 1990 levels by 2020, and to just 20 per cent of their 1990 levels by 2050.

Between 2008 and 2010 the use of public transport increased, hundreds of hybrid buses were added to Chicago's fleet, millions of litres of water were conserved, and over 13,000 housing units and nearly 400 commercial buildings had improved energy efficiency.

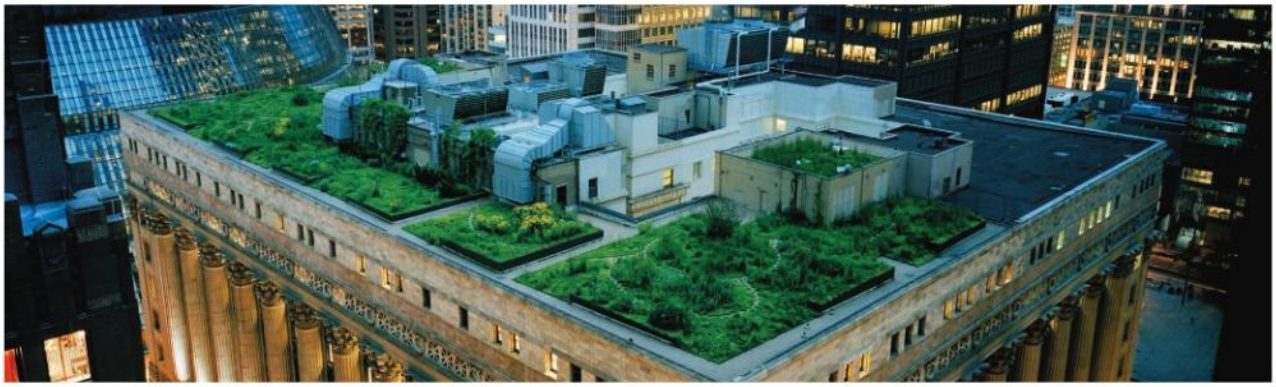
These changes have come as a result of simple tweaks. City buses inevitably need replacing, and old buses were replaced by new hybrid models that are 30 per cent more fuel efficient with carbon emissions 60 per cent lower. They will save an estimated $7 million a year in fuel and upkeep. Chicago has over 3,000 km of alleys that will eventually need repaving. There are plans to repave them with permeable, light-coloured surfaces rather than asphalt to reduce water run-off into sewers and to reflect rather than retain the sun's light and heat.

C40 cities and climate change

C40 is a network of 83 of the world's megacities committed to addressing climate change, working together to share technical expertise and best practice. Their shared goals include:

- improving public transport, whether public (such as switching to hybrid or electric taxis and buses) or personal (such as encouraging cycling) or both
- more efficient outdoor lighting, which accounts for almost one-fifth of energy consumption across C40 cities and is mostly old and inefficient
- making infrastructure and water supply more reliable and efficient

Photo G.21: The roof of Chicago's City Hall



Case study

Managing waste – landfill or renewable energy?

There are more than 1,900 municipal landfill sites in the USA. The largest is the Puente Hills landfill near Los Angeles. It is about 150 metres high and contains over 130 million tonnes of rubbish. Nevertheless, it is run in a very high-tech way. Without costly plumbing, landfills produce large amounts of methane, a greenhouse gas that does more than 20 times more damage to the environment than comparable emissions of carbon dioxide. The methane produced at Puente Hills is collected via a network of pipes that penetrate the mountain, and burned in incinerators to produce electricity for 70,000 homes.

Since much municipal rubbish (for example, paper, cardboard, wood, cloth, food scraps) has a biological origin, the electricity and heat produced by waste-to-energy (WTE) plants can be considered a form of renewable energy. For every tonne of municipal waste that avoids being buried in a landfill and is burned instead in a WTE plant, the amount of methane entering the atmosphere is reduced by the equivalent of almost a tonne of carbon dioxide.

However, these municipal incinerators have an image problem. The main objection to WTE incineration is not that it is so bad, but that better WTE technologies are being developed. Rather than burn municipal waste, as much as possible should be recycled. That means sorting the refuse into recyclable metals, plastics, glass and paper, and then breaking down the biological residue into biogas and compost. The biogas can then be used to generate electricity. However, this can be very labour intensive.

- retrofitting homes and offices to make them more energy-efficient – especially crucial in densely built cities such as New York, where buildings account for 75 per cent of greenhouse-gas emissions.

These measures are not only environmentally sound; by and large they also save money.

ATL **Research skills**

Watch the video about Puente Hills landfill at http://www.youtube.com/watch?v=NnAs0MYFPwU&feature=related.

In what ways does Puente Hills landfill differ from most ordinary landfills?

What are the opportunities for this kind of scheme in a low-income country?

See also the Ankara landfill gas-to-energy scheme at http://www.carbonneutral.com/images/uploads/projects/Ankara_Landfill_Gas_to_Energy_Turkey_GS.pdf.

Traffic management

Bolivia's cable cars – linking El Alto with La Paz

A cable-car system, called Mi Teleferico, connects El Alto, the world's highest and Bolivia's second largest city, with its capital, La Paz. It is the largest urban cable-car system in the world, and has three routes (a further seven are planned). The cable-car system was opened in 2014, at a cost

ATL Research skills

Read the Chicago Climate Action Plan at http://www.chicagoclimateaction.org/.

Read the progress report at http://www.chicagoclimateaction.org/filebin/pdf/CCAPProgressReportv3.pdf.

of $324 million, and offers an affordable route for the 85–90 per cent of the population that relies on public transport. The alternative route is a winding, congested highway. The number of passengers is over 40,000 each day.

Social equity and transport planning

When a new urban redevelopment is announced, planners and city officials often consider how it will be financed, what its environmental impact will be, and how to gain the support of local stakeholders. Often the social dimension is given least priority.

In Bogotá, Colombia, planners have successfully integrated social equity into the Transmilenio bus rapid transit (BRT) system, opened in 2000. The network was designed to improve access to jobs for low-income communities living on the city's periphery. Its success in improving social equity was helped by providing free feeder transport connecting the low-income communities to main routes.

Car-free Helsinki and Hamburg

Helsinki and Hamburg have both announced plans to reduce the need for cars in the city within a generation. According to the *Helsinki Times*, future residents will not own a car. Hamburg has announced plans to create and link over 60 km^2 of green space throughout the city. Both cities are pursuing the goal of people-powered mobility.

Helsinki aims to revitalize public and shared transport networks by 2025, with a mobility on-demand system. The plan is to provide a range of transport options that are cheap, flexible and well coordinated in order to be competitive with private car ownership. A smartphone app will function as a journey planner and as a method of payment – thus limiting accessibility to this system to those who can afford a smartphone and are comfortable using it. Hamburg hopes to eliminate the need for cars within 20 years by creating a green network from the edge of the city to the city centre, with pedestrian and cycle paths connecting the city's green spaces (which cover 40 per cent of the land).

There are few car-free cities: central Venice is Europe's largest car-free urban area. The Medina of Fez el Bali – the old walled city within Fez, Morocco – is one of the largest car-free urban areas in the world. With narrow streets and a population of 150,000, the main form of transport is walking. Goods are moved by donkey and cart.

Smart cities

A "smart city" is a city that is performing well in six categories: namely economy, environment, people, living conditions, governance and mobility. Some smart cities are entirely new – as in the case of Songdo (South Korea) – whereas others have smart aspects added to them.

The concept of the smart city is relatively new and is quite fashionable. A city is defined as smart when investments in social and human capital, along with physical infrastructure and ICT, enable sustainable development and a high quality of life. Sustainable development suggests a wise management of the resources available to the city. The quality of ICT is only part of the definition of a smart city – the role of human capital is also crucial.

The success of urban development depends upon the physical infrastructure of cities (roads, railways, buildings, and so on) but also, increasingly, on the availability and quality of information communication technology and social infrastructure – intelligence and skills. The latter is essential for the success of urban competitiveness. The most rapid urban growth rates have taken place in urban areas with a high proportion of educated workers.

Some see new smart cities as the solution to rising populations and dwindling resources. However, others believe that the majority of cities that will exist in the future already exist and so efforts should be directed at improving those cities rather than building new ones. The transformation of industrial waterfronts in New York, Newcastle and Oslo are examples of re-adaptation and upgrading of existing cities.

Case study

Songdo International Business District, South Korea

Songdo in South Korea is one model for a brand-new smart city. It is a £23 billion project located on 600 hectares of reclaimed land near the Yellow Sea, 64 km from Seoul and just 11 km from Incheon International Airport (Figure G.31). Started in 2005, it is home to 65,000 people and 300,000 workers. It is also known as a "ubiquitous city", or U-city. It has an array of sensors that control heating in houses and monitor traffic flow but also allow video conferencing and the delivery of health care, education and government services.

The city is the first LEED (Leadership in Energy and Environmental Design) certified district in Korea and the largest project outside North America to be included in the LEED Neighbourhood Development Pilot Programme. With more than $10 billion invested, it is expected that Songdo IBD will quickly become the central business hub in north-east Asia.

Songdo is part of the Incheon Free Economic Zone (FEZ) – a special economic zone with minimized regulation and maximized business incentives and opportunities for foreign investment. Compared to the rest of Korea, the Incheon FEZ offers exceptional measures such as tax breaks to encourage foreign investment, foreign exchange circulation, foreign language service, labour flexibility, and the establishment of foreign education and medical institutions. FEZ provides foreign-invested enterprises with an optimal business and living environment in order to attract their investment in high-end industries and global services.

The IFEZ project comprises three separate districts within Incheon Metropolitan City covering 20,000 hectares – the Cheongna reclaimed area, Songdo and Yeongjong, which surrounds Incheon International Airport. These areas are earmarked for major projects by 2020.

▲ **Figure G.31:** The location of Songdo, South Korea

Smart developments on the scale of Songdo are extremely expensive and would be beyond the means of many countries. However, they are giving Songdo a competitive edge in an ever-competitive world.

Songdo City

The new Songdo City will be developed in three phases by 2020. The first phase, built by 2008, included the International Convention Centre (Songdo Convensia) and the 68-storey Northeast Asia Trade Tower, office buildings, deluxe hotels,

Case study (continued)

shopping malls and a golf course. It also has a technology park and Institute of Technology along with other research centres. In addition, there are 250 hectares of open space including the 40 hectare Central Park. Songdo also has an arts centre housing a concert hall, an opera house and a museum of Asian contemporary art. The 151-Songdo Incheon Tower, which was being developed by a consortium of Samsung, Hyundai and Portman Holdings, was scaled back to 103-storeys, partly as a result of the global financial crisis. There are a number of schools and a hospital designed to boast the latest in medical technologies. Partners such as 3M and Microsoft will also participate in the development of this world-class health care facility.

There is a wide range of smart technologies in use at Songdo. For example, TelePresence allows video conferencing from every building. It also reduces the need to travel and thereby reduces Songdo's carbon footprint. All venues are within 15 minutes' walk of Central Park. The city is compact and accessible and contains 25 km of bike lanes. Water conservation measures mean that commercial buildings use 30 per cent less water than average. Information technology enables Songdo to reduce energy loss by 30 per cent as well. Smart meters measure energy consumption and there is micro-generation of wind power and photovoltaics. Plug-in hybrid electric vehicles can buy electricity when it is cheap and store it in batteries in the car.

Cheongna

Cheongna has been developed as an international business, culture and recreational site for foreign investors, tourists and metropolitan residents. It includes a floral complex, golf course, and a sports and leisure complex. The Cheongna area has excellent traffic routes to Incheon International Airport, making it a convenient place to live for international businesspeople.

▲ **Photo G.22:** Building Songdo on reclaimed land

Yeongjong

With the world's second-largest cargo capacity, Yeongjong will be developed as an international logistics base and airport support area by 2020. It has abundant tourism resources including scenic vistas and sandy beaches, and so it will also be developed as an international leisure complex.

Incheon has many advantages that are ideal for establishing a free economic zone and a smart city in Songdo. It is a coastal city equipped with an internationally competitive seaport and an airport that is the main entry point to Korea. Two billion people in 61 cities, each with populations of over 1 million, or 32 per cent of the world's population, live within 3.5 hours of flight time from Incheon. Nevertheless, some of the incentives offered in the free economic zones may lead to expensive foreign schools in the FEZ, widening the education gap between rich and poor.

▼ **Table G.9:** The Incheon FEZ Planned Population and Development Strategy

Area	Total size (hectares)	Planned population	Project period	Development strategy
Total	20,987	487,300	2003–20	
Songdo	5,366	252,500	2003–20	International Business Centre
Yeongjong	13,833	144,800	2003–20	Logistics Hub
Cheongna	1,788	90,000	2003–20	International Finance Centre

Activity 11

1. Outline the range of smart developments in Songdo City.
2. To what extent is location important for the success of Songdo City?
3. Outline the potential of smart cities for LICs.
4. Comment on the potential of smart cities for landlocked countries.
5. Are smart cities worth it? Discuss this question.

ATL Research skills

Visit the following website, which provides videos about Songdo and an interactive map: http://newsroom.cisco.com/songdo.

Comment on the smart initiatives in relation to office space, well-being, transportation, home and classroom, retail and entertainment, and energy. Use this site to find specific information to use in an examination to support your comments about smart cities.

Concepts in context

Urban areas are expected to grow significantly by 2050. Some cities will develop into megacities, while others may be new developments. All cities face challenges of managing growth. There are opportunities for managing cities in a more environmentally friendly way, through clean energy, recycling and urban farming/vertical farms. There are also possibilities to expand the use of smart technology in cities.

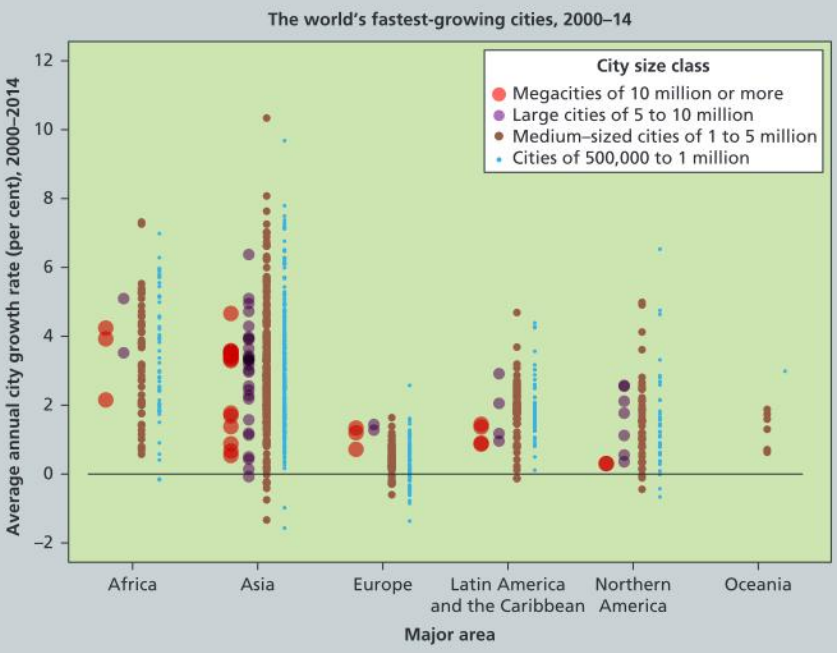
Some of the early attempts at sustainable settlements, for example BedZED and Masdar City, have either been very expensive or have affected only a small number of people. However, without such developments, there is less chance of developing sustainable strategies in the future.

Check your understanding

1. Explain the reasons for promoting green spaces in cities.
2. Identify the features of urban structures that could be changed to improve sustainability.
3. Outline the details of the Chicago Climate Action Plan.
4. Explain one way in which city waste could be used more effectively.
5. Why is the improvement of sanitation in LIC cities so important?
6. Suggest improvements that could be made to relieve traffic congestion in cities.
7. Give two examples of urban projects that have benefited the poor.
8. Explain how and why cities lose population.
9. What are the risks involved in a narrow urban economy?
10. Suggest why rapid urbanization is the underlying cause of urban poverty.

Synthesis and evaluation

- In this chapter, we have seen how urban change over time is affected by a place's economic and social interaction with other places. This can be positive, as in the case of Shanghai, or negative, as in the case of Detroit.
- Urban areas are changing at different rates: some cities are developing into megacities, while others are growing slowly. Coastal locations favour trading relationships, whereas cities in landlocked countries are disadvantaged.
- Urban management strategies affect people in different ways. Some people (as in the case of gentrification and urban regeneration) become better off, while others are disadvantaged.
- Urban changes are complex and, to show these complexities, geographers often make use of graphical techniques.



(a) (i) Identify the type of city that grew most between 2000 and 2014, and state its growth rate. (1 mark)

(ii) State the continent in which city growth was most rapid and least rapid. (1 mark)

(iii) Identify the continent that experienced the most decline in cities with under one million residents. (1 mark)

(iv) Briefly explain one reason why cities would decline in population. (2 marks)

(b) Explain the changing location of retailing in urban areas. (5 marks)

(c) Either

"Eco-cities and smart cities offer great opportunities for high-income countries." Discuss this statement. (10 marks)

Or

Examine the view that urban growth is having an ever-increasing impact on the natural environment. (10 marks)

UNIT 1
CHANGING POPULATION

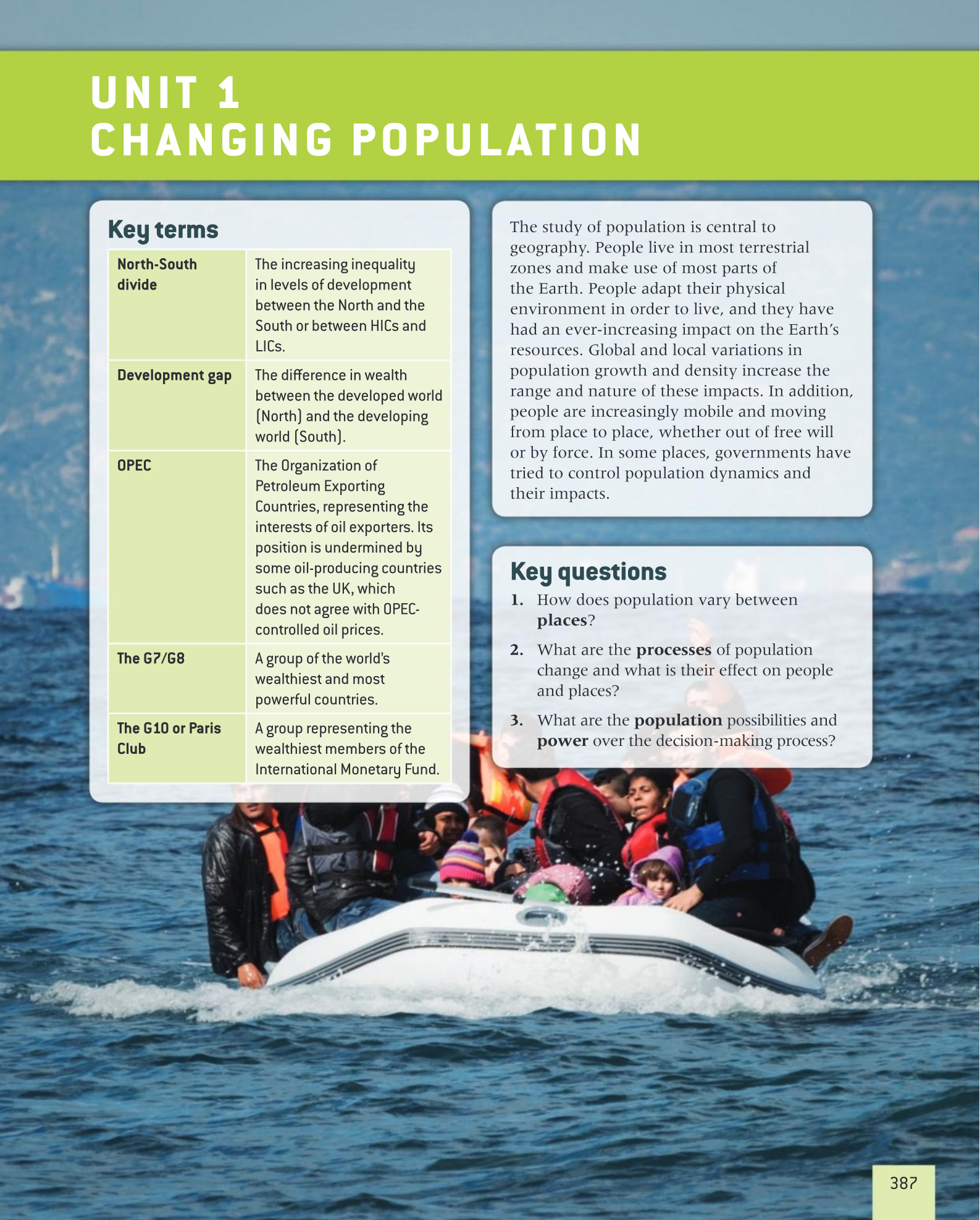
Key terms

North-South divide	The increasing inequality in levels of development between the North and the South or between HICs and LICs.
Development gap	The difference in wealth between the developed world (North) and the developing world (South).
OPEC	The Organization of Petroleum Exporting Countries, representing the interests of oil exporters. Its position is undermined by some oil-producing countries such as the UK, which does not agree with OPEC-controlled oil prices.
The G7/G8	A group of the world's wealthiest and most powerful countries.
The G10 or Paris Club	A group representing the wealthiest members of the International Monetary Fund.

The study of population is central to geography. People live in most terrestrial zones and make use of most parts of the Earth. People adapt their physical environment in order to live, and they have had an ever-increasing impact on the Earth's resources. Global and local variations in population growth and density increase the range and nature of these impacts. In addition, people are increasingly mobile and moving from place to place, whether out of free will or by force. In some places, governments have tried to control population dynamics and their impacts.

Key questions

1. How does population vary between **places**?
2. What are the **processes** of population change and what is their effect on people and places?
3. What are the **population** possibilities and **power** over the decision-making process?



1 Population and economic development patterns

Conceptual understanding

Key question

How does population vary between **places**?

Key content

- Physical and human factors affecting population distribution at the global scale.
- Global patterns and classification of economic development in low-income countries (LICs), middle-income countries (MICs) and emerging economies.
- Global patterns and classification of economic development in high-income countries (HICs).
- Population distribution and economic development at the national scale, including voluntary internal migration, core–periphery patterns and megacity growth.

Factors affecting population distribution at the global scale

Population distribution refers to where people live. On a global scale:

- 75 per cent of the population live within 1,000 km of the sea
- 85 per cent live in areas less than 500 m high
- 85 per cent live between latitudes 68°N and 20°N
- less than 10 per cent live in the southern hemisphere.

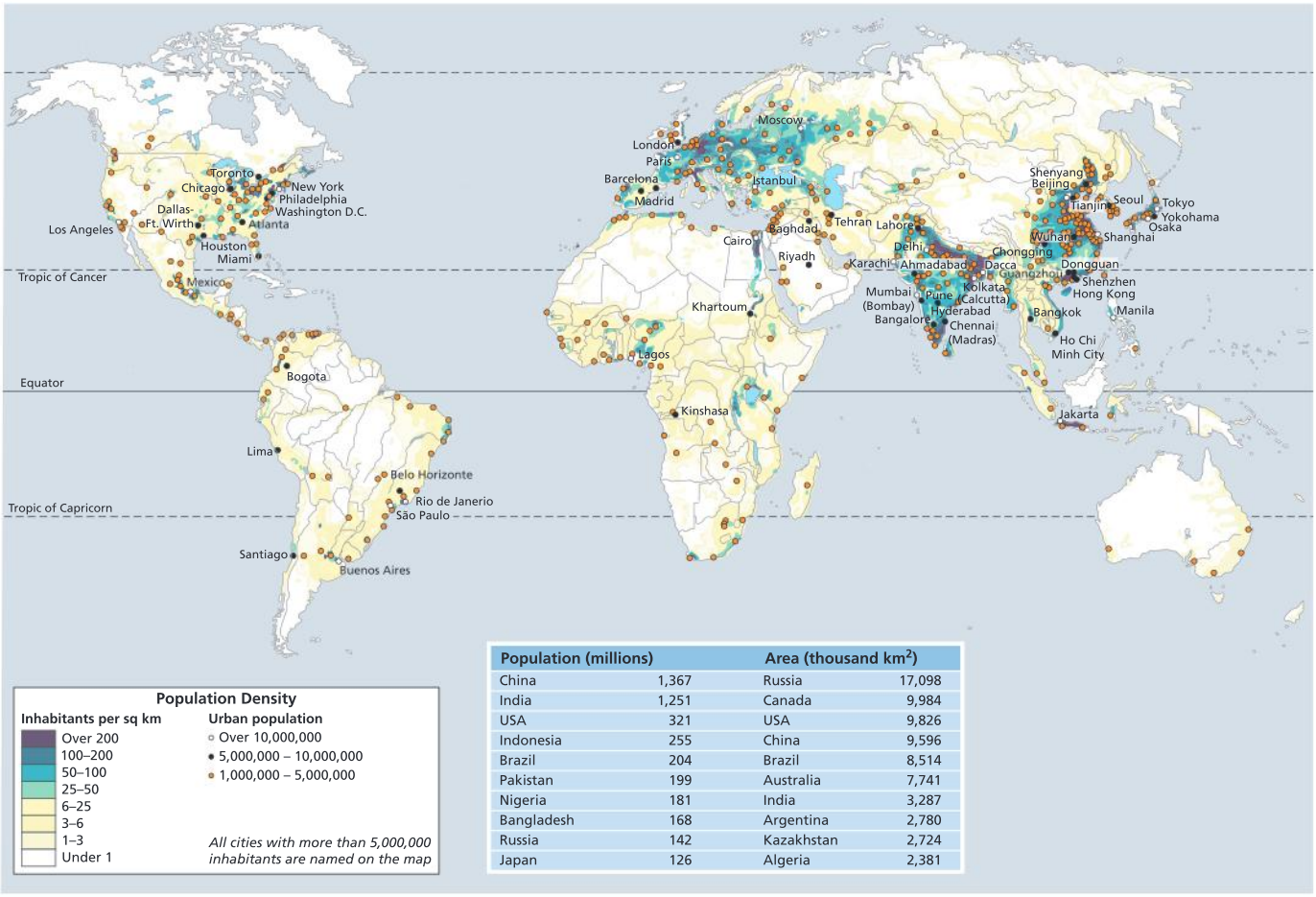
The most favoured locations include:

- fertile valleys, such as the Nile valley
- places with a regular supply of water, such as in temperate climates
- a climate that is not too extreme, such as a temperate climate
- places with good communications.

Disadvantaged areas include deserts (too dry), mountains (too steep), high latitudes (too cold) and rainforests (too infertile). There is no such thing as a "best" climate; many people live in South East Asia and this has a monsoonal climate, with hot, wet seasons and hot, dry seasons.

Global patterns and classification of economic development

According to the World Bank, the per capita annual income of a high-income country (HIC) was over $12,735 in 2014. The term "HIC" is often used interchangeably with "developed", or "more developed", or

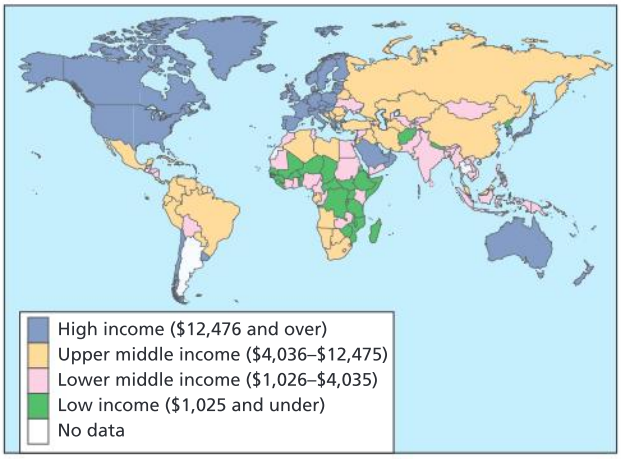


Population (millions)		Area (thousand km²)	
China	1,367	Russia	17,098
India	1,251	Canada	9,984
USA	321	USA	9,826
Indonesia	255	China	9,596
Brazil	204	Brazil	8,514
Pakistan	199	Australia	7,741
Nigeria	181	India	3,287
Bangladesh	168	Argentina	2,780
Russia	142	Kazakhstan	2,724
Japan	126	Algeria	2,381

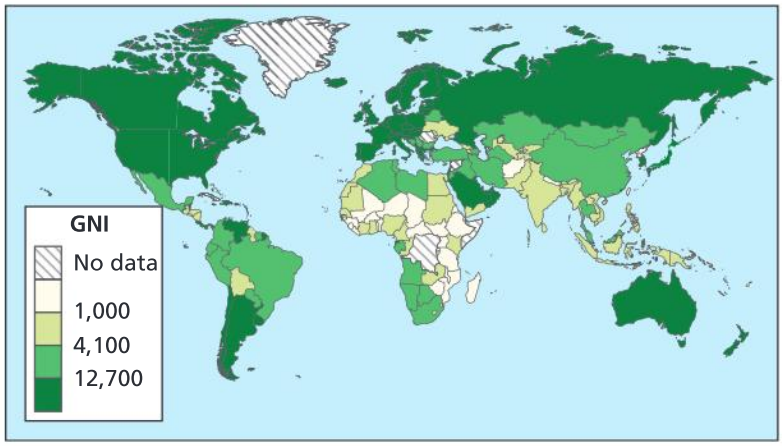
▲ **Figure 1.1:** Population distribution and density at the global scale

"advanced". Low-income countries (LICs) are defined as those with a per capita income of less than $1,025, and that of middle-income countries (MICs) is between $1,026 and $12,475. A distinction is sometimes made between lower middle-income countries ($1,026–$4,035) and upper middle-income countries ($4,036–$12,475). Some 5 billion people live in middle-income countries, and about one-third of global GDP is produced in MICs.

Fewer countries than ever before are classified as low income. The percentage of people living in LICs fell by 80 per cent between 1994 and 2014. In 1994, 3.1 billion people lived in 64 LICs, whereas in 2014 just over 600 million people were living in 30 LICs. Some countries, including Bangladesh, India and Kenya, have moved out of the LIC into the lower MIC category and others moved from the upper MIC to the HIC category, including Argentina, Venezuela and Hungary, as a result of economic growth. Mexico and China are classified as upper middle-income countries. Some LIC countries, such as Malawi, have seen their gross national income (GNI) per capita rise very slowly between 1994 and 2014, from $180 to $250. By contrast, income in HICs has increased massively. Norway's per capita income, for example, rose from $26,010 to $103,050 during the same period.



▲ **Figure 1.2:** World Bank classification of countries, July 2016



▲ **Figure 1.3:** Gross national income (**GNI**) per capita, $

GNI per capita is measured by dividing a country's gross national income by its mid-year population. Problems with data collection mean that some countries may not have accurate and reliable data.

Case study

Economic classifications

At its most basic, the world can be divided into rich and poor. There is evidence to suggest that the rich are getting richer and the poor relatively poorer, but such a dichotomous (twofold) classification is simplistic. Nevertheless, it is still widely used in the media and by politicians and activists, and characterized by the use of the Brandt line or the North-South Divide (Figure 1.4).

Another, formerly common, method of classification, is as follows:

- **The First World** (developed): Western Europe, North America, Australia, New Zealand and Japan
- **The Second World**: state-controlled communist countries such as the former Soviet Union
- **The Third World**, or developing world: all the other less developed countries.

A more detailed way of classifying countries is as follows:

- **More economically developed countries (MEDC)** such as the UK and the USA

These are the most developed countries and have a high standard of living. They are now referred to as high-income countries (HICs).

- **Newly industrializing countries (NICs)** such as South Korea and Taiwan

These are countries that have experienced rapid industrial, social and economic growth since 1960.

There are many categories of NICs, all showing rapid economic growth or potential for growth. These include:

- **BRICs** – Brazil, Russia, India and China – who were joined by South Africa in 2010 to form the **BRICS**
- **MINT** – Mexico, Indonesia, Nigeria and Turkey
- **CIVETS** – Colombia, Indonesia, Vietnam, Egypt, Turkey and South Africa
- **Next Eleven (N11)** – Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, Turkey, South Korea and Vietnam – countries that have potentially the fastest growing economies in the twenty-first century.
- **Centrally planned economies (CPEs)** such as North Korea

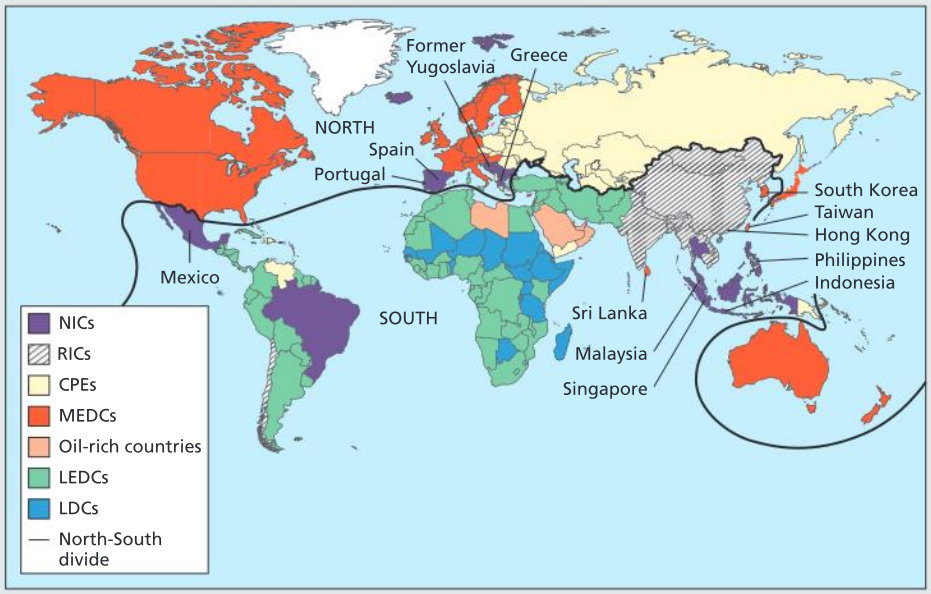
These are socialist countries under strict government control. Living standards are higher than in LEDCs, although freedom of speech is limited. Many former communist countries remain in this category.

- **Oil-rich countries** such as Saudi Arabia and Libya

These are very rich in terms of GNP per head, although it may not be distributed very evenly. Without oil, many of these countries would be LEDCs.

- **Recently industrializing countries (RICs)** such as Chile

Case study (continued)



▲ **Figure 1.4:** Some economic classifications

These are countries that have followed the same path as NICs, only more recently.

- **Less economically developed countries (LEDCs)** such as Namibia and Egypt

These countries are at a lower stage of development and have a lower quality of life. They can be subdivided into middle-income and low-income LEDCs. These are now referred to as low-income countries (LICs).

- **Least developed countries (LDC)** such as Afghanistan and much of sub-Saharan Africa

Here, standards of living are very low, as are many indicators of development.

Most classifications of global economic groupings are related to levels of development, which is difficult to define. The categories should therefore be considered as a **continuum**, that is, there is a range of development from the very least developed to the most developed, rather than an either/or dichotomy. They refer to both economic and human development including economic growth, stable population growth, standards of living, and levels of technology, employment, health, nutrition, literacy, and GNI/capita. More developed countries, such as the UK, the USA, and Japan, have high levels of these. By contrast, countries that are less developed have worse levels.

Population distribution and economic development at the national scale

Population distribution in China

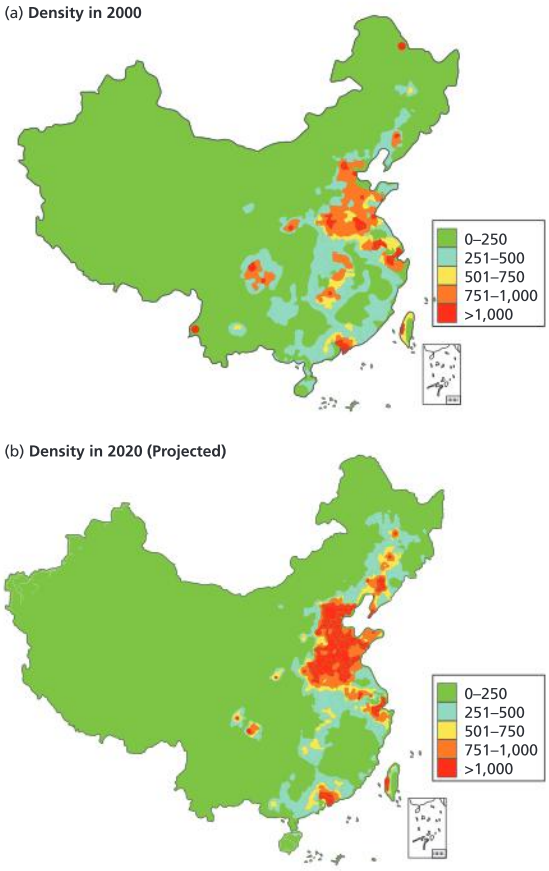
China's population is concentrated in the eastern part of the country, especially in coastal zones and the lower reaches of river valleys. Much of the rest of the country is characterized by desert (for example, the Gobi Desert), the steep slopes of the Himalayas and the dry grasslands of the north-west. For example:

- 11 per cent of the population (115 million people) live on just 0.5 per cent of the land (47,000 km^2)
- 50 per cent of the population live on just 8.2 per cent of the land
- 90 per cent of the population live on 30 per cent of the land
- at the other end of the scale, less than 4 per cent of the population live on 50 per cent of the land, in places such as Tibet and Inner Mongolia.

Common misconceptions

✗ Some students think that a millionaire city is one with a large number of millionaires. This is not necessarily the case.

✓ A millionaire city is a city with one million or more residents.



▲ **Figure 1.5:** Changes in population density (per square km), 2000–2020

The uneven population distribution of China results primarily from the country's physical geography. Only a small proportion of the country is able to provide for rain-fed agriculture – much of the land is too dry or too steep to allow for much agriculture. In addition, the favoured coastal and river locations are also the more favoured sites for trade and commerce. The western provinces remain less developed than the eastern ones.

The result of China's economic growth has been to reinforce the inequalities in population distribution. China now has more than 50 cities with over a million inhabitants each, and it is predicted that there will be a further 350 million urban inhabitants by 2020. One of the characteristics of this urbanization process is that it is creating mega-regions, housing a number of megacities and millionaire cities (Figure 1.6 and Table 1.1). The mega-regions are concentrated towards the east of the country, reinforcing the core–periphery inequality of the east (core) and west (periphery).

▼ **Table 1.1:** Area, population and density of China's mega-regions

Mega-region	Area (,000 sq km)	Population (millions)	Average density (population/ sq km)
Capital economic zone	181	70.6	391
Chuanyu mega-region	267	105.5	395
Guanzhong mega-region	56	21.7	390
Haixia mega-region	52	24.4	465
Liaoning mega-region	90	29.6	331
Pearl River Delta	73	50.2	691
Shandong mega-region	70	38.9	558
Wuhan mega-region	147	58.5	397
Yangtze River Delta	93	76.7	825
Zhongyuan mega-region	58	37.5	642

Source: http://scroll.in/article/663824/chinas-mega-cities-are-combining-into-mega-regions-and-theyre-doing-it-all-wrong

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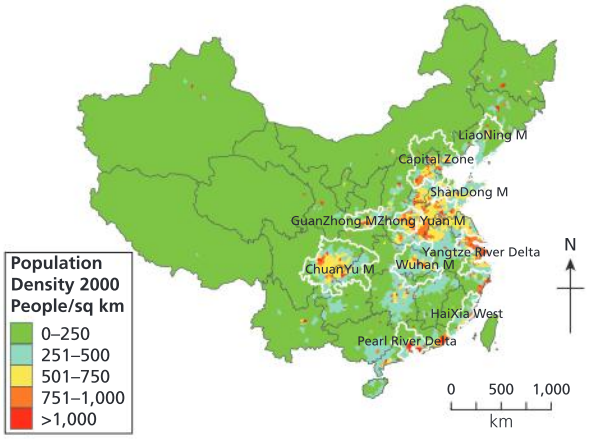
A megalopolis like Boston–Washington in the USA (see Option G) is a similar concept to China's mega-region.

The capital economic zone includes Beijing and Tianjin; the Pearl River Delta includes Shenzhen, Hong Kong and Guangzhou, and the Yangtze River Delta region is centred around Shanghai.

▼ **Figure 1.6:** Mega-regions in China



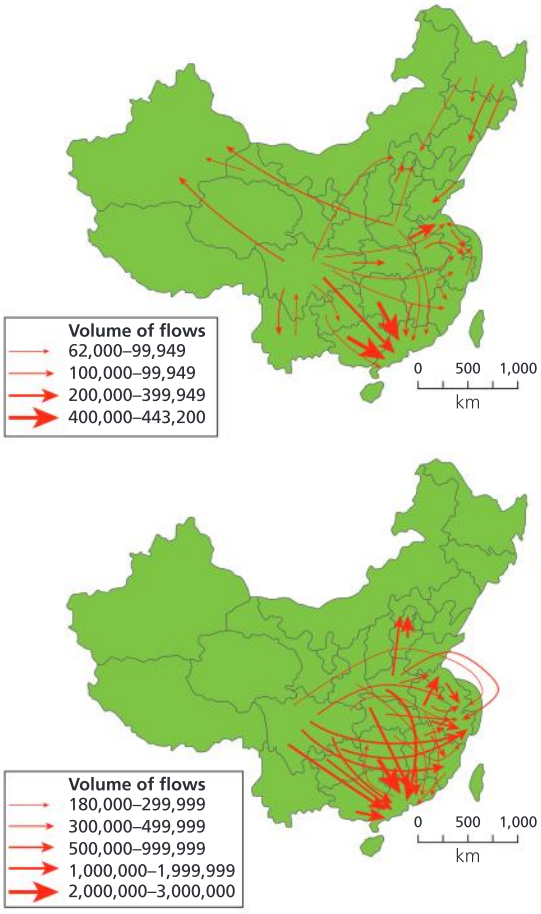
Activity 1

1. Describe the variations in population density in China in 2000, as shown in Figure 1.5.
2. Outline the main projected changes in population density by 2020 compared with 2000.
3. Compare and contrast the pattern of internal migration in China betwen 1990 and 1995 with that of 2000–2005.
4. Explain why the population densities in Table 1.1 are lower than those shown in Figure 1.5.

Internal migration in China

Since 1978, China has experienced the world's largest internal population movement, as 160 million migrants have left rural areas to seek work in urban areas. The main reason for this migration was that wages in urban areas were 40 per cent higher than in rural areas. Most of the migrants moved to the urban industrial cities by the coast. Between 1990 and 1995, 10 million people moved; this grew to 32 million during 1995–2000 and 38 million between 2000 and 2005 (Figure 1.7).

Internal migration has been good for the Chinese economy, and generally beneficial to the migrants, but at a personal and an environmental cost. During the 1990s, rural–urban wealth inequalities widened, although they have reduced since. In 1978 Shenzhen was a settlement of a few thousand people; by 2010 its population had reached 12 million and is predicted to reach 15 million by 2020. Land and labour costs are rising, and so the Chinese government has attempted to direct recent industrial development, and the destination of internal migrants, to interior locations.



▲ **Figure 1.7:** Migration flows in China, (a) 1990–95 and (b) 2000–2005
Source: Kam Wing Chan, 2013, China, Internal Migration, University of Washington

Population distribution in South Africa

The distribution of South Africa's population is very uneven (Figure 1.8). Some parts of the core economic regions, such as Gauteng, have population densities of over 1,000 people/km^2, whereas large areas of the Northern Cape Province have densities of less than 5/km^2. High population densities are found in areas where there are good mineral resources, such as gold and diamonds, good farming potential, and good trading potential, such as Durban and Cape Town.

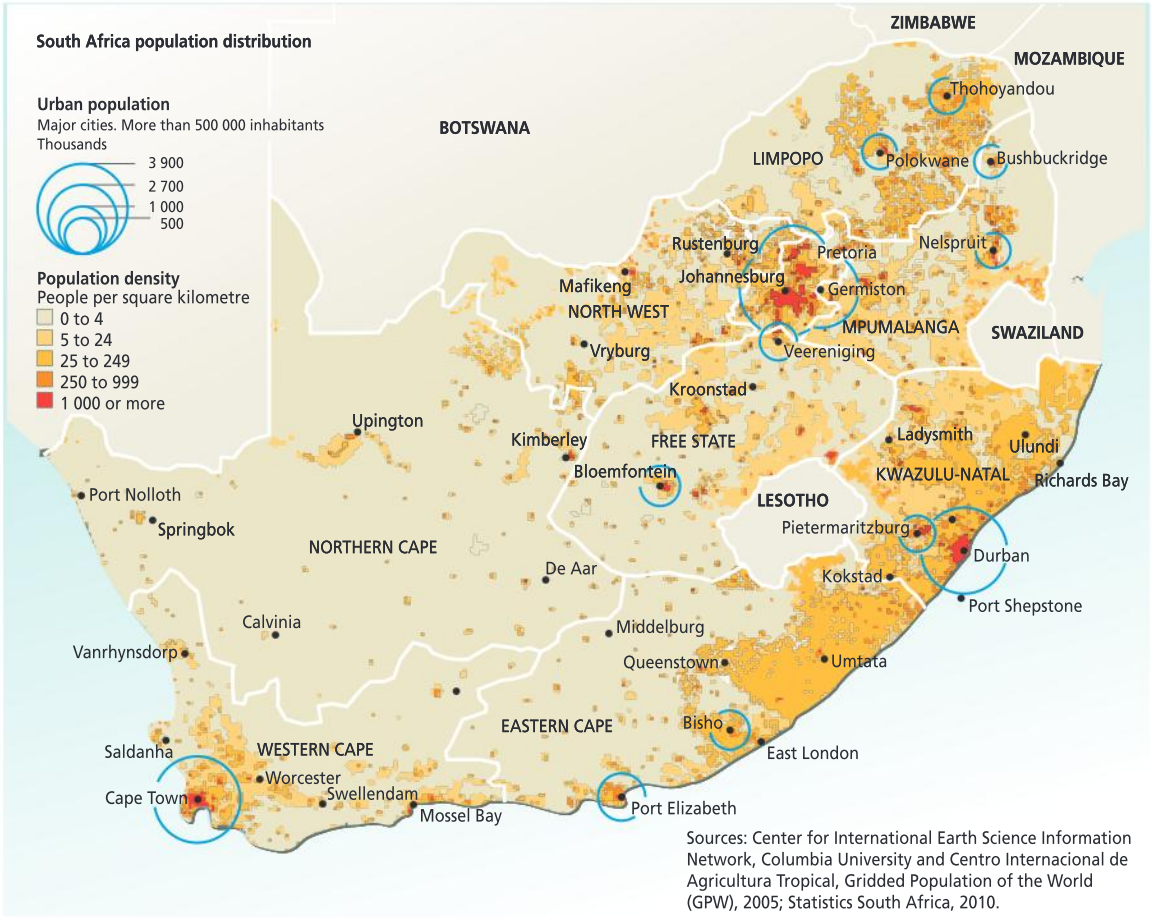
In general, the population decreases from the south-east to the north-west. This partly reflects the distribution of rainfall in South Africa: the lowest densities are found in the most arid areas and also in parts of the mountain regions.

Internal migration in South Africa

South Africa has had three main periods of internal migration during the 20th and 21st centuries:

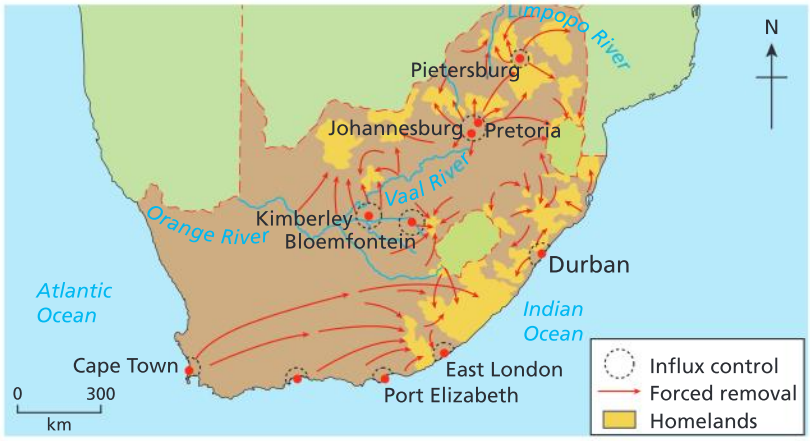
- economic migration linked with industrial development until 1950
- forced migration related to the apartheid movement
- voluntary migration following the collapse of the apartheid system.

Industry in South Africa developed rapidly between the two world wars. Many black people moved from the countryside to cities to work as **migrant labourers** in the gold and diamond mines. Between 1948 and 1994 the white National Party had political control of South Africa and set up the apartheid policy. Under this policy, over 4 million black people were forcibly removed from "white" areas and relocated to "homelands" (Figure 1.9). At the same time, there were severe restrictions on black people entering "white" towns, a policy known as "influx control".



▲ **Figure 1.8:** Population distribution and density in South Africa

Since the end of the apartheid era, many blacks have migrated from the former homeland areas to large cities, in search of work. However, poverty forces many to live in substandard housing on the edge of towns. South Africa's urban population grew from 55 per cent in 1995 (the first post-apartheid census) to 65 per cent in 2015. However, much of this growth was due to natural increase – 70 per cent in Gauteng between 1996 and 2001. While large urban areas have been attracting migrants, small towns and rural areas have been losing them. Up to 2.4 million blacks left white-owned commercial farms between 1994 and 2004. Many moved to nearby small towns. Farm workers are generally poor and unskilled, so their job prospects are limited.



▲ **Figure 1.9:** Forced migration within South Africa during the apartheid era

A feature of South Africa's migration is so-called **circular migration**, when a worker moves repeatedly between home and host areas. Within the former homelands, some 4 million people practise some form

of subsistence farming. In South Africa, farms represent a sense of security, identity, history and a preferred place for retirement. In order to supplement income, however, a family member will generally seek work in an urban area. Increasingly, it is women who are migrating to towns and cities to work, leaving their children in the rural area to be cared for by grandparents. Circular migrants frequently take poorly paid and insecure jobs in the informal economy. The high cost of living in urban areas and the need for grandparents to care for children make this form of migration common. However, the poorest are unable to migrate without finance or social networks to help them.

ATL Research skills

Find out about the apartheid system in South Africa. When was it introduced, and by whom? What were its aims? When did it end?

Activity 2

1. Describe the distribution of population in South Africa, as shown in Figure 1.8.
2. Contrast the main type of migration in China (Figure 1.7) with that in South Africa during the Apartheid era (Figure 1.8)
3. Study Figure 1.8 and identify the main core region of South Africa and the main peripheral region. Suggest two or more factors that may have contributed to South Africa's core and periphery.

Check your understanding

1. Identify three physical factors that affect the distribution of population at the global scale.
2. Identify two human factors that affect the distribution of population at the global scale.
3. State the meaning of the following acronyms: CPE, NIC, LIC, HIC.
4. Describe the main patterns of migration in China.
5. Briefly explain two physical reasons for the distribution of population in China.
6. Name the political system in South Africa that was responsible for the redistribution of population.
7. Identify the main areas of high population density in South Africa.
8. Explain two contrasting reasons for the distribution of population in South Africa.
9. State the proportion of population in China that live on the most densely populated 0.5 per cent of the land.
10. State the proportion of population in China that live on the least densely populated 50 per cent of the land.

Concepts in context

We have seen how population distribution is affected by physical and human factors. Human factors – such as level of development – have a major impact on population migration and distribution. However, no two **places** are the same, and each place has its own unique situation and development.

Synthesis and evaluation

Both physical and human factors affect population distribution. Initially, physical factors were more important, for example access to water and fertile soils. Although these are still important, human factors such as accessibility and potential for trade have become more important over time. Population density is normally shown using choropleth maps, while migration is often shown using flow maps.

2 Changing populations and places

Conceptual understanding

Key question

What are the **processes** of population change and their effect on people and places?

Key content

- Population change and demographic transition over time, including natural increase, fertility rate, life expectancy, population structure and dependency ratios, and contrasts between countries.
- The consequences of megacity growth for individuals and societies.
- The environmental and political causes and consequences for people and places of forced migration and internal displacement.

Population change and demographic transition over time

Population change includes changes brought about by the birth rate, the death rate and migration. The general demographic transition model (DTM) shows the change in the birth rate and death rate over time (Figure 1.10).

The DTM suggests that death rates fall before birth rates, and that the total population expands. However, the DTM is based on the data from just three countries – England, Wales and Sweden. Not only is the timescale for the DTM in these countries longer than in many LEDCs, but there are other types of DTM (Figure 1.11). For example, Ireland's DTM was based on falling birth rates and rising death rates as a result of emigration following the 1845–9 famine. The DTM in Japan shows a period of population expansion before the Second World War, followed by population contraction once the country's expansionist plans could not be fulfilled. Other nations have experienced a similar drop in birth rates and death rates (for example, the former Yugoslavia).

Stage 1
High and variable:
- birth rates and death rates are high and variable
- population growth fluctuates
- no countries, only some indigenous (primitive) tribes still at this stage
- UK at this stage until about 1750

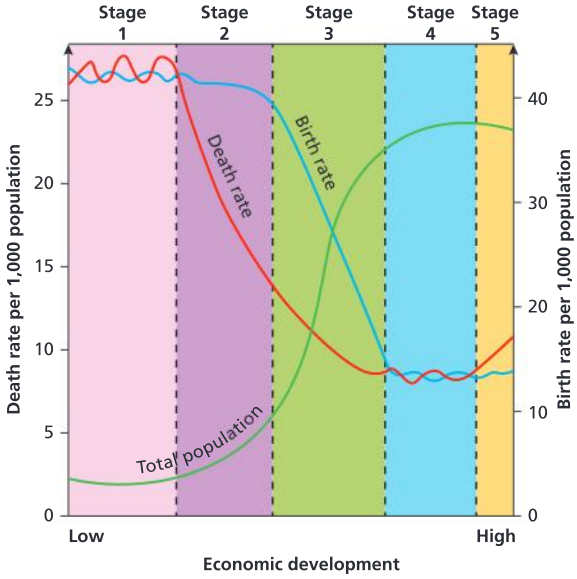
High birth and death rates
Parents want children:
- for labour
- to look after them in old age
- to continue the family name
- prestige
- to replace other children who have died

People die from:
- lack of clean water
- lack of food
- poor hygiene and sanitation
- overcrowding
- contagious diseases
- poverty

Stage 2
Early expanding:
- birth rates remains high but the death rate comes down rapidly
- population growth is rapid
- Afghanistan, Sudan and Libya are at this stage
- UK passed through this stage by 1850

Stage 3
Late expanding:
- birth rate drops and the death rate remains low
- population growth continues but at a smaller rate
- Brazil and Argentina are at this stage
- UK passed through this stage in 1950

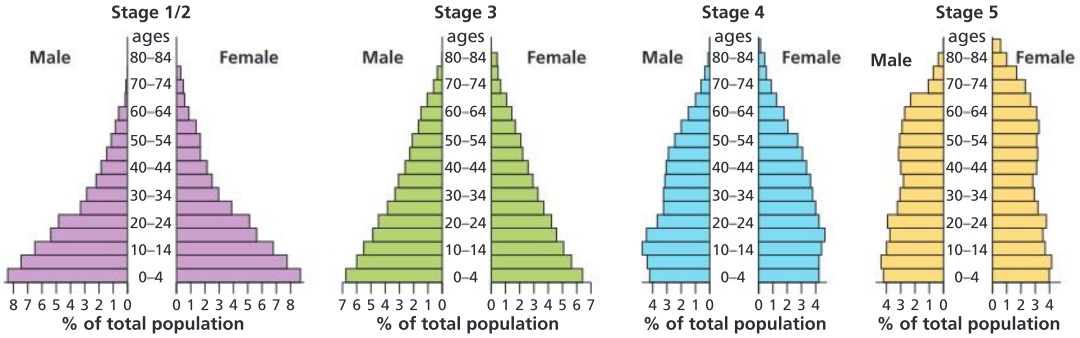
Stage 4
Low and variable:
- birth rates and death rates are low and variable
- population growth fluctuates
- UK and most developed countries are at this stage



Stage 5
Low declining:
- the birth rate is lower than the death rate
- the population declines
- Japan is at this stage

Low birth and death rates
Birth rates decline because:
- children are very costly
- the government looks after people through pensions and health services
- more women want their own career
- their is more widespread use of family planning
- as the infant mortality rate comes down there is less need for replacement children

Death rates decline because of:
- clean water
- reliable food supply
- good hygiene and sanitation
- lower population densities
- better vacations and healthcare
- rising standards of living

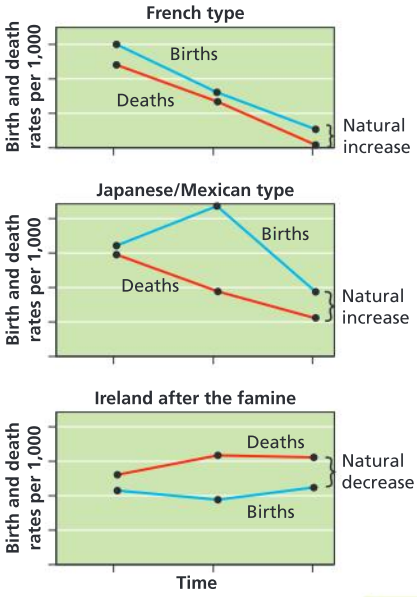


▲ **Figure 1.10:** The demographic transition model (DTM)

Natural increase

Natural increase is calculated by subtracting the crude death rate from the crude birth rate. It is expressed as a percentage. Natural decrease occurs when the death rate exceeds the birth rate. Natural change (increase or decrease) does not take migration into account. By contrast, population change is the balance between birth rate, death rate and migration.

Doubling time is the number of years needed for a population to double in size. It is found by dividing 70 (years) by the rate of natural increase (in per cent). It is expressed in years.



▶ **Figure 1.11:** Alternative demographic transitions

Activity 3

1. Describe the main features of the general demographic transition model.
2. Briefly explain why Ireland's demographic transition differed from that of Japan.

Population momentum is the tendency for a population to grow despite a fall in the birth rate or fertility levels. It occurs because of a relatively high concentration of people in the pre-childbearing and childbearing years. As these young people grow older and move through their reproductive years, the greater number of births will exceed the number of deaths in the older populations, and so the population will continue to grow.

Population projections are predictions about future population based on trends in fertility, mortality and migration.

Total fertility rate

The **total fertility rate (TFR)** is the average number of births per thousand women of childbearing age. It is the completed family size if fertility rates remain constant. In general, the highest fertility rates are found among the poorest countries, although some LICs have made the transition from high fertility rates to low fertility rates. Most HICs, by contrast, have experienced much reduced fertility rates.

Changes in fertility are a combination of both sociocultural and economic factors. While there may be strong correlations between these sets of factors and changes in fertility, it is impossible to prove the linkages or to prove that one set of factors is more important than the other. The following factors affect a country's TFR.

The status of women – this is assessed by the gender-related development index (GDI), which measures the inequality between the sexes in life expectancy, education and the standard of living. In countries where the status of women is low and few women are educated or involved in paid employment, birth rates are high. In countries such as Singapore, where the status of women has improved, the birth rate has fallen. Between 1960 and 2000 there were great social and economic changes there, resulting in full employment, including female employment. As a result, the total fertility rate fell from over 3.0 to 1.5 in 2000 and 0.81 in 2015.

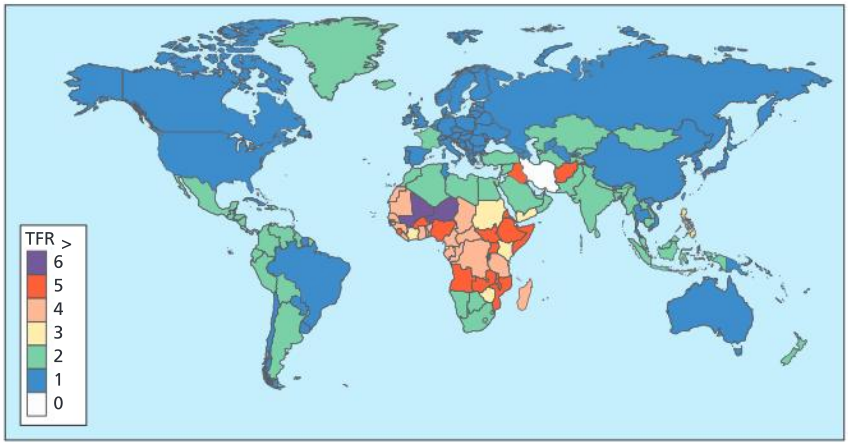
Level of education and material ambition – in general, the more highly educated the parents are, the fewer children they will have. Middle-income families with high aspirations but limited means tend to have the smallest families. They wish to improve their standard of living and will limit their family size to achieve this. Poor people with limited resources or ambition often have large families. Affluent people can afford large families.

Location of residence – people in rural areas tend to have more children than those in urban areas. Reasons for this include:

- more rigid social pressures on women
- greater freedom and less state control (for example China's one-child policy is enforced less rigorously in rural areas)
- fewer educational and economic opportunities for women.

▼ **Table 1.2:** Doubling times for selected countries, 2016

Country	Growth rate (%)	Doubling time
Burundi	3.28	21 years
China	0.45	155 years
South Korea	0.14	500 years
Austria	0.55	127 years



▲ **Figure 1.12:** Total fertility rate (TFR), 2016

In some urban areas, such as shanty towns, there are high levels of fertility because of their youthful population structure.

Religion – the role of religion in relation to fertility rates is commonly confused. The lowest birth rates in Europe include those of Italy and Spain, both Catholic countries. In contrast, some poor Catholic countries, such as Mexico and Brazil, have high birth rates. In general, most religions are pro-natalist (they favour large families) and opposed to birth control, sterilization and contraception. In HICs, however, most people do not follow the dictates of religious beliefs very strictly.

Health of the mother – although more pregnancies are successful for women who are well nourished and healthy, women who are not healthy may become pregnant more frequently. This is because they may experience a higher infant mortality and more unsuccessful pregnancies. Hence they become pregnant again in order to compensate for the child they have lost.

Economic prosperity – the correlation between economic prosperity and the birth rate is not total, but there are links. Economic prosperity favours an increase in the birth rate, while increasing costs lead to a decline in the birth rate. Recession and unemployment are also linked with a decline in the birth rate. This is related to the cost of bringing up children. Surveys have shown that the cost of bringing up a child in the UK can be over $300,000, partly through lost parental earnings. Whether the cost is real or imagined (perceived) does not matter. If parents believe they cannot afford to bring up a family, or that by having more children their standard of living will fall, they are less likely to have children.

At the global scale, a strong link exists between fertility and the level of economic development. The UN and many civil societies, including non-governmental organizations (NGOs), believe that a reduction in the high birth rates in HICs can be achieved only by improving the standard of living in those countries. There is also evidence to suggest that the more equitable the distribution of wealth within a country, the lower the fertility rate.

The need for children – high infant mortality rates increase the pressure on women to have more children. Such births, to offset the high mortality losses, are termed replacement births or compensatory births. In some agricultural societies, parents have large families to provide labour for the farm and as security for the parents in old age. This is much less important now as fewer families are engaged in farming, and many farmers work as labourers rather than owning their own farms.

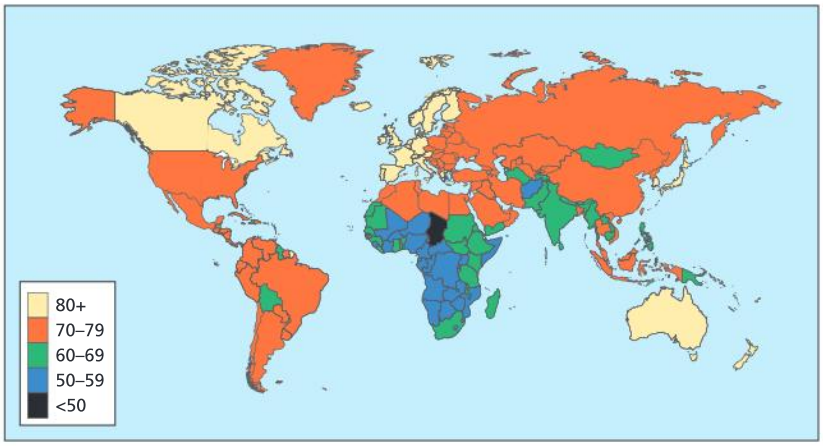
Activity 4

Using located examples, explain why some countries have higher fertility rates than others.

Life expectancy

Life expectancy is the average number of years that a person can be expected to live, usually from birth, assuming that demographic factors remain unchanged.

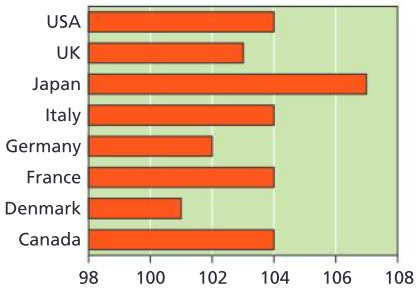
Life expectancy varies – from over 80 years in a number of developed countries, such as Monaco, Japan, Singapore and Macau, to under 50 years for men in Chad. The reason for the low and declining life expectancy in many sub-Saharan countries is a combination of poverty,



▲ **Figure 1.13:** Life expectancy, 2016

conflict and the AIDS virus. In the 40 countries with the lowest life expectancy (below 64 years), only two are not in sub-Saharan Africa, namely Haiti (63.5 years) and Afghanistan (50 years).

Most countries would expect to see life expectancy rise over time. In some HICs over 50 per cent of those born in 2007 will live to over 100 years (Figure 1.14). As a country develops, it should have better food supply, clean water and adequate housing. However, a number of countries saw their life expectancy fall between 1970 and 2000–2005. These include Zambia (from 50 years to 39 years), and Zimbabwe (55 to 40 years). By contrast, in Myanmar (Burma) one of the poorest nations in Asia, life expectancy rose from 53 years to nearly 60 years.



▲ **Figure 1.14:** Life expectancy of babies born in 2007 in selected HICs

Life expectancy is often higher for women than for men. This may be for a number of reasons. In some countries, the male retirement age is higher for men than women; more men are likely to take part in heavy physical labour; men are more likely to be involved in conflict; more men have "self-destructive" lifestyles and smoke and/or drink alcohol to excess.

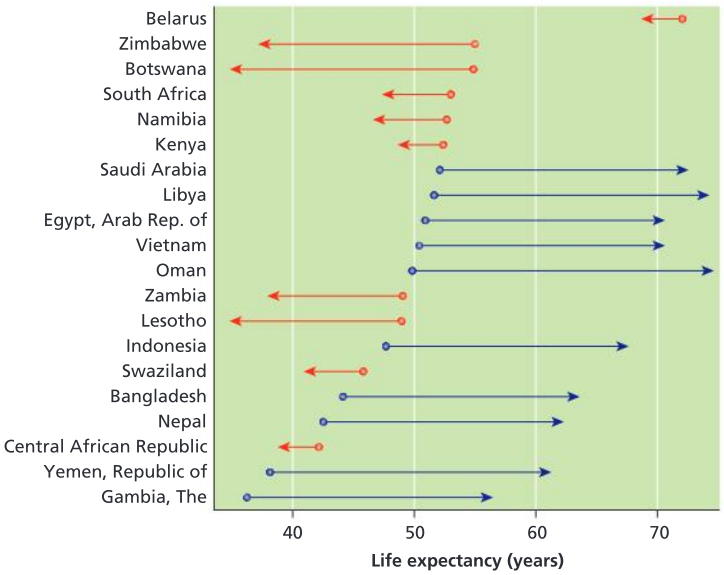
Moreover, a longer life expectancy does not necessarily mean that the latter years are spent in good health. Many of the elderly have life-changing disabilities such as Alzheimer's disease, or physical incapacities such as arthritis. In addition, many widows may experience loneliness following the death of their husbands.

ATL Research skills

Update data on life expectancy for at least five contrasting countries, using either the CIA World Factbook https://www.cia.gov/library/publications/the-world-factbook/

or the Population Reference Bureau's Data Sheet, http://www.prb.org/pdf15/2015-world-population-data-sheet_eng.pdf.

Identify some countries where female life expectancy is greater than male life expectancy, and find out whether there are any countries in which male life expectancy is greater than or equal to female life expectancy.



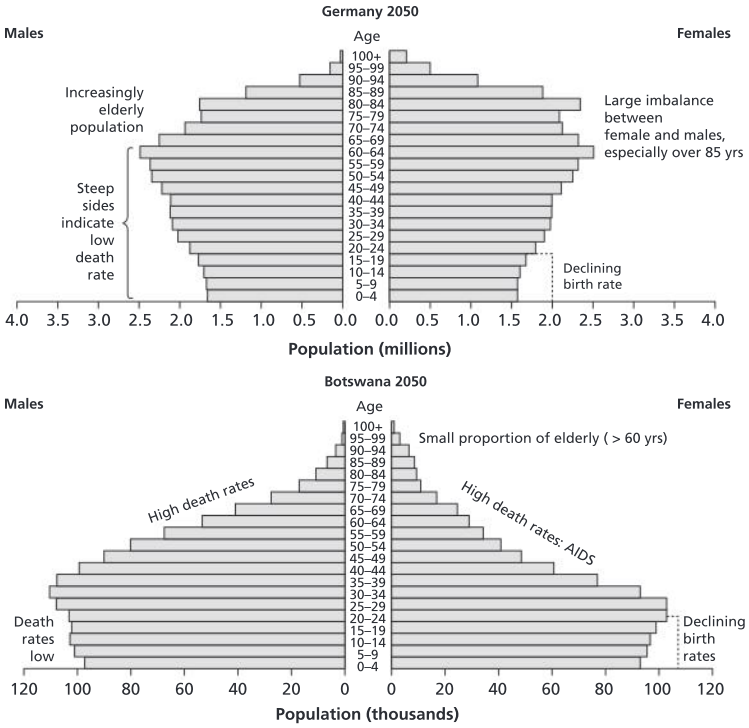
▲ **Figure 1.15:** Changes in life expectancy, 1970–2005

Age/sex pyramids

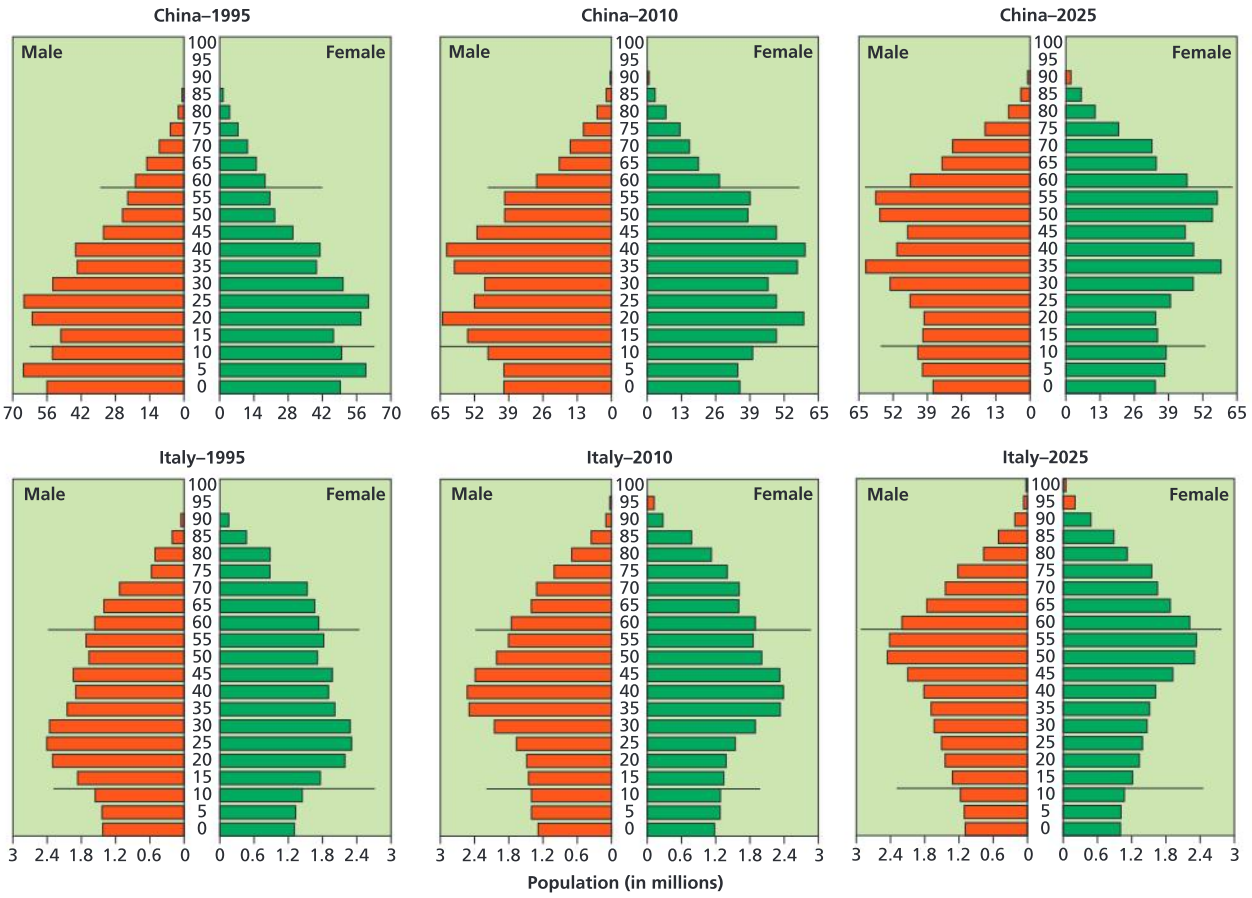
Population structure or composition refers to any measurable characteristic of a population. This includes the age, sex, ethnicity, language, religion and occupation of the population. Population pyramids (Figure 1.16) are used to show these characteristics.

Population pyramids tell us a great deal about the age and sex structure of a population:

- A wide base indicates a high birth rate.
- A narrowing base suggests a falling birth rate.
- Straight or near-vertical sides reveal low death rates.
- Concave slopes characterize high death rates.
- Bulges in the slope suggest high rates of immigration or in-migration (for instance, excess males 20–35 years will be economic



▲ **Figure 1.16:** Annotated population pyramids



▲ **Figure 1.17:** Population pyramids for China and Italy, 1995, 2010 and projected for 2025

migrants looking for work; excess elderly, usually female, will indicate retirement resorts) and/or baby booms.

- "Slices" in the slope indicate emigration or out-migration, or age-specific or sex-specific deaths (epidemics, war).

Dependency ratios

The dependency ratio measures the working population and the dependent population. It is worked out by a formula:

$$\frac{\text{Population aged } <15 + \text{population aged } >64 \text{ (the dependents)}}{\text{Population aged 16–64 (the economically active)}} \times 100$$

It is a very crude measure – for example, many people stay on at school after the age of 15 and many people work after the age of 64 – but it is useful for comparing countries or tracking changes over time.

- In the developed world there is a high proportion of elderly.
- In the developing world there is a high proportion of youth.

These can be shown on a triangular graph.

Triangular graphs

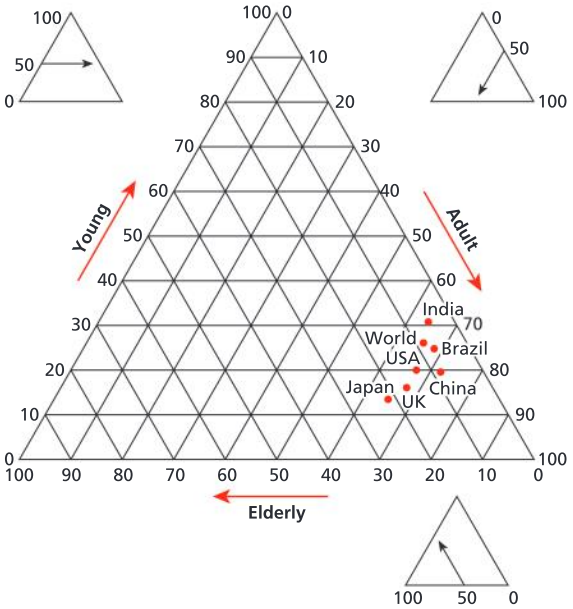
Triangular graphs are used to show data that can be divided into three parts. As well as showing the age structure of a population, triangular graphs can also show variations in soil structure (sand, clay, silt) and employment (primary, secondary and tertiary sectors). They are useful for several reasons.

- They can show a large amount of data.
- Groupings can be recognized easily.
- Dominant characteristics can be shown.
- Classifications can be made.

Sometimes only part of the graph is shown, but at a larger scale.

Activity 5

On a copy of Figure 1.17, annotate the population pyramids to show the main changes in population structure over time.



▲ **Figure 1.18:** A triangular graph showing the age structure of populations

Activity 6

From Figure 1.18, work out the population structure for China, the USA and the world.

On a copy of Figure 1.18, add a dot to locate the population age structure for Ethiopia, Vietnam and Zimbabwe, using the information in this table:

	Youthful	Adult	Elderly
Ethiopia	46	51	3
Vietnam	26	68	6
Zimbabwe	44	52	4

Ageing ratios

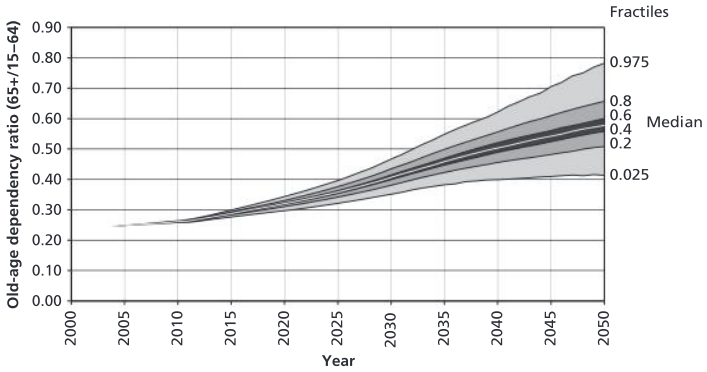
Within certain ranges, the future trends of fertility, mortality and migration shaping the pattern of population ageing in Europe are uncertain. Methods of statistical probability have been developed to describe these uncertainty ranges in a quantitative way.

Figure 1.19 shows the future trend in the old-age dependency ratio for EU member countries. Currently there are four people in the age group 15–64 (considered as the potential working age) for each person aged 65 or older. There is an 80 per cent chance that the ratio will more than double by 2050, which means there will be fewer than two people of working age per person above age 65. At the high end there is about a 20 per cent chance that there will be only three people of working

age for any two above age 65. Since not everybody aged between 15 and 64 will be actually working – due to being in education, unemployed, retired, or for other reasons – the actual ratio of contributors to beneficiaries of the pension system may even be less favourable.

There is significantly more demographic uncertainty about the future trend in the proportion of the population above age 80.

Currently only 4 per cent of the population are of this advanced age, but over the course of time this proportion might well increase to about 6–7 per cent, increasing thereafter as the "baby boom" cohorts gradually enter this age group. By 2050, the 95 per cent interval ranges from a low of 7 per cent to a high of 20 per cent of the population above the age of 80.



▲ **Figure 1.19:** Ageing ratios

▼ **Table 1.3:** Population indicators for countries at different levels of development

	China	India	Cuba	DR Congo	USA	UK	Germany
Population (millions)	1,367	1,251	11	79	321	64	81
Area (1,000 km^2)	9,596	3,287	110	2,267	9,809	244	357
Population growth (%/year)	0.45	1.22	-0.55	2.45	0.78	0.54	-0.17
Birth rate (per 1,000)	12.49	19.55	9.9	34.88	12.49	12.17	8.47
Death rate (per 1,000)	7.53	7.32	7.72	10.07	8.15	9.35	11.42
Infant mortality rate (per 1,000)	12.44	41.8	4.63	71.47	5.87	4.38	3.43
Life expectancy	75.4	68.1	78.4	56.9	79.7	80.5	80.6
Urban population (%)	55.6	32.7	77.1	42.5	81.6	82.6	75.3
Fertility rate (no. of children per woman)	1.6	2.48	1.47	4.66	1.87	1.89	1.44
Use of contraceptives (%)	84.6	54.8	74.3	17.7	76.4	84.0	62.2
Age structure							
0–14 years	17	28	16	43	19	17	13
15–24 years	14	18	13	21	13	12	10
25–64 years	59	48	58	33	53	53	55
≥65 years	10	6	13	3	15	18	22
Employment structure							
Agriculture	33.6	49	18	35	1	1	1.5
Industry	30.3	20	10	21	20	15	24.5
Services	36.1	31	72	44	79	84	74
Average income ($) (PPP)	14,100	6,200	10,200	800	55,800	41,200	46,900
Literacy (%)	96.4	71.2	99.8	63.8	99	99	99
Health expenditure (% of GNP)	5.6	4	8.8	3.5	17.1	9.1	11.3

TOK

The total number of births in China in any single year is going to be much greater than in Cuba, for example, partly because China is a much larger country with a larger population. In order to compare the number of births in different countries, we have to standardize the number of births. This is usually done by giving an average figure such as the number of births that every 1,000 people would produce in a given year. This allows us to compare two or more countries. However, the figure does not take into account the age structure of a population. A country with a younger population would be expected to have a higher birth rate than a country with an elderly population. Consequently, the birth rate (and the death rate) are referred to as **crude** rates, as they do not take into account the age structure of the population.

Activity 7

Using two or more countries from Table 1.3 (or of your choice), describe the main demographic characteristics of each country.

Using data to support an answer

The difference between a very strong answer and a moderate answer is sometimes explained by the amount of support that is given. For example, a question that asks "Why is fertility high in some countries but not in others?" could be answered by saying that the status of women is low, the need for children is high and there is lack of access to contraception. These reasons may all be correct but are not very convincing.

A strong response might say:

"DR Congo is an LIC, with an annual growth rate of 2.45%. The TFR is very high – on average women have over four children each. There are many reasons for the high fertility rate. DR Congo has a high IMR – over 70‰, and so women may have more children to compensate for the high death rate. In addition, use of contraceptives is limited to less than 20% of the population. DR Congo is largely an agricultural society with around one-third of the workforce working in farming. Having children may be a bonus as they can work on the land and help their parents. With low levels of literacy and high levels of poverty (average PPP is just $800), people continue to have large families.

"In contrast, fertility levels in Germany are low, just 1.44 children on average per woman. This may be because Germany is an HIC, with an average PPP of $46,900 and most of its employment is in the service sector. Most women are likely to be employed. Most of the population live in urban areas (over 75%), and literacy levels are high. Over 60% of families use contraceptives; hence the TFR is low."

The consequences of megacity growth for individuals and societies

One of the most important geographical phenomena of the late 20th and early 21st centuries has been the growth of megacities. For individuals, megacities offer the prospects of a job, a home and an opportunity to improve their standard of living and quality of life. For some, migration to megacities does improve their standard of living, but for others migration may result in unemployment or underemployment, poor-quality housing and the risk of many environmental hazards. For societies, having large numbers of people in close proximity may make it easier to provide housing and health care for example, but if there are too many people, the provision of such services is inadequate. Megacity growth is associated with expansion of the built area, increased traffic congestion, air pollution and declining water quality. However, the perception of megacities as a place of potential economic benefit for migrants fuels their growth.

Case study

Megacity growth – Mumbai

Mumbai is India's largest city, with a population of about 18 million. Originally, it was a collection of fishing villages situated on seven islands. Until the 1970s, Mumbai's economy was largely based on textiles and imports/exports through the port. Since then, it has diversified and includes such industries as aerospace, engineering, computers and electronic equipment. Now it is the financial, commercial and entertainment centre of India. It accounts for 25 per cent of India's industrial output, over 6 per cent of its total GDP and 40 per cent of its foreign trade. Many TNCs are based in Mumbai, such as the Tata Group, and it is home to the Bombay Stock Exchange, the Reserve Bank

Case study (continued)

of India and the National Stock Exchange of India. It contains many of India's scientific and nuclear industries, such as the Department of Atomic Energy. It is also the centre of the Bollywood film industry. Mumbai has more millionaires and billionaires than any other Indian city but is also home to millions of impoverished people. Mumbai's per capita income is about three times the national average.

Mumbai contains two distinct regions, namely Mumbai City district (also known as South Mumbai, or the Island City) and Mumbai Suburban district.

The 2011 Census stated that Mumbai's population was over 12 million people, of which about 9 million lived in slums. The gender ratio was 838 females per 1,000 males (lower in South Mumbai than in the suburbs) and less than the national average (F/M 914/1,000). This partly reflects the greater incidence of male migration to the city. The number of households in Mumbai is predicted to grow from 4.2 million in 2008 to 6.6 million in 2020.

Mumbai experiences many of the problems resulting from rapid city growth – poverty, unemployment and underemployment, limited access to health care and education, and poor sanitation and access to electricity. There are up to 4,000 cases of diphtheria and typhoid a day, partly the result of a lack of a proper sewerage system. Access to water is limited and many pumps are only available for two hours a day. The residents living in slums also have limited security of tenure. Dharavi, the main slum in South Mumbai, is an area of about 2 km^2, and home to up to 1 million people. Due to its close proximity to Mumbai's financial and commercial district, there is great pressure to clear parts of Dharavi for modern developments.

On the other hand, Dharavi has many informal activities that provide a livelihood for a lot of its residents. Up to 85 per cent of Dharavi adults work locally, and there are major recycling industries and pottery industries. However, the working conditions for the recycling industry can be very dangerous.

Mumbai has also suburbanized, initially north towards Shivaji Park, Matunga and Mahim. More recent developments have been towards the east of Mumbai, including Navi Mumbai, Vashi, Vasai and Mahim Creek.

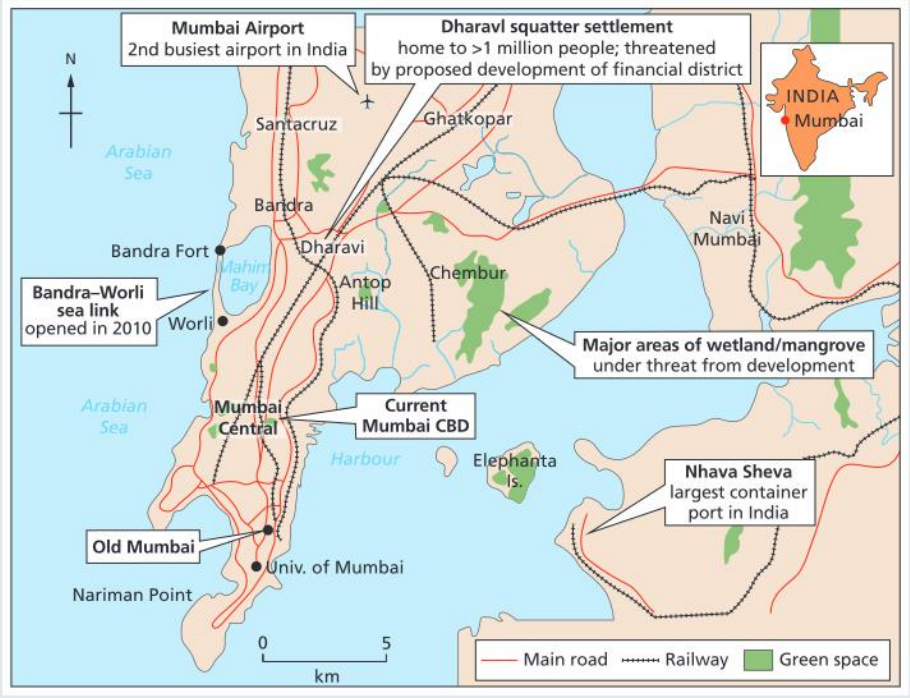


Figure 1.20: Mumbai

Activity 8

1. Briefly explain the reasons for Mumbai's growth as a megacity.
2. Suggest reasons why Mumbai has a mix of billionaires as well as millions of impoverished people.

The causes and consequences of forced migration

According to the International Association for the Study of Forced Migration (IASFM), forced migration is a general term that refers to "the movement of refugees and internally displaced people (those displaced by conflicts) as well as people displaced by natural or environmental disasters, chemical or nuclear disasters, famine or development projects".

There are several types of forced migration.

1. Conflict-induced displacement. This includes people who are forced to move due to armed conflict such as civil war, violence or persecution on the basis of their nationality, race, religion, political opinion or social group. In 2015 there were some 15 million refugees and approximately 40 million internally displaced people (IDPs).
2. Development-induced displacement. This includes people forced to move as a result of large-scale infrastructure projects such as dams, motorways, airports, urban redevelopment, mining, deforestation, and even the creation of conservation schemes. On average, 10 million people a year are displaced due to dam developments. The South–North Water Diversion Project in China has displaced around 345,000 people and the creation of the Three Gorges dam displaced some 1.25 million people.
3. Disaster-induced displacement. Natural disasters resulting in large numbers of displaced people include volcanoes, hurricanes, landslides, environmental change (global warming, desertification, land degradation) and human-induced disasters such as releases of radiation and chemicals.

TOK

What's in a name?

What do the following terms suggest to you?

Refugee, migrant, illegal, illegal immigrant

How does the language related to migration influence the way in which some migrants are perceived by certain groups?

Types of forced migrant

There are several types of forced migrant.

1. Refugees. According to the 1951 UN Convention Relating to the Status of Refugees, a refugee is a "person residing outside his or her country of nationality, who is unable or unwilling to return because of a well-founded fear of persecution on account of race, religion, nationality, membership in a political social group or political opinion".
2. Asylum seekers. An asylum seeker is a person who has left their country of origin in search of protection in another country, under the 1951 UN Refugee Convention, but whose claim for refugee status has not been decided.
3. Internally displaced persons (IDPs). According to the UN, IDPs are groups of people who have been "forced to flee their home suddenly or unexpectedly in large numbers, as a result of armed conflict, internal strife, systematic violations of human rights or natural or man-made disasters, and who are within the territory of their own country".
4. Development displacees. These are people compelled to move as a result of policies and projects to promote development.
5. Environmental and disaster displacees. These people are sometimes referred to as environmental refugees or disaster refugees. (See

Option B, p.166 for environmental refugees in Kivalina, Alaska.)

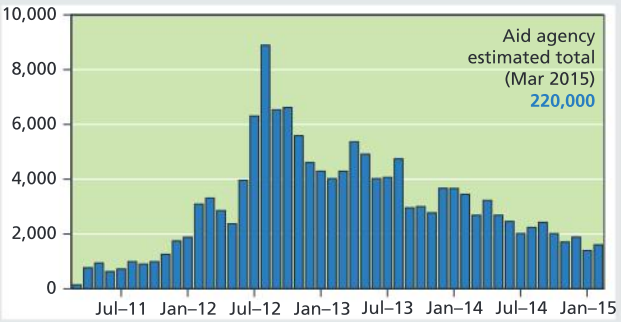
6. Smuggled people. Smuggled people are moved illegally for profit. They may include those who have been forcibly displaced as well as those who have left their homes in search of a better standard of living.
7. Trafficked people. These are people moved by deception or coercion for the purpose of exploitation and profit.

Case study

Forced migration in and from Syria

In Syria, the repression of the ruling Assad regime and the emergence of the fundamentalist Islamic group Isis (also known as IS) have led to the displacement of over 10 million people. The Syrian conflict began as a civil war, but extended to include parts of Iraq when Isis declared Syria and Iraq an Islamic "caliphate". Syrians near Damascus feared that government forces were being used on their own people, whereas in other parts of Syria, people feared they would be killed, captured or forced to live under a severe and harsh Islamic rule. The result has been a stream of refugees and displaced people into neighbouring countries and other parts of Syria.

There were over 4 million IDPs in Syria and 4.5 million Syrian refugees in just five other countries: Turkey, Lebanon, Iraq, Egypt and Jordan. The Zaatari refugee camp in Jordan, just 8 km from the Syrian border, is the world's second largest refugee camp (Dadaab in Kenya is the largest) and now the fourth largest city in Jordan. According to the 1951 Geneva Convention on refugees, the burden of taking in refugees should not fall on a small number of countries, but should be shared out.

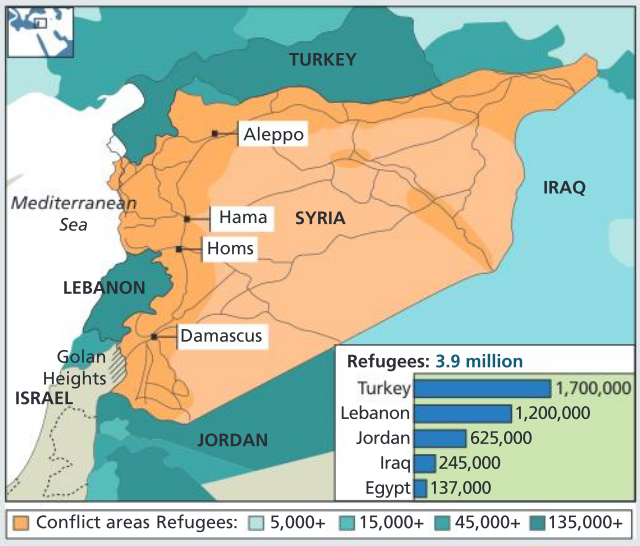


▲ **Figure 1.21:** The Syrian conflict death toll, July 2011–January 2015

The impact of Syrian refugees on Lebanon

There are more than 1.4 million Syrian refugees in Lebanon, about half of whom are children. This is around one-quarter of Lebanon's population. Most of the refugees live in poverty and are dependent on aid for survival. Lebanon has the highest number of refuges per capita in the world. As a result, the country has suffered severe economic and environmental consequences. There has been strain on Lebanon's health and education services, and its electricity, water and sanitation systems. The humanitarian appeal has only received around one-eighth of its target amount of funds.

The number of refugee schoolchildren is greater than the number of Lebanese children at school. Schools have been forced to provide places for up to 100,000 Syrian children, although most of them are not attending school.



▲ **Figure 1.22:** Numbers of Syrian refugees, March 2015
Source: UNHCR, Reliefweb (Figures up to 12 March 2015)

Case study

Forced migration in Nigeria

In 2014 the terrorist group Boko Haram kidnapped 276 schoolgirls from the village of Chibok in northern Nigeria. The violence associated with Boko Haram has caused many people to flee the region. Over 3 million people have been internally displaced in Nigeria, including some 250,000 as a result of Boko Haram. Nigeria has the third largest number of IDPs after Syria and Colombia.

The disruption caused by Boko Haram has strained relations between Nigeria and its neighbours Cameroon, Chad and Niger. People in the region the group controls have been left unable to feed themselves after some 60 per cent of the region's farmers were displaced, leading to less land being farmed and less produce harvested. Over a third of health care facilities closed down, and health workers have been abducted and killed.

People in the region lack access to fresh water and sanitation. Homes, services and infrastructure have been extensively damaged, and Boko Haram has made many attacks on schools.

Check your understanding

1. Describe the main changes shown by the demographic transition model.
2. Outline the main characteristics of Ireland's demographic transition model.
3. Define the term "natural increase".
4. How is doubling time calculated?
5. Describe the main pattern of the total fertility rate (TFR) at the global scale.
6. Describe the main pattern of life expectancy at the global scale.
7. Distinguish between the dependency ratio and the ageing ratio.
8. Suggest reasons for the growth of megacities.
9. Outline three different types of forced migration.
10. Briefly explain the impacts of forced migrations.

Concepts in context

Population change is a dynamic process. Populations change due to variations in birth and death rates and migration. This may lead to changes in population structure, which in turn contributes to the process of population change.

Synthesis and evaluation

Differences in population change are most commonly shown by maps. This allows geographers to pick out major contrasts in demographic trends. However, it may over-emphasise political boundaries and might not reveal important differences at a sub-national scale. Annotated population pyramids can be used to show changes in the birth and death rates and migration. Spatial interactions can be shown through the use of flow lines and located bar charts. Visual methods are often more effective in conveying a message compared with tables of data.

3 Challenges and opportunities

Conceptual understanding

Key question

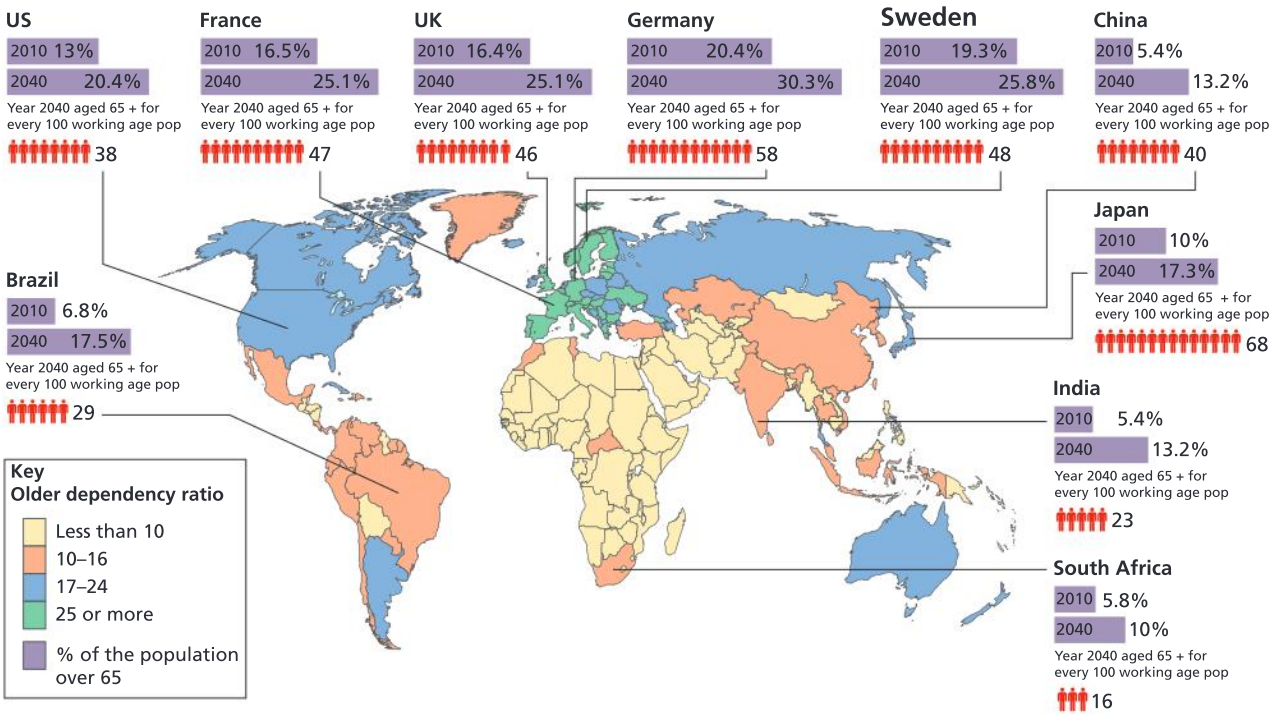
What are the population **possibilities** and **power** over the decision-making process?

Key content

- Global and regional/continental trends in family size, sex ratios and ageing/greying.
- Policies to manage population change that focus on policies related to ageing societies and pro-natalist or anti-natalist policies.
- Policies to manage population change that focus on gender equality policies and anti-trafficking policies.
- The demographic dividend and the ways in which population could be considered a resource when contemplating possible futures.

Ageing populations

An ageing population has certain advantages. The elderly may have skills (including social skills) and training, and some employers, especially supermarkets and DIY/furniture stores, prefer them to younger workers.



▲ **Figure 1.23:** The global pattern of the older dependency ratio

The elderly may look after their grandchildren and therefore allow both parents to work. This is important in Japan and also in South Africa, where a "granny culture" occurs in many areas. In HICs, the elderly are often viewed as an important market – the "grey economy" – and many firms, ranging from holiday companies to health care providers, have developed strategies to target this market.

TOK

Is an ageing world an advantage or a disadvantage?

By 2035, the number of over-65s is expected almost to double to 1.3 billion – a leap from 7 to 14 per cent of the world's population. Already the number is increasing at an average of 870,000 each month. The proportion of the global population aged 65 years and over is set to outnumber that of children under five for the first time. A report by the US Census Bureau, *An Aging World 2008*, highlights a huge shift towards not just an ageing but also an old population, with formidable consequences for rich and poor countries. New challenges for families and policymakers range from how to care for older people living alone to how to pay for unprecedented numbers of pensioners.

▲ **Photo 1.1:** Proverty and ill health are experienced by many of South Africa's rural black population

The shift is due to a combination of the time-delayed impact of high fertility levels after the Second World War and more recent improvements in health that are reducing death rates at older ages. The change will bring widespread challenges at every level of human organization, starting with the structure of the family, which will be transformed as people live longer. There will in turn be new burdens on carers and social services providers, while patterns of work and retirement will similarly have huge implications for health services and pensions systems.

Europe is the greyest continent, with 23 of the world's 25 oldest countries. Such dominance of the regional league table will continue. By 2040 more than one in four Europeans is expected to be at least 65, and one in seven at least 75. Japan's life expectancy at birth – 82 years – is matched only by Singapore's, although in Western Europe, France, Sweden and Italy all have life expectancies of more than 80 years.

The contrast in life expectancy between rich and poor nations remains glaring. The report shows that a person born in an HIC can expect to outlive his or her counterpart in an LIC by 14 years. Zimbabwe has the lowest life expectancy, which has been cut to 40 through a combination of AIDS, famine and dictatorship. By 2040, LICs are projected to be home to more than a billion people aged 65 and over – 76 per cent of the world total.

Online case study

Family size and gender ratios

The **older dependency ratio**, or ODR, acts as an indicator of the balance between working-age people and the older population that they must support. It varies widely, from just 6 in Kenya and 7 in Bangladesh, to 33 in Italy and Japan. Countries with a high ODR are already suffering under the burden of funding prolonged retirement for their older population. In France, life expectancy after retirement has already reached 21 years for men and 26 years for women. With women living on average seven years longer than men, more older women are living alone. Around half of all women aged 65 and over in Germany, Denmark and Slovakia are on their own, with all the consequent issues of loneliness and access to care.

Case study

Japan's ageing population

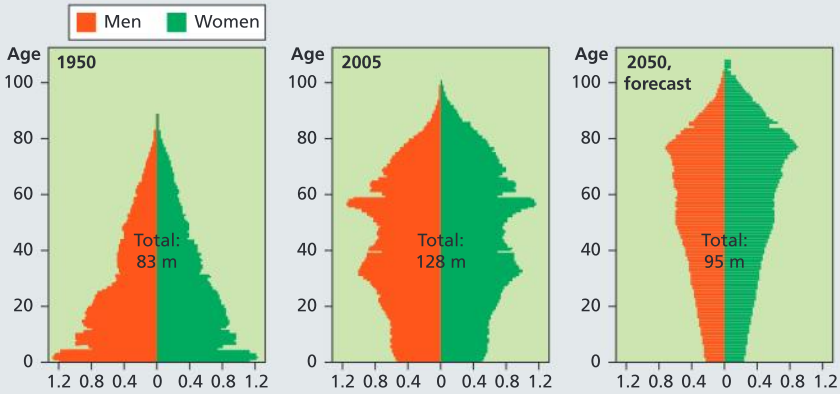
Since 1945 the age structure of Japan's population has greatly changed, largely due to a decrease in both birth and death rates. The population is ageing much more rapidly than that of other countries (although a number of European countries, such as Italy and Greece, are not far behind). The number of elderly people living alone in Japan increased from 0.8 million in 1975 to over 2.5 million in 2000. Since 1975 the percentage of young people has gradually declined, and by 2015 they accounted for only 13 per cent of the population.

At present, 26 per cent of the Japanese population are aged over 65 years. This is creating a huge burden on pension funds and social welfare programmes, especially health care. Problems include:

- inadequate nursing facilities
- depletion of the labour force
- deterioration of the economy
- a trade deficit
- migration of Japanese industry to other countries
- the high cost of funding pensions and health care
- falling demand for schools and teachers
- new jobs needed for the elderly
- new leisure facilities needed for the elderly
- an increase in the burden on the working population to serve the dependent population
- reduced demand for goods from the smaller working population
- a need for in-migration to fuel any increase in the workforce.

▲ **Photo 1.2:** Japan's ageing population

Options for the government include raising taxes, raising the retirement age, cutting back on social welfare programmes, and increasing care in people's homes for example.



▲ **Figure 1.24:** Japan's changing population pyramids

▲ **Photo 1.3:** Shanghai's solitary children

Activity 9

1. Describe the global pattern of the ODR, as shown in Figure 1.23.
2. Comment on the change in the ODR between 1990 and 2040, as shown in Figure 1.23.
3. Outline the advantages of an ageing population.
4. Describe the changes in Japan's population pyramids, as shown in Figure 1.24.
5. Briefly explain the disadvantages of ageing populations.

Pro-natalist and anti-natalist policies

Governments attempt to control population numbers in a number of ways. Their strategies will depend on whether the country wishes to increase its population size (**pro-natalist**) or limit it (**anti-natalist**). Family planning methods include contraceptives such as the pill and condoms, as well as drastic methods such as forced sterilization, abortion and infanticide.

TOK

Should all governments have policies to dictate family size in order to control population numbers, as happened in China with its one-child policy?

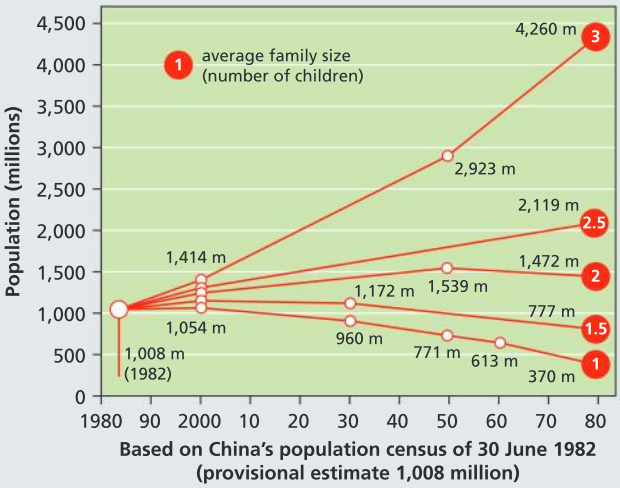
Case study

China's one-child policy

China has operated the world's most severe and controversial family planning programme with its one-child policy. The policy, imposed in 1979, had a drastic impact: the birth rate fell to 17 per 1,000 from its 1970 rate of 33. The policy is estimated to have reduced population growth in a country of 1.3 billion by as much as 300 million people over its first 20 years alone, and prevented as many as 400 million births. The Chinese government has predicted that the population will peak at 1.5 billion in 2033. In 2015 the Chinese government changed the policy to allow couples to have two children.

Such draconian family planning has resulted in a disparate ratio of 118 male to every 100 female births, above the global norm of between 103 and 107 boys to every 100 girls. This reflects the fact that many people in China value female infants less highly than males, and millions of females were aborted or died as a result of neglect, abandonment or even infanticide.

The one-child policy was not an all-encompassing rule but was restricted to ethnic Han Chinese living in urban areas, who comprise only about 36 per cent of the population. While the growing middle classes in urban areas do not discriminate against daughters as much, people in the countryside remain traditionally focused on male heirs, and in most provincial rural areas couples



▲ **Figure 1.25:** Five possible options for China's future population

Case study (continued)

could have two children if the first one was a girl. In other provinces, parents could have two children regardless of the sex of the first child, and in a few areas the rules were even more relaxed.

The declining fertility rate, now about 1.6 births per woman, has eased food security fears. However, the downsides of maintaining a one-child quota include a shrinking labour force and an ageing population. By 2050 China will have nearly 450 million people aged over 60 and 100 million over 80; there will be just 1.6 working adults to support every person aged over 60 compared with more than seven in the 1970s. At its peak in the 1960s, the fertility rate was 5.8 babies for each woman of childbearing age and it is now just 1.8, well below the replacement rate of 2.1. The fertility rates in Beijing, Shanghai and Guangzhou are among the lowest in the world.

2013 reforms

The prospect of an ageing society in which one worker is left to support two parents and four grandparents has led China to relax the one-child policy. The loosening of the policy, first announced in November 2013, allows couples to have a second child if either parent is an only child. It is meant to signal the beginning of a more family-friendly bureaucracy. Provinces can set their own timetable for implementing the reform.

Party conservatives still fear two things about loosening population controls. The first is that, without proper controls, the population may grow beyond the country's planned capacity to feed itself (1.5 billion people by the year 2033). The second is that loosening too quickly may spur a baby boom that would strain public services.

But there are reasons to be optimistic that this will not happen.

Factors other than the one-child policy, such as a lack of social security support, have also encouraged couples to limit their offspring, so the policy's relaxation is unlikely to lead to a population boom. Many urbanites, already burdened by rocketing education and housing costs, consider multiple children an exclusive province of the rich.

Activity 10

Study Figure 1.25, which shows different population scenarios for various levels of fertility in China.

1. How much larger would China's population be in 2080 if it had had a two-child policy rather than a one-child policy?
2. Outline the main advantages of the one-child policy.
3. What are the main disadvantages of the one-child policy?
4. What are your views on the one-child policy? Justify your answer.

ATL Research skills

Visit http://wiki.idebate.org for opposing views on China's one-child policy.

Case study

Pro-natalist policies in Russia

Russia has had low fertility for a number of decades. The reasons include poor reproductive health care services, a relative lack of modern contraceptives, widespread and unsafe abortions, high divorce rates, an ageing population structure, infertility and women choosing to have fewer children.

The Soviet Union and the Russian Federation have a long history of pro-natalist policies, starting in 1936, when families were rewarded for having a third or fourth child, and then later for having two children. The government also imposed a tax on childlessness, from 1941 to 1990.

Case study (continued)

In the 1970s, fertility rates were slightly below replacement level, which led to renewed pro-natalist policies in 1981. However, analysis of the 1981 policy suggests that it reduced the childbearing age rather than increasing the number of children born.

By 2006, fertility had dropped to less than 1.3 births per woman, and President Putin announced further measures to increase the birth rate. These included:

- an increase in pregnancy, birth and child benefits according to the number of children a family had
- increased parental leave following the birth of a child
- increased payments to mothers of second and third children (which was up to $12,500 in 2012).

The government was also considering a tax on childlessness.

These measures had a positive impact. Between 2006 and 2011, fertility increased by 21 per cent. The increase in second births was 40 per cent and in third children 60 per cent. However, these increases were from a very low starting point, and were even less successful than the 1981 reforms. Further analysis of the results suggests that the effects of the policies wore off year by year. After five years of the policy, women's intentions to have another child had hardly changed. As they had under the 1981 policy, families had children earlier but did not have significantly more.

In May 2012, President Putin announced that he wanted Russia to have a TFR of 1.75 by 2018. Demographers (people who study population trends) believe that Russia will have to double the state's financial support if this is to have any chance of success. Others believe that Russia will need to increase the immigrant population if it is to increase the fertility rate, but some two-thirds of Russians want the number of immigrants reduced, not increased.

Russia's population decline is therefore likely to continue. TFR is likely to remain at less than 1.7 (that is, below replacement level) for the next 20 years. As the population continues to age, the number of people entering childbearing age is likely to be 20 per cent less than those currently of childbearing age.

It is possible that Russia's population in 2100 will be similar to what it was in 1950: 100 million. Not only are there problems with a low birth rate, but there are also problems with a high death rate, partly as a result of smoking, alcohol consumption and obesity. As the population ages, the workforce is predicted to decline by about 15 per cent by 2024. This could be reduced by increasing the retirement age – currently 60 years for men and 55 years for women.

Case study

Literacy and gender equality policies in Kerala

Kerala, a largely agricultural state in south–west India, is the most densely populated area of India but with an even spread of population and no large cities. It has had remarkable success in improving health, literacy and education, and in bringing down the birth rate. Its success is even more remarkable because it has a much lower per capita income than the rest of India.

A number of factors help to account for Kerala's success. These include:

- the autonomy and stability of the government
- long-standing and continuing social reform
- the status of women in society.

The result is a society that has enabled large sections of the population to give voice to their views and needs.

The role of women in Kerala

The status of women in Kerala has been extremely important in the region's development.

- There is a tradition of female employment, with girls educated to the same standard as boys.

Case study (continued)

▲ **Figure 1.26:** Location map of Kerala

- There is open access to universities and colleges where women often study to be doctors and nurses.
- Jobs have been open to women in health and education since the early 20th century.
- Women have autonomy in their personal life, where there is no tradition of dowries and there are no obstacles to remarriage.

Kerala has the highest female:male sex ratio in India, with 1,084 females to 1,000 males, compared with the national average of 940:1,000. Kerala's literacy rate increased from 90 per cent in 1991 to 94 per cent in 2011, and female literacy increased from 86 to 92 per cent over the same period. Kerala has a low infant mortality rate of 13 per thousand (‰), compared with the national average of 80‰, and a high life expectancy of 74 years for females and 70 years for males. The TFR is low, just 1.9 below the replacement level.

However, despite the high literacy levels, women are marginalized in the economic process and have a lack of control over resources. The work participation rate for women is just 18 per cent compared with 53 per cent for men, and women are concentrated in low-paid jobs such as farming, cottage industries, domestic services and informal economies.

The three main ways of gaining access to economic resources are through participation in the labour market, acquiring a share of the family property and establishing a business or taking part in the informal economy. Women's share in the labour market in Kerala is among the lowest in India. The reasons are unclear but could be related to their role in looking after the household, collecting water and fuelwood, and looking after elderly relatives. While 18 per cent of educated men are unemployed, 71 per cent of educated women are and, for those in work, a higher proportion of women have low-paid jobs and are more likely to be in the informal sector. Women account for 71 per cent of primary school teachers but only 36 per cent of university lecturers.

▶ **Photo 1.4:** Schoolgirls in the garden of Hill Palace, near Kochi, Kerala

A number of self-help groups (SHG) have been set up to empower women from poor households. Groups of women are organized into neighbourhood groups and have weekly meetings to share experiences, have discussions and undertake training. They also have micro-finance systems that all the participants pay into, and receive money from. The women empowerment programmes cover welfare and support services, training, and advice about income generation.

Nevertheless, life still remains hard for many women in Kerala. The fishing villages on the coast are very overcrowded, and here mortality rates are higher than the state average. Although there is good progress in social development (health and education), women's role in decision-making is limited. The legal system, for example, is male dominated. Violence and sexual harassment against women is still common, much of it related to their husbands' alcohol consumption.

Overall, given the high educational level of women, their good health, and numerous government programmes, women cannot be considered completely disadvantaged. However, although the Kerala model has resulted in some improvements in conditions for women, there is still much to be done.

ATL Research skills

Read the article on the state of education in rural India at https://socialissuesindia.wordpress.com/2013/04/02/right-to-education-act-status-of-implementation-after-3-years/.

Comment on your views about the contents of the article.

Anti-trafficking policies

Human trafficking occurs in most countries, and is often a trans-border phenomenon. In the past, trafficking may have been more likely between two nations, whereas now it is more likely to be a multinational phenomenon. In 2015, anti-trafficking measures were incorporated into three of the 17 UN Sustainable Development Goals.

The USA publishes a Trafficking in Persons Report annually (http://www.state.gov/j/tip/rls/tiprpt/) and the United Nations has produced two reports on global trafficking. The USA's Trafficking and Violence Protection Act (TVPA 2000) encourages governments to join in the fight against human trafficking.

The TVPA contains three main components:

- Protection – increased efforts to protect foreign national victims as well as non-immigrants.
- Prosecution – of traffickers related to forced labour and sexual exploitation.
- Prevention – to assist other governments to reduce trafficking.

Attempts to reduce trafficking include increasing public awareness about the risks involved as well as designing policies to prevent trafficking. Governments can start by having up-to-date registration of births and migration into an area. By allowing trade unions, workers' rights are more likely to be protected and trafficking reduced.

ATL Research skills

Find out which of the SDGs contain anti-trafficking measures.

It is likely that no single measure, nor any single country, can end human trafficking, and a multi-governmental approach with many responses will be needed. Approximately 90 per cent of countries have now become parties to the UN 2003 Protocol to Prevent, Support and Punish Trafficking in Persons, Especially Women and Children. In 2003, around two-thirds of countries lacked specific offences that criminalized trafficking, but by 2006 this had fallen to just over a quarter. South Korea, Singapore and Sri Lanka became parties to the Protocol in 2015.

Overall, some two billion people live in areas where trafficking is still not criminalized.

Eight countries in Africa and the Middle East lack anti-trafficking legislation. Some of these contain large populations, so the number of people unprotected is large. Also, some large populations in Asia and South America have only partial coverage.

Populations at risk of trafficking

Certain populations are at an increased risk of discrimination or marginalization. These include refugees and migrants; lesbian, gay, bisexual, transgender and intersex (LGBTI) people; religious minorities; people with disabilities and those who are stateless. All these groups are at increased risk of human trafficking.

Refugees and migrants

Since 2015, the increased number of migrants and refugees fleeing to Europe has been associated with an increase in trafficking. Migrants and refugees are also at increased risk of trafficking even when they have reached their destination. The overburdened asylum systems in Europe have provided opportunities for traffickers to continue to operate. For migrants who arrive without papers, the risk of being trafficked increases.

Governments could reduce the risk of trafficking of migrants and refugees by increasing staffing levels at entry ports and distributing information sheets to migrants and refugees about the risk of trafficking and the support available. Inspectors could inspect documentation at workplaces to ensure that everything is legal.

LGBTI people and religious minorities

In 2015, UNHCR reported that 76 countries criminalized same-sex sexual relationships, and seven countries imposed the death penalty for such activities. In the USA, NGOs report that LGBTI adolescents make up a disproportionate number of runaway and homeless people. Elsewhere, religious minorities have an increased vulnerability to trafficking.

People with disabilites

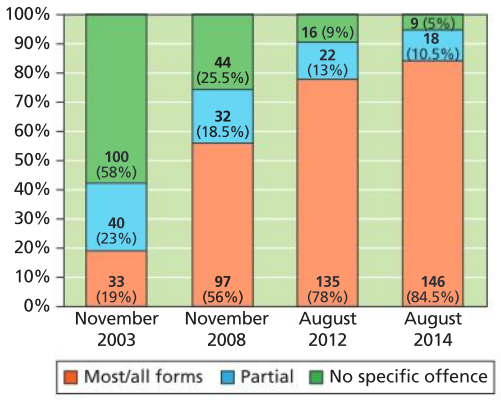
Traffickers have targeted children with disabilities, on account of their potential to beg. National and local governments can reduce the risk of trafficking by banning discrimination and offering a range of community-based support systems for people with disabilities.

Stateless people

Stateless people are also at risk of trafficking. The UNHCR estimates that there are some 10 million stateless people, one-third of whom are children. In Burma, the 800,000 Rohingya people who live in Rakhine state are denied citizenship. Their lack of legal status and identity documents increases the risk of labour and sex trafficking.

The criminal justice response

According to the UN, the number of convictions for trafficking remains very low. Of the 128 countries covered in the latest UN report, 15 per cent did not record a single conviction. In addition, the number of countries that punished traffickers operating in their territory was very limited. Moreover, the pattern shows little change. When the ratio of convictions per population is compared, Europe



▲ **Figure 1.27:** Criminalization of human trafficking with a specific offence – number and share of countries, 2003–14

Source: *Global Report on Trafficking in Persons*. UNODC, 2014

Activity 11

Countries that have not signed up to the UN Protocol to Prevent, Support and Punish Trafficking in Persons, Especially Women and Children include Bangladesh, Bhutan, Brunei, Comoros, Rep. of Congo, Fiji, Iran, Japan, North Korea, the Maldives, the Marshall Islands, Nepal, Pakistan, Palau, Papua New Guinea, Somalia, South Sudan, Tonga, Uganda and Yemen.

1. Plot these countries on a blank world map.
2. Comment on the distribution of the countries that you have plotted.

and Asia have more than 0.3 convictions per 100,000, South Asia and east Asia around 0.3, and the Americas, Africa and the Middle East fewer than 0.1. Globally, fewer than a quarter of suspects are convicted, although about one in three suspects in Western and Central Europe are convicted.

Many governments and NGOs believe that confiscating the proceeds of crime is appropriate and effective as a punishment and a deterrent. It also disrupts criminal activity by cutting off some of the funding available, creates an image that crime does not pay, and helps win over public support. However, support for the victims is less forthcoming. Although many countries have laws that allow victims to claim compensation, trafficked people rarely receive any.

Case study

Trafficking of Nigerian women to Europe

Many women are trafficked between Nigeria and Western Europe for the purpose of sexual exploitation. It is one of Europe's most persistent trafficking flows, with Nigerian women frequently accounting for over 10 per cent of the trafficked people in Western and Central Europe. The women, believing that they are going to a prosperous new life, sign a contract in Nigeria that is "blessed" in a ritual (called *juju*) by a priest. Having been trafficked to Europe, they are forced into prostitution to pay back a debt, sometimes as much as €40,000–€70,000. Threats may be made to family members, and the women are controlled by "madams", older Nigerian women who have themselves been victims in the past. UN evidence suggests that corruption and blackmail are rife, and the prostitution gangs may also be engaged in the distribution of drugs on Europe's streets.

ATL Research and communication skills

Open a copy of the United Nations Global Report on Trafficking, https://www.unodc.org/documents/data-and-analysis/glotip/GLOTIP_2014_full_report.pdf.

View the infographics in the report, and make a short presentation on the patterns of global trafficking.

The demographic dividend

The **demographic dividend** refers to a bulge in the number of adults in a population. It occurs when fertility rates decline, allowing faster economic growth. The decline in fertility often follows a decline in infant and child mortality rates, as well as increased life expectancy. As families recognize that fewer of their children will die during infancy or childhood, they begin to have fewer children. However, this drop in fertility rates is not immediate. The lag between falling death rates and falling fertility produces a bulge in the population that surges through

age groups (cohorts). For a period of time, this "bulge" increases the dependency ratio. Eventually, this cohort begins to enter the workforce.

As fertility rates continue to fall and the elderly population still have relatively short life expectancies, the dependency ratio drops dramatically. With fewer younger dependents and fewer older dependents, the largest segment of the population is people of productive working age. Thus the dependency ratio declines dramatically, leading to the demographic dividend.

▲ **Photo 1.5:** The demographic dividend will only bring a dividend if the younger population has skills and resources to work. Otherwise a youthful population may lead to higher rates of unemployment

The benefits of the demographic dividend

The demographic dividend can deliver a number of benefits. The first is the increased labour supply. However, this depends on the ability of the economy to absorb and productively employ the extra workers. The second is the increase in savings. As the number of dependents decreases, individuals can save more. Thirdly, decreases in fertility rates result in healthier women and fewer social and economic pressures at home. This also allows parents to invest more resources per child, leading to better health and educational outcomes. Finally, the increasing domestic demand brought about by the increasing GDP per capita and the decreasing dependency ratio leads to economic growth.

The challenge of attaining the demographic dividend

Many countries in Asia and Latin America have experienced impressive economic growth since 1990. These gains are due, in part, to demographic changes that have facilitated this growth. This demographic contribution to accelerating economic growth is the "demographic dividend".

Many of the least developed countries will be challenged to achieve the economic benefit without substantially lowering birth and child death rates – they must go through the "demographic transition". While child survival has greatly improved in developing countries, birth rates remain high in many of them, especially in parts of sub-Saharan Africa.

In the world's least developed countries, more than 40 per cent of the population is under age 15 and depends on financial support from working-age adults between the ages of 15 and 64. Another 90 million people between 15 and 19 are on their way to becoming financially independent as they enter adulthood.

The demographic dividend and family planning

To achieve the economic benefits of the demographic dividend, developing countries must substantially lower both birth and child death rates. While fertility has declined in most countries in sub-Saharan Africa, women in the region today still have on average 5.1 children. Norms related to family size are changing, however, and families are choosing to have smaller families.

To achieve a demographic transition, countries must therefore focus on providing women with voluntary family planning information and services. One in four women in developing countries wants to avoid

becoming pregnant or delay or space their births, but is not using a modern family planning method. Investment in voluntary family planning helped Thailand, for example, to accelerate economic growth. This provides a model for sub-Saharan African countries. Thailand's contraceptive use increased from 15 per cent in 1970 to 70 per cent by 1987, and fertility levels declined from 5.5 children per woman in 1970 to 2.2 by 1990.

Rwanda is one of several countries in eastern and southern Africa where investments in voluntary family planning and child survival have led to significantly lower fertility. Child mortality has been cut in half in just a decade, modern contraceptive use has increased more than fourfold, and Rwandan women are having on average 4.6 children. If the impressive progress continues, Rwanda will, by 2030, have achieved the demographic conditions necessary for accelerated economic growth.

Improved health, education and gender equality

While family planning is necessary for establishing the conditions for a demographic dividend, investments in child health, education and gender equality are critical additional steps that contribute to family planning use and economic growth.

Promoting healthy timing and spacing of pregnancies can improve child health. Children conceived less than two years after the previous birth have a much higher risk of dying (1.5–3 times higher) than children conceived three or more years after the previous birth.

For young women, family planning can help delay their first pregnancy until an age when they are physically, psychologically and socially prepared for childbearing, thus improving health outcomes for both mother and infant.

Girls' education – especially at the secondary level – helps delay marriage and first pregnancy. Women who are educated are also more likely to work outside the home, increasing the size of the labour force and the potential for economic development.

Recommended actions

The demographic dividend in many developing countries remains a possibility, but for the process to begin, countries must give high priority to substantially lowering fertility and child mortality through the following actions:

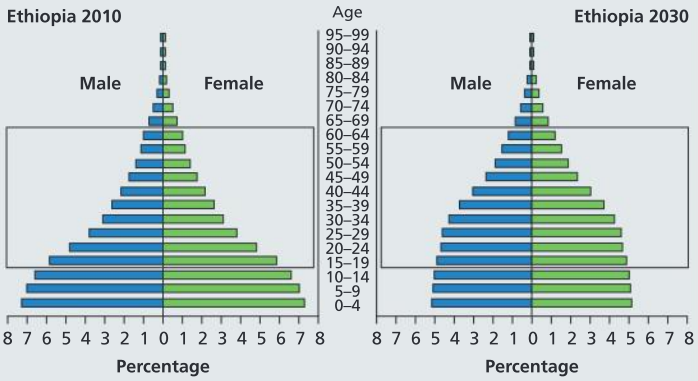
- investing in child survival and health programmes
- committing to voluntary family planning to achieve the demographic transition
- investing in the reproductive health needs of both married and unmarried youth
- prioritizing education – especially secondary education for girls.

Case study

Ethiopia and the demographic dividend

Since 2000, Ethiopia has made very good progress in improving the health and development of its people. Infant and maternal mortality are on the decline, under-5 mortality has been cut in half, and literacy has nearly doubled. In addition, women's reproductive health has increased greatly. Among married women, use of modern contraceptive methods grew from 6 per cent in 2000 to 27 per cent in 2012. Women are now having on average 4.8 children, compared with 6.5 a decade ago; and in Addis Ababa, the capital, women on average have just over two children.

However, Ethiopia will have to substantially increase investment in meeting family planning needs to create the age structure needed for a demographic dividend. More than 40 per cent of the population is under age 15, and the population pyramid in 2010, despite the declines in mortality and fertility, is still dominated by a large base of young people. By 2030 Ethiopia will approach the age structure conditions that can facilitate accelerated economic growth. Thus, Ethiopia remains nearly two decades away from a possible demographic dividend, even with continued progress.



▲ **Figure 1.29:** Ethiopia's age and sex structure, 2010 and 2030 (black boxes encompass working-age population)
Source: United Nations Population Division. 2011. *World Population Prospects: The 2010 Revision.* New York, USA. UNFPA

Case study

South Korea's demographic dividend

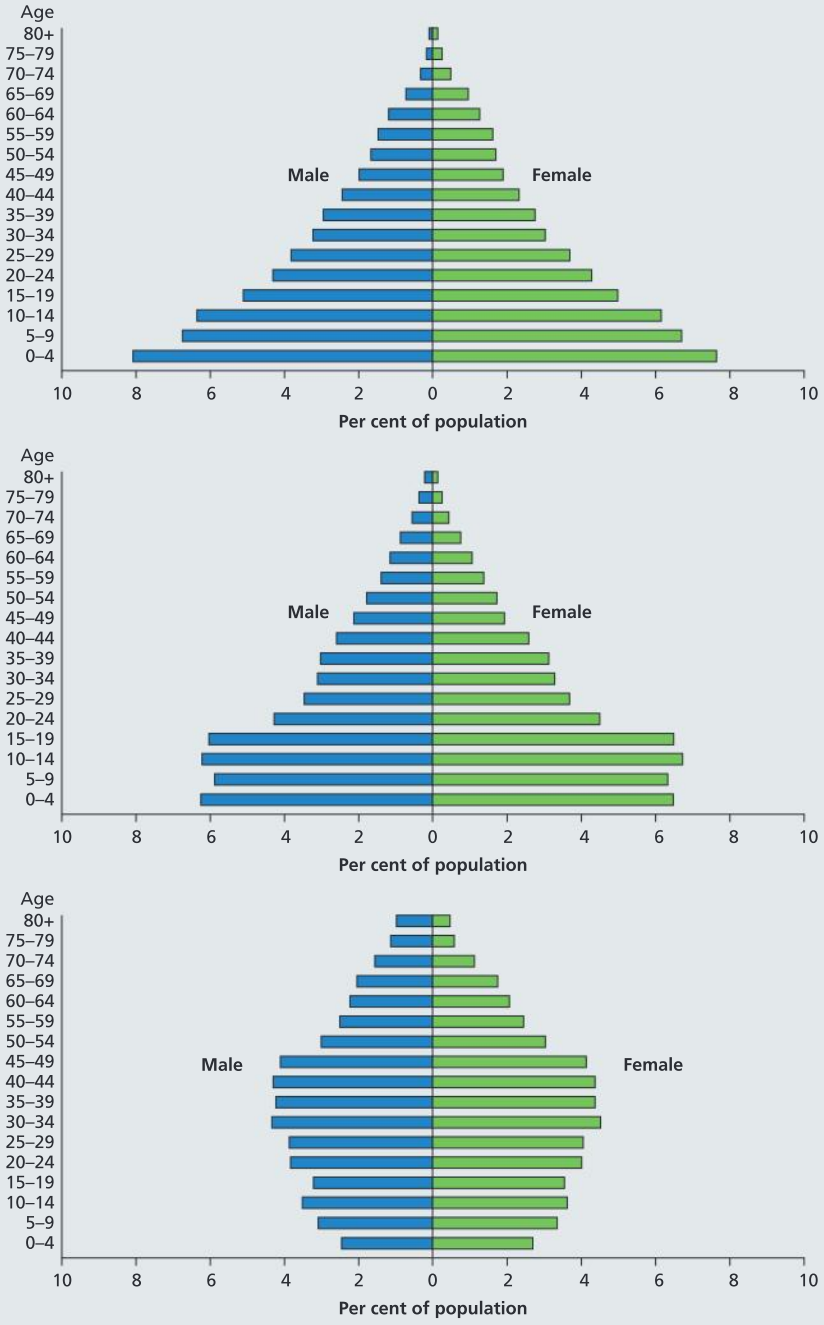
The "Asian Tigers" of Hong Kong, Singapore, South Korea and Taiwan are good examples of the advantages to be gained from reducing fertility rates. South Korea, for example, made a rapid transition from high to low fertility between 1960 and 1990, and this transition was a springboard for economic growth. South Korea's success was the result of addressing population issues while also investing in reproductive health programmes, education and economic policies to create infrastructure and manufacturing.

Korea followed an aggressive population policy. The government invested in health centres to provide a range of services, including family planning. Field workers visited homes and provided family planning information and methods. The government set a target of 45 per cent of married couples using family planning. A contributing factor to reducing fertility was that people saw that having fewer children improved family life. As a result, between 1950 and 1975, fertility dropped from 5.4 children per woman to 2.9. By 2005, fertility had dropped to 1.2 children per woman.

Shifting the education strategy

The government also focused on education. Between the 1950s and 1960s, South Korea's education strategy shifted to universal schooling,

Case study (continued)



▲ **Figure 1.28:** South Korea's age and sex structure, 1950, 1975 and 2005
Source: United Nations Population Division. 2011. *World Population Prospects: The 2010 Revision.* New York, USA. UNFPA

where previously primary education had served only about 54 per cent of children. A "production-oriented" education would provide people with the knowledge and skills they needed to achieve economic development. The shift in focus and increased commitment to education contributed to 97 per cent of school-age children attending school in 1990.

Economic planning

At the same time, South Korea's economic plans were comprehensive. In the 1950s, South Korea's economy, based largely on farming and fishing, was weak. Improved relations with Japan led to investment capital that strengthened agricultural, fishing and manufacturing industries, including shipping. The South Korean government also addressed unemployment through a rural construction programme that provided minimum wages for workers involved in the construction of infrastructure, including dams and roads. This effort contributed to both the development of a national infrastructure and economic growth.

ATL Research and communication skills

Study the pages at http://china.org.cn/business/2013-01/29/content_27821010.htm and http://english.peopledaily.com.cn/90778/8145883.html which deal with China's demographic dividend.

Outline the concerns of some people about the "end of the demographic dividend" and explain the arguments of others who believe that worrying about China's demographic dividend is "unnecessary".

After the demographic dividend

After the demographic dividend, the dependency ratio begins to increase again. The population cohort that created the demographic dividend grows old and retires. With a disproportionate number of old people relying upon a smaller generation following behind them, the demographic dividend becomes a liability. This is currently seen most dramatically in Japan, with younger generations essentially abandoning many parts of the country.

Check your understanding

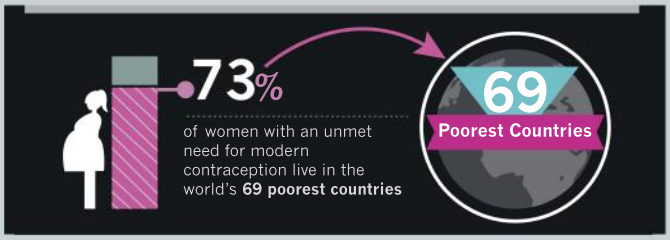
1. Explain the term "older dependency ratio".
2. Describe Japan's population structure.
3. Distinguish between pro-natalist policies and anti-natalist policies.
4. Briefly describe the impact of China's one-child policy.
5. Outline the successes of Kerala in terms of gender equality.
6. Suggest ways in which gender equality in Kerala could be improved.
7. Outline the main methods of tackling trafficking of people.
8. Evaluate methods to combat the trafficking of people.
9. Define the term "demographic dividend".
10. Outline the advantages of the demographic dividend.

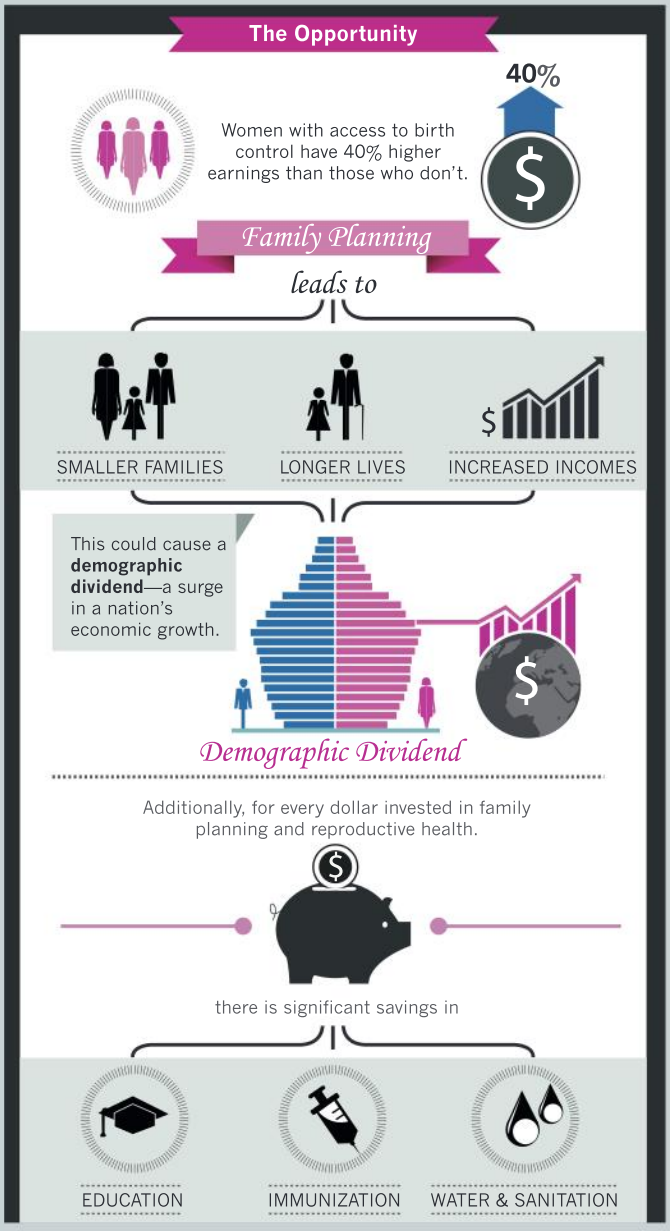
Concepts in context

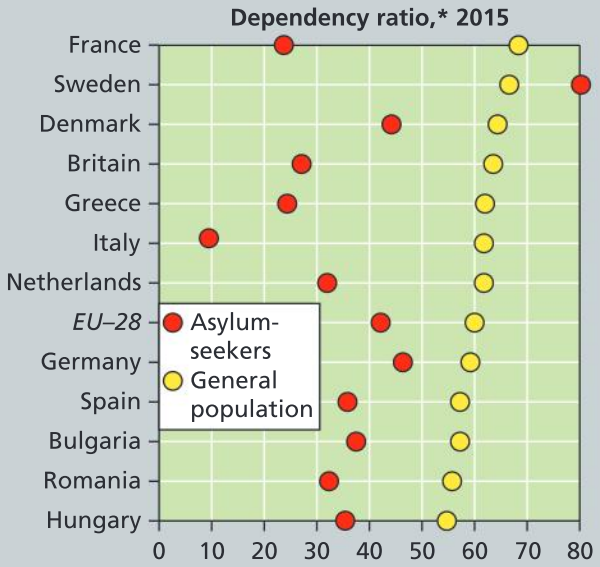
Human decision-making in terms of population policies, gender equality and anti-trafficking measures suggests that people, organizations and/or governments have the **power** to alter processes, and that there are different **possibilities** for humanity. The demographic dividend shows that it is possible to influence population outcomes in a positive way.

Synthesis and evaluation

Population change may affect the influence of certain groups within a country. This can happen at a local or a national scale. For example, in many HICs and MICs, there are ageing populations. This may well affect the provision of health care, pension availability and retirement ages, and can have an effect on service provision for other age groups. Governments may introduce policies to change their population size in order to achieve a balance between population, resources and the ability to afford to pay for sevice provision. In many societies, women are discriminated against, and have lower rates of educational achievement and labour force participation. In some regions, people are trafficked and the quality of their lives is extremely poor. Many minority groups face major discrimination and they may suffer as a result. Nevertheless, there may be some benefits from having a large number of young workers – a demographic dividend.







*Population aged less than 18 and over 65 per 100 people aged 18–64

The graph shows the dependency ratio of the resident population in a number of EU countries, and that of asylum seekers to those countries.

(a) (i) Define the term "dependency ratio". (1 mark)

(ii) Compare the dependency ratio of asylum seekers with that of the general population. (4 marks)

(iii) Suggest reasons for the differences you have outlined. (4 marks)

(b) (i) Outline the meaning of the term "family planning". (1 mark)

(ii) Describe the inequalities in access to family planning, as shown on the infographic. (2 marks)

(iii) Outline the economic benefits of family planning. (4 marks)

(iv) Explain **two** reasons why family planning may lead to economic benefits for a family. (2 + 2 marks)

(c) Either

"No population policy has ever been successful". Discuss this statement. (10 marks).

Or

Examine the importance of the demographic dividend. (10 marks)

UNIT 2
GLOBAL CLIMATE – VULNERABILITY AND RESILIENCE

Key terms

Adaptation	Initiatives and measures to reduce the vulnerability of human and natural systems to climate change.
Albedo	The amount of incoming solar energy reflected back into the atmosphere by the Earth's surface.
Anthropogenic	Human-related processes and/or impacts.
The enhanced greenhouse effect	The increasing amount of greenhouses gases in the atmosphere, as a result of human activities, and their impact on atmospheric systems, including global warming.
Global warming	The increase in temperatures around the world that have been noticed since the 1960s, and in particular since the 1980s.
The greenhouse effect	The process by which certain gases (water vapour, carbon dioxide, methane and chlorofluorocarbons (CFCs)) allow short-wave radiation from the sun to pass through the atmosphere and heat up the Earth, but trap an increasing proportion of long-wave radiation from the Earth. This radiation leads to a warming of the atmosphere.
Mitigation	Attempts to reduce the causes of climate change.
Resilience	The ability of a population or a human or natural system to absorb change without having to make a fundamental change.
Vulnerability	The degree to which a human or natural system is susceptible to, and unable to cope with, the adverse impacts of climate change.

Climate is one of the most important aspects of geography. Variations in climate throughout the world influence food production, energy consumption, demand for manufactured goods, tourism and recreation, patterns of disease, coastal flooding and weather systems.

Increasingly, people are realizing that human activities are influencing global climate. The impacts of global climate change vary from place to place and some regions are more vulnerable than others. Action to reduce global climate change is taking place in some areas. (However, some people still deny that global climate change is happening.) Societies have the option of taking action to try to limit climate change or adapting to and living with its consequences.

Key questions

1. How do natural and human **processes** affect the global energy balance?
2. What are the effects of global climate change on **places**, societies and environmental systems?
3. What are the **possibilities** for responding to climate change and who has **power** over the decision-making process?

1 The causes of global climate change

Conceptual understanding

Key question

How do natural and human **processes** affect the global energy balance?

Key content

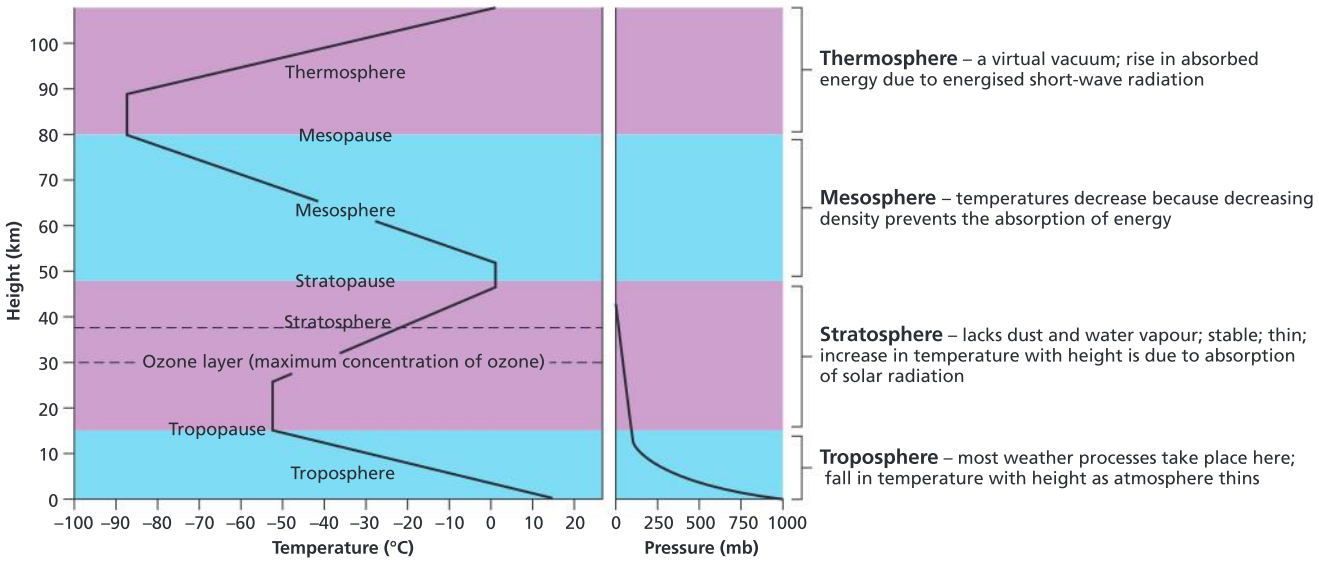
- The atmospheric system, including the natural greenhouse effect and the energy balance (incoming short-wave radiation and outgoing long-wave radiation).
- Changes in the global energy balance, and the role of feedback loops, resulting from solar radiation variations, including global dimming due to volcanic eruptions.
- Changes in the global energy balance resulting from terrestrial albedo changes and methane gas release and feedback loops.
- The enhanced greenhouse effect and international variations in greenhouse gas sources and emissions, in relation to economic development, globalization and trade.

The structure of the Earth's atmosphere

The atmosphere is a mixture of solids, liquids and gases that are held near to the Earth by gravitational force. Up to a height of around 80 km, the atmosphere consists of nitrogen (78 per cent), oxygen (21 per cent), argon (0.9 per cent) and a variety of other trace gases such as carbon dioxide, helium and ozone. In addition, there is water vapour and solids (in the form of aerosols) such as dust, ash and soot.

Most "weather" occurs in the lowest 16–17 km, the troposphere. In the troposphere, temperatures fall with height (on average 6.5°C per km). Certain gases are concentrated at height (Figure 2.1). Most water vapour is contained in the lowest 15 km of the atmosphere. Above this, the atmosphere is too cold to hold water vapour.

At high altitude, there are significant concentrations of gases, such as ozone between 25 km and 35 km, nitrogen between 100 km and 200 km and oxygen between 200 km and 1,100 km. These concentrations have a significant impact on the temperature of the atmosphere. At the tropopause – the boundary between the troposphere and the stratosphere – temperature decline ceases and above this, in the stratosphere, there is an increase in temperature associated with the presence



▲ **Figure 2.1:** Variations in atmospheric composition, temperature and air pressure with altitude

of ozone. Temperatures fall again in the layer above the stratosphere, the mesosphere, but rise again in the highest layer, the thermosphere.

The atmospheric energy balance

The atmosphere is an open energy system receiving energy from both the Sun and Earth. Although the Earth's energy is very small, it has an important local effect, as in the case of urban climates (see pages 360–63). Incoming solar radiation is referred to as **insolation**.

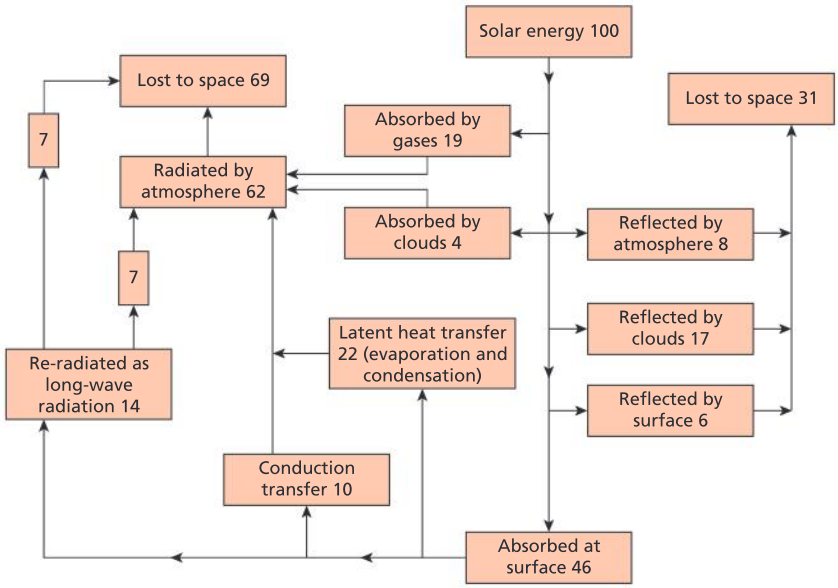
The energy that drives all weather systems and climates comes from the Sun. The Earth absorbs most of this energy in the tropical regions, whereas there is a loss of energy from regions nearer the poles. To compensate for this, there is also a redistribution of energy from lower latitudes to higher latitudes, caused by wind circulation and ocean currents.

The atmospheric energy budget

The Earth's atmosphere constantly receives solar energy, and yet until recently the atmosphere was not getting any hotter: there was a balance between inputs (insolation) and outputs (re-radiation). This recent heating – known as global warming – has been linked with human activities such as land-use changes and the use of fossil fuels.

Under "natural" conditions, the balance is achieved in three main ways:

- **Radiation** – the emission of electromagnetic waves such as X-rays, short waves and long waves; as the Sun is a very hot body, radiating at a temperature of about 5,700°C, most of its radiation is in the form of very short wavelengths such as ultraviolet and visible light.
- **Convection** – the transfer of heat by the movement of a gas or liquid.
- **Conduction** – the transfer of heat by contact.



▲ **Figure 2.2:** The Earth's atmospheric energy budget

▼ **Table 2.1:** Selected albedo values

Surface	Albedo (%)
Water (Sun's angle over 40°)	2–4
Water (Sun's angle less than 40°)	6–80
Fresh snow	75–90
Old snow	40–70
Dry sand	35–45
Dark, wet soil	5–15
Dry concrete	17–27
Black road surface	5–10
Grass	20–30
Deciduous forest	10–20
Coniferous forest	5–15
Crops	15–25
Tundra	15–20

Activity 1

1. Study Table 2.1.
   a. What is meant by the term "albedo"?
   b. Why is albedo important?

Only about 46 per cent of the insolation at the top of the atmosphere actually gets through to the Earth's surface. About 31 per cent of it is reflected back into space and a further 19 per cent is absorbed by atmospheric gases – especially oxygen and ozone at high altitudes and CO_2 and water vapour at low altitudes. Scattering accounts for a net loss of 8 per cent, and clouds and water droplets reflect 17 per cent. In fact, clouds can reflect up to 80 per cent of total insolation. Reflection from the Earth's surface (known as the **planetary albedo)** is generally about 6 per cent.

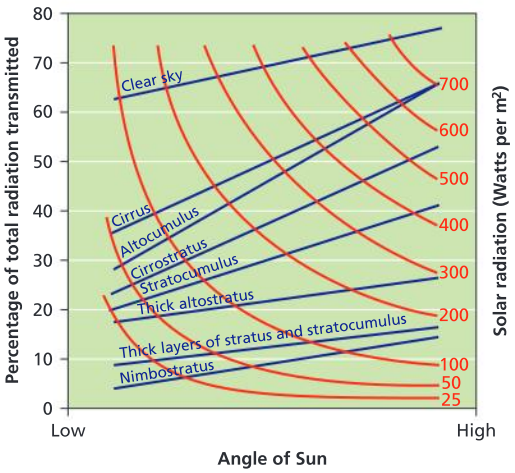
Energy received from the Sun by the Earth is re-radiated at a long wavelength. (While very hot bodies such as the Sun emit short-wave radiation, cold bodies such as the Earth emit long-wave radiation.) Of this energy, 46 per cent is absorbed by the Earth's surface and 7 per cent is lost to space. Clouds and the atmosphere absorb some of the energy and re-radiate it back to earth. Evaporation and condensation account for a loss of heat of 22 per cent. In addition, a small amount of condensation occurs (carried up by turbulence).

▲ **Photo 2.1:** Stratocumulus clouds

The atmosphere is largely heated from below. Most of the incoming short-wave radiation is let through, but CO_2 traps the outgoing long-wave radiation, warming the atmosphere. This is known as the greenhouse principle.

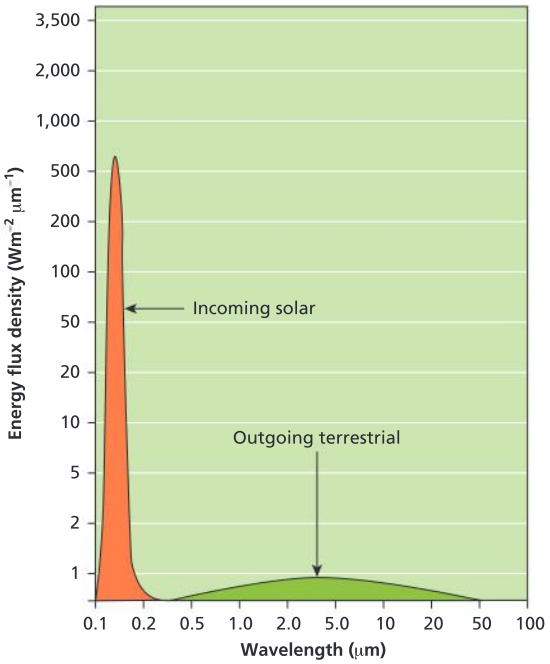
Incoming (short-wave) solar radiation

Incoming solar radiation (insolation) is the main energy input and it is affected by latitude, season and cloud cover. Figure 2.3 shows how the amount of insolation received varies with the angle of the Sun and with cloud type. For example, with stratocumulus clouds (like those in Photo 2.1) when the Sun is low in the sky, about 23 per cent of the total radiation transmitted is received at the Earth's surface – about 250 watts per m^2. When the Sun is high in the sky, about 40 per cent is received, just over 450 watts per m^2. The less cloud cover there is, and/or the higher the cloud, the more radiation reaches the Earth's surface.



▶ **Figure 2.3:** Energy, cloud cover/type and the angle of the Sun

Incoming solar radiation is mostly in the visible wavelengths (Figure 2.4). These are not absorbed by the Earth's atmosphere; instead, they heat the Earth, which, in turn, emits long-wave radiation.



▲ **Figure 2.4:** Solar radiation, terrestrial radiation and wavelength

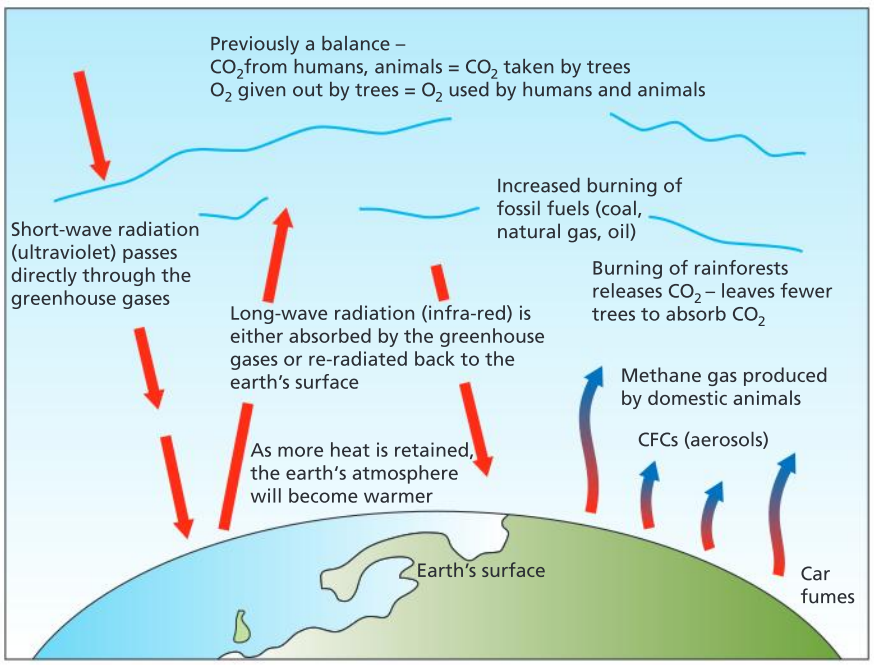
Long-wave radiation

Long-wave radiation refers to the radiation of energy from the Earth (a cold body) into the atmosphere and, for some of it, eventually into space. There is, however, a downward movement of long-wave radiation from particles in the atmosphere. The difference between the two flows is known as the net radiation balance. During the day, the outgoing long-wave radiation transfer is greater than the incoming long-wave radiation transfer, so there is a net loss of energy from the Earth's surface.

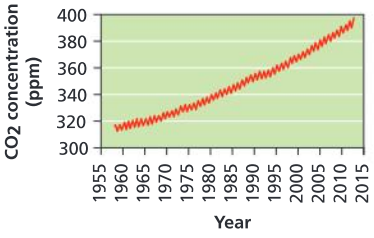
During a cloudless night there is a large loss of long-wave radiation from the Earth. Because of the lack of clouds, there is very little return of long-wave radiation from the atmosphere. Hence there is a net loss of energy from the surface. In contrast, on a cloudy night the clouds return some long-wave radiation to the surface, which reduces the overall loss of energy. Thus, in hot desert areas, where there is a lack of cloud cover, the loss of energy at night is maximized. In contrast, in cloudy areas the loss of energy (and change in daytime and night-time temperatures) is less noticeable.

The greenhouse effect

The greenhouse effect is the process by which certain gases (greenhouse gases) allow short-wave radiation from the Sun to pass through the atmosphere but trap an increasing proportion of outgoing long-wave radiation from the Earth (Figure 2.5). This radiation leads to a warming of the atmosphere. The greenhouse effect is a good thing, for without it there would be no life on Earth. For example, the Moon is an airless planet that is almost the same distance from the Sun as the Earth. However, daytime temperatures on the Moon may reach as high as 100°C, whereas by night they may be –150°C. Average temperatures on the Moon are about –18°C compared with about 15°C on Earth. The Earth's atmosphere therefore raises temperatures by about 33°C.



▲ **Figure 2.5:** The greenhouse effect



▲ **Figure 2.6:** Keeling curve to show the change in atmospheric CO_2, 1960–2012

There are a number of greenhouse gases. **Water vapour** accounts for about 95 per cent of greenhouse gases by volume and for about 50 per cent of the greenhouse effect. However, the gases mainly implicated in global warming are carbon dioxide, methane and chlorofluorocarbons.

Carbon dioxide (CO_2) levels have risen from about 315 parts per million (ppm) in 1950 to over 400 ppm in 2012 (Figure 2.6), and are expected to reach 600 ppm by 2050. The increase is due to human activities: burning fossil fuel (coal, oil and natural gas) and land-use changes such as deforestation. Deforestation of the tropical rainforest is a double blow, since it not only increases atmospheric CO_2 levels but it also removes the trees that convert CO_2 into oxygen. Carbon dioxide accounts for about 20 per cent of the greenhouse effect but an increased proportion of the enhanced greenhouse effect.

Methane is the second-largest contributor to global warming, and its presence in the atmosphere is increasing at a rate of 1 per cent per annum. It is estimated that cattle convert up to 10 per cent of the food they eat into methane, and emit 100 million tonnes of methane into the atmosphere each year. Natural wetland and paddy fields are other important sources: paddy fields emit up to 150 million tonnes of methane annually, while, as global warming increases, bogs trapped in permafrost will melt and release vast quantities of methane.

Chlorofluorocarbons (CFCs) are synthetic chemicals that destroy ozone as well as absorbing long-wave radiation. CFCs, which are increasing at a rate of 6 per cent per annum, are up to 10,000 times more efficient at trapping heat than CO_2.

Changes in the global energy balance

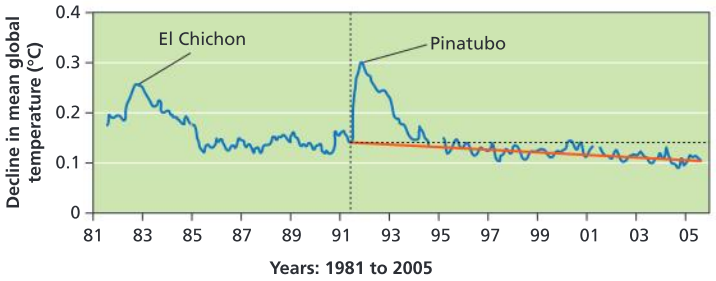
Variations in solar radiation

The Earth's temperature changes for a number of reasons, one of the most obvious of which is a change in the output of energy from the Sun. There is evidence of an 11-year solar cycle, and longer periods of changes in the movement of the Earth, the Milankovitch Cycles, also occur. Small variations in the Earth's orbit affect the seasonal and latitudinal distribution of solar radiation, and are responsible for initiating ice ages. On a shorter timescale, changes in atmospheric composition are linked to an increase in global temperature. The Earth's atmosphere is vital for life, and changes to it disrupt the natural balance of the earth's energy budget, in terms of both the amount and type of radiation. Changes in reflectivity (**albedo**) also affect global climate change: for example, as ice melts and is replaced by darker-coloured vegetation, the amount of insolation absorbed increases and temperatures rise.

Global dimming

After the 9/11 attacks on the World Trade Center, the US air fleet was grounded for three days in the interests of national security. In the three-day absence of vapour trails, the temperature rose by an average of 1.1°C. Air pollution also has a cooling effect, a phenomenon scientists call **global dimming**. It is possible that global dimming has

been masking what would be even faster global warming than is currently occurring. There are at least two timescales with global dimming, namely short-term cycles lasting less than a decade following volcanic eruptions (Figure 2.7) and long-term changes related to anthropogenic sources of pollution.



▲ **Figure 2.7:** Decline in mean global temperature following volcanic eruptions (the red line shows the global decline in sun-blocking aerosols following the eruption of Mt Pinatubo in 1991)

Scientists have shown that from the 1950s to the early 1990s, the level of solar energy reaching the Earth's surface had dropped 9 per cent in Antarctica, 10 per cent in the USA, 16 per cent in parts of the UK, and almost 30 per cent in Russia. This was all due to high levels of pollution at that time. Natural particles in clean air provide condensation nuclei for water. Polluted air contains far more particles than clean air (for example, ash, soot, sulphur dioxide) and therefore provides many more sites for water to bind to. The droplets formed tend to be smaller than natural droplets, which means that polluted clouds contain many more smaller water droplets than naturally occurring clouds. Many small water droplets reflect more sunlight than fewer larger droplets, so polluted clouds reflect far more light back into space, thus preventing the Sun's heat from getting through to the Earth's surface.

Water distributed around large natural particles forms a few large droplets with moderate reflectivity, which eventually fall as rain. The same amount of water distributed around small polluting particles forms many small droplets with increased reflectivity. This water does not fall as rain.

ATL Research skills

Visit *The Guardian*'s "Science Weekly" podcast at www.guardian.co.uk/science/blog to find out more about the Sun's effect on climate change.

Activity 2

Look at the image of dimming at http://i.dailymail.co.uk/i/pix/2012/11/15/article-2233590-160CC421000005DC-540_468x368.jpg

Suggest why India is experiencing global dimming.

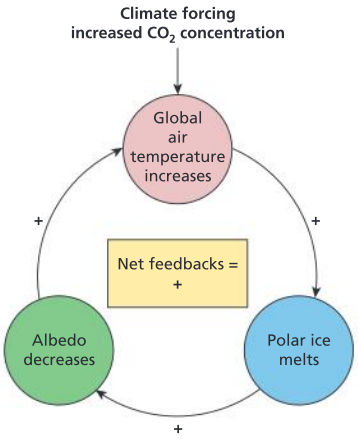
Feedback loops

Feedback mechanisms play a key role in controlling the Earth's atmosphere, and any changes to these mechanisms are likely to have implications for the climate. Both positive and negative feedback mechanisms are associated with changes in mean global temperature.

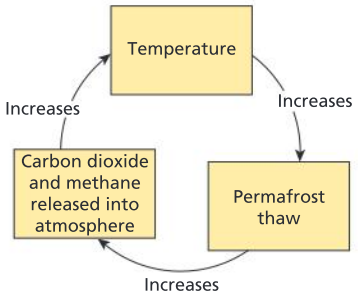
Positive feedback

Some scientists believe that the impacts of global warming may be greatest in tundra environments. These are regions of seasonal ice cover at the edges of otherwise permanent glaciers and ice sheets. Moreover, it is believed that the effects will be most noticeable in terms of winter warming. Melting of the polar ice caps results in less ice and lowers planetary **albedo**. Since ice is more reflective than water, less ice means less reflection. Lowering albedo increases the amount of solar energy absorbed at the Earth's surface, and leads to an increase in temperature (Figure 2.8).

Rotting vegetation trapped under permafrost in the tundra releases methane that is unable to escape because of the ice covering. Increased thawing of permafrost will lead to an increase in methane levels as the gas escapes, adding to global warming gases in the atmosphere and thereby increasing mean global temperature.



▲ **Figure 2.8:** The positive feedback loop of melting ice reducing the planet's albedo



▲ **Figure 2.9:** A positive feedback mechanism involving methane and enhancing climate change

Other mechanisms of positive feedback include:

- increased carbon dioxide released from increased biomass decomposition due to rising temperatures, especially in forest regions, leading to a further rise in temperature as greenhouse gases are added to the atmosphere
- increased forest cover in high latitudes, decreasing albedo and increasing warming.

Feedback mechanisms associated with global warming tend to involve very long time lags. By the time effects appear, the mechanisms responsible may have already gone past the tipping point (the point of no return), and attempts to alleviate the problem may be doomed to fail.

Negative feedback

Increased evaporation in low latitudes, as a result of higher levels of precipitation, may lead to increased snowfall on the polar ice caps, reducing the mean global temperature. Similarly, an increase in carbon dioxide in the atmosphere leads to increased plant growth by allowing higher levels of photosynthesis. Increased plant biomass and productivity would reduce atmospheric concentrations of carbon dioxide.

Other mechanisms of negative feedback include:

- burning, leading to more aerosols and thus reduced solar radiation at the surface, thereby causing cooling
- increased evaporation, increasing cooling.

Increased evaporation in tropical and temperate latitudes leading to increased snowfalls in polar areas would be an example of negative feedback. There is some evidence to suggest this has happened in parts of Norway, with the growth of the Boyabreen Glacier. Growth of glaciers and ice caps, albeit localized, can reduce mean temperatures.

Case study

Negative feedback in Greenland

Since 2002, large areas of the Greenland ice shelf, previously too high and too cold to melt, have been pouring billions of gallons of fresh water into the northern Atlantic. The Greenland ice sheet's maximum melt area increased on average by 16 per cent from 1979 to 2002. In particular, the northern and north-eastern part of the ice sheet experienced melting up to an elevation of 2,000 metres. In April 2016 almost 12 per cent of the ice sheet was melting, two months early, beating the previous record of 10 per cent in 2010.

The amount of ice melting from the surface of the Greenland ice sheet means a rise in sea levels and the threat of the return of very cold winters to Britain. Increased melting of the Greenland ice could shut off the currents of the Gulf Stream, allowing depressions to dump snow rather than rain on Britain and thus leading to a much colder continental climate. This would be comparable to the situation on the eastern seaboard of Canada, which is at the same latitude as Britain but without the mitigating effects of a warm ocean current like the Gulf Stream. Were this to happen, the sea could freeze and snow lie for weeks or months instead of a day of two. This is why there is uncertainty about whether global warming will lead to an increase or decrease in temperatures over Britain.

The enhanced greenhouse effect

The enhanced greenhouse effect is the impact of increasing levels of greenhouses gases in the atmosphere as a result of human activities. It is often referred to as global warming. Global climate change refers to the changes in the global patterns of rainfall and temperature, sea level, habitats and the incidence of drought, floods and storms, resulting from changes in the Earth's atmosphere, believed to be caused mainly by the enhanced greenhouse effect.

TOK

Global warming challenges views of certainty within the sciences. In the popular perception, global warming is having a negative impact on the world. However, people disagree about who – if anyone – is causing it, who suffers most, and what should be done to solve it. There is also some confusion about the terms "global warming" and "the greenhouse effect". The greenhouse effect is a natural process, without which there would be no life on Earth. There is, however, an enhanced or accelerated greenhouse effect, which is synonymous with global warming. The enhanced greenhouse effect is largely due to human (anthropogenic) forces, although feedback mechanisms may trigger some natural forces too.

Some lobby groups and politicians may take views that suit their own economic and political ends, and it is possible to hide behind the uncertainties around global warming (causes, consequences and potential solutions). In the USA, the strength of the oil companies during the George W. Bush presidency was seen by many as an example of economic groups – and the politicians they supported – choosing a side that was not in the long-term environmental, social or economic interest of the world. However, in the short term it benefited the oil companies and the politicians they supported.

The world has moved on since then, and there is now more acceptance that the enhanced greenhouse effect is happening and that something needs to be done to manage its effects.

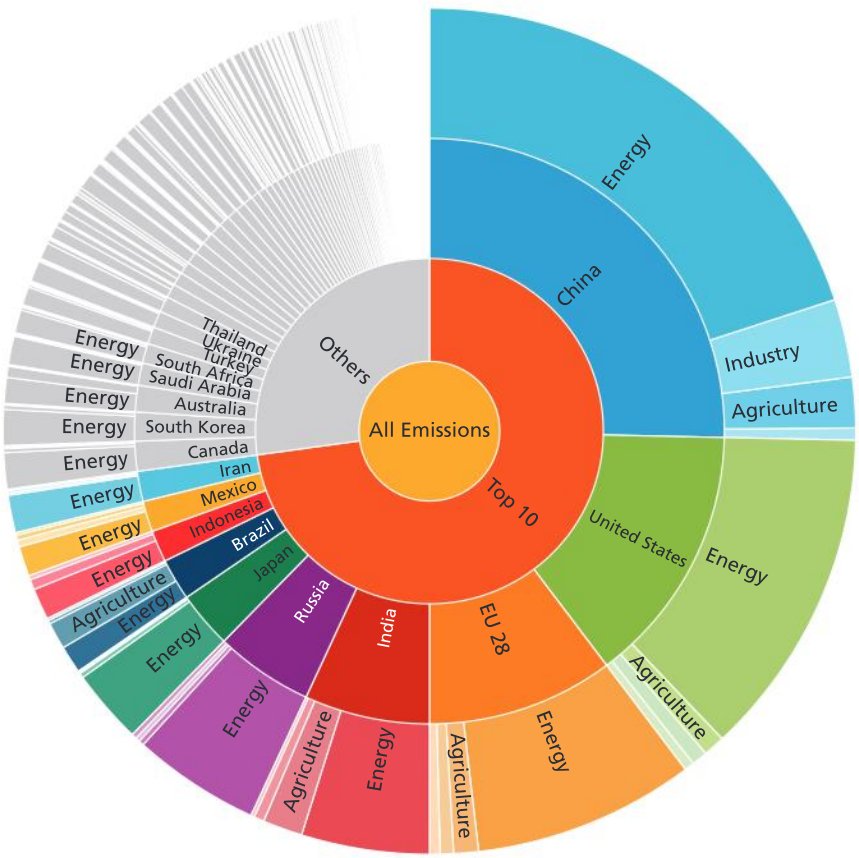


Figure 2.10: The main contributors to greenhouse gas emissions

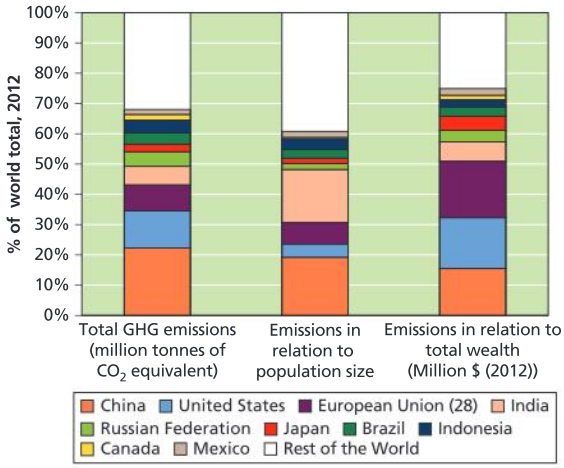


Figure 2.11: Total greenhouse gas emissions by the top ten emitters, 2012

The increase in the world's greenhouse gases is linked to industrialization, trade and globalization. As industrialization has increased, so too has the increase of atmospheric CO_2. Many LICs and NICs are actively industrializing and adopting a consumer culture. Industrial activity among the NICs has great potential to add to atmospheric CO_2. Nevertheless, the per-capita emissions in HICs are responsible for much of the growth in atmospheric CO_2.

Common mistake

✗ Some students confuse global warming with the greenhouse effect and fail to distinguish between the natural greenhouse effect and the enhanced greenhouse effect.

✓ The natural greenhouse effect is vital for life on Earth. The enhanced greenhouse effect refers to the additional greenhouse gases added by human activity that are leading to climate change (global warming) and having a serious negative impact on many societies.

Activity 3

1. Study Figure 2.10.
   a. Estimate the proportion of the world greenhouse gas emissions generated by the top 10 greenhouse gas producers.
   b. Comment on the types of countries that are generating most of the world's greenhouse gases.
2. Study Figure 2.11.
   a. Identify two countries that account for a higher proportion of global greenhouse gas emissions compared with their proportion of global population.
   b. Identify two countries that account for a higher proportion of global population than their proportion of global greenhouse gas emissions.
   c. Outline the relationship between wealth (GDP–PPP) and greenhouse gas emissions.
3. Study the following table, which provides data for CO_2 emissions in 2013.

Country	Largest emitters, billion tonnes (rounded)	Emissions per person (tonnes, rounded)
China	10.2	6.6
USA	5.4	12.1
India	2.1	1.7
Russia	1.9	8.4
Japan	1.2	10.1
Germany	0.8	10.1
South Korea	0.7	10.1
Canada	0.65	11.2
Brazil	0.6	2.4
Indonesia	0.6	2.0
Saudi Arabia	0.5	12.4
United Kingdom	0.5	7.5
Mexico	0.4	3.9
Iran	0.3	5.2
Australia	0.2	12.5

a. i. Construct two bar charts to show the largest emitters and emissions per person by country.

ii. Identify the main characteristics of the countries with the top five emissions of carbon dioxide.

iii. Identify the countries with the top four emissions per person.

iv. State the likely characteristics of the countries with the top five emissions per person.

b. i. Draw a scatter graph to show the relationship between total emissions and emissions per person. Add a line of best fit.

ii. Describe the relationship that you have drawn.

iii. Suggest reasons for the relationship.

Concepts in context

In this section, we have seen how natural and human processes affect the global energy balance. Natural processes include the greenhouse effect, global dimming by volcanoes and feedback loops. Human processes include the enhanced greenhouse effect, as the result of the use of greenhouse gases, and global dimming due to pollution.

Check your understanding

1. Identify the main type of radiation emitted by (a) the Sun and (b)the Earth.
2. Briefly explain the meaning of the terms "convection", "conduction", and "radiation".
3. Explain why the Earth has a warmer climate than the Moon.
4. Identify the main constituents of the Earth's atmosphere.
5. Use examples to explain why albedo and its effects vary.
6. State the cloud type that is most effective at reducing the amount of solar radiation the Earth receives.
7. State one natural cause of global dimming and one anthropogenic cause of global dimming.
8. Using an example, describe the effect of positive feedback on global climate change.
9. Distinguish between the greenhouse effect and global warming.
10. Suggest how globalization is linked to the enhanced greenhouse effect.

Synthesis and evaluation

Climate change is a very complex issue for a number of reasons:

- It has a number of global features, including the atmosphere, oceans and landmasses. The interactions between these three areas are complex and not fully understood.
- It includes natural as well as anthropogenic forces. There are many feedback mechanisms involved, not all of which are fully understood.
- Many of the processes are long term and so the impact of changes that have already occurred may not yet be felt.

2 The consequences of global climate change

Conceptual understanding

Key question

What are the effects of global climate change on **places**, societies and environmental systems?

Key content

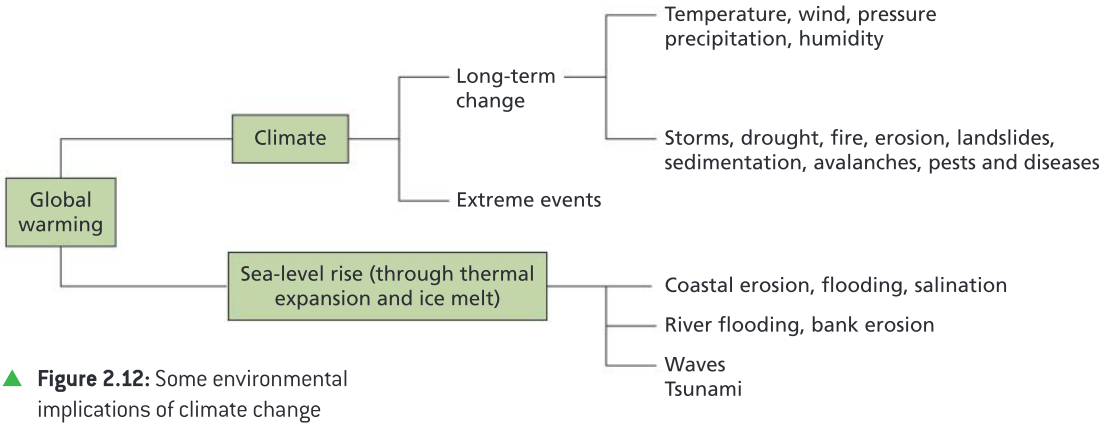
- Climate change and the hydrosphere, atmosphere and biosphere, including water stored in ice and oceans, and changing sea levels; and carbon stored in ice, oceans and the biosphere.
- The incidence and severity of extreme weather events, including drought.
- Spatial changes in biomes, habitats and animal migration patterns; and changes to agriculture, including crop yields, limits of cultivation and soil erosion.
- The impacts of climate change on people and places, including health hazards, migration and ocean transport routes.

The implications of climate change

Global warming is predicted to have various far-reaching effects on the natural, social and economic environment:

- Sea levels will rise, causing flooding in low-lying areas such as the Maldives and Kiribati.
- Storm activity will increase (owing to more atmospheric energy).
- Agricultural patterns will change, for example the USA's grain belt will shrink and production is likely to decline, but Canada's growing season will get longer and probably more productive.
- There will be less rainfall over the USA, southern Europe and the Commonwealth of Independent States (CIS).
- Up to 40 per cent of wildlife species will become extinct.

Nevertheless, there is a great amount of uncertainty in geography, and nobody knows exactly what the impact of climate change will be. The different scenarios are based on different possible temperature changes. Some people even suggest that certain areas might get colder, such as north-western Europe if the Gulf Stream shuts down. We do not know what will happen, and the results may be very different from the predictions.



▲ **Figure 2.12:** Some environmental implications of climate change

Changes to the hydrosphere

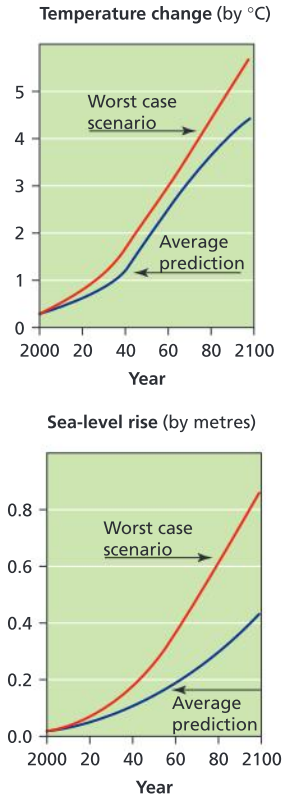
The potential impacts of global climate change on the hydrosphere (freshwater, seawater and ice/glaciers) are great and the impact that this has, in turn, on human populations is far-reaching. For example, impacts could include:

- a rise in sea levels causing flooding in low-lying areas such as the Netherlands, Egypt and Bangladesh, which could displace up to 200 million people
- floods from melting glaciers threatening 4 million km^2 of land – home to 5 per cent of the world's population.

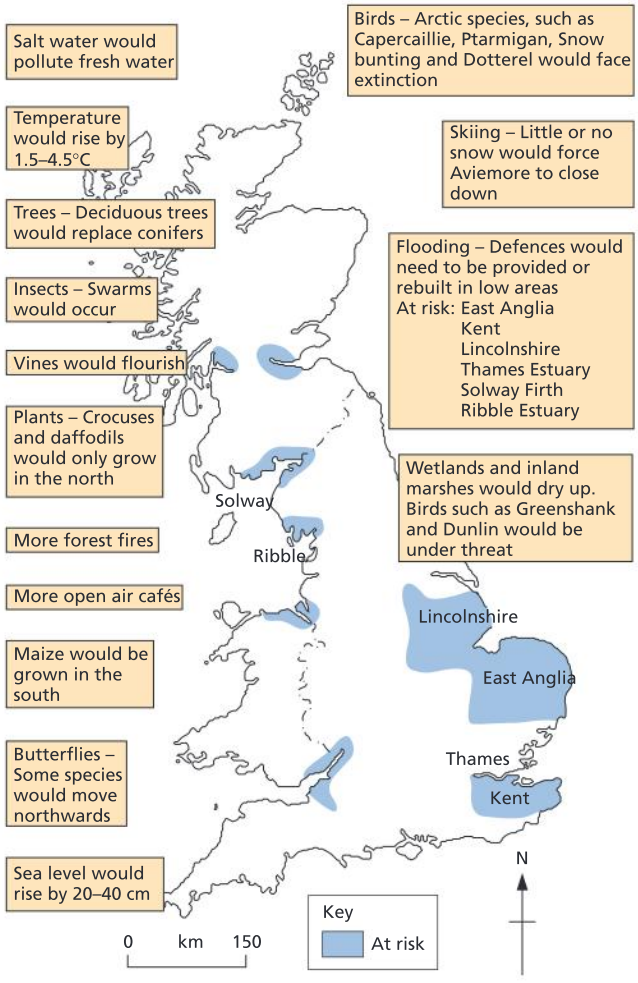
As global temperatures increase, sea level is predicted to rise as the ice caps and glaciers melt and also as a result of the steric effect – the expansion of water as it gets warmer, thereby leading to a slight rise in sea level. By 2100, it is estimated that sea levels will have risen by between 40 cm (average prediction) and 80 cm (worst-case scenario) (Figure 2.13).

▼ **Table 2.2:** The potential impact of temperature increase on aspects of the environment and society

Feature	Effect or impact
Environmental features	
Ice and snow	Melting of polar ice caps and glaciers
Coastlines	Increase in sea level causing coastal flooding
Water cycle	Increased flooding; more rapid circulation
Ecosystems	Change in biome distribution and species composition, e.g. poleward and altitudinal migration
Societal features	
Water resources	Severe water shortages and possibly wars over supply
Agriculture	May shift towards poles (away from drought areas)
Coastal residential locations	Relocation due to flooding and storms
Human health	Increased disease, e.g. the risk of malaria



▲ **Figure 2.13:** Temperature change and sea-level rise



▲ **Figure 2.14:** The impact of global climate change on the UK

It is not just mean sea level that would rise but also the level of high tide and storm surges. Cities such as New York and London would be at increased risk of coastal flooding. Indeed, many parts of the UK would be affected by a rise in sea level (Figure 2.14).

Changes in sea ice

Arctic sea ice has declined dramatically since about 1975. The main reason is believed to be global warming, although this is not the only reason. The sea ice recorded on 3 February 2016 was the lowest recorded volume on record. The Arctic is believed to be at its warmest for 40,000 years, and the length of the melting season has increased by nearly three weeks since 1979.

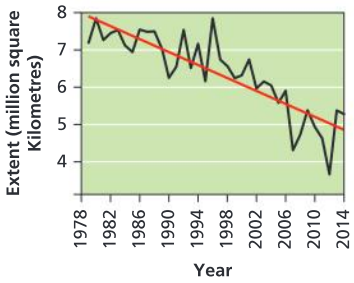
The Arctic sea ice minimum is generally reached during September and the maximum during March (Figure 2.16). However, the overall volume, thickness and extent have been declining for decades. In addition, the time the ice remains is changing. For example, in 1988, ice that was more than four years old accounted for over one-quarter of the Arctic sea ice, but by 2013 it was less than one-twelfth.

As the ice has receded, the potential for wave formation has increased. In 2012, five-metre waves were recorded in the Beaufort Sea. These waves helped break up the sea ice, thus establishing a positive feedback loop of disappearing sea ice and wave formation. Under "normal" conditions, sea ice prevents the formation of waves.

Scientists have debated when (not "if") the Arctic will become ice-free during summer. Predictions range from 2016 to 2040.

There are many impacts of sea ice decline. One is that methane emissions from the tundra will increase because of the release of chlorine atoms from the sea. Another study has linked the decline in Arctic sea ice with wet summers in northern Europe, as a result of a weakened jet stream. There are correlations between extreme weather in the northern mid-latitudes and the disappearance of ice.

Sea ice decline has been linked with increased primary productivity in the Eastern Bering Sea, due to plankton blooms. However, the melting ice has adversely affected polar bears, which have less time to hunt seal pups and must spend more time on land. Their diets have become less nutritious and there are reports of reduced body size and decreased reproductive success.



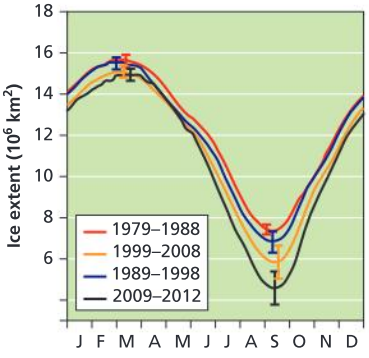
Source: National Snow and Ice Data Center http://nsidc.org/arcticseaicenews/files/2014/10/monthly_ice_NH_09.png

▲ **Figure 2.15:** The extent of Arctic sea ice, 1979–2014

Glaciers and ice caps

Many Himalayan glaciers are retreating. This may have a major impact on the region's water supply, although the consequences are unclear. The Hindu Kush Himalayan region is the source of many of Asia's major river systems, which provide water for drinking, irrigation, industry and other uses for about 1.5 billion people. Studies have shown that at lower elevations glacial retreat is unlikely to cause major water shortages in the near future (due to the monsoon rain system), although other factors such as population growth and groundwater depletion could have a serious impact.

However, for higher-elevation glaciers, glacial retreat could alter stream-flow characteristics in many basins. For example, the Gangotri Glacier is one of the largest glaciers in the Himalayas. It is 30 km long and between 0.5 and 2.5 km wide. It has been in retreat since 1780, although the retreat has intensified since 1971. Since 1990 it has retreated more than 800 m, and between 1996 and 1999 it retreated by 76 m.



Source: http://www.metoffice.gov.uk/media/image/i/e/Sea-ice_fig3_seasonal-cycle_arctic.png

◀ **Figure 2.16:** Seasonal variations in Arctic sea ice, 1979–2012

ATL Research and communication skills

To access the report "Himalayan glaciers: Climate Change, Water Resources, and Water Security", visit http://www.nap.edu/catalog.php?record_id=13449.

Use the report to investigate the potential impact of climate change on water resources and water security in the Himalayas.

Case study

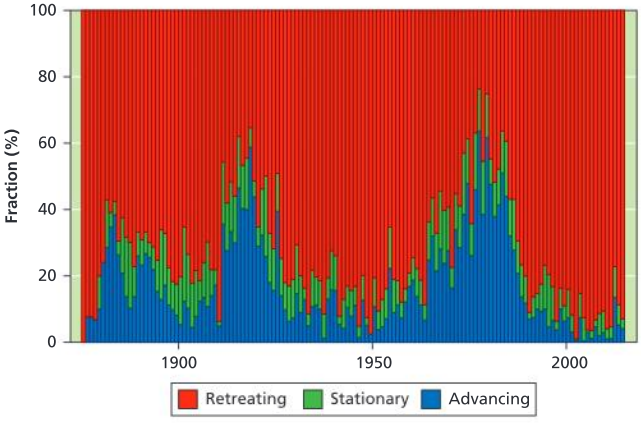
The retreat of Swiss glaciers

Glaciers in Switzerland are predicted to recede at an accelerated rate. Such a process will lead to a massive change in the landscape and changes in water balance, glacial lake outbursts, mudslides and debris slides. The glaciated surface of the Swiss Alps declined from 1,800 km^2 in 1850 to 1,300 km^2 in 1971, a loss of one-third. The surface area (as a proportion of the total land area) decreased from 4.4 to 3.15 per cent, a loss of 1.3 per cent.

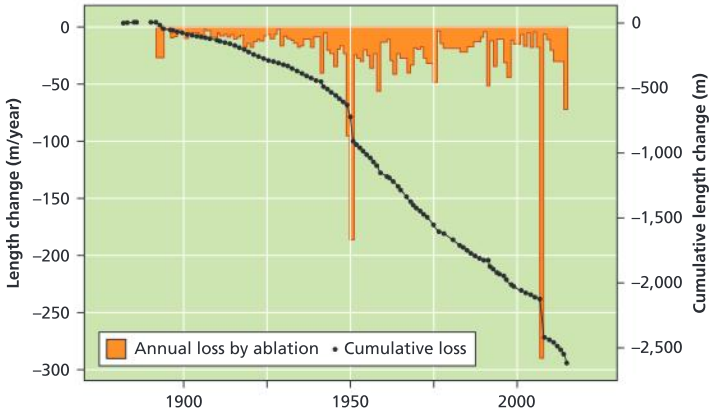
Figure 2.17 shows changes in the length of the Gorner Glacier between 1882 and 2015. In 1882 the glacier was about 15 km long. Between 1883 and 1885 the glacier grew very slowly – 4 m. It remained steady for a few years, and then retreated by 26 m/yr for a couple of years (the first peak on the graph). It then retreated more slowly, generally by less than 10 m/year until 1920. Annual retreat increased in the 1930s and 1940s, and in 1950 it retreated by a massive 186 m (the second peak on the graph). From the 1950s, retreat was in the order of tens of metres per year. In 2007–8 it retreated by 290 m (the third peak). It has retreated over 2.5 km over the last 130 years. Since 1892, it has been in continuous decline. The reason is likely to be global warming and the impacts are economic, social and environmental.

Large glaciers, including Gorner Glacier, had the greatest amount of recession in surface area, volume and length in absolute terms, but their relative losses (120–125 per cent) were less than those of the medium glaciers (30–50 per cent) and the small glaciers (50–80 per cent).

▲ **Photo 2.2:** The Gorner Glacier, Switzerland, has been in retreat for over 125 years



▲ **Figure 2.18:** Changes to Swiss glaciers, 1880–2015



Source: http://glaciology.ethz.ch/messnetz/glaciers/gorner.html

▲ **Figure 2.17:** Changes in the length of the Gorner Glacier, Switzerland, 1882–2015

Changes in carbon stored in ice, oceans and the biosphere

Prior to the Industrial Revolution, the amount of ice stored on land, in oceans and in the biosphere was relatively balanced. However, human activity has tipped the balance, and some carbon sinks have become carbon sources.

Most of the Earth's carbon is stored in rocks, but this is largely unavailable in the natural carbon cycle owing to its very slow rate of turnover. The rest of the carbon is stored in the atmosphere (2 per cent), in the biomass (5 per cent), in fossil fuels (8 per cent), and in the oceans (85 per cent). The earth's carbon cycle has been altered, largely as a result of human activity.

Before the Industrial Revolution, the main changes to the carbon cycle were infrequent events such as volcanic eruptions, sea floor spreading and meteorite impacts. Human activity, in particular the burning of fossil fuels, has moved some of the carbon that was buried deep underground into the atmosphere.

In the 1990s, human activity added 8.0 PgC (1 PgC = 10^{15} grams of carbon) annually, of which 6.4 PgC came from the burning of fossil fuels and 1.6 PgC/year from deforestation. The oceans absorbed 28 per cent of the carbon, the land 32 per cent, and the rest (40 per cent) remained in the atmosphere. In contrast, between 2000 and 2008, human activity added 9.1 PgC to the atmosphere annually, 7.7 PgC of which came from fossil fuels and 1.4 PgC from deforestation and land-use changes. Up to 45 per cent of this is believed to have remained in the atmosphere.

Oceans

In pre-industrial times, the Earth's atmosphere contained 578 Pg of carbon. The atmosphere now contains about 766 Pg of carbon. In contrast, the oceans contain about 38,000–40,000 Pg of carbon – about 50 times more than the atmosphere.

However, with climate change, the atmospheric carbon content is driving changes in the ocean carbon content. The carbon content of both is rising. Increased carbon in the atmosphere warms the Earth and may make plants grow more and store more carbon. In contrast, increased carbon in the oceans acidifies the water, endangering much marine life. About 30 per cent of the carbon dioxide that humans have put into the atmosphere has diffused into the oceans.

This increases the acidity of the water (see pages 63–64 on ocean acidification). Since 1750, the oceanic pH has dropped by about 0.1, a 30 per cent change in acidity. Some of the excess carbon dissolves in the ocean to become carbonic acid. Carbonic acid reacts with carbonate in the water to form bicarbonate. With less carbonate available, shell-building organisms such as crabs, lobsters and coral end up with thinner shells. In addition, acidic water is better able to dissolve calcium carbonate, and so the shells of marine organisms are more likely to be weakened.

Moreover, warmer oceans may decrease the abundance of phytoplankton, which grow more vigorously in cool, nutrient-rich waters. Nevertheless, carbon dioxide may stimulate the growth of certain phytoplankton that can obtain carbon dioxide directly from the ocean.

The biosphere

Terrestrial plants have absorbed approximately 25 per cent of the carbon dioxide that humans have released into the atmosphere. Some plants grow extremely rapidly with increased carbon dioxide. Estimates suggest that with a doubling of carbon dioxide, plant growth increases by 12–76 per cent, providing there are no other limiting factors such as a shortage of water.

Agriculture has had a variable impact on the Earth's carbon cycle. When farmland is abandoned, for example following the eruption of the Soufrière volcano in Montserrat, the vegetation may revert to forest. However, by preventing wildfires, humans prevent carbon from entering the atmosphere and allow carbon to build up in plants instead. In many tropical areas, the use of fire to create new farmland is releasing considerable amounts of carbon into the atmosphere.

Until recently, many Canadian forests were sinks, converting carbon dioxide through photosynthesis into biomass. In addition, forest soils store large amounts of carbon. Deforestation leads to the release of carbon from trees and soils to the atmosphere. Modern farming practices also influence the carbon cycle. Soils are important carbon sinks and contain about 75 per cent of land-based carbon.

Ice

Periglacial areas (see pages 107–109) are characterized by seasonally low temperatures and permafrost – permanently frozen soil. Permafrost contains large deposits of carbon, accumulated over thousands of years. The low temperature reduces the rate of decomposition of organic plant matter. This low rate of decomposition in relation to plant productivity has allowed the large accumulation of carbon to develop, in the form of dead organic matter (DOM). Periglacial environments contain some 400–500 gigatonnes(Gt) of carbon stored as DOM, compared with 700–800 Gt of atmospheric carbon. It is believed that 30–40 per cent of the global soil carbon is stored in periglacial soils.

However, in many areas the permafrost is beginning to thaw. The likely impact of global warming on periglacial environments is to increase net primary productivity, as long as a lack of nutrients does not limit productivity. Currently, the low temperatures limit the release of nutrients, but as temperatures rise, decomposition of DOM may increase and release more nutrients.

Warming of periglacial environments will lead to increased methane emissions. Periglacial areas already dominate emissions of methane, particularly in western Siberia and central Canada. Currently, about 25–40 megatonnes (Mt) of methane are released each year; a 4°C global

temperature increase could lead to a 45–65 per cent increase in the release of methane.

Changes in snow cover and permafrost could have important feedback mechanisms. Decreased snow reduces the reflectivity of the surface, increasing the absorption of solar radiation. As permafrost thaws, its stored carbon is released to the atmosphere in the form of methane, a process that could lead to a rise in air temperature, although the timescale for this is unknown. Research suggests that if 10 per cent of the permafrost were to thaw, it could release enough methane into the atmosphere to raise temperatures by an extra 0.7°C.

Changes in biomes

Climate change in the geological past can show how we might expect biomes to move with changes in future global temperatures. Models suggest a north-to-south shift in biomes relative to the equator (a latitudinal shift). Biomes will also move up slopes (an altitudinal shift) such as on mountains. Low-lying biomes such as mangroves may be lost as a result of changes in sea level.

Species composition in ecosystems is also likely to change. Climate change in the past has happened over long periods of time, allowing animals to adapt gradually to the new conditions. Current increases in temperature are happening very rapidly, so there is little time for organisms to adapt. Some organisms will be able to migrate to new areas that offer the conditions they need, but those facing insurmountable obstacles to migration (for example, rivers and oceans), or even no suitable habitat, will become extinct.

A reduction in biodiversity may also occur as species change their distribution in response to changes in climate. Some species – especially those in high-altitude and high-latitude habitats – have fewer options for migration and so are more endangered. Up to 40 per cent of wildlife species could become extinct if temperatures rise by 2°C.

ATL Research skills

Visit http://www.climatecentral.org/news/map-animal-migration-climate-change-20646 for a series of maps and information about possible future plant and animal migrations in North and South America

Case study

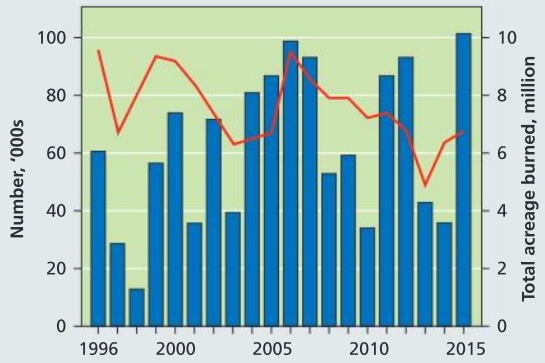
The destruction of forests in the USA

Dense American forests are a significant carbon sink, absorbing around 13 per cent of the greenhouse gases that the US emits through burning fossil fuels. However, climate change is causing devastation in America's forests, owing to fire, insect infestations, and drought. All these threats are related to a warming climate.

In 2015 over 10 million of America's 766 million acres of forest were consumed by wildfires. This was the biggest area burned since 1960, and it cost the US government over $2 billion. In 2013 Yosemite National Park was affected by California's third-largest wildfire ever, which burned over a quarter of a million acres.

▲ **Photo 2.3:** Forest fires in the USA are becoming larger and more frequent as a result of global warming

Case study (continued)



▲ **Figure 2.19:** Wildfires in the USA, 1996–2015

Source: National Interagency Fire Centre

The growth of wildfires is a worldwide problem. Siberia, Tasmania, Canada and Indonesia have seen record-breaking fires in recent years. Fire consumed over 7 million acres of Russian forest in 2015–16. The area of Canada's forest burning each year has roughly doubled since the 1970s. In May 2016 a wildfire near Fort McMurray, in Alberta, destroyed 1.5 million acres of forest and 2,400 buildings. The fire is believed to be Canada's most expensive natural disaster.

Fire is an important part of the natural system. Wildfires clear away disease, remove leaf litter and create space for new growth. They prevent the build-up of woody material. However, mismanagement is also fuelling the flames: since 1910, the US government has suppressed wildfires and planted dense forest to replace that lost by logging – increasing the impact of wildfires when they do occur. Climate change is believed to have made California's drought 15–20 per cent more severe; in Alaska, where the average winter temperature has risen by over 3°C since 1950 – over twice the average for the rest of America – its impact is even greater. By accelerating the melting of winter snow, for example, in Alaska and the mountains of the West – the Rockies, the Cascades and Sierra Nevada – hotter temperatures have made the fire season longer, from an average duration of 50 days to 125 days since 1970.

The devastation of forests by insects is ecologically as dramatic as wildfires. The United States Forest Service (USFS) claimed that insects as well as drought killed 26 million trees in California. Such destruction, partly caused by global warming, will itself cause more warming. Drought-stressed trees lose their ability to repel insects: since the 1990s, 42 million acres of North American pine forest are estimated to have succumbed to bark beetles. In the boreal forest, spruce beetle populations are increasing rapidly. The reasons for the surging insect numbers are similar to those for wildfires. Warmer, drier weather, including milder, shorter winters, has led to an increase in insect populations as well as in the number of stressed trees they infest.

Both problems, fire and pests, are liable to get worse as the climate warms. The USFS expects the area of forest burned to double by the middle of the 21st century. However, it predicts that beetles will often kill more trees in a given year than fire. Even if the climate were stable, this onslaught would make it hard for the forests to regenerate. The USFS predicts that, by 2036, American forests could become a carbon source.

Mitigating the effects

Mitigating the effects of forest devastation would require a massive intervention to clear dead trees and plant new ones, which is currently unthinkable. In 2015 the USFS spent more than half its budget on firefighting, and by 2025, it estimates that 67 per cent of its budget will be used for firefighting. That leaves very little for prevention.

However, the effect of fire and bug-death has created an opportunity for a massive experiment in tree migration and regrowth. A warmer, drier climate should force trees uphill and to higher latitudes. The Ponderosa pine, for example, would climb up from the montane to the subalpine zone, displacing or finding refuge among white firs and lodgepole pines. Whether a species can migrate may depend as much on factors such as soil type, distance from a seed source, the pace at which it reaches reproductive maturity and the vulnerability of higher-elevation vegetation to infiltration as on temperature alone. It took the Ponderosa pine 11,000 years to migrate from New Mexico to Wyoming after the most recent Ice Age; it is unlikely to keep pace with rapid warming.

Case study (continued)

The USFS suggests that nearly 60 per cent of tree species are experiencing a contraction in their environmental range. Only 20 per cent are making the predicted northward shift. High-elevation species, such as whitebark pine and Rocky Mountain fir, are likely to become extinct. The losses will be partially offset by new growth. America's forests will be vast and productive for a long time yet. As its snows melt and permafrost thaws, the Arctic is getting greener, so Alaska should grow more and bigger trees.

There is a growing acceptance in the USA of the need to thin forests, including by controlled burning. Since 2000, partnerships have been formed in many cities to improve management of their forested watersheds. Some, such as in Denver, Flagstaff and Santa Fe, include provisions for downstream water users to help pay for forest management. In the Ashland drainage basin in Oregon, foresters and environmentalists work together to survey, thin and improve the forest. Ashland has introduced a water tax on households in the city, to help pay for the work.

Changes to agriculture

As global temperatures rise, changes in agricultural patterns are likely. It is suggested that if temperatures rise by 3°C, there will be a 35 per cent drop in crop yields across Africa and the Middle East. If temperatures rise by 2°C, 200 million more people could be exposed to hunger; if world temperatures rise by 3°C, up to 550 million may be affected.

Changes in the location of crop-growing areas can be expected, with movements north and south from the equator. For example, viticulture – the growing of grapes to produce wine – will move polewards, as will corn and wheat. (Past evidence suggests that vineyards existed in the north of England in the 1300s.) Recent models predict dramatic changes to the wheat-growing regions of the USA, with many becoming unviable by 2050. Scientists project a northward shift of wheat-growing in North America, with a decline in the USA's grain belt but an increase in Canada's growing season. This would have serious effects on the US economy. Similarly, wheat yields in the north of the UK are predicted to rise by 30 per cent and those in the south of the country to fall by 30 per cent.

Since drought reduces crop yield, the reduction in water resources will make it increasingly difficult for farmers in many areas to irrigate fields. Crop types may need to change and changing water resources will either limit or expand crop production depending on the region and local weather patterns.

The impact of climate change on people and places

The effects of global warming are varied. Much depends on the scale of the changes. For example, up to 60 million more Africans could be exposed to malaria if world temperatures rise by 2°C. Mosquitoes would be able to breed in areas previously too cool for them. Other tropical diseases can also be expected to spread as warmer conditions extend to higher latitudes.

Global warming may well lead to an increase in human migration. Already, some communities are claiming to be environmental refugees,

ATL Research skills

Visit http://www.thehumanimpact.com/?p=1912 for information on climate migrants.

forced to leave their homes as a result of sea-level rise caused by global warming. Residents of low-lying islands such as Kiribati in the South Pacific have abandoned their homes, while others, such as in Kivalina, Alaska (see pages 158–159), are expecting to leave before long.

One benefit of climate change may be the opening up of sea routes as sea ice melts, such as the Russia's Arctic coastline and the North-West Passage connecting the Atlantic Ocean and the Pacific Ocean via the Arctic Ocean. Nevertheless, there are geopolitical issues to be resolved before either of these sea routes is used for international shipping.

Tourism is also likely to change as global warming changes weather patterns. Summer seasons may be extended and coastal resorts selling sunshine, sea and sand may develop in more northerly locations. Winter sports holidays, however, may be stopped by lack of snow and ice. Reduced precipitation in some areas may make some currently popular resorts uneconomic due to lack of water resources.

Social problems

The impacts outlined above will indirectly lead to social problems such as hunger and conflict, which will have implications for levels of economic development. National resource bases will change, which will drive economic, social and cultural change. These issues are more likely to affect low-income countries (LICs) than high-income countries (HICs) because LICs are technologically and economically less able to cope. Moreover, a greater percentage of the population in LICs is already vulnerable to the effects of climate change (for example, in Bangladesh 20 per cent of gross domestic product (GDP) and 65 per cent of the labour force is involved in agriculture that is threatened by floods in low-lying areas).

Coastal flooding, caused by the melting of the polar ice caps and the thermal expansion of the oceans, will particularly affect countries that have land below sea level, such as the Netherlands, and may lead to economic and social stress due to loss of land and resources. LICs are more likely to have weak infrastructure, communications and emergency services, which will also make them less able to respond to the effects of climate change.

Climate change may also lead to a loss in ecosystem services. Ecosystems provide a range of services, for example primary productivity, pollination, flood control, climate regulation and provision of timber products, and these may be at risk if there are significant changes to climate.

Extreme weather events

Climate change can lead to changes in weather patterns and rainfall (in both quantity and distribution). Climates may become more extreme, and more frequent and unpredictable extreme weather events can be expected as atmospheric patterns are disturbed.

Probable impacts include:

- 200 million people at risk of being driven from their homes by flood or drought by 2050
- an increase in storm activity such as more frequent and intense hurricanes (owing to more atmospheric energy)

- reduced rainfall over the USA, southern Europe and the Commonwealth of Independent States (CIS) leading to widespread drought
- up to 4 billion people suffering from water shortages if temperatures rise by 2°C.

The potential impacts of temperature increase

The impacts of climate change will vary with the scale of the temperature change.

Up to 1°C increase

A maximum rise in temperature of 1°C is vital for the survival of low-lying island states, but it is now thought to be virtually impossible to achieve. The Arctic sea ice is already disappearing and, with a 1°C global average temperature rise, it will disappear for good in the summer months. Heatwaves and forest fires will become more common in the subtropics, and the worst-hit areas will be the Mediterranean region, southern Africa, Australia and the south-west United States. Most of the world's corals will die, including the Great Barrier Reef. Glaciers that provide fresh water for crops for 50 million people will begin to melt, and climate-related diseases such as malaria and diarrhoea will affect 300,000 people every year.

Up to 2°C increase

This is the temperature limit the scientists want. The heatwaves seen in Europe during 2003, which killed tens of thousands of people, will come back every year with a 2°C global average temperature rise. Southern England will regularly see summer temperatures of around 40°C. The Amazonian rainforest will turn into desert and grasslands, and increasing CO_2 levels in the atmosphere will make the world's oceans too acidic for any remaining coral reefs and thousands of other marine life forms. More than 60 million people, mainly in Africa, will be exposed to higher rates of malaria. Agricultural yields around the world will drop, exposing half a billion people to a greater risk of starvation. The west Antarctic ice sheet will collapse, the Greenland ice sheet will melt and the world's sea level will begin to rise by 7 metres over the next few hundred years. Glaciers all over the world will recede, reducing the fresh water supply for major cities, including Los Angeles. Coastal flooding will affect more than 10 million extra people. A third of the world's species will become extinct if the 2°C rise changes their habitats too quickly for them to adapt.

Up to 4°C increase

This scenario is possible if countries agree to only an extremely weak climate deal (see also pages 34–36). At this level of increase, the Arctic permafrost would enter the danger zone, releasing into the atmosphere much more of the methane and carbon dioxide currently locked in the frozen soil. At the Arctic itself, the ice cover would disappear permanently, meaning extinction for polar bears and other native species that rely on the presence of ice. Further melting of Antarctic ice sheets would mean a further five-metre rise in sea level, submerging many island nations. Italy, Spain, Greece and Turkey would become deserts

TOK

The poor are more vulnerable to global warming than the rich. However, on average, people in rich countries produce a larger amount of greenhouse gases per person than people in poor countries. Is this morally just?

and central Europe would reach desert temperatures of almost 50°C in summer. Southern England's summer climate could resemble that of modern southern Morocco.

Case study

Climate change and the UK

These are the likely impacts of climate change on the UK for the 2020s and beyond (see also Table 2.3).

- **Rising temperatures**

Temperatures are expected to increase at a rate of about 0.2°C per decade; higher rates of increase will occur in the south-east, especially in summer. It will be about 0.9°C warmer than the average of 1961–90 by the 2020s and about 1.6°C warmer by the 2050s. This temperature change is equivalent to about a 200 km northward shift of the UK climate.

- **Increased rainfall and wind speeds**

Annual precipitation over the UK as a whole is expected to increase by about 5 per cent by the 2020s and by nearly 10 per cent by the 2050s; winter precipitation will increase everywhere but it will be more pronounced over the south. The UK will be subject to more intense rainfall events and extreme wind speeds, especially in the north. Gale frequencies will increase by about 30 per cent.

- **Droughts and floods**

The contrast in the UK's climate is likely to become exaggerated: the currently dry south-east will become drier and the moist north-west will get wetter. Drought in the south-east and flooding in the north-west will both become more common. The current cost of flooding in the UK is estimated at £340 million per year. This is predicted to rise to approximately £430 million if global temperatures rise by 2°C. By 2050 more than 180,000 homes in the UK will be at risk of flooding.

- **Rising sea levels and higher tides**

Sea level is expected to rise (as a result of glacial melt) at a rate of about 5 cm per decade. This is likely to be increased in southern and eastern England by the sinking land, whereas in the north it will be offset by rising land. By the 2050s, average sea levels will be about 35 cm higher and the probability of storm surges will increase. Extreme high tides will be more frequent. For some east-coast locations, such tides could occur 10 to 20 times more frequently by the 2080s than they do now. Rising sea levels could well affect the UK's coastal defences: about 20 per cent of the total length of coastal defences could be vulnerable to failure if sea levels rise by 50 cm.

- **Potential storm surges**

The 1953 storm surge that struck the UK killed 531 people, left more than 40,000 homeless, ruined more than 65,000 hectares of farmland with salt water, and caused widespread livestock losses. Partly as a result of these losses, the Thames Barrier was built to protect London from tidal flooding. Another storm surge similar in size to the 1953 surge would flood the petrochemical complex at Grangemouth, which handles 40 per cent of the UK's fuel supplies. It would also cause a combination of tidal, river and surface flooding affecting London for the first time in 70 years, inundating more than 50 underground stations, gas and electricity services, and telephone exchanges. The economic cost of such an event is estimated at £200 billion.

TOK

For many years the UK government has debated whether to replace the Trident nuclear programme, which protects the UK against a nuclear attack. Its cost would be over £200 billion. Currently, the UK spends about £3 billion on flood defences. Which do you consider to be the more likely threat to the UK – nuclear attack or flooding?

▼ **Table 2.3:** Some potential effects of a changing climate in the UK

Positive effects	Negative effects
An increase in timber yields (up 25% by 2050), especially in the north, with perhaps some decrease in the south	Damage from increased storminess, flooding and erosion to natural and human resources and human resource assets in coastal areas
A northward shift of farming zones by about 200–300 km per °C of warming, or 50–80 km per decade, which will improve some forms of agriculture, especially pastoral farming in the north-west	An increase in insects, resulting from northward migration from the continent and a small decrease in the number of plant species as a result of loss of northern and montane (mountain) types
Enhanced potential for tourism and recreation as a result of increased temperatures and reduced precipitation in the summer, especially in the south	An increase in soil drought, soil erosion and shrinkage of clay soils

▲ **Photo 2.4:** The effects of global warming

▲ **Photo 2.5:** Dry conditions in the south of the UK, predicted to become more frequent

ATL Research and communication skills

Visit *The Guardian*'s "Science Weekly" podcast on climate change at www.guardian.co.uk/science/blog. Scroll down through the blogs and look at some of those that relate to climate change. For example, find out about game theory and climate change at https://www.theguardian.com/science/blog/2016/apr/13/can-game-theory-help-solve-the-problem-of-climate-change.

Activity 4

1. Compare the impacts of a global rise in temperature of 2°C with those of a 4°C rise.
2. Suggest why low-lying island states are particularly at risk from climate change.

Concepts in context

We have seen how global climate change has an effect on different **places**, societies and environmental systems. Climate change affects the cryosphere, oceans, the atmosphere ecosystems, agriculture, hazards, human health, migration and transport routes.

Check your understanding

1. Describe the annual pattern of sea ice in the Arctic.
2. Describe the changes in the length of the Gorner Glacier between 1882 and 2015.
3. Comment on the movement of Swiss glaciers between 1900 and 2000.
4. Distinguish between a carbon sink and a carbon source.
5. Suggest two reasons for the increase in severity of forest fires in the USA.
6. Briefly explain the potential impact of global climate change on agriculture.
7. Outline the positive impacts of global climate change on the UK.
8. Explain how global climate change affects sea levels.
9. Explain why the distribution of diseases may change with global climate change.
10. Outline the links between global climate change and migration.

Synthesis and evaluation

- No one is sure of the exact magnitude of climate change, but we do know that people around the world will feel its effects in different ways. While timings are uncertain, climate change will have an influence on factors such as the spread of disease, flooding, migration, economic well-being, ocean transport routes, extreme weather events and biomes. Some of these effects will be positive but many will be negative. Population growth and changes in standards of living may fuel these changes.
- Geographers use time-series graphs to predict likely changes, and these usually have high, low and mean predictions.

3 Responding to climate change

Disparities in exposure to climate change

Although there are uncertainties about the nature and scale of its effects, there is no doubt that climate change will have a serious impact on many places and communities. Levels of climate change risk and vulnerability will vary according to a person's location, wealth, social differences (age, gender, education) and risk perception.

Vulnerability to global climate change refers to the degree to which people are susceptible to, or unable to cope with, the adverse impacts of climate change. There are three main factors associated with vulnerability:

- Exposure – the degree to which people are exposed to climate change
- Sensitivity – the degree to which they could be harmed by exposure to climate change
- Adaptive capacity – the degree to which they could mitigate the potential harm by taking action to reduce their exposure or sensitivity.

It is not just people who are affected by climate change. Institutions such as the emergency services, schools, transport services, physical infrastructure, political organizations and economic activities may all be at risk.

Some population groups are more vulnerable to climate change than others. These include the very young, the elderly, those with disabilities, the poor, minority groups, refugees and indigenous people. Carers, who are generally women, are also vulnerable, because of their burden of caring for the young, the elderly and the sick. Single-parent households are often very vulnerable to climate change as they may combine a number of at-risk characteristics, such as age, gender and poverty.

Some locations are more at risk than others. These include low-lying islands, river mouths and valleys, coastal areas and regions that derive their water supplies from mountain glaciers. Many islands in the Indian Ocean and the Pacific Ocean are among the areas most vulnerable to climate change risks. These include the Kiribati, Tuvalu, and the Marshall Islands, the Maldives, and Antigua and Nevis in the Caribbean. Much of the infrastructure and socio-economic activities of these islands is located along the coastline. An 80 cm rise in sea level could inundate about 66 per cent of Kiribati and the Marshall Islands. A 90 cm rise in sea level could inundate 85 per cent of Male, capital of the Maldives.

The problems these low-lying islands face include:

- increased coastal erosion
- saline intrusion into groundwater supplies
- deterioration of coral reefs

Conceptual understanding

Key question

What are the **possibilities** for responding to climate change and who has **power** over the decision-making process?

Key content

- Disparities in exposure to climate change risk and vulnerability, including variations in people's location, wealth, social differences and risk perception.
- Government-led adaptation and mitigation strategies for global climate change: geopolitical efforts, recognizing that the sources of greenhouse gas emissions may be spatially distant from the countries most affected.
- Government-led strategies for global climate change: carbon emissions trading and offsetting, and technology, including geo-engineering.
- Civil society and corporate strategies, and the actions of non-governmental stakeholders, to address global climate change.

▲ **Photo 2.6:** A low-lying island at risk from rising sea levels

- out-migration of people
- loss of income as a result of a decline in economic activities and infrastructure.

Indigenous people often live in extreme environments. In addition, they often experience socio-economic problems such as low incomes, poor health and limited access to resources, including water. These factors make them vulnerable to climate change. Most indigenous populations have adapted their lifestyles to their environment, and they are therefore vulnerable to any changes in that environment. For example, the Inuit people in the Mackenzie Basin in Canada have experienced a rise in temperature of about 3.5°C since the 1980s. This has caused permafrost to melt, changing the ecosystem and leading to an increase in landslides and forest fires, and reduced water availability. Wildlife in the Basin is a major source of food, clothing and income. However, in the Peace Athabasca Delta, the muskrat population has declined due to the lack of available water, and trapping, once a major economic activity, has disappeared. It is likely that many Inuit will have to abandon their traditional lifestyle and seek employment in urban areas instead, which will lead to the destruction of their cultural heritage and values.

Case study

Flooding in Bangladesh

Most of the country of Bangladesh forms a delta from three main rivers, which periodically burst their banks and flood the land. This flooding waters the crops and increases soil fertility but, since 1970, the scale, intensity and duration of the floods have increased. Scientific projections predict that flooding will continue to increase considerably in the main river basins of Bangladesh. A rise in temperature of 2.6°C will lead to widespread, repeated flooding. Due to sea-level rise, the densely populated coastal zone of Bangladesh is also increasingly vulnerable to coastal floods.

The potential flood damage is likely to worsen as a result of increased intensity of extreme precipitation events (Table 2.4). The Global Circulation Model projects an increase in monsoon rainfall of 14–40 per cent by the 2030s and 52–135 per cent by the 2090s.

A number of government and non-government organizations have been involved in initiatives to reduce the impacts of flooding in Bangladesh. In 1988, following some of the most severe floods of the 20th century, the government of Bangladesh developed its Flood Action Plan, with the aim of protecting the country from the effects of future flooding. Sluice gates were built on a number of rivers. These also provide protection from flooding by tidal waves and storm surges. The government has built about 5,700 km of embankments, nearly 4,000 km of them along the coast. It has dug nearly 5,000 km of drainage channels to divert floodwater away from buildings. It also constructed 200 flood shelters on stilts for the evacuation of people threatened by floods, and built brick toilets with septic tanks to reduce water contamination.

In Bangladesh's Padma River islands, frequent flooding makes the life and livelihoods of people extremely vulnerable. The factors affecting risk are extremely varied (Table 2.5).

Case study (continued)

Table 2.4: Impacts of flooding on Bangladesh

Impacts	Effects in Bangladesh
Personal security	• Deaths from drowning (three-quarters of all flood victims) • Deaths from diarrhoea, dysentery, typhoid and cholera (two-thirds of all deaths in any given flood) • Loss of income • Loss or unavailability of fuelwood, gas
Buildings and infrastructure	• Tin-wall and mud houses washed away • Damage to mosques, temples and churches • Damage to garment factories
Crops and animals	• Loss of livestock • Grain shortages • Damage to vegetation

Source: Dewan, T. 2014. "Societal impacts and vulnerability to floods in Bangladesh and Nepal". *Weather and climate extremes*. Vol 7. Pp 36–42

Table 2.5: Measuring risk factors for flooding in Bangladesh

Risk factor	Indicator
Flood hazard	
Magnitude	Water discharge in past 51 years and people's experience
Probability	Flood frequency
Rainfall	Pre-monsoon, monsoon and annual average
Water level	Water level above the danger level
Duration	People's perception of flood duration
Exposure	
People at risk	Percentage of affected population (every year)
Unprotected settlement	Percentage of houses built with flood-resistant materials
Infrastructure	Value of infrastructure at risk
Household contents	Value of household contents at risk
Properties	Value of properties at risk
Vulnerability	
Flood-prone settlements	Percentage of settlement in flood-prone area
Unprotected settlements	Proportion of buildings that go under water
Literacy rate	Level of education
Access to basic needs	Percentage of people with access to basic needs

Case study (continued)

Risk factor	Indicator
Household size	Members of a household
Medical services	Time/distance from house to services
Income	Level of income
Diversification	Percentage of population
Savings	Savings in Bangladeshi currency (taka)
Green space	Proportion of green space per household
Land erosion	Percentage of people suffering from land erosion
Resilience	
Location	Percentage of people with access to safe location
Environmental resources	Available environmental resources
Age	Age of the respondent
Emergency groups	Assistance available from emergency groups
Awareness and capacity-building programmes	Frequency of awareness-building programmes
Access to livelihood assets	Access to physical, social, economic, environmental and financial assets; employability, good health and knowledge
Access to national and international emergency funds	People's access to emergency funds
Early-warning system	Percentage of population getting early warning
Interaction	Level of risk-management institution available
Coping strategies	Economic, social and technological/structural coping strategies

Source: Sultana, R., Rumi, S Rafiqul Alam and Hanif Sheikh, MA. 2013. "Climate change induced flood risk and adaptation in the Padma River Islands, Bangladesh: a local-scale example. *J. Life Earth Sci.* Vol 8. Pp 41–8.

Since 1990 the frequency of extreme precipitation has increased. In Narayanpur island, for example, normal floods become catastrophic due to higher vulnerability and reduced resilience.

Fragile construction materials increase the potential impact of flooding. Most of the houses in Bangladesh are built from sand

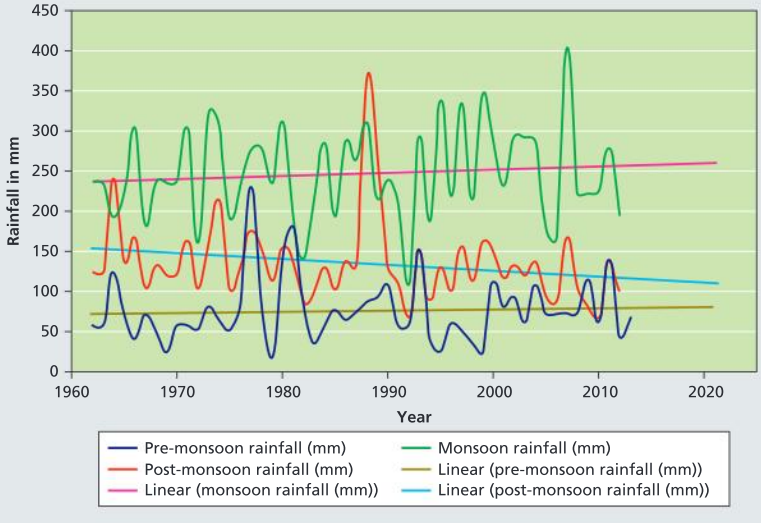


Figure 2.20: Rainfall at Rajshahi, Bangladesh, 1962–2012

Source: Sultana, R., Rumi, S Rafiqul Alam and Hanif Sheikh, MA. 2013. "Climate change induced flood risk and adaptation in the Padma River Islands, Bangladesh: a local-scale example. *J. Life Earth Sci.* Vol 8. Pp 41–8.

Case study (continued)

▼ **Table 2.6:** Coping mechanisms among communities along the Padma River, Bangladesh

Coping mechanism		Period of use (pre, during or post disaster)
Economic coping strategies	Saving money	Pre
	Searching for relief materials	Post
	Selecting flood-resilient crop varieties	Pre
	Diversifying income sources	All
	Repairing damage to the house	Post
	Borrowing money	Post
	Selling assets	Post
	Adjusting consumption	Post
Social coping strategies	Preparing to shelter at a friend's or relative's house	Pre
	Evacuating family, especially children and the elderly, to a safe place	During
	Evacuating important items to a safe place	Pre and during
	Helping other community members	During and post
	Preserving food and fuel on the selling of the house	Pre and during
Technological or structural coping strategies	Getting flood warnings via TV, radio or other means	Pre
	Building dykes in front of house with sandbags	Pre
	Building house with transferable construction materials	Pre
	Raising the base of the house	Pre
	Building *Machan* for saving properties	Pre and during

Source: Sultana, R., Rumi, S Rafiqul Alam and Hanif Sheikh, MA. 2013. "Climate change induced flood risk and adaptation in the Padma River Islands, Bangladesh: a local-scale example. *J. Life Earth Sci.* Vol 8. Pp 41–8.

and mud. Income levels are generally very low – the larger the household size, the lower the social status. Moreover, income sources are not diversified enough to cope with the possible effects of global climate change. In the Narayanpur district, fewer than 1 per cent can reach medical help within one hour. For those living by the Indian border, there is no suitable means of transport.

In the pre-disaster stage of a flood, residents can try to prepare by increasing their savings, raising their house on stilts, and moving important items to safer places. In the post-disaster period, people sell assets to buy food and equipment.

Case study

Vulnerability and adaptation in Ghana

Climate change is likely to lead to conditions outside the normal range of experience for many communities around the world. Adaptation refers to an adjustment in response to actual or predicted aspects of climate change. In Ghana, West Africa, there are a number of adaptation responses to climate impacts (Table 2.7).

Types of adaptation include infrastructure development, ecosystem-based measures and capacity development. Infrastructure development includes building dams, levees and sea walls. Ecosystem-based adaptation includes preserving and restoring natural habitats, such as mangrove swamps and wetlands, to provide ecosystem services. Capacity development includes education and extension services to teach people new techniques and to empower them.

▼ **Table 2.7:** Climate change impacts and adaptations in different environmental regions of Ghana

Zone	Climate change impact	Adaptation response
Northern Savanna	Increased morbidity and disease prevalence Increased vulnerability of the poor Increased out-migration and loss of human capital	Strengthening traditional social security support systems Strengthening public health-care delivery Targeting social transfers and safety nets Increasing investment in urban social services
Transition	Increased demand – water, energy and basic services Decreased income for people in fish industry Increased out-migration Increased food insecurity Threat to forest-based livelihood Potential conflicts and social tensions	Public–private partnerships in service provision Developing and raising awareness of early warning systems Promoting conflict management mechanisms Providing social safety nets for communities and migrants Developing alternative and additional livelihoods
Forest	Decreased food security Dry-ups of water bodies and underground water Pressure on land	Improving social services to poor people Providing small-scale irrigation Offering security of tenure Community-based land administrative systems
Coastal savanna	Decreased water availability and quality Higher burden on women Increased migration Increased cholera	Recycling and total rainwater harvesting Improving formal and informal safety nets Social protection for immigrants Economic diversification in secondary towns Increasing accessibility of health care Education and raising awareness of health issues

Source: Bizikova, , Bellali, J, Habtezion, Z, Diakhite, M and Pinter, L. 2009. "Vulnerability and climate change impact assessments for adaptation", IEA Training manual.

Table 2.8: Different types of adaptation measure in Ghana

Infrastructure development and changes in practices	Ecosystem-based measures	Governance, training and capacity development
• Building grain silos • Improving post-harvest technologies such as setting up small-scale agro-processing industries to utilize farm products • Building small and medium-sized dams • Building flood-resistant roads to ensure market access	• Promoting sustainable agriculture, organic farming and appropriate technology to reduce degradation • Encouraging contour farming and water storing to control erosion • Restoring vegetation around river beds to limit flooding	• Sustainable water management • Farmers' education – water harvesting and contour ploughing • Training centres and micro-finance to develop skills for off-farming season activities • Vocational training – especially for youth, in places with high in-migration; and creating markets and skills training in other sectors including hairdressing, sewing, carpentry • Developing agricultural extension services

Source: Bizikova, Bellali, J, Habtezion, Z, Diakhite, M and Pinter, L. 2009. "Vulnerability and climate change impact assessments for adaptation" IEA Training manual.

Government-led action on climate change

There are many obstacles to achieving a low-carbon world – technological, economic and political. Political obstacles are found nationally and internationally. The fossil fuel industry is the most powerful lobby group in the USA, where coal, oil and gas interests have managed to veto climate control regulations. The main obstacle to a global agreement on climate change remains the bargaining power of the major fossil fuel countries such as the USA, Canada, China, Russia and countries in the Middle East.

There are international efforts and conferences to address mitigation and adaptation strategies for climate change. Organizations include the Intergovernmental Panel on Climate Change (IPCC), National Adaptation Programmes of Action (NAPAs) and the United Nations Framework Convention on Climate Change (UNFCCC).

The UN Framework Convention on Climate Change, 1992

In 1992, at the Rio de Janeiro Earth Summit, the world's governments adopted the UN Framework Convention on Climate Change (UNFCCC).

Its main objective is to:

> achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. (Article 2)

UNFCCC went into effect in 1994 but failed in its attempt to slow down greenhouse gas emissions. The Kyoto Protocol, signed in 1997, was the first major attempt to implement the treaty. High-income countries were required to cut their carbon emissions by 20 per cent by 2012, compared with their 1990 emissions. Low-income countries were not obliged to meet specific targets. The USA did not sign the treaty, and although Canada and Australia signed, they did not implement it. At the same time, emissions soared in China and other rapidly industrializing nations.

The USA argued that to sign would give China a competitive edge in world trade.

The UNFCCC encouraged high-income countries to lead the way in climate change mitigation. This was because:

- they have the technology
- they are better able to bear the costs of low-carbon energy developments
- they have caused a disproportionate amount of historic CO_2
- low-income countries need time to develop their economies.

The Kyoto Protocol, 1997

The Toronto Conference of 1988 called for the reduction of carbon dioxide emissions by 20 per cent of 1988 levels by 2005. Also in 1988, the United Nations Environment Programme and the World Meteorological Organization established the Intergovernmental Panel on Climate Change (IPCC). In 1997, at an international and intergovernmental meeting in Kyoto, Japan, 183 countries around the world signed up to an agreement that called for the stabilization of greenhouse gas emissions at safe levels that would avoid serious climate change. The agreement is known as the Kyoto Protocol and it aimed to cut greenhouse gas emissions by 5 per cent of their 1990 levels by 2012.

The Kyoto Protocol came into force in 2005 and was due to expire in 2012 but was extended to 2015. Within the agreement, countries were allocated amounts of carbon dioxide they were allowed to emit. These permitted levels were divided into units – and countries with emission units to spare are allowed to sell them to countries that have gone or would otherwise go over their permitted allowance. This carbon trading now works like any other commodities market and is known as the carbon market.

The coordinating body of the Kyoto Protocol is the Conference of Parties (COP); it meets every year to discuss progress in dealing with climate change.

The Kyoto Protocol encourages the use of energy sources that do not emit greenhouse gases. Avoiding fossil fuels and using more hydroelectric, solar and wind power are actively encouraged. Some countries (for example, France) have adopted nuclear power as a method of "clean energy" generation, although the problems of disposal of the radioactive waste mean that this method of energy generation remains controversial. Incidents such as the Fukushima Daiichi disaster have made nuclear power less attractive for many.

The success of international solutions to climate change depends on:

- the extent to which governments wish to sign up to international agreements
- whether governments are preventive (that is, they act before climate change gets out of hand) or reactive (that is, they respond once the problem becomes obvious).

The Paris Agreement, 2015

The 2015 UN Climate Change Conference was held in Paris. France was taken as an example of an HIC that had decarbonized its energy production – it generates over 90 per cent of its energy from nuclear power, hydroelectric power and wind energy. The conference resulted in the Paris Agreement on the reduction of climate change. One hundred and seventy-four countries signed the agreement. The key objective is to limit global warming to 2°C compared with pre-industrial levels. It also seeks for zero net anthropogenic greenhouse gas emissions between 2050 and 2100. To achieve a 1.5°C goal would require zero net emissions by 2030–50. Unlike the Kyoto Protocol, there are no country-specific goals or a detailed timetable for achieving the goals. Countries are expected to reduce their carbon usage "as soon as possible". However, there is no mechanism to force a country to set a specific target, nor is there any measure to penalize countries if their targets are not met.

The 2015 conference wanted to achieve a binding and universal agreement on climate change from all the world's countries. The USA and China both agreed to limit greenhouse emissions.

▲ **Figure 2.21:** The logo of the UN Climate Change Conference, Paris

Case study

The "three amigos" summit

In 2016, the leaders of the USA, Canada and Mexico met and agreed a set of initiatives covering climate change actions, involving an integration of their domestic policies with regard to the electricity sector, transport and pollution. They pledged to achieve 50 per cent clean energy by 2025, a pledge that will require a considerable expansion of clean energy in each of the countries. They will also need to increase their energy efficiency. Cross-border cooperation will be essential and modernization of the electricity grid will be a major requirement.

The summit also considered methane, of which North America produces over 10 per cent of global emissions. The USA and Canada agreed to reduce their methane emissions by 40–45% by 2025. All three countries have also agreed to reduce and regulate the use of hydrofluorocarbons (HFCs), which are among the most rapidly growing greenhouse gases and are mainly used as refrigerants. They also agreed to tackle vehicle emissions and to align fuel efficiency and/or greenhouse gas emissions by 2025–7.

Mitigation strategies

Mitigation involves the reduction and/or stabilization of greenhouse gas (GHG) emissions and their removal from the atmosphere. Mitigation strategies to reduce GHGs in general may include:

- reducing energy consumption
- reducing emissions of nitrous oxides and methane from agriculture
- using alternatives to fossil fuels
- geo-engineering.

Mitigation strategies for carbon dioxide removal (CDR techniques) include:

- protecting and enhancing carbon sinks through land management (as in the UN-REDD Programme; see below)
- using biomass as a fuel source

- using carbon capture and storage (CCS)
- enhancing carbon dioxide absorption by the oceans, either by fertilizing oceans with nitrogen, phosphorus and iron (N/P/Fe) to encourage the biological pump or by increasing upwellings to release nutrients to the surface.

Pollution management and control

▲ **Photo 2.7:** Solar panels, Aero Island, Denmark

National and international methods to prevent further increases in mean global temperature include:

- controlling the amount of atmospheric pollution
- reducing atmospheric pollution
- stopping forest clearance
- increasing forest cover
- developing alternative renewable energy sources
- improving public transport
- setting national limits on carbon emissions
- developing carbon dioxide capture methods
- recycling programmes.

Reduction of energy consumption

Climate change mitigation is therefore an enormous priority. One of the main ways to reduce emissions of greenhouse gases is to consume less energy. This can be done in a variety of ways, for example increasing the use of public transport, car-pooling and energy conservation. Since about three-quarters of greenhouse gases are carbon dioxide, the main mitigation priority should be to reduce the emissions of CO_2. Since most of the CO_2 emissions come from the burning of fossil fuel, the reduction of energy-related CO_2 emissions is the most important item on the mitigation agenda. The next most important is land-use change (deforestation), followed by reducing emissions of methane and nitrous oxide.

There are many possible trajectories of future CO_2 emissions. The business-as-usual trajectory will result in emissions of about 60 billion tonnes of CO_2 in 2040. This is because the world economy is growing rapidly, and as it grows it uses more and more fossil fuels. With this trajectory, temperatures could increase by as much as 4–7°C above pre-industrial levels. If CO_2 levels can be held to below 450 ppm, it may be possible (but not certain) to contain the rise in temperature to less than the 2°C limit. Such a trajectory will be very tricky to accomplish.

The term **decarbonization** refers to a large reduction of CO_2 per value of gross world product. Since most of the carbon dioxide comes from burning fossil fuel, a sharp reduction in the use of fossil fuel or a large-scale system to capture and sequester the carbon dioxide is needed. There are three key steps of deep decarbonization:

- The first is **energy efficiency**, to achieve much greater output per unit of energy input. Much can be saved in the heating, cooling and ventilating of buildings, and in electricity use by appliances.

- The second step is to **reduce the emissions of CO_2 per MWh of electricity**. This involves increasing dramatically the amount of electricity generated by zero-emission energy, such as wind and solar, while reducing the amount of power produced by fossil fuels. Emissions reduction may also involve carbon capture and sequestration.
- The third step is a **fuel shift**, from direct use of fossil fuels to electricity based on clean primary energy sources. This kind of substitution of fossil fuel by clean energy can happen in many sectors. Internal combustion engines in automobiles can be replaced by electric motors. Battery-powered vehicles can be recharged on a renewable power grid.

Reductions of emissions of oxides of nitrogen and methane from agriculture

Agriculture is a major source of greenhouse gases, in particular oxides of nitrogen from fertilizers and methane from livestock. Agriculture would have less of an impact on global climate change if fewer chemical fertilizers were used and if there was less intensive livestock farming.

Using alternatives to fossil fuels

There are also many approaches to low-carbon energy. For example, photovoltaic (PV) cells convert energy in light rays (photons) into electrical energy. There is great potential to expand wind power in the US Midwest and north-east, in the desert regions of North Africa, in northern Europe and in parts of central and western China.

Some of the areas with the highest potential for renewable energy are very distant from centres of population, and their source of energy is intermittent. Hence, large-scale renewable energy will require the construction of new transmission lines. For example, the Desertec project is designed to link North Africa, the Middle East and Europe into a single grid. This system would tap the strong solar and wind potential of North Africa and the Arabian Peninsula, both to supply energy for these economies and to export the surplus to Europe. The idea is potentially a key solution to Europe's unsolved challenge of deep decarbonization and an enormous boost to the economies of North Africa and the Middle East. See pages 154–155 for a map and discussion of the Desertec project.

Geo-engineering

Some scientists have suggested using the sulphate aerosol particles in the air in order to dim the incoming sunlight and thereby cool the planet to offset the warming effects of carbon dioxide. Another idea is to place giant mirrors in space to deflect some of the incoming solar radiation. These are fairly radical, and perhaps unworkable, ideas.

The UN-REDD Programme

The UN-REDD Programme is the United Nations initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in low-income countries. The programme was launched in 2008 and involves

the Food and Agriculture Organization (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). In 2007, it was estimated that the forests, through deforestation, forest degradation and land-use changes, contributed approximately 17 per cent of global greenhouse gases.

The UN-REDD Programme supports nationally led REDD+ processes in over 50 countries in Africa, Asia-Pacific and Latin America. It offers:

- direct support to the design and implementation of UN-REDD national programmes
- complementary support to national REDD+ action.

REDD stresses the role of conservation, the sustainable management of forests and the increase in forest carbon stocks. By June 2014, total funding had reached almost US$200 million. Norway is the leading donor country.

Carbon capture and sequestration (CCS)

Currently, when fossil fuels are burned, the CO_2 enters the atmosphere, where it may reside for decades or centuries. A potential solution is to capture the CO_2 instead of allowing it to accumulate in the atmosphere. Two main ways to do this have been proposed:

- Capture the CO_2 at the site where it is produced (the power plant) and then store it underground in a geologic deposit (for example, an abandoned oil reservoir).
- Allow the CO_2 to enter the atmosphere but then remove it using specially designed removal processes (for example, collecting the CO_2 with special chemical sorbents that attract the CO_2). This approach is called "direct air capture" of CO_2.

There are many technical and policy issues surrounding the feasibility and cost-effectiveness of large-scale CCS technologies. First, how costly will it be to capture CO_2 on a large scale? How costly will it be to ship the CO_2 by a new pipeline network and then store the CO_2 in some safe, underground geologic deposit? If the CO_2 is put underground, how certain are we that it will stay where it is put, rather than returning to the surface and then into the atmosphere? Tens of billions of tonnes of CO_2 would have to be captured and stored each year for CCS to play the leading role in addressing CO_2 emissions. Is there enough room for all this carbon? There is relatively little research and development underway to test the economic and geologic potential for large-scale CCS.

Ocean fertilization

Carbon dioxide absorption can be increased by fertilizing the ocean with compounds of iron, nitrogen and phosphorus. This introduces nutrients to the upper layer of the oceans, increases marine food production and removes carbon dioxide from the atmosphere. In some cases, it may trigger an algal bloom. The algae trap carbon dioxide and sink to the ocean floor.

Sperm whales transport iron from the deep ocean to the surface during prey consumption and defecation. Increasing the number of sperm whales in the Southern Ocean could help remove carbon from the atmosphere.

There are certain issues regarding ocean fertilization. The 2007 London Dumping Convention stated that large-scale iron fertilization could have "negative impacts on the marine environment and human health".

In some locations, upwelling currents bring nutrients to the surface, for example off the coast of Peru. These support large-scale fisheries and also help to absorb and store carbon. Devices that help pump water to the surface can produce artificial upwelling. Ocean wind turbines can also cause upwellings. These can then support plankton blooms, which help lock up carbon. However, these are costly to build and run.

Carbon taxes

Some countries are introducing carbon taxes to encourage producers to reduce emissions of carbon dioxide. These environmental taxes can be implemented by taxing the burning of fossil fuel (coal, petroleum products such as gasoline and aviation fuel, and natural gas) in proportion to their carbon content. These taxes are most effective if they are applied internationally, but are also valuable nationally.

CO_2 imposes high costs on society (including future generations) but those who emit the CO_2 do not pay for the social costs that they impose. The result is the lack of a market incentive to shift from fossil fuels to the alternatives. One option is for users of fossil fuel to have an extra "carbon tax" equal to the social cost of the CO_2 emitted by the fuel. This would raise the costs of coal, oil and gas compared with wind and solar, for example, thereby shifting energy use towards the low-carbon options. Economists have suggested a carbon tax in the order of $25–$100 per tonne.

Carbon trading

Carbon trading is an attempt to create a market in which permits issued by governments to emit carbon dioxide can be traded. In Europe, carbon permits are traded through the Emissions Trading System (ETS). Governments set targets for the amount of carbon dioxide that industries can emit, divided between individual plants or companies. Plants that exceed that limit are forced to buy permits from others that do not. Targets are set to reduce pollution, but through a market system. It is working by putting a limit on total emissions, but critics argue that the targets are too generous.

Carbon offset schemes

Carbon offset schemes are designed to neutralize the effects of the carbon dioxide human activities produce by investing in projects that cut emissions elsewhere. Offset companies typically buy carbon credits from projects that plant trees or encourage a switch from fossil fuels to renewable energy. They sell credits to individuals and companies that want to go "carbon neutral". Some climate experts say offsets are dangerous because they dissuade people from changing their behaviour.

The effectiveness of reducing carbon dioxide emissions, and the implications for economic growth and national development, vary

depending on the level of development of the country in question. HICs have greater economic resources to help solve the problem (for example, by developing alternative sources of energy).

Adaptation strategies

It is possible to reduce human emissions of greenhouse gases substantially. The technologies are within reach, and measures such as energy efficiency, low-carbon electricity, and fuel switching (for example, electrification of buildings and vehicles) are all possible. Nevertheless, even with these, CO_2 will continue to increase for a number of decades. By the time the oceans warm they are likely to add a further 0.6°C to global temperatures. Thus, as well as trying to mitigate climate change, humanity will need to adapt to climate change.

Adaptation strategies can be used to reduce adverse effects and maximize any positive effects. Examples of adaptations include flood defences, vaccination programmes, desalination plants and planting of crops in previously unsuitable climates. Adaptive capacity varies from place to place and can depend on financial and technological resources. HICs can provide economic and technological support to MICs and LICs.

In agriculture, crop varieties must be made more resilient to higher temperatures and more frequent floods and droughts. Cities need to be protected against rising ocean levels and the greater likelihood of storm surges and flooding. (See pages 82 for a case study of the Thames Barrier.) The geographic range of some diseases, such as malaria, will spread as temperatures rise, so more widespread vaccination programmes will be needed to deal with this. To cope with changes in the supply of (and demand for) water, more desalination plants will be required. These are expensive and some LICs may struggle to meet the demand for fresh water.

Civil society and corporate strategies to address climate change

There are many examples of civil societies engaged in global climate change, including the World Wide Fund for Nature (WWF), Greenpeace and Climate Action Network. For example, the WWF is attempting to tackle climate change in a number of ways, by:

- pressurizing major mature economies and emerging economies to reduce greenhouse gas emissions
- calling on governments to sign up to international agreements to:
  - reduce the use of fossil fuels and to conserve forests
  - work towards a transition to 100 per cent renewable energy by 2050
  - reduce emissions from aviation
- trying to encourage people to use new technologies, have greener lifestyles and to call for climate-smart legislation.

One of WWF-UK's schemes is the One in Five Challenge, which aims to encourage companies and government agencies to reduce the environmental impact of their business travel and other activities. It challenges companies to cut one flight out of five and gives public recognition for the achievement. WWF-UK argues that not only is this

Activity 5

1. Suggest why some people believe that attempts to reduce emissions of greenhouse gases could cause job losses and make a country less competitive internationally.
2. Suggest how attempts to reduce emissions of greenhouse gases could create jobs and make a country more competitive internationally.

reduction in number of flights good for the environment but it also benefits the companies and organizations involved. These benefits include:

- financial savings through reductions in flights and accommodation
- time savings and less time spent travelling, giving more time for working
- improvements in productivity as it is easier to work in an office or a train than on a plane
- improvements in family life as there is much less time away from home, fewer early starts and late finishes
- higher staff retention due to improved working conditions.

One company that took the One in Five Challenge was Vodafone. Vodafone routinely uses a mix of video-conferencing, voicemail, instant messaging and web software to facilitate communications between its staff. In 2010 it invested £600,000 in video-conferencing facilities. In the first five months after the investment, it spent 3,600 hours on video-conferencing and travelled 320,000 km less on business. The number of business flights was cut from 14,379 to 10,630 km and it reduced its CO_2 emissions by 617 tonnes. The company saved about one-third of its previous costs of air travel.

ATL Research skills

To find out how Vodafone is trying to reduce its impact on the natural environment, visit its Responsibility Store at www.vodafone.co.uk/our-responsibilities/our-environment/.

How successful have these initiatives been? Make a short presentation of your results.

Case study

Corporate change mitigation efforts in the USA

In the Climate Change Performance Index of 2011, the USA was placed 54th out of 60 in terms of emission trends, emission levels, and government climate policy. By 2016 it had risen to 34th position. Part of this improvement in performance is the result of state and corporate initiatives. A number of large companies have strategies for CO_2 emissions and the states involved include California, Connecticut, Hawaii, Maine, Maryland and Massachusetts. The most ambitious plans are in California, Florida and New York, which have legislation in place to reduce greenhouse gas emissions by 80 per cent, compared with 1990 levels, by 2050.

The USA has a large-scale wind, solar, biomass and waste-from-energy sector and industries associated with these sectors are showing an interest and a desire to replace fossil fuels. However, companies not associated with the renewable energy industry are also attempting to reduce CO_2 emissions. In 2007, 28 companies formed the US Climate Action Partnership (USCAP), including Chrysler, General Electric, General Motors, Rio Tinto, Shell and Siemens. USCAP has lobbied the government to set legally binding emissions targets and has called for a reduction target of 80 per cent by 2050. It suggests a "cap and trade" system, carbon capture and storage (CCS), and more efficient technology for buildings and transport. However, critics argue that USCAP has no power and that its role is primarily one of public relations for the companies involved.

In 2008, Levi Strauss, Nike, Starbucks and others joined with the Coalition for Environmentally Responsible Economies to form the Business for Innovative Climate and Energy Policy (BICEP). BICEP calls for a reduction in greenhouse gas emissions to 25 per cent below 1990 levels by 2020, and 80 per cent by 2050. It also calls for increased energy efficiency, investments in low-carbon energy, and the contribution of green energy sources to increase to 20 per cent by 2020

Case study (continued)

and 30 per cent by 2030, as well as a limit on the construction of new coal-fired power stations unless they have the technology to capture and store carbon.

Thus, many US corporations are calling for climate mitigation. Nevertheless, many US companies continue to lobby the government to block such measures, and many US citizens do not want their government to pursue policies that they feel would lead to a decline in US competitiveness and job losses.

Concepts in context

There are many **possibilities** in relation to adaptation and mitigation strategies to deal with climate change. Decision-makers have the **power** to implement various choices. There are large-scale variations in the exposure and vulnerability to climate change, just as there are large-scale variations in adaptation and mitigation schemes. Climate change strategies may be initiated by NGOs, national governments, civil societies, corporations and individuals.

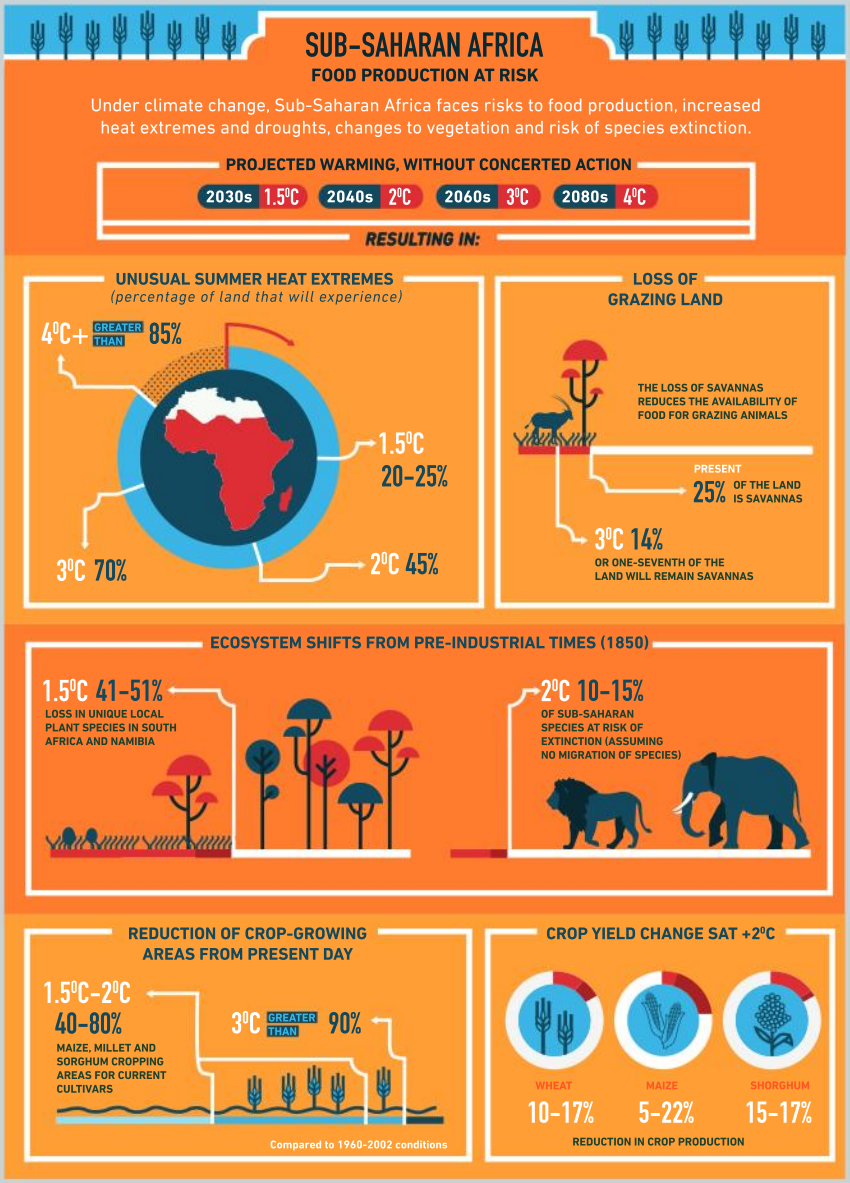
Check your understanding

1. Outline the groups of people most vulnerable to global climate change.
2. Examine the factors that increase the vulnerability to global climate change.
3. Describe the changes in rainfall at Rajshahi Station, Bangladesh, between 1962 and 2012.
4. Compare the pre, during and post-disaster coping mechanisms for communities along the Padma River, Bangladesh.
5. Outline the main differences between the Kyoto Protcol and the Paris Agreement.
6. Distinguish between adaptation and mitigation.
7. Outline the main pollution management strategies for global warming.
8. Explain the term "carbon capture and sequestration" (CCS).
9. Explain how carbon taxes operate.
10. Examine the role of civil societies and corporations in the attempt to address global climate change.

Synthesis and evaluation

The material in this chapter has shown the complexity of the dynamic climate system and the **spatial interactions** of different processes and feedback mechanisms.

There are many different perspectives on the urgency of climate change. For those most affected, such as indigenous peoples or communities living in low-lying areas like the Padma River, the threat is very real and immediate. In contrast, some stakeholders may decide that the need for economic development and improving the standard of living are more important than the environmental damage caused by climate change. There are winners and losers in the fight against global climate change, and poor communities/LICs are potentially less able to deal with its consequences. Geographers use decision-making skills to suggest the best and most practical ways to deal with global climate change. Actions to address the challenges of climate change range in scale, from the individual and the household to nation states and the international community.



(a) **(i)** Describe the change in albedo as ice melts and is replaced by soil/bare rock. (2 marks)

(ii) Distinguish between the greenhouse effect and global warming. (2 marks)

(iii) Using examples, distinguish between methods of adaptation and mitigation in relation to climate change. (3+3 marks)

The infographic shows the potential of climate change on sub-Saharan Africa.

(b) **(i)** Outline the likely changes in crop production in sub-Saharan Africa, if there is a temperature increase of 2°C. (2 marks)

(ii) Suggest **two** reasons for the changes you have identified in (i). (2 marks)

(iii) Explain **two** reasons why there could be a decrease in biodiversity in sub-Saharan Africa due to climate change. (2+2 marks)

(iv) Explain **one** social problem that could result from climate change in sub-Saharan Africa. (2 marks)

(c) **Either**

"Climate change is a vast global experiment with very uncertain outcomes for human and biological communities." Discuss this statement. (10 marks)

Or

Eamine the effects of global climate change on communities and natural systems. (10 marks)

UNIT 3
GLOBAL RESOURCE CONSUMPTION AND SECURITY

Key terms

Biocapacity	The land and water to provide resources for humanity.
Ecological footprint	The hypothetical area of land required by a society, a group or an individual to fulfil all their resource needs and assimilate all their waste. It is measured in global hectares (gha).
Energy security	Access to clean, reliable and affordable energy sources for cooking, heating, lighting, communications and productive uses.
Food security	The "availability and access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active and healthy life" (FAO).
Nexus	The interrelationship, interdependence and interactions between water, food and energy.
Virtual (or embedded) water	The way in which water is transferred from one country to another through its exports.
Water security	Continuing access to safe drinking water and sanitation.

Key questions

1. How do global development **processes** affect resource availability and consumption?
2. How does pressure on resources affect the future security of **places**?
3. What are the **possibilities** for managing resources sustainably and **power** over the decision-making process?

As countries increase their standard of living, the global demand for resources – including water, food and energy – is increasing. New sources of modern energy include hydropower, wind, solar and electric. The use of any one of these resources has an impact on other resources. For example, the export of food has implications for water and for energy. In addition, countries that trade are essentially trading water and energy resources "virtually". Resource use can be measured by using the ecological footprint concept, which varies between countries and changes over time.

As demand for resources increases, issues related to national resource security are also likely to increase. Some countries are using resources from other countries to reduce pressure on their own resources but at the expense of those other countries. Moreover, some countries export their waste, which has important health implications for receiving countries. Methods of waste management are tending to encourage more recycling, reuse and reduction of waste.

There is an ongoing debate between the neo-Malthusians and the anti-Malthusians over the relationship between population and resources. The circular economy attempts to reuse and recover the resources that are used, and the UN Sustainable Development Goals include "Affordable and clean energy" as well as "Responsible consumption and production".

1 Global trends in consumption

Poverty reduction and the global middle class

One of the main successes of the Millennium Development Goals (MDGs) was the global reduction in extreme poverty between 2000 and 2015. In 1990 around 50 per cent of people in LICs lived on less than $1.25 a day; by 2015 it was around 14 per cent. In absolute terms, the number of people living in extreme poverty fell from 1.9 billion in 1990 to 836 million in 2015. In contrast, the number of people classified as middle class – that is, living on at least $4/day – almost tripled between 1900 and 2015. This population accounted for 18 per cent of people in LICs in 1900 and nearly 50 per cent in 2015.

These increasing numbers of middle-class people are the result of the increase in average incomes and the fall in the number of people living in absolute poverty (Figure 3.1). In 2009, there were around 1.8 billion middle-class people, mainly in Europe (664 million), Asia (525 million) and North America (338 million). However, there was a small but increasing proportion of middle class in all other regions, too.

The increasing middle-class sector is an important economic feature, since it helps to increase sales of goods such as electrical goods, mobile phones and cars. For example, sales of cars and motorbikes have increased by over 800 per cent since 2009. However, continued growth is not always guaranteed. For example, during the 1960s Brazil and South Korea had similar incomes and economic growth rates. By the 1980s, Brazil's middle class accounted for less than 30 per cent of the population, whereas Korea's was over 50 per cent.

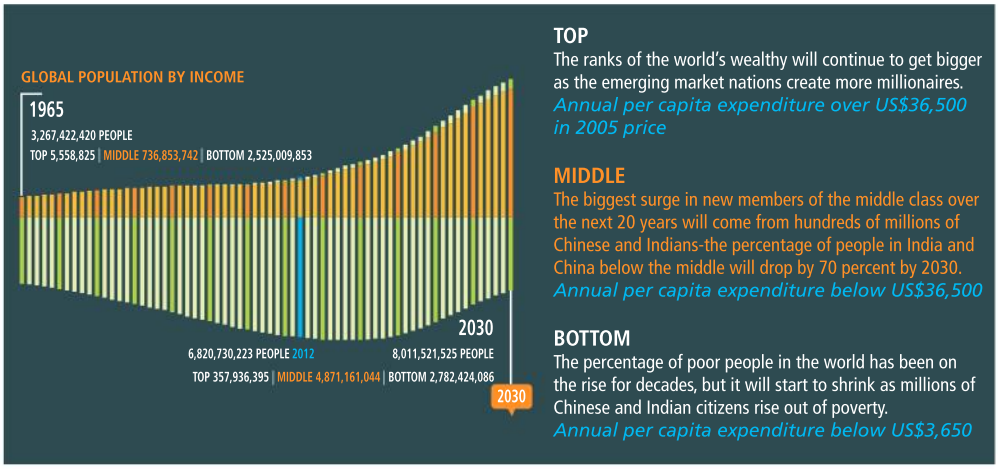
Conceptual understanding

Key question

How do global development **processes** affect resource availability and consumption?

Key content

- Global and regional/continental progress towards poverty reduction, including the growth of the "new global middle class".
- Measuring trends in resource consumption, including individual, national, and global ecological footprints.
- An overview of global patterns and trends in the availability and consumption of water, including embedded water in food and manufactured goods.
- An overview of global patterns and trends in the availability and consumption of:
- water, including embedded water in food and manufactured goods
- land/food, including changing diets in middle-income countries
- energy, including the relative and changing importance of hydrocarbons, nuclear power, renewables, new sources of modern energy.

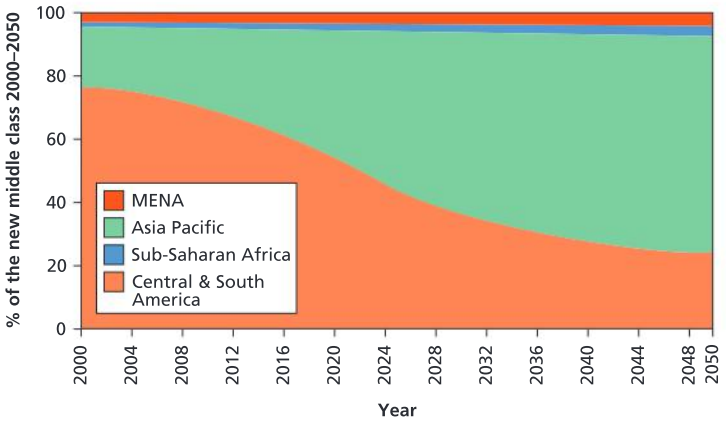


▲ **Figure 3.1:** The rising numbers of the middle class

ATL Research skills

Visit http://www.reuters.com/middle-class-infographic

and see how the distribution of the world's middle class changed since 1965 and is predicted to change by 2030.



▲ **Figure 3.2:** The growth of the middle class by world region

Korea's middle class allowed Korea to diversify its economy away from export-orientation to domestic consumption.

Not all the middle class has economic security, however. Many people on incomes of over $4/day remain vulnerable to unemployment and underemployment. For many working in informal activities, there is little or no economic or social security.

There has also been uneven progress in reducing poverty. Some 800 million people still live in extreme poverty and approximately half of all global workers work in unsafe conditions. People are disadvantaged on account of their gender, ethnicity, disability and geographic location.

Case study

Economic growth in Vietnam

Since 1990, economic growth in Vietnam has averaged 6 per cent per year. As a result, it has developed from one of the world's poorest countries into a middle-income country (MIC). One of the main reasons for its success has been its proximity to China, which gives it a competitive advantage. As wages in China have risen, firms have relocated to low-cost Vietnam. In addition, Vietnam has a young population (see pages 35–35 for a discussion of the demographic dividend); whereas China's median age is 36, Vietnam's is only 30.

The Vietnamese government has also used a series of five-year plans to guide its development. It has invested in education, spending some 6.3 per cent of its GDP on education, around 2 per cent more than most LICs and MICs. In addition, Vietnam is a member of the Trans-Pacific Partnerships (TPP), a 12-country trade bloc that includes the USA and Japan. It also has a free trade agreement with Korea and is negotiating one with the EU.

There is no single reason for Vietnam's emergence as a middle-income country, but it has created a number of features that make it a good country to invest in.

Country profile

Population 92.5 million
Average annual growth rate 2009–2014: 5.9%

Structure of employment:

Agriculture 46.8%
Industry 21.2%
Services 32.0%

Trade

Principal exports ($bn):

Telephones and mobile phones 23.6
Textiles and garments 20.9
Computers and electronic products 11.4
Footwear 10.3
Total 150.1

Principal imports ($bn):

Machinery and equipment 22.4
Electronics, computers and parts 18.7
Telephones and mobile phones 9.4
Textiles 8.5
Total (incl. other) 149.3

Main export destinations (% of total)
USA 20.0
China 10.4
Japan 10.3
South Korea 5.0

Main origin of imports (% of total)
China 30.3
South Korea 15.0
Japan 8.9
Thailand 4.9

In Latin America, for example, women are more likely to live in poverty than men: the proportion of poor women to poor men increased from 108 women to 100 men in 1997 to 117 women to 100 men in 2012. Globally, about 75 per cent per cent of men are part of the global labour force, but only around 50 per cent of women are, and women earn, on average, 25 per cent less than men.

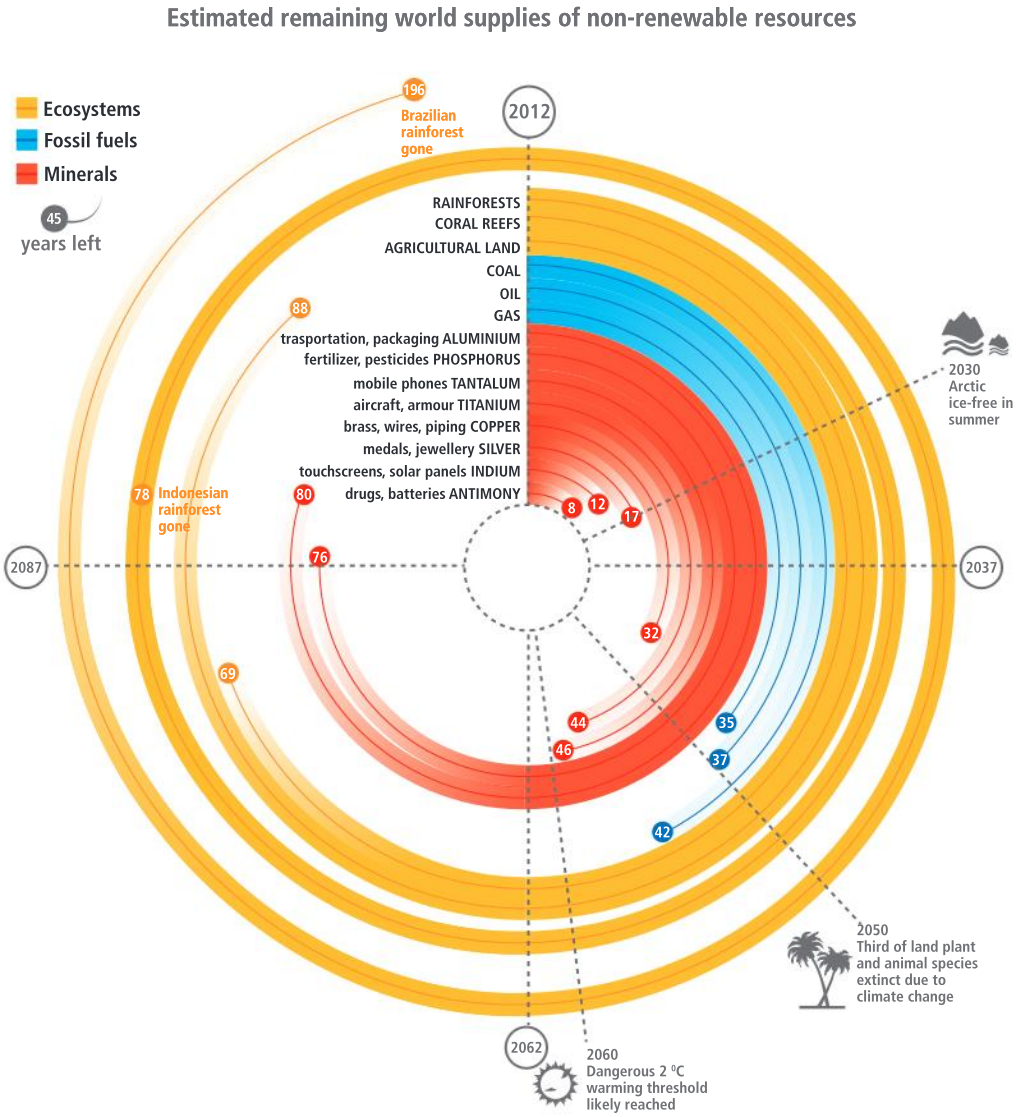
Global consumption of resources

As the world's population increases, and particularly as the number of wealthy people grows, consumption of resources increases. Many of the world's resources are in danger of being used up, as shown in Figure 3.3.

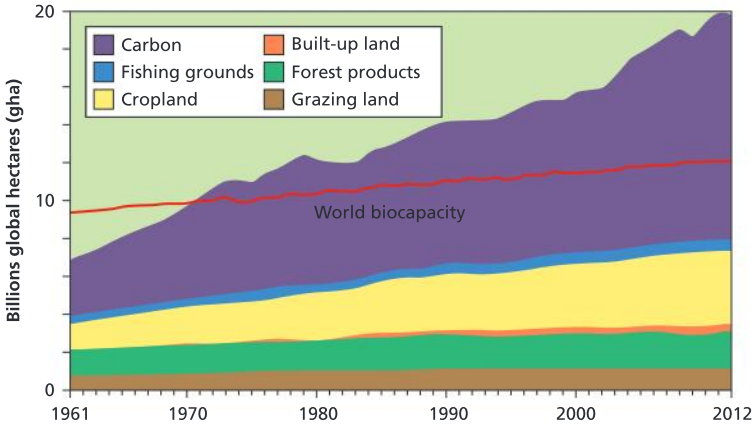
Ecological footprints

An ecological footprint is the hypothetical area of land required by a society, a group or an individual to fulfil all their resource needs and assimilate all their wastes. It is measured in global hectares (gha). The term was initially coined by William Rees in 1992, and further developed with Mathis Wackernagel in his book *Our Ecological Footprint: Reducing Human Impact on the Earth* (1998). A country described as having an ecological footprint of 3.2 times its own geographical area is consuming resources and assimilating its wastes on a scale that would require a land area 3.2 times larger than the actual size of the country.

Ecological footprints can act as a model for monitoring environmental impact. They can also allow for direct comparisons between groups and individuals, such as comparing LICs and HICs. They can highlight sustainable and unsustainable lifestyles; for example, populations with a larger footprint than their land area are living beyond sustainable limits.



▲ **Figure 3.3:** The human consumption of major global resources



▲ **Figure 3.4:** Changes in the components of the ecological footprints, 1961 to 2012

Wackernagel and Rees originally estimated that the available biological capacity for the population of the Earth (around 6 billion people at that time but more than 7 billion now) was about 1.3 hectares of land per person (or 1.8 global hectares if marine areas are included as a source of productivity).

The United Nations estimates that by 2030 we will need the equivalent of two Earths to supply the world's population with all the resources it wants. The Global Footprint Network uses the concept of Earth Overshoot Day – the day in the year when humanity has used up all the resources that it takes the planet to regenerate. In 2000, Earth Overshoot Day was in October, by 2015 it was 13 August and by 2016 it was 8 August.

A country increases its ecological footprint by:

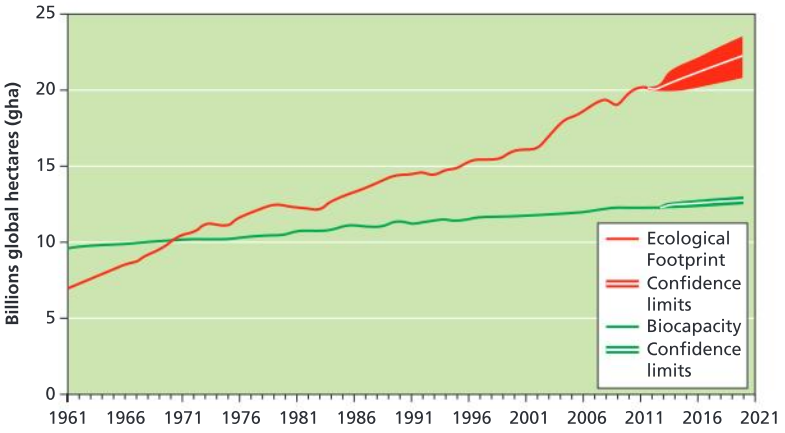
- relying heavily on fossil fuels
- increasing its use of technology and, therefore, energy (but technology can also reduce the footprint)
- high levels of imported resources (which have high transport costs)
- large per capita production of carbon waste (that is, high energy use, high fossil fuel use)
- large per capita consumption of food
- having a meat-rich diet.

A country can reduce its ecological footprint by:

- reducing the amounts of resources it uses
- recycling resources
- reusing resources
- improving the efficiency of resource use
- reducing the amount of pollution it produces
- transporting waste to other countries to deal with
- improving technology to increase carrying capacity
- importing more resources from other countries
- reducing its population to reduce resource use
- using technology to increase carrying capacity (for example, using GM crops to increase yield on the same amount of land)
- using technology to intensify land use.

However, humanity is increasing the amounts of resources that it uses, and the capacity of the Earth to sustain this use of resources is diminishing (Figure 3.5).

Many innovations for reducing ecological footprints are still in the early stages (for example, renewable technologies) but these could have a huge impact in the future. The funding to support technological change exists in HICs, which currently face the biggest problem with their ecological footprints (Figure 3.6).



▲ **Figure 3.5:** Changes in ecological footprint and the world's biocapacity

Calculating ecological footprints

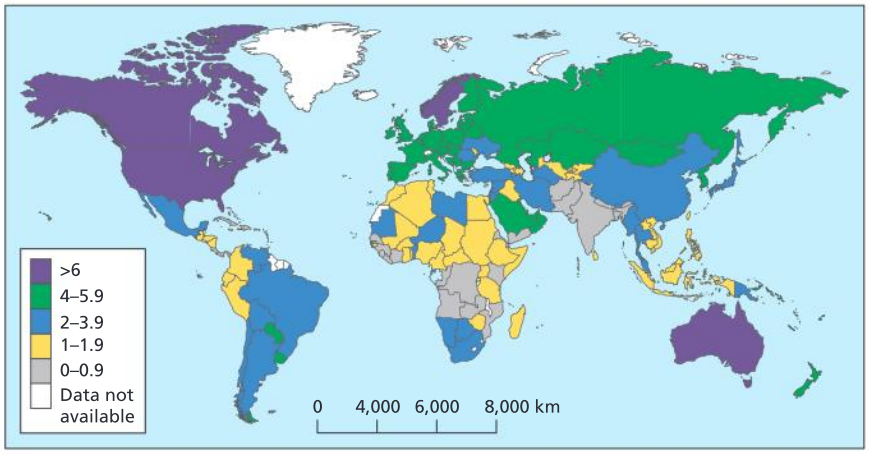
Ideally, all resource consumption and land uses are included in an ecological footprint calculation. However, this would make the calculation very complex. Ecological footprints are usually simplified, and an approximation achieved, by using only net carbon dioxide emissions.

Factors used in a full ecological footprint calculation include the following:

- bioproductive (currently used) land – land used for food and materials such as farmland, gardens, pasture and managed forest
- bioproductive sea – the sea area used for human consumption (often limited to coastal areas)
- energy land – an equivalent amount of land that would be required to support renewable energy instead of non-renewable energy. The amount of energy land depends on the method of energy generation (large in the case of fossil fuel use) and is difficult to estimate for the planet
- built (consumed) land – land used for development, such as roads and buildings
- biodiversity land – land required to support all non-human species
- non-productive land – land such as deserts, subtracted from the total land available.

Thus the simplified calculation of ecological footprint clearly ignores the following factors that influence the amount of land a population needs to support itself:

- land or water required to provide aquatic and atmospheric resources
- land or water needed to assimilate wastes other than carbon dioxide
- land used to produce materials imported into the country to subsidize arable land and increase yields
- replacement of productive land lost through urbanization.



▲ **Figure 3.6:** The ecological footprints (in global hectares) of countries around the world, 2014

Table 3.1: The world's largest and some of the smallest ecological footprints, 2016

Rank	Country	Ecological footprint (gha/person)
1	Luxembourg	15.82
2	Qatar	10.80
3	Australia	9.31
4	USA	8.22
5	Canada	8.17
64	China	3.38
152	India	1.16
159	Ethiopia	1.02
162	Nepal	0.98
171	Bangladesh	0.72

Ecological footprints in HICs and LICs

Given their different standards of living and levels of resource consumption, energy usage and waste production, disparities are to be expected between the ecological footprints of LICs and HICs. LICs tend to have smaller ecological footprints than HICs (Table 3.1) because of their much smaller rates of resource consumption. In HICs, people have more disposable income, which means that consumption and demand for energy resources are high. HICs' resource use is often wasteful and HICs produce far more waste and pollution as by-products of production. People in LICs, by contrast, have less to spend on consumption and the informal economy in LICs is responsible for recycling many resources. However, as LICs develop, their ecological footprint size increases.

A meat-eating diet, prevalent in HICs where 30 per cent of the diet may be based on animal protein, requires the use of much more land than a vegetarian diet. This is because animals use up about 90 per cent of the food they eat for things like respiration, mobility and feeding; only a small percentage is converted into new biomass. More of the energy from the crop goes to humans if the crop is eaten directly (as in LICs, where less meat features in the diet – about 12 per cent). Data for food consumption are often given in grain equivalents; so a population with a meat-rich diet consumes a higher grain equivalent than a population feeding directly on grain. Since people in HICs obtain more than twice as much energy from animal products as people in LICs, grain production is higher, using high-yield farming strategies.

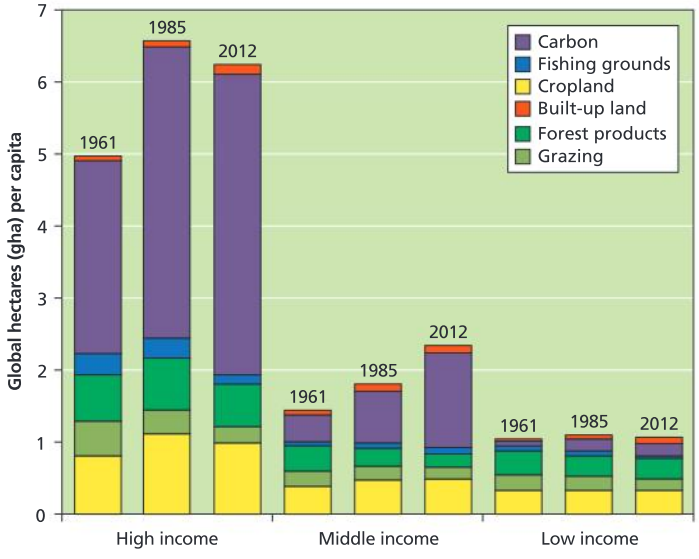
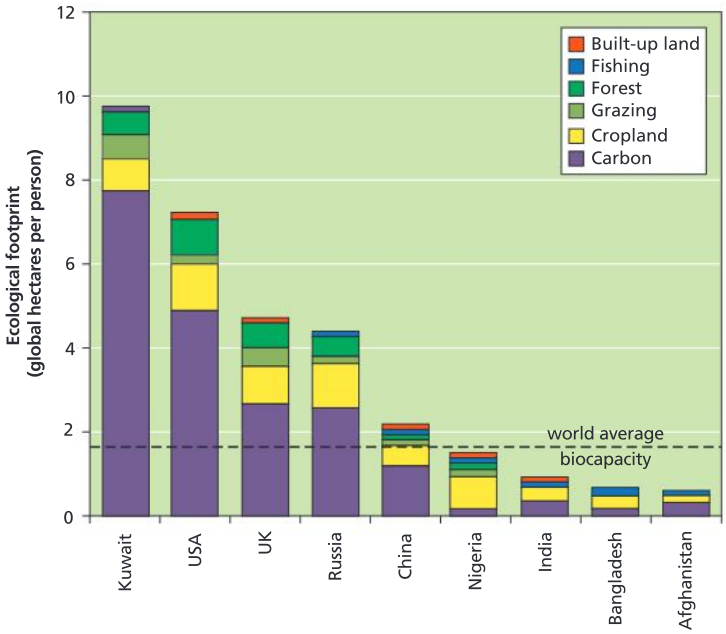


Figure 3.7: Changes in ecological footprints for HICs, MICs and LICs over time

Greenhouse gas emissions from agriculture also affect footprint totals. According to the International Panel on Climate Change (IPCC), the agricultural sector emits between 5.1 and 6.1 billion tonnes of greenhouse gases annually, about 10–12 per cent of total greenhouse gas emissions. The main sources of these gases are nitrous oxides from fertilizer, methane emissions from cows, and biomass burning.

Populations more dependent on fossil fuels have higher carbon dioxide emissions. Fixation of carbon dioxide is clearly dependent on climatic region and vegetation type, with countries nearer the equator containing vegetation with higher rates of net primary production. Lower rates of carbon dioxide uptake in HICs compared to LICs, and higher rates of emissions, contribute to the higher ecological footprints in HICs.

Ecological footprints are useful for describing the impact of humans on resources. However,



▲ **Figure 3.8:** Selected ecological footprints for 2014

they are only a tool and much of the data is generalized. The 2014 data show a large difference between the ecological footprints of rich countries (HICs), with oil-rich countries at one end of the scale and poor countries (LICs) at the other.

Patterns and trends in water availability and consumption

Water is unevenly distributed over the world, and over 780 million people do not have access to clean water. The global population is likely to increase to 9 billion by 2050, which, combined with changes in diet, will increase demand for water. Moreover, the increased demand for water for hydroelectric power will further strain the earth's water resources.

Water availability is likely to decrease in many regions. For example, 300 million people in sub-Saharan Africa live in a water-scarce environment and climate change increases water stress in many areas. Central and Southern Europe are predicted to get drier as a result of climate change.

HICs are tending to maintain or increase their consumption of resources such as water, although an increasing proportion of this water is embedded in agricultural and manufactured products. The average North American and Western European adult consumes $3m^3$/day, compared with around $1.4m^3$/day in Asia and $1.1m^3$/day in Africa. In some cases, it is not just the transfer of water through products that reduces availability but also the loss of land through land grabs. Saudi Arabia cut production of cereals at home by 12 per cent but, through a series of land grabs, produced the cereals it needed in parts of Africa.

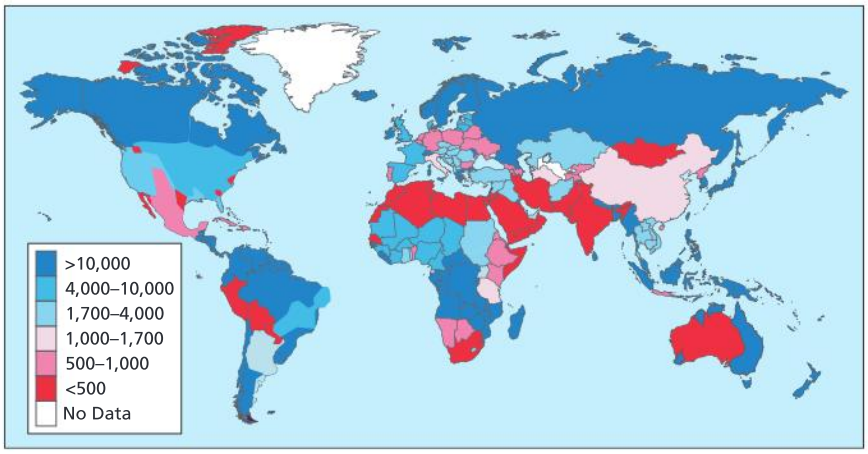
Activity 1

1. Describe the changes to the world ecological footprint, as shown in Figure 3.4.
2. Compare and contrast changes in the size and composition of ecological footprints for high-, middle- and low-income countries between 1961 and 2012 (Figure 3.7).
3. a. Compare and contrast the ecological footprints for the countries shown in Figure 3.8.
   b. Suggest reasons for the differences you have described.
4. Visit http://footprint.wwf.org.uk/ and calculate your ecological footprint. Which country has the nearest ecological footprint to yours?

Common mistake

✗ Some students think that the only impact people have is ecological, as measured by ecological footprints.

✓ There are social and economic impacts as well. People may exploit workers, and have an impact on sustainable development for others.



▲ **Figure 3.9:** Annual renewable water (m^3/person/year)

There are major differences in how water is used by HICs, NICs and LICs. Industrial use of water increases with GNI, rising from around 10 per cent for LICs to about 60 per cent for HICs (Figure 3.10).

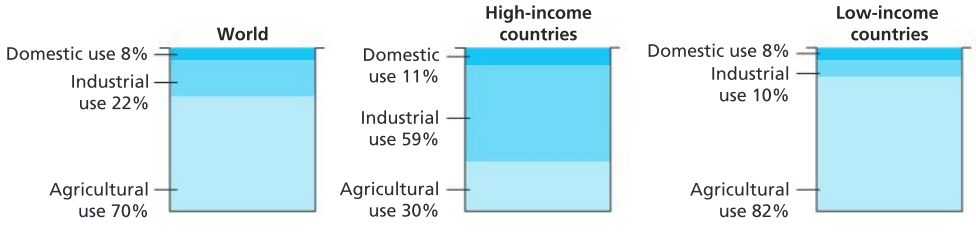
More water will be required to produce food for the world's growing population, partly because of changes in diet. Many industries, in particular the food, drinks, textiles and pharmaceuticals industries, need large quantities of water for their products, which will increase demand for water over the coming decades. Much of the growth will be in LICs, many of which are already experiencing water stress.

A number of trends are increasing the pressure to manage water more efficiently. These include:

- population growth – set to reach 9 billion by 2050; some estimates say it may eventually peak at 11 billion
- the growing middle class – increasing affluence leads to greater water consumption, for example showers, baths, gardening
- the growth of tourism and recreation, for example golf courses, water parks, swimming pools
- urbanization – urban areas require significant investment in water and sanitation facilities to get water to people and to remove waste products hygienically
- climate change – no one is precisely sure how this will influence the water supply but there will be winners and losers in the supply of fresh water.

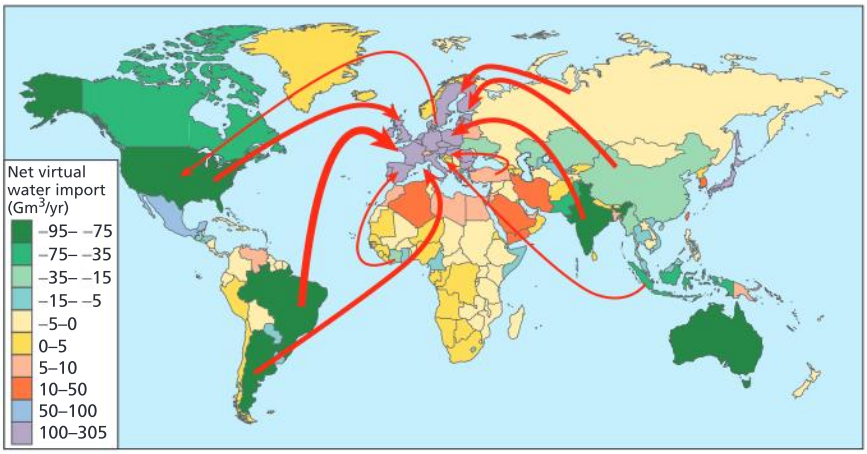
See also Option A, Freshwater.

The concept of virtual (or embedded) water refers to the way in which water is transferred from one country to another through its exports



▶ **Figure 3.10:** Water use in the two main income groups of countries and the world

(Figures 3.11 and 3.12). These exports may be foods, flowers or manufactured goods, for example. It allows countries with limited water resources to "outsource" their water from countries that have more water resources. It also allows a country to reduce the use of its own water resources by importing goods. For example, Mexico imports maize, and thereby saves 12 billion cubic metres of water each year.

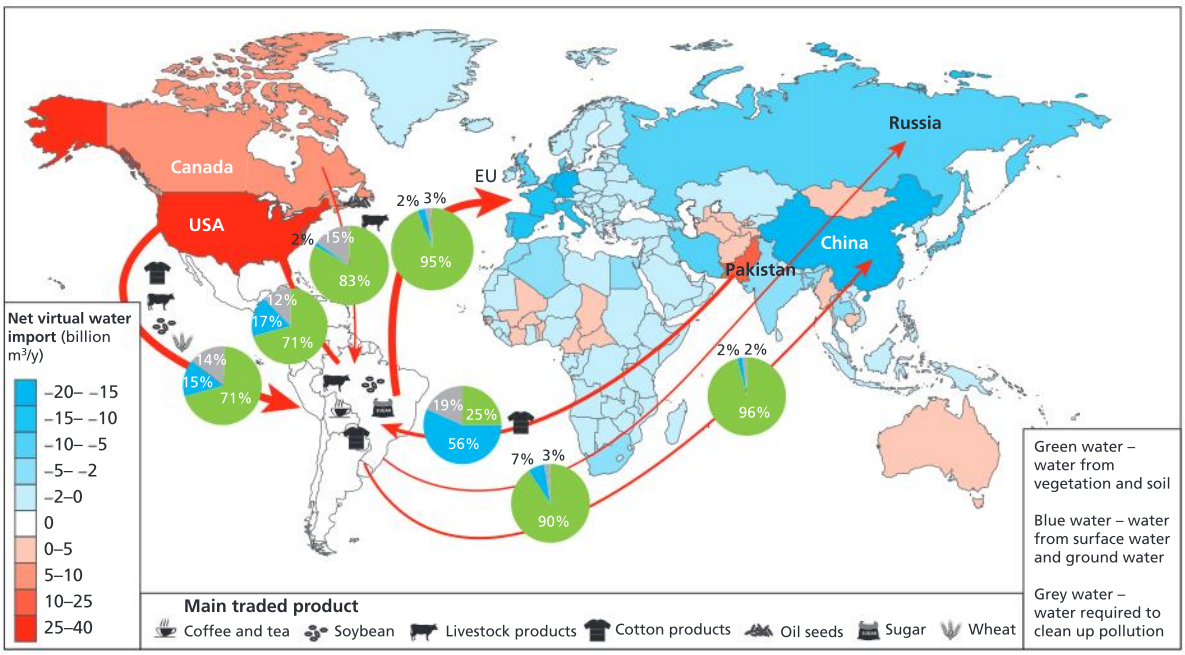


▲ **Figure 3.11:** Virtual water imports into Europe, 2011 (negative values identify exports of virtual water, positive values identify imports)

Figure 3.12 shows countries with net virtual water imports related to the import of agricultural and industrial products from Latin American countries and countries with net virtual water exports from agricultural and industrial products to Latin American countries, 1996–2005. Only the biggest gross virtual water flows (over 10 billion cubic metres per year) are shown.

Activity 2

1. Describe the global variations in renewable water supplies.
2. Compare the uses of water between HICs and LICs, as shown in Figure 3.10.
3. Compare and contrast the imports and exports of virtual water from Latin America, as shown in Figure 3.12.



▲ **Figure 3.12:** Virtual water imports from Latin American countries (green) and virtual water exports to Latin American countries (red), 1996–2005

Patterns and trends in availability of land and food consumption

Despite the increase in the world's population, food intake (measured in calorie intake) has steadily increased on a global scale. While calorie intake has remained steady in sub-Saharan Africa, it has increased dramatically in East Asia, the Middle East and North Africa.

There has also been a change in diet away from cereals towards a more varied diet including meat, vegetables and dairy products. This pattern is most clearly observed as LICs become MICs. Between 1964 and 1999, meat consumption per capita increased by 150 per cent in LICs, and consumption of milk and dairy products rose by 60 per cent. Global meat production rose from 218 million tonnes in 1998–9 and is predicted to reach 376 million tonnes by 2030. Food consumption is price-dependent: following a decline in meat prices, consumption increases, especially among poorer households. However, demand is "inelastic", which means that a person's consumption of food will only increase up to a certain point, even if they have more money available to pay for it.

Increasing urbanization is another factor influencing the demand for meat. Some of this is used for the fast-food industry, and some for mass-produced products (see food deserts on page 292). It has been estimated that the number of people that can be supported on 1 hectare varies from 22 for potatoes, 19 for rice, 2 for lamb and 1 for beef.

Since 1961, total fish supply and consumption have increased by about 3.6 per cent per year while the world's population has grown by 1.8 per cent over the same period. However, production from the world's ocean fisheries has levelled off since the 1970s, largely because of overfishing in the world's main fisheries. However, the considerable growth in aquaculture has filled the gap left by the drop in wild fish stocks.

In recent years, the growth rates of food production and crop yields have been falling. Some of this reduction can be put down to natural hazards (fires, floods, drought), global climate change, and the use of land to produce biofuels. Food shortages have led to riots in Indonesia, Egypt and across North Africa. Some of these in turn have led to widespread protest, and in the case of the MENA region, the Arab Spring.

There are three main ways of increasing crop production:

- expanding the area farmed
- multicropping, often using irrigation
- using high-yielding varieties or genetically modified organisms.

Some scientists believe that all three of these may be reaching their limits. Equally, others suggest that there are many other ways of increasing food production, including reducing food losses and improving food storage.

As the world's population growth slows and high rates of food consumption per person have been reached in many countries, the growth in the demand for food is decreasing. According to the FAO, the

ATL Research activity

Use the CIA World Factbook to find out which countries have the largest proven oil reserves. https://www.cia.gov/library/publications/resources/the-world-factbook/.

Choose any country with proven oil reserves. Click on the country and scroll down to energy. Click on Crude oil proven reserves, and then click on Country comparison to the world. This will provide you with a list of the world's countries with proven oil reserves.

Outline the implications of your findings.

growth in the demand for food is likely to fall from 2.2 per cent per year to 1.5 per cent per year for the next 30 years or so.

Patterns and trends in availability and consumption of energy

According to the analyst Chris Ruppel (2006), the period from 1985 to 2003 was an era of energy security, and since 2004 there has been an era of energy insecurity. Ruppel claims that following the energy crisis of 1973 and the Iraq War (1990–91), there was a period of low oil prices and energy security. However, insecurity has risen for a number of reasons, including:

- increased demand, especially from newly industrializing countries (NICs)
- decreased reserves as supplies are used up
- geopolitical developments: countries with oil resources such as Russia have been able to "flex their economic muscles" in response to the decreasing resources in the Middle East and the North Sea
- global warming and natural disasters such as Hurricane Katrina (2005), which have increased awareness about the misuse of energy resources
- terrorist activity such as in Syria
- the conflict between Russia and Ukraine.

For most consumers, a diversified energy mix offers the most energy security. Depending on a single source, especially from a single supplier, is more likely to lead to energy insecurity.

The Middle East controls about 50 per cent of the world's remaining oil reserves. Saudi Arabia alone controls over 20 per cent. On the other hand, the USA, for example, consumes over 200 million barrels of oil per day but possesses less than 2 per cent of the world's oil reserves. This means that the USA has to source much of its oil from overseas, notably the Middle East. This gives the Middle East an economic and political advantage – countries that want oil may have to stay on friendly terms with those that supply it. (There are obvious exceptions, such as the US–British invasion of Iraq and the Iraq invasion of Kuwait.)

Countries that depend on the region for their oil need to:

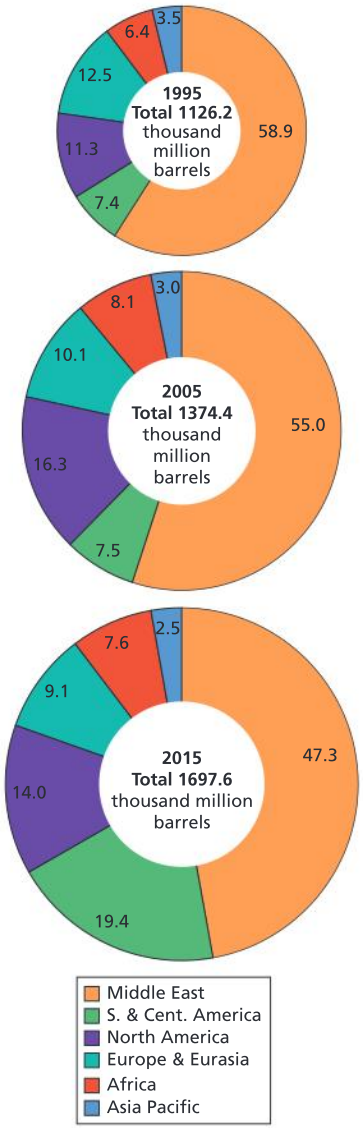
- help ensure political stability in the Middle East
- maintain good political links with the Middle East
- involve the Middle East in economic cooperation.

On the other hand, the situation is also an incentive for rich countries to increase energy conservation or develop alternative forms of energy. There is a need to reassess other energy sources such as coal, nuclear power and renewables, and to use energy less wastefully.

Energy can be generated from both renewable and non-renewable resources.

Activity 3

Compare and contrast the countries with the world's major oil reserves with those that are the main users of the reserves.



▲ **Figure 3.13:** Distribution of proved oil reserves, 1995, 2005 and 2015

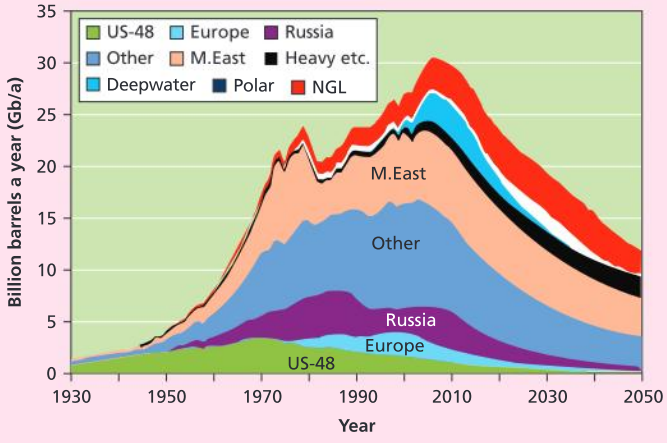
TOK: Has peak oil already happened?

Peak oil production refers to the year in which the world or an individual oil-producing country reaches its highest level of production, with production declining thereafter.

We depend on oil for many things: we use it for fuel, transport and heating, as a raw material in the plastics industry, and for fertilizers in food production. As oil production decreases after peak oil, so will all of these, unless we can find new materials and alternatives.

Peak oil varies country by country. The peak of oil discovery occurred in the 1960s, and by the 1980s the world was using more oil than was being discovered. Since then, the gap between use and discovery has been increasing, and many countries have passed their peak oil production. However, reliable data is hard to come by, and some data is jealously guarded.

▼ **Photo 3.1:** Nodding donkey, Brunei oilfield



▲ **Figure 3.14:** Peak oil

The International Energy Agency (IEA) suggests that global peak oil will occur before 2037. In contrast, the US Geological Survey suggests it will not occur until 2059. M. King Hubbert, who popularized the theory of peak oil, predicted that it would occur in 1995 "if there were no changes in contemporary trends". The Association for the Study of Peak Oil (ASPO) suggests it was in 2011. It claims that in 1950 the world consumed 4 billion barrels of oil per annum and the average discovery was 30 billion barrels per annum. Now, it says, the figures are reversed: new discoveries are around 4 billion barrels per year, with consumption of 30 billion barrels.

Non-renewable energy supplies include fossil fuels (such as coal, gas and oil). Fossil fuels contribute to the majority of humankind's energy supply and their use is expected to increase to meet global energy demand. The impact of their production and their emissions varies widely.

Fossil fuels cannot be renewed at the same rate as they are used; this results in depletion of the stock. Nuclear power can be considered non-renewable because the source of the fission process is uranium, which is a non-renewable form of natural capital.

Renewable energy sources include solar, hydroelectric, geothermal, biomass and tidal schemes. They can be large scale (such as country-wide schemes of energy generation) or small scale (microgeneration), within single houses or communities. Renewable energy resources are sustainable because there is no depletion of natural capital.

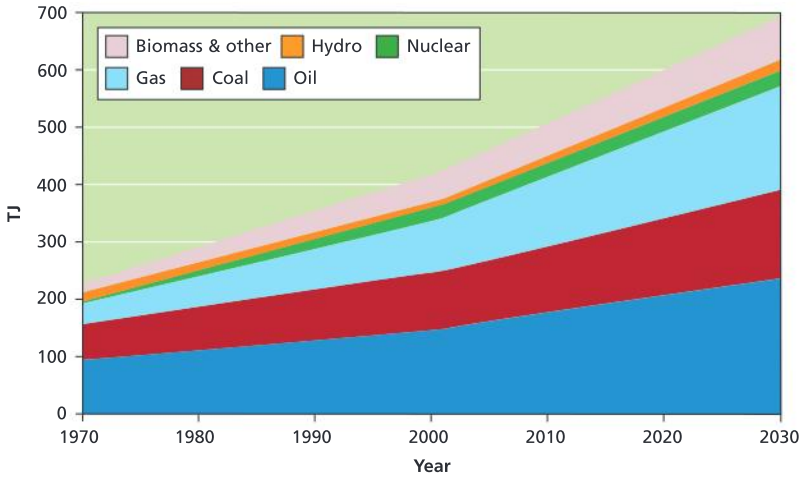
Activity 4

1. Describe the changing importance of energy sources between 1970 and 2015.
2. Comment on the predicted trend in energy sources between 2015 and 2030.

Non-renewable energy sources

The majority of the world's fuel comes from non-renewable sources and this is unlikely to change much by 2030 (Figure 3.15).

The economies of HICs have been based on high-energy generation built on fossil fuel use, whereas energy demands in LICs have traditionally been much lower because of less available technology and more reliance on natural resources (wood burning or other biomass sources). However, fossil fuel consumption is expected to increase in LICs in future because of their increasing population, rising incomes and technological development.



▲ **Figure 3.15:** The world's fuel sources, 1970–2030 (1 TJ = 1000 gigajoules)

Renewable sources of energy have been slow to grow globally. There are several reasons for this. Non-renewable sources of energy (such as gas) are generally cheaper than renewables. Gas is cheap because it is relatively plentiful, can be burned directly without the need for refining, and the technology is already in place to access the gas and burn it in existing gas-fired power stations. Renewables such as wind power often require high set-up costs (the installation of new wind turbines) and may still be unreliable.

In future, the cost of non-renewable energy is likely to be much higher. This is because stocks will become depleted and the easiest and most accessible resources will have already been mined. Only resources that are difficult to access (and therefore more costly to reach) will remain. The increasing scarcity of non-renewable resources will push costs up, and environmental taxes to compensate for global warming will also make fossil fuels more expensive. Therefore, in the future, renewable sources of energy will become more attractive and their increased use is likely. Adoption of sustainable energy will have a significant beneficial effect on the planet.

Advantages and disadvantages of fossil fuels

The advantages of fossil fuels are that they are relatively cheap and plentiful. At the same time, advanced technologies have been developed to allow safe extraction and the technology already exists for their use (for example, the combustion engine). The technology for controlling pollution from these fuels also exists. At present, no other energy source is close to replacing the amount of energy generated by fossil fuels. Oil and gas have a particular advantage in that they can be delivered over long distances by pipeline.

The two main disadvantages of fossil fuels are their contribution to climate change and their unsustainability. They are the most important contributor to the build-up of carbon dioxide in the atmosphere and consequently global warming. Use of fossil fuels is unsustainable because it implies liquidation of a finite stock of the resource: we can extend the lifetime of this resource through the use of shale gas and tar sands, but it is ultimately unsustainable. Other disadvantages are that these fuels will become increasingly difficult to extract, and extraction may become more and more potentially dangerous as mines get deeper and oil rigs like the Deepwater Horizon oil platform in the Gulf of Mexico (2010) are

placed further out to sea. Oil spillages from tankers and burst pipelines can severely damage natural ecosystems, and it is very expensive to clear up this sort of pollution. While coal from underground (extraction techniques using tunnelling) causes minimal disturbance at the surface, opencast mining clears habitat from the surface and can cause extensive environmental damage.

The availability of energy still relies extensively on fossil fuels, which account for around 80 per cent of global energy consumption. Consumption varies by country and by region (Table 3.2). The biggest consumers are the USA, China and Europe (together accounting for more than half of all fossil fuel consumption).

Renewable and alternative energy sources

Sources of energy with lower carbon dioxide emissions than fossil fuels include renewable energy (solar, biomass, hydropower, wind, wave, tidal and geothermal) and their use is expected to increase. Nuclear power is a low-carbon, low-emission, non-renewable resource but it is controversial due to the problem of storing the radioactive waste and the potential scale of any accident.

Advantages and disadvantages of nuclear power

Nuclear power plants produce radioactive wastes, including some that can remain dangerous for tens of thousands of years. Radioactivity is the result of nuclear changes in which unstable (radioactive) isotopes emit particles and energy continuously until the original isotope is changed into a stable one. When people are exposed to radiation, the DNA in their cells can be damaged by mutation, resulting in cancers, miscarriages or burns. If the mutation occurs in the reproductive cells (eggs or sperm), genetic defects can appear in subsequent generations.

Nuclear power generation has the following advantages:

- It does not emit carbon dioxide and so does not contribute to global warming.
- The technology is readily available.
- A large amount of electrical energy is generated in a single plant.
- It is very efficient, especially in comparison to fossil fuels: 1 kg of uranium contains 20,000 times more energy than 1 kg of coal.

Nuclear power generation has the following disadvantages:

- The radioactive waste from nuclear power stations is extremely dangerous and remains so for thousands of years. How best to dispose of this is still an unresolved problem.
- The associated risks are high. It is impossible to build a plant with 100 per cent reliability and there will always be a small probability of failure, as happened in the Chernobyl and Fukushima-Daiichi disasters. The more nuclear power plants (and nuclear-waste-storage shelters) are built, the higher the probability of a disastrous failure somewhere in the world.

- The potential of nuclear power plants to become targets for terrorist attack has been pointed out by opponents of this type of power generation.
- The energy source for nuclear energy is uranium, which is a scarce and non-renewable resource. Its supply is estimated to last for only the next 30–60 years depending on demand.
- The time frame needed to plan and build a new nuclear power plant is 20–30 years; uptake of nuclear power will therefore take time.

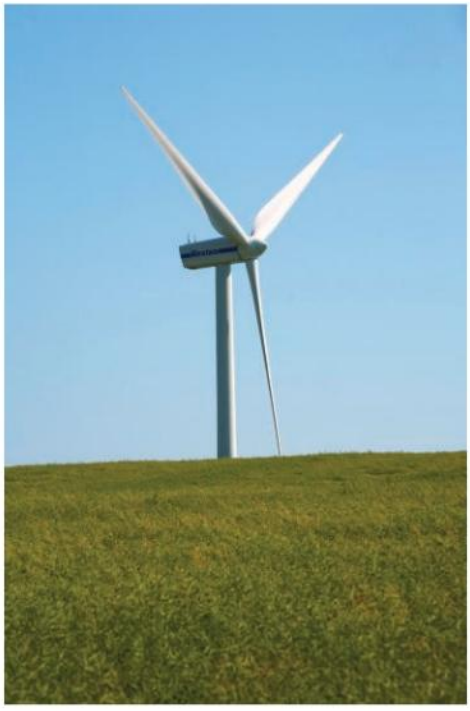
Advantages and disadvantages of renewables

Renewable energy sources include solar, biomass, hydropower, wind, wave, tidal and geothermal. The general advantages of renewable sources of energy are that they do not release pollutants such as greenhouse gases or chemicals that contribute to acid rain. Because they are renewable, they will not run out. Renewable energy produces fewer greenhouse gas emissions.

There are several restrictions that currently limit large-scale use of renewable energy sources. Fossil fuel resources are still economically cheaper to exploit, and the technologies to harness renewable sources are not available on a large scale. Inertia within the culture, for example the USA's car culture and traditions of both HICs and LICs, means that non-renewable resources are favoured (although certain renewable energy supplies have always been widely used in LICs). The locations available for renewable energy sources are often limited by politics – for example, sites for wind turbines are often not exploited because people living nearby do want their environment "spoilt" by the presence of the turbines. All these factors mean that renewable resources are not able to meet current demand.

Hydroelectric power (HEP) is a reliable form of energy generation using turbines that can be switched on whenever energy is needed. Once construction is complete, HEP schemes are relatively cheap to run. The dams that block the flow of water form large artificial lakes that can be used for leisure purposes, as food sources and for irrigation as well as electricity generation. However, there are several disadvantages to HEP. Vast areas may be flooded, involving loss of habitats, farmland and displacement of people, and dams may restrict the flow of sediment, thereby affecting ecosystems or farming downstream. They may also lead to increased erosion rates downstream and disrupt the flow of natural river systems. The cost of building dams is high, and dams may eventually silt up, rendering them unusable. (See also Option A, page 24 on dam building.)

▲ **Photo 3.2:** Solar panels – large flat panels made up of many individual solar cells



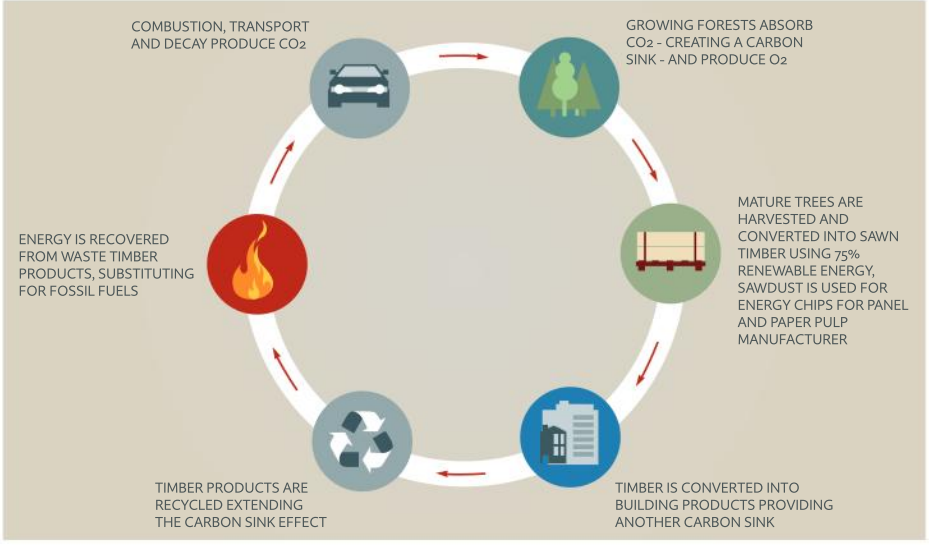
▲ **Photo 3.3:** Wind turbines, Aero Island, Denmark

Tidal power (see also Option 2) uses the ebbing or flooding tide to turn turbines that produce energy. The major limitations of this method are that a good tidal range is required to generate sufficient energy, and the coastline must be the right shape to channel water through the turbines. Such installations may interfere with navigation and can have an impact on wildlife. They are expensive to set up.

Solar energy is usually harnessed through panels containing solar cells. Passive solar energy (combined with insulation) is much cheaper for heating homes than fossil fuels, but it is very expensive to turn solar energy into the high-quality power needed for manufacturing (compared to fossil fuels). Solar energy also has the disadvantage that its usefulness is limited in northern countries during winter months.

Wind power is produced by wind turbines driven by available wind energy. The wind turns the rotor blades, which rotate a metal shaft, which transfers the rotational energy into a generator. The generator generates electricity using electromagnetism. The energy is then supplied to an electrical grid. The major limitations of wind turbines are that if there is no wind no energy is generated. Placement of the turbines is therefore critical: they need to be in areas of consistently high wind.

Biofuel energy can be produced by burning plant material to give off heat, by transforming plant matter into ethanol, which is then used as a fuel, or by using digestion methods to convert biomass to methane, which is then burned to generate electricity. The use of biofuels has great potential for the circular economy (see Figure 3.16). The disadvantages of these techniques are that they produce emissions and require large amounts of land to grow the biofuel crop. Biofuel crops may take up land once used for growing food crops, thus pushing up the price of food and disadvantaging local people who cannot get enough food to live. Biofuel crops are often planted at the expense of natural ecosystems, when land is cleared to create space for growing the biofuel crop.



▲ **Figure 3.16:** Carbon cycle of wood building products, Ellen MacArthur Foundation

Wastes can be used to produce energy. Organic waste decomposes and gives off methane gas, which can be burned. Waste such as straw can also be burned directly to generate energy. The advantages are that waste is readily available, its use does not deplete natural capital, and waste that would otherwise have to be disposed of in some other way is serving a useful purpose. The disadvantages are that the burning adds to global warming gases in the atmosphere – although it could be argued that decomposition of the waste would do this in any case.

Activity 5

Study Figure 3.15 and comment on the ways in which the use of biofuels can contribute to the circular economy through recycling and re-use.

Changing global energy demand

The major consumers of energy are the HICs, although demand for and use of energy resources by NICs has been rapidly increasing. Energy resources are used in large quantities for manufacturing and transport. The world continues to use fossil fuels – mainly oil, natural gas and coal – despite the growth in renewable energy sources. This is partly because there are still recoverable resources, the infrastructure is already in place, and, in some cases, the energy companies are important sources of revenue for governments, as well as being powerful lobbyists.

The geographical pattern of demand is projected to shift from the OECD region to NICs. According to the US Energy Information Administration, OECD countries accounted for 42 per cent of energy use in 2016 (USA 17 per cent of the total), China 23 per cent and Africa 4 per cent. It predicts that by 2040, OECD countries will account for 35 per cent of energy use (USA 13 per cent of the total), China 23 per cent and Africa 5 per cent.

LICs and MICs will continue to grow faster than HICs but their consumption remains low by comparison, as the figures above indicate. However, as economic growth rates slow down as economies mature, there may be a small decline in the use of energy. However, countries with high standards of living consume large amounts of energy and import many goods and services, thereby "outsourcing" their energy consumption in a similar way to virtual water.

Nevertheless, there will be changes. Some countries have reached peak oil, and there have been declines in output from Venezuela's oilfields and from the North Sea. Middle East oil was expected to peak in 2015, although Saudi Arabia has increased production and output since 2014. New sources of energy may emerge – fracking and tar sands, for example. The BRICS and other emerging economies will demand an increasing proportion of the world's energy resources.

Activity 6

Study the data in Table 3.2.

a. Produce two maps to show (i) the top 10 producers and (ii) the top 10 consumers of energy.

b. Suggest reasons for the differences between the top 10 producers and the top 10 consumers.

▼ **Table 3.2:** The world's largest producers and consumers of energy (2014)

Producers	Million tonnes of oil equivalent	Consumers	Million tonnes of oil equivalent
China	2,614	China	3,022
USA	1,881	USA	2,188
Russia	1,340	India	775
Saudi Arabia	615	Russia	731
India	523	Japan	455
Indonesia	460	Germany	318
Canada	435	Brazil	294
Australia	344	South Korea	264
Iran	299	Canada	253
Nigeria	256	France	253

Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Check your understanding

1. Calculate the minimum annual wage of the middle class.
2. Where is most of the growth in the middle class predicted to occur?
3. Outline the components of the ecological footprint.
4. Explain how ecological footprints can be reduced.
5. Explain why the ecological footprint of HICs is greater than that of LICs.
6. Identify the countries in Europe that have (a) the best and (b) the worst rates of recycling.
7. Outline how the use of water varies between HICs and LICs.
8. Explain the term "virtual water".
9. Briefly explain why more food will need to be produced in future.
10. Explain how demand for energy resources is changing.

Concepts in context

Global development **processes** have a major impact on resource consumption. As countries develop, their consumption of resources increases. Diets change, and the consumption of water and energy increases. Ecological footprints are used to measure resource consumption.

Synthesis and evaluation

The demand for resources – including water, food and energy – is increasing. The use of any one of the these resources has an impact on other resources. For example, the export of food has implications for water and for energy. In addition, countries that trade are essentially trading water and energy resources "virtually". As countries increase their standard of living, their resource use increases. This can be measured by using the ecological footprint concept. The composition of the footprint also changes over time.

Flow diagrams are often used to show trade in goods, and proportional symbols may be used to show relative resource endowment.

2 Impacts of changing trends in resource consumption

The water–food–energy nexus

The water–food–energy nexus refers to the very close links between these three sectors and the ways in which changes in one sector have an impact on one or both of the other sectors. The nexus approach stresses the need for stewardship of these resources.

Water security is defined in the SDGs as "access to safe drinking water and sanitation". Food security is defined by the FAO as the "availability and access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active and healthy life". Energy security refers to having access to clean, reliable and affordable energy sources for cooking, heating, lighting, communications and productive uses.

Interactions

There is a range of interactions between water, food and energy. For example, water is essential for the mining, extraction, refining and transport of energy sources, as well as being central in the production of crops and the rearing of livestock. Food production is the world's largest single user of water, accounting for about 70 per cent of water usage. In turn, food production may affect water supply through water extraction, water pollution (eutrophication, salinization) and land-use changes. Energy is required for the extraction, transport and distribution of water, and for the creation of hydrological schemes such as dams and irrigation networks. Energy is needed for farming: for ploughing, for chemical fertilizers, for machinery and for harvesting, transport, and so on. Agriculture accounts for about 30 per cent of global energy use. Thus, resource use and future challenges are highly interconnected.

Conceptual understanding

Key question

How does pressure on resources affect the future security of **places**?

Key content

- The water–food–energy "nexus" and how its complex interactions affect national water security, including access to safe water; national food security, including food availability; and national energy security, including energy pathways and geopolitical issues.
- The implications of global climate change for the water–food–energy nexus.
- Countries with contrasting levels of resource security.
- The disposal and recycling of consumer items, including international flows of waste.

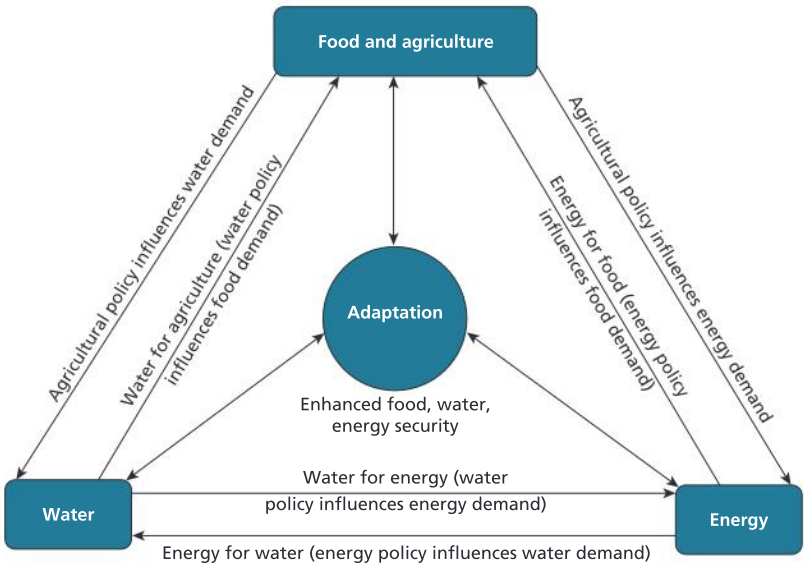


Figure 3.17: Interactions between water, food, energy and adaptation

Many countries face difficulties providing for the growing demand for water, food and energy, which are intensified by the uncertainties of climate change. Adapting to climate change will require effective use of scarce resources and a coordinated response. The rapid increase in resource use since the mid-1990s, particularly in the emerging economies of Brazil, Russia, India and China, has accelerated the risk of resource scarcity.

The nexus approach can be applied at a number of scales, from small-scale local competition over access to water for irrigation or livestock, to large-scale global interactions between energy, food and water providers. At times there are positive impacts, where changes in one area lead to improvements in another; for example, the increased use of fertilizers to increase total food production. More often, though, the impacts are negative; for example, the increased use of fertilizers leads to higher energy use and greenhouse gas emissions, and water pollution.

The nexus approach also offers possibilities for the circular economy, for example by turning waste outputs from food production into useful inputs to energy generation.

According to the World Economic Forum (2011), any strategy that focuses on one part of the water–food–energy nexus without considering its interconnections risks serious unintended consequences. Table 3.3 illustrates the benefits and complementarities of the nexus approach.

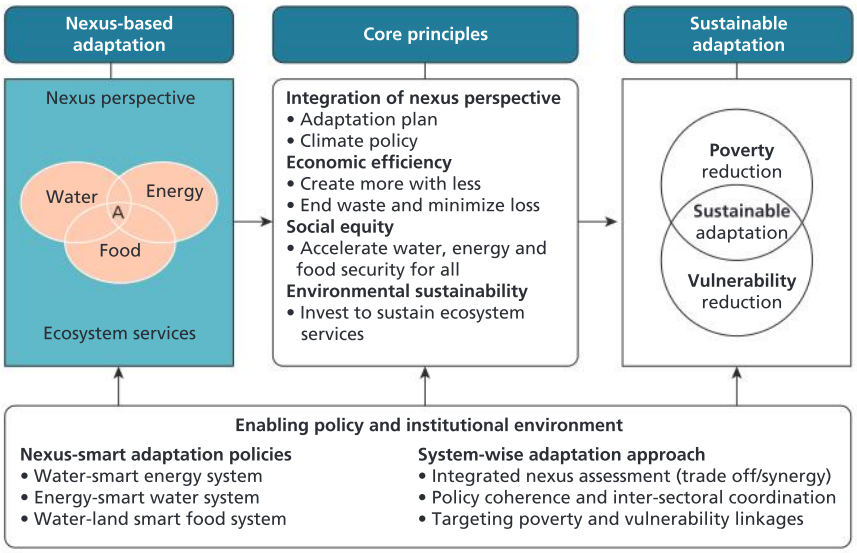
Table 3.3: Complementarities and co-benefits from nexus-based adaptations

Key characteristic	Nexus approach	Climate change adaptation	Complementarities and co-benefits from nexus-based adaptations
Goal	Achieve water, energy and food security objectives and sustain resources through efficient use of available resources.	Build resilience and enhance adaptive capacities against climate and other risks.	Understanding adaptation to climate change is critical for addressing nexus challenges, and efficient use of resources is critical for effective adaptations.
Core principles	Minimize resource waste and maximize economic efficiency, while accelerating the sustainable supply.	Reduce vulnerability by managing climate risks and building response capacity.	Since resource scarcity often increases people's vulnerability, the nexus approach may contribute to facilitating adaptation and vice versa.
Main focus	Provide integrated solutions at multiple scales.	Minimize shock, risks and vulnerability and address impacts and risks associated with climate change.	Understanding vulnerability to climate change is critical for assessing nexus challenges; equally, integrated nexus solutions can contribute to reducing vulnerability and poverty.
Broad strategies	Policy integration, harmonization and governance to build synergies and generate co-benefits across sectors by engaging multiple stakeholders, public–private partnership.	Address the drivers of vulnerabilty to climate change in specific sectors through building adaptive capacity and resilience.	Cross-sectoral nexus analysis identifies trade-offs and synergies and integrates policy implementation; diversification increases resilience; nexus strategy is critical for integration of climate adaptation and mitigation, while broadening the scope to address poverty–vulnerability linkages.

Source: Rasul, G. and Sharma, B. 2015. "The nexus approach to water-energy-food security: an option for adaptation to climate change". http://www.sciencedirect.com/science/article/pii/S2211464515300646

Climate change and the nexus

Climate change could influence the water–food–energy nexus in many contrasting ways. In some areas it may reduce agricultural productivity, whereas in other areas it may increase it. Water supplies will diminish in some areas and increase in others. The demand for energy will also change. Climate change is expected to increase the frequency of climate-related shocks, and these will have an impact on food, water and energy supplies. Moreover, due to their interconnections and interdependence, an impact on one part will have an influence on the other two.



▲ **Figure 3.18:** An outline for a nexus-based adaptation framework

Climate change will influence food availability, crop yields, water availability, and the need for irrigation. It will also influence the distribution of pests and diseases. Higher temperatures and evapotranspiration rates will reduce water supplies and increase the need for additional water provision. Energy demand may rise as a result of the increased need for the pumping or purification of water, and there may be increased competition between the agricultural and energy sectors for scarce water resources.

Moreover, attempts to limit climate change may have an impact on the water–food–energy nexus. The production of biofuels and hydroelectric power may create new demands for water resources. Some methods of adaptation to climate change, such as the use of drip irrigation and desalinization of seawater, are very energy intensive. Increased groundwater use would also require extra pumping and therefore energy resources.

There have been many attempts to adapt to climate change. The nexus approach focuses on the interactions between sectors and their interdependence.

▼ **Table 3.4:** Evolving approaches to adaptation

Feature	1990s	2000s	2010s
Overall objective	Reduce climate risks and impacts	Reduce climate risks and uncertainties	Reduce climate risks and impacts with socio-economic improvement Maintain climate change adaptation into development
Scope	Sector-based approach, location-specific	Sector-based approach, but adaptation mainstreamed into sectoral planning	Trans-sector and transboundary approaches started
Focus of activities	Protective: coping strategies; protection of those most vulnerable to climate risks and with low adaptive capacity	Protective: coping strategies; prevention of damaging strategies arising from risks to climate-sensitive livelihoods	Transformative: building adaptive capacity; transforming social relations to combat discrimination and underlying social and political vulnerability; improving livelihoods; building local institutions

Feature	1990s	2000s	2010s
Implementation	Activities seek to address impacts exclusively associated with climate change: provision of social services; social transfers (food/cash) including safety nets; social pension schemes; public works programmes	Managing climate risks: activities seek to incorporate climate-related information into decision-making	Building response capacities: activities seek to build robust systems for problem-solving, improving livelihoods Addressing the drivers of vulnerabiliity: activities seek to reduce poverty and other climatic stressors that make people vulnerable; promotion of minority rights; proactive challenging of discriminatory behaviour

Source: http://www.tandfonline.com/doi/full/10.1080/14693062.2015.1029865

There are a number of benefits of adaptations to climate change that have knock-on effects for the nexus (Table 3.5).

▼ **Table 3.5:** Synergies between the climate change adaptation and nexus approaches

Sector-specific adaptation measures	Positive implications for the sector	Potential for synergies across the nexus
Water		
Increasing water use efficiency	Reduced water per capita	Increased availability of water for energy and agriculture
Switching from use of freshwater to waste water	Reduced freshwater use per capita	Increased availability of freshwater for food, energy and other uses
Switching from wet to dry cooling at thermoelectric power plants	Reduced water use and associated thermal pollution	Increased availability of water for energy and agriculture
Desalinization	Increase in brackish and freshwater supplies	Increased availability of freshwater and overall water supply for energy and agriculture and other uses
New storage and conveyance of water to serve new demands	Increased water supplies to meet demand	Increased availability of fresh water and overall water supply for energy and agriculture and other uses
Watershed management	Increased water supplies to meet demand	Increased water supply for energy and other uses, improved water quality, reduction in flood potential
Land		
Switching to drought-tolerant crops	Increased/maintained crop yields in drought areas	Reduced water demand
Using waste or marginal lands for biofuels	Increase in renewable energy	Reduced pressure on non-renewable energy as some fossil fuels are replaced with biofuels
Energy		
Increasing transmission capacity	Reduced economic and social impacts	Potential for reduced emissions if new transmission and wind/solar power supplied to the grid
Increasing renewable energy, e.g. solar, wind, biogas, bioenergy	Increased clean energy and reduced pressure on energy	Reduced GHG emissions, reduced water demand for cooling, thermal power

Source: Rasul, G. and Sharma, B. 2015. "The nexus approach to water-energy-food security: an option for adaptation to climate change". http://www.sciencedirect.com/science/article/pii/S2211464515300646

Resource security

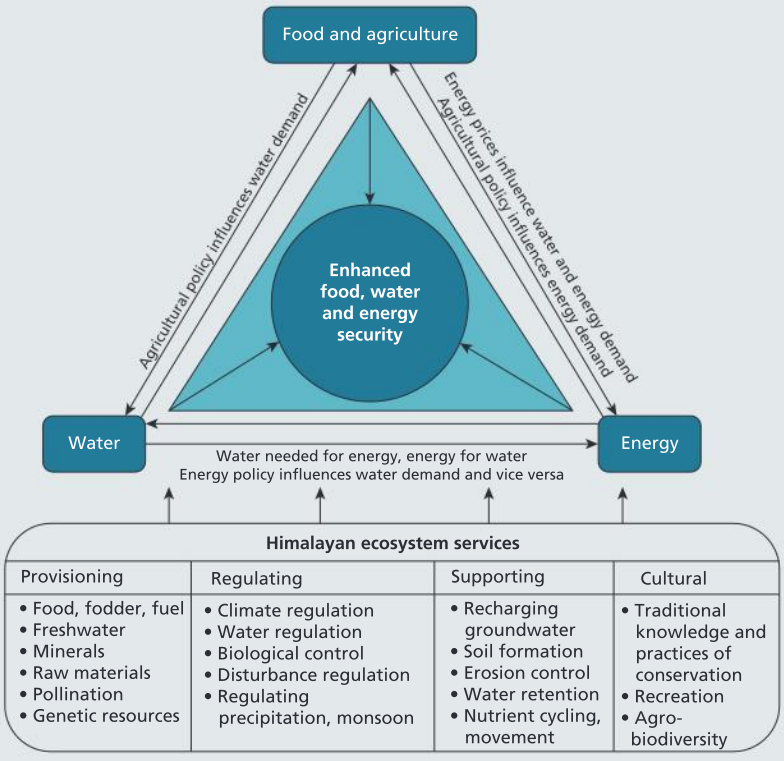
Case study

Food, water and energy security in South Asia – a nexus perspective from the Hindu Kush Himalayan region

South Asia faces the challenge of providing enough water and energy to grow enough food for the increasing population. The Hindu Kush Himalayan (HKH) ecosystem is vital for the promotion of food, water and energy security downstream. The issues and challenges in the food, water and energy sectors are interrelated in many ways and cannot be managed effectively without integration. Moreover, there is a high degree of dependency of downstream communities on upstream ecosystem services such as water for irrigation, HEP and drinking water.

▲ **Photo 3.4:** The many ecosystems benefits of the Hindu Kush Himalayan region for the water–food–energy nexus: the Rampur dam in India

Asia accounts for around 66 per cent of the world's population, and 59 per cent of water consumption. South Asia has just 3 per cent of the world's land but around 25 per cent of the world's population. Thus, water and food security are vital. South Asian countries, including Afghanistan, Bangladesh, India and Pakistan, are home to 40 per cent of the world's poor population, and over half the population is food-energy deficient. About 20 per cent of the population lack access to safe drinking water.



▲ **Figure 3.19:** The interdependence of water, food, energy and ecosystem services

Just as food and water are essential for human existence, energy is key to human development. The nexus approach to water, food and energy is an integrated method for achieving security in all three elements. The nexus approach stresses the need for cooperation among the water, food and energy sectors, despite the competition for scarce resources. The ecosystem services provided by the Hindu Kush Himalayan (HKH) region are vital for the security of all three sectors. For example, 1.3 billion people rely on fresh water from the HKH region.

There are many challenges facing South Asia, including population

Case study (continued)

Table 3.6: Key indicators related to agriculture, water and energy security in South Asia

Indicator	2007	2050 projection
Population (millions)	1,520	2,242
Annual population growth rate (%)	1.5	0.53
Population below $1.25/day (million)	596	14.1
Undernourished population (%)	21.8	4.2
Arable land (million ha)	204	213
Irrigated area (million ha)	104	135
Cultivated land (ha per person)	0.12	0.08
Agricultural growth rate (%)	2.4	1.3
Total water consumption in agriculture (km^3)	1,479	1,922
Total water withdrawal for irrigation (km^3)	1,095	1,817

growth, rapid urbanization, industrialization as well as the uncertainties of climate change. These changes are leading to increased demand for, and pressure on, resources. Most ecosystem services are used and managed at a variety of scales, from the local to the international, and managed by a variety of stakeholders, for example farmers, politicians, industrialists, water engineers and urban populations. In addition, there are upstream–downstream linkages in the case of the HKH.

Table 3.7: Key features and challenges of food, water and energy security in South Asia

Key characteristics	Adaptation challenges	Interface among food, water and energy resources and adaptation to climate change
Food security		
Huge, chronically undernourished population		
About half of the world's poor (46%) and 35% of the world's undernourished live in South Asia	Provision of food, water and energy to a large malnourished population without degrading the natural resource base and environment	To meet the nutritional needs of all, food production to double in the next 25 years
Burgeoning human population		
About 25% of the world's population (projected to amount to 2.3 billion by 2050) lives in just 3% of the world's land area	To feed the growing population, agricultural production will have to increase by 70%, energy by 40%, and water by 57%	Increased pressure on land, water and energy to meet demand
Declining cropland		
Per capita arable land continually declining due to population growth, urbanization and increasing biofuel cultivation to meet energy demand	Limited option for growing more food grain by expanding crop area	Competing demand for land for food, bioenergy production and ecosystem services

Case study (continued)

Key characteristics	Adaptation challenges	Interface among food, water and energy resources and adaptation to climate change
Intensive food production		
Food production becoming increasingly water and energy intensive	Adapting to the declining groundwater table	Agricultural growth constrained due to shortage of energy and water
Changing food preferences towards meat		
The meat production process requires more energy and water	About 7 kg of grain equivalent required to produce 1 kg of meat	Increased pressure on water to meet the food requirement
Sensitivity to climate change		
Food production highly vulnerable to climate change due to rising temperatures, accelerated glacial melting, increased evapotranspiration and erratic rainfall	Uncertainty in water availability due to rapid glacier melt and changes in monsoon pattern in the Himalayas	Climate change likely to be a critical factor in increasing water and energy demand for food production and land demand for biofuel production
Water security		
Growing water stress		
Growing water demand for agriculture, energy, industry and human and livestock use; annual water demand predicted to increase by 55% compared with 2005	Providing access to safe drinking water in the face of increasing variability in the water supply	Water-intensive adaptation practices leading to increased water pollution and waterborne diseases, high child mortality, poor human health
Upstream–downstream dependence on water		
High dependence of downstream communities on the upstream for water to grow food and generate hydropower	Need for enhanced upstream–downstream coordination and cooperation for sustainable development of Hindu Kush Himalayan (HKH) water resources	HKH rivers are the lifeline for dry-season water for irrigation, hydropower and major economic activities
Increasing dependence on groundwater for food production		
About 70–80% of agricultural production dependent on groundwater irrigation	Adapting to declining water tables	Groundwater pumping for irrigation requires excessive energy, further increasing electricity demand
Energy security		
High energy poverty		
About 63% of the population without access to electricity; 65% use biomass for cooking	Providing adequate and reliable energy to a large population without increasing pollution	Growing demand for water and land for energy production

Case study (continued)

Key characteristics	Adaptation challenges	Interface among food, water and energy resources and adaptation to climate change
Under-utilized potential for hydropower and clean energy		
Hydropower in the Himalayas limited in places due to the risk of causing landslides	Restricted adaptation options	Energy diversification to meet growing demand for food, water and economic growth

Source: http://www.tandfonline.com/doi/full/10.1080/14693062.2015.1029865

Between 1950 and 2010 the population of South Asia almost tripled. The increased demand for water poses problems for farming. Up to half of the food energy comes from rice and wheat, but these are very water dependent – up to 1,000 tonnes of water are needed to produce 1 tonne of rice. They depend on water from the HKH region during the dry season. The HKH is also the source of water for hydroelectric power. However, the region is experiencing deforestation, land degradation, soil erosion, overgrazing and declining productivity. Soil erosion has led to an increase in the frequency and severity of flooding. Without proper ecosystem management in the HKH, water, food and energy security are all at risk.

Online case study

Energy resources in Nepal

Activity 7

1. Outline the factors that will make food security in Asia in 2050 difficult to achieve.
2. Explain the importance of ecosystem services in the functioning of the water–food–energy nexus.

Case study

Improving food security in South Africa

A number of studies have looked at the potential impact of climate change on maize and potato production in South Africa. A 10 per cent reduction in rainfall is likely to lead to a 4 per cent reduction in maize yields, whereas an increase in rainfall is likely to cause a rise in the maize yield. Increased temperatures would lead to a decrease in potato production. Farmers have already started taking measures to adapt to these changes. There has been diversification, substitution of crops, changes in planting times, greater use of shade crops, a change from flood irrigation to sprinkler irrigation, and soil conservation measures. Irrigation has been the most favoured adaptation, as water is the main limiting factor for agriculture in South Africa.

▲ **Photo 3.5:** Modern farming in South Africa

Case study (continued)

Table 3.8: The nexus approach to the impact of climate change on food security in South Africa

Impact of climate change	Direct consequences
Impacts on crop productivity	• The increase in temperature and changes in the timing, amount and frequency of rainfall may have severe effects on all agricultural systems in South Africa. • In the dry western areas, crop production will become more marginal, while in the high-potential eastern areas there may be a slight increase in production. • The AVOID programme agreed over the possibility of decreased yields for nearly all cropland in South Africa, but cautioned that there is a high degree of uncertainty. • While the possibility exists that nearly all croplands could experience early and sustained declines in suitability, even under the mitigation scenario, there is a high degree of uncertainty among projections regarding the amount of area undergoing decline.
Impacts on food production	• Yields could potentially increase for rice and groundnuts, although confidence is limited by the small number of studies. In the case of groundnuts, rain-fed groundnut production is likely to increase. This is interesting from a protein food security perspective because groundnuts are currently a relatively minor crop in the country. Moreover, while nutritionally rich, groundnuts do not form a major dietary component for the country. • Sugar cane appears to be the most resilient to climate change. Both yield and harvested area are projected to increase. Yield is projected to increase by about 55% and area by about 16%, increasing total production by about 80%. The difference in yields between the least favourable and the most favourable climate models is only about 5%, as is the difference in yields between the pessimistic and optimistic scenarios. • For barley, yield reductions of 20–50% are predicted for warmer regions, but this effect might be somewhat compensated for by rising atmospheric CO_2, suggesting a reduction in the order of 10–40%. Warming will also lead to a reduction in malting quality. • In the case of hops, responses are presently unknown, but are likely similar to those of barley in terms of production and quality. However, given the fact that hops are an irrigated crop, rainfall deficit and variability would subject farmers to greater irrigation costs. • Sorghum is likely to benefit from increasing temperatures and higher atmospheric CO_2 levels, but no estimates are available yet. • Soil type is a significant determinant of the impact of climate change on food production. Certain soil types, such as vertisols and xerosols, are less productive and therefore affect crops negatively in the face of climate change; other types, such as acrisols and arenosols, have a positive effect on crops and may help control adverse climatic effects. • A look at the distribution of crop farming in the country suggests that large portions of field crop farming are located in the arid zone of the Free State (32%), the North West (17%) and Mpumalanga (14%) provinces. The implication is that if the arid zone becomes even warmer, the majority of field crop production in the country will be displaced. • The agricultural sector consumes 60% of the total water resource in the country. Only about 10% of farms are under irrigation. This means that if climate change obliges farmers to irrigate more, especially in the western parts of the country that are arid and desert zones, further pressures will be put on the country's already scarce water resources. This could have trade-offs for (a) agricultural activities elsewhere in the country or (b) for water resources for different uses, such as energy production, that could compete directly with food production.

Case study (continued)

Impact of climate change	Direct consequences
Impacts on food quality	• Rising minimum temperatures are a problem for the fruit industry, especially for apple farming, in terms of fruit quality. • An accelerating increase of minimum temperatures during autumn (1–2° C since the 1960s) has led to reduced fruit quality due to sunburn and heat stress. This appears to have decreased the country's critical export-grade apple production. • In the case of apples, a certain number of chilling units during autumn and winter are needed to ensure coordinated budburst and subsequent harvest. In their absence, hormone sprays are used to ensure this coordination. But EU countries demand that these be phased out within the next few years, due to possible health concerns. Developing and replanting appropriate cultivars that are less sensitive to this effect may take several years. • Heatwaves cause sunburn of apples and induce water stress in trees, which leads to smaller fruit size.
Impacts on livestock	Livestock farming will be affected in terms of greater water requirements for livestock and livestock heat stress. The Northern Cape, which is a desert zone, accounts for the largest proportion of livestock (44%) in the country. It is followed by the Eastern Cape (14%) and the Free State (12%), both in the arid zone. The Western Cape, which falls in the winter rainfall zone, is the next largest. This suggests that if climate change exacerbates water shortages in the desert or arid zones, livestock farming will be affected.

Source: WWF. 2014. "Climate change, the Food Energy Water Nexus and food security in South Africa", http://awsassets.wwf.org.za/downloads/1_a16231_wwf_climate_change_few_and_food_security_in_sa_online.pdf

◀ **Photo 3.6:** The WEEE man at the Eden Project, Cornwall: a robotic figure 7 metres tall and weighing 3.3 tonnes, made from waste electrical and electronic equipment

Activity 8

1. Study Photo 3.5. Describe how the nexus approach can be used to explain the farming practices shown.
2. Using examples, outline the potential impact of climate change on food security in South Africa.
3. Suggest ways in which farmers in South Africa may adapt to changes in climate.
4. Examine the ways in which climate change and agricultural change in South Africa could affect the water–food–energy nexus.

The disposal and recycling of waste

A variety of strategies can be used to manage solid domestic waste (SDW), including:

- altering human activity, including reducing consumption and composting food waste

Table 3.9: Waste management options for solid domestic waste

Waste management options	How it works
Reduce the amount of waste	• Producers think more about the lifespan of goods and reduce packaging • Consumers consider packaging and lifespan when buying goods
Reuse goods to extend their lifespan	• Bring-back schemes where containers are refilled (e.g. milk bottles) • Refurbish/recondition goods to extend their useful life (e.g. using old car tyres to stabilize slopes/reduce soil erosion) • Used goods put to another use rather than thrown out (e.g. plastic bags used as bin liners; old clothes used as cleaning cloths) • Charity shops pass on goods to new owners
Recover value	• Recycle goods such as glass bottles and paper • Compost biodegradable waste for use as fertilizer • Incinerate (burn) waste – collect electricity and heat from it
Dispose of waste in landfill sites	• Put waste into a hole (natural or the result of quarrying) or use to make artificial hills

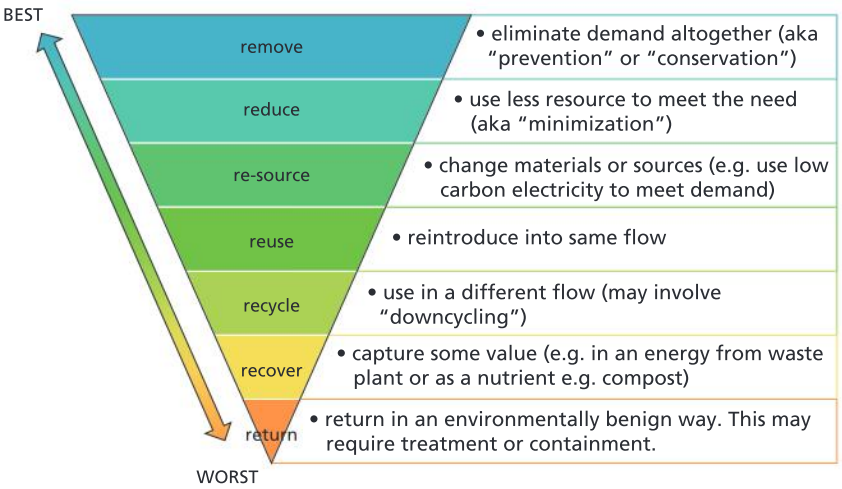


Figure 3.20: Methods of waste disposal

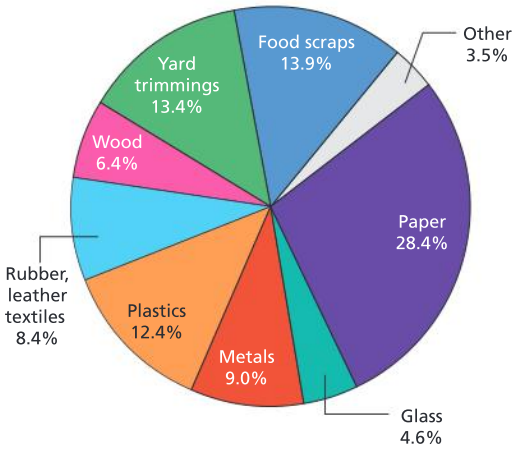
- controlling release of pollutants, by governments legislating to encourage recycling and reuse initiatives and imposing taxes on SDW collection and on disposable items
- reclaiming landfills, using SDW for "trash to energy" programmes and clean-up and restoration programmes.

These strategies may be influenced by:

- cultural factors – for example, is it acceptable?
- economic factors – for example, is it affordable?
- technological factors – for example, can it be achieved?
- political factors – for example, is there support for the strategy?

Types of solid domestic waste

The amount of waste produced by the global population is steadily increasing. The world faces an ongoing problem in how and where



▼ **Figure 3.21:** The composition of solid domestic waste, USA

to dispose of this waste. Household waste is composed of a wide variety of materials. Figure 3.21 shows the composition for solid domestic waste in the USA.

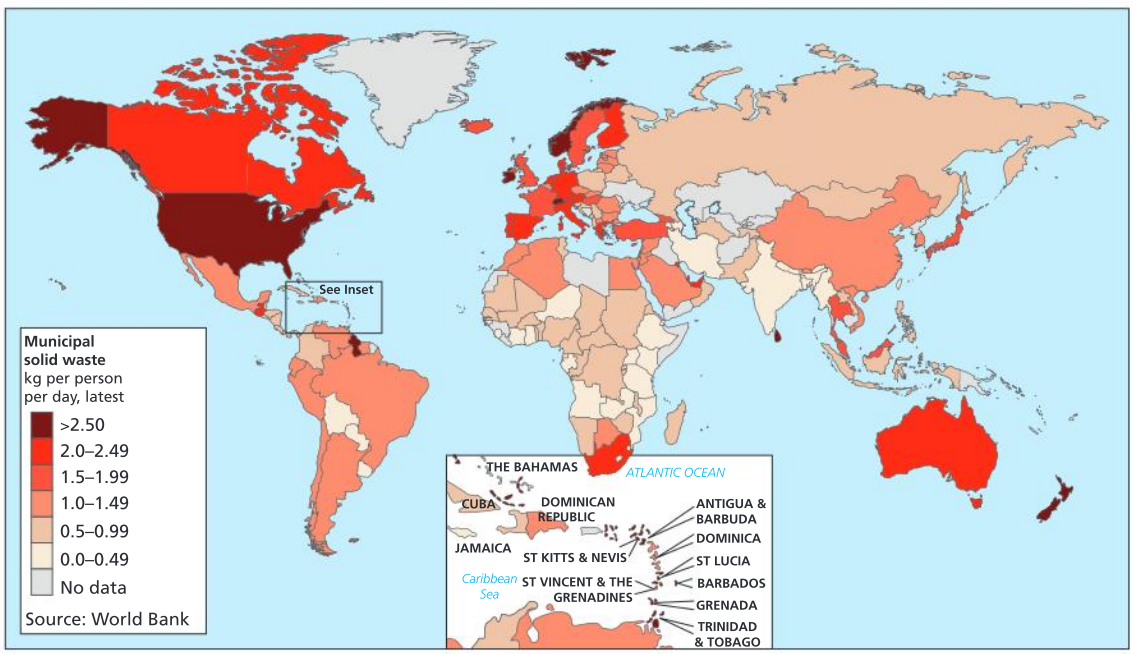
The volume of waste varies by society and over time. HICs generate more waste than LICs and there is now more non-biodegradable waste (e-waste and plastics). Waste increases as countries become more developed. It also increases when there are festivities such as Christmas, Easter, Ramadan, Diwali, birthdays, and so on.

A global comparison of garbage

Much of the world's rubbish is generated by city dwellers. According to the World Bank, the potential costs of dealing with increasing rubbish are high. The world's cities currently generate around 1.3 billion tonnes of solid domestic waste a year, or 1.2 kg per city dweller per day. Almost half of this comes from rich countries. With increasing urbanization, this figure is expected to rise to 2.2 billion tonnes by 2025, or 1.4 kg per person. China's urban population will throw away 1.4 billion tonnes in 2025, up from 520 million tonnes in 2015. By contrast, the USA's urban population will throw away 700 million tonnes compared with 620 million tonnes in 2015.

Rubbish tips

Up to half of the world's population lacks access to the most basic collection and safe disposal of waste. Of the waste generated globally, 40 per cent is disposed of unsafely in open dumps. Many of these rubbish tips are found in poor countries, close to urban areas, and they



▲ **Figure 3.22:** The world's rubbish
Source: *The Economist*, http://www.economist.com/blogs/graphicdetail/2012/06/daily-chart-3

Case study

The hazards of working with rubbish

Many people in developing countries make a living collecting, sorting, recycling and selling materials recovered from waste dumps. In some of the world's larger cities, thousands of people live and work in municipal dumps – 20,000 in Calcutta, 12,000 in Manila and 15,000 in Mexico City.

According to the World Bank, 1 per cent of the global urban population – many of them women and children – earn a living from waste collection and/or recycling (Photo 3.7). In the least developed countries, up to 2 per cent of the urban population make their living in this way. Waste pickers tend to have low social status and face public scorn, harassment and sometimes violence. Waste pickers are also vulnerable to exploitation by the middlemen who buy their recovered material. In some cities of Colombia, India and Mexico, waste pickers can receive as little as 5 per cent of the prices that industry pays for the recyclables, with the rest going to middlemen.

On account of their low earnings, waste pickers tend to live in deplorable conditions, lacking water, sanitation and other basic infrastructure. Their poor working and living conditions also make them vulnerable to health and safety risks, including exposure to dangerous waste, and various illnesses and diseases. Not surprisingly, life expectancy rates are low in waste-picking communities. In Mexico City, for example, dumpsite waste collectors live an average of 39 years, compared with an average of 69 years for the general population.

▲ **Photo 3.7:** Woman picking garbage in Zwelitsha, South Africa

pose a major threat to the environment and to people. The Mbeumbeuss waste dump in Senegal covers some 175 hectares. Whereas the dump used to receive a few thousand tonnes of rubbish a year in the 1960s, now it takes in 475,000 tonnes of rubbish a year – increasingly e-waste from computers, televisions and mobile phones.

The world's largest dumps pollute rivers, groundwater, air and soil, and have an adverse impact on those who live and work nearby or on the dump. Waste pickers often have no protective clothing and commonly suffer human health problems such as gastrointestinal (stomach) disorders, skin disorders, and respiratory and genetic diseases.

There are a number of methods of dealing with solid domestic waste. The most common ones include recycling, composting, landfill and incineration. In addition, it is possible to reduce the amount of waste generated and reuse goods to extend their lifespan.

Recycling

The recycling of paper, glass and some metals and plastics saves scarce raw materials and helps reduce pollution (Photo 3.8). In Europe, there are high rates of recycling in Austria, Germany, the Netherlands and Switzerland (Figure 3.23).

▼ **Photo 3.8:** Recycling

▼ **Photo 3.9:** Toys made from recycled tins in Cuba

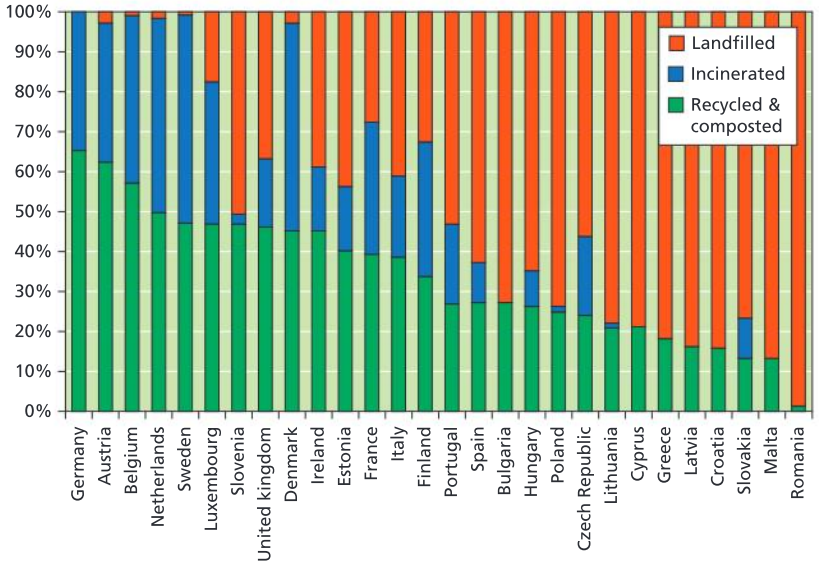
Up to 60 per cent of household waste in the USA is recyclable or compostable, but Americans compost only 8 per cent of their waste. Surveys suggest that the main reason Americans do not compost is because they think it is a complicated process. In contrast, the Zaballeens (literally, "garbage people"), who are responsible for much of the waste collection in Cairo, Egypt, recycle as much as 80 per cent of the waste collected.

Reduce and reuse

Reuse is usually more energy and resource efficient than recycling. It can also involve individual reuse of items such as containers, bags and pots. Reduction (or "reduce") includes using less energy such as turning off lights when not needed, or using only the amount of water needed when boiling a kettle. Substitution of one resource for another may mean using renewable rather than non-renewable resources, and is a major benefit to the environment.

Composting

Composting is the decomposition of biodegradable material. It recycles organic household waste into a humus-like soil, or compost, which returns valuable nutrients to the soil.



▲ **Figure 3.23:** Waste management in Europe

Landfill

Landfill may be cheap but it is not always healthy (an indirect cost), and landfill sites will eventually fill up. Recent research and surveys show that living near to landfill sites increases the risk of health problems including heart problems and birth defects. Landfills need to be located relatively close to the source of waste to be economic, so they tend to be found near areas of high population density. Landfill can give off gases such as methane and may contaminate water supplies, although landfills are generally lined with impermeable clay to prevent leaching. Many landfills are sited in old quarries, which could be turned into lakes or nature reserves instead.

Currently, much domestic waste ends up in landfill sites. However, our reliance on landfill is unsustainable for a number of reasons:

- Many areas already struggle to find suitable new landfill sites. This shortage of space will become more acute as the amount of waste continues to grow.
- When biodegradable waste such as food decomposes anaerobically, it releases methane, which, as a greenhouse gas, contributes to global warming. It is also explosive.

- Chemicals and heavy metals can pollute the soil and groundwater. Leachate that drains from organic waste also contains harmful substances, causing the same problem.
- The noise, smell and vermin associated with landfill means that they should be sited away from residential areas.
- Communities are often violently opposed to the creation of new sites (the not-in-my-back-yard, or NIMBY principle).

Unfortunately, the measures used to try to reduce the escape of gases and leachates (liner systems, waste compaction and capping) also stop oxygen entering, which increases the generation of methane.

▲ **Photo 3.10:** The reuse of plastic bottles for growing herbs, Casuarina Hotel, Barbados

Incineration

Incineration means burning. It converts waste into ash and gas particulates. The heat, in turn, can be used to generate electricity. Incinerators can reduce the volume of the original waste by as much as 80–90 per cent. Thus the technology could significantly reduce the volume of waste for which landfill disposal is necessary. Incineration has particularly strong benefits for the treatment of certain types of waste, notably clinical and hazardous waste, as it can dispose of these products safely.

The major environmental problems associated with incineration are as follows:

- Air pollution – this comes from carbon dioxide, sulphur dioxide, nitrogen dioxide, nitrous oxide, chlorine, dioxin and particulates. In turn, these lead to other environmental problems such as acid rain and smogs, which lead to a higher incidence of lung disease.
- Increased volume of traffic – this comes from the need to get the waste to the incinerators, again leading to greater air pollution, noise, vibration, and accidents.
- Toxic ash – this is usually equal to 10–20 per cent of the mass of the original waste, and still needs to be disposed of in landfill.
- The high initial capital cost.

Energy from waste (EfW) or waste to energy (WTE)

Many municipal incinerators are trying to produce energy from waste. However, communities in many areas prefer these facilities to be located "somewhere else". The USA has some 1,900 municipal landfill sites. The largest is Puente Hills landfill in Los Angeles, which is over 160 metres high. With 60 years' worth of decomposing rubbish, Puente Hills produces enough methane to generate electricity for 70,000 homes.

The export of waste

China imports more than 3 million tonnes of waste plastic and 15 million tonnes of paper and cardboard each year. Containers arrive in the UK and other countries, with goods exported from China, and load up with waste products for the journey back. A third of the UK's waste plastic

and paper (200,000 tonnes of plastic rubbish and 500,000 tonnes of paper) is exported to China each year. Low wages and a large workforce mean that this waste can be sorted much more cheaply in China, despite the distance it has to be transported.

E-waste

According to the UN's Step Initiative (set up to tackle the world's growing electronic waste – e-waste – problem) millions of mobile phones, laptops, tablets, toys, digital cameras and other electronic devices are being dumped illegally in developing countries.

The global volume of e-waste was predicted to grow by 33 per cent between 2013 and 2017. In 2012 approximately 50 million tonnes of e-waste was generated worldwide – some 7 kg for every person on the planet. These goods are made up of hundreds of different materials and contain toxic substances such as lead, mercury, cadmium, arsenic and flame retardants. Once in landfill, these toxic materials seep out into the environment, contaminating land, water and the air. Workers at these sites suffer frequent bouts of illness.

The increase in e-waste is happening because there's so much technical innovation. TVs, mobile phones, and computers are all being replaced more and more quickly. The lifetime of products is also shortening.

In 2012 China generated 11.1 million tonnes of e-waste, followed by the US with 10 million tonnes. However, per capita figures were reversed: on average, each American generated 29.5 kg of e-waste, compared to less than 5 kg per person in China. In Europe, Germany discards the most e-waste in total, but Norway and Liechtenstein throw away more per person.

The European Environment Agency estimates that between 250,000 tonnes and 1.3 million tonnes of used electrical products are shipped out of the EU every year, mostly to west Africa and Asia. Research by the Massachusetts Institute of Technology (MIT) suggests that, in 2010, the US discarded 258.2 million computers, monitors, TVs and mobile phones, of which only 66 per cent were recycled. The life of a mobile phone is now less than two years. In 2011 in the US, only 12 million mobile phones were collected for recycling, even though 120 million were bought.

Most phones contain precious metals. The circuit board can contain copper, gold, zinc, beryllium and tantalum; the coatings are typically made of lead; and phone makers are now increasingly using lithium batteries. Part of the reason that fewer than 10 per cent of mobile phones are dismantled and reused is that phones and other devices are becoming increasingly complex and made of smaller and smaller components. The failure to recycle is also leading to shortages of rare-earth minerals to make future generations of electronic equipment.

Guiyu in China has been described as the e-waste capital of the world. Most of the recycling takes place in people's homes. The industry is worth $75 million to the town each year, but Guiyu's population has elevated rates of lead poisoning, cancer-causing dioxins, and miscarriages.

▲ **Photo 3.11:** E-waste recycling in Guiyu, China

Check your understanding

1. Define the term "food security".
2. Explain how the use of water affects energy resources.
3. Briefly explain the water–food–energy nexus.
4. Outline the problems of trying to feed Asia's growing population.
5. Comment on the global variations in the world's rubbish.
6. Which countries in Europe have (a) the best and (b) the worst rates of recycling?
7. State two examples of goods that can be (a) recycled, (b) reused, or (c) reduced.
8. Outline the problems associated with incineration.
9. Comment on the export of waste to China.
10. Briefly explain the problems associated with landfill.

Activity 9

Visit the photo essay on Guiyu in China – the world's largest electronics waste dump – at http://news.trust.org/slideshow/?id=c03216ba-68ee-4558-a50f-b8f360d90d9b.

Concepts in context

Pressure on resources will affect the future security of different **places**. The water-food-energy nexus describes how these three resources are interconnected. Water-, food- and energy-security are all related to each other, and developments in one sector may affect the other two sectors.

Waste disposal is increasing in volume. There are a number of schemes to obtain energy from waste. The circular economy tries to eliminate waste by incorporating it as a new raw material.

Synthesis and evaluation

Issues related to national resource security are likely to increase as populations increase and standards of living increase. Resources should not be looked at in isolation, but need to be considered in terms of their impact on other resources. The nexus approach stresses this interdependence of water, food and energy resources. Interactions vary from the local scale to the global scale. In addition, some countries are using resources from other countries, and so may be reducing pressure on their own resources at the expense of other countries' resources. Moreover, some countries are now exporting their waste. Some of this has important health implications. Methods of waste management are tending to encourage greater use of recycling, reuse and reduce.

A nexus approach encourages geographers to think about knock-on effects, choices and impact assessments.

3 Resource stewardship

Conceptual understanding

Key question

What are the **possibilities** for managing resources sustainably and **power** over the decision-making process?

Key content

- Divergent thinking about population and resource consumption trends: pessimistic views, including neo-Malthusian views; and optimistic views, including Boserup.
- Balanced views about population and resource consumption, including resource stewardship.
- Resource stewardship strategies, including the value of the circular economy as a systems approach for effective cycling of materials and energy.
- The role of the UN Sustainable Development Goals and progress made towards meeting them.

Contrasting views of population and resources

Thomas Malthus's theory of population

In 1798 the Reverend Thomas Malthus produced his *Essays on the Principle of Population Growth*. He believed that there was finite optimum population size in relation to food supply, and that any increase in population beyond this point would lead to a decline in the standard of living and to "war, famine and disease". He based his theory on two principles:

1. In the absence of checks, population will grow at a geometric or exponential rate, that is, 1, 2, 4, 8, 16 ... etc., and could double every 25 years.
2. Food supply at best only increases at an arithmetic rate, that is, 1, 2, 3, 4, 5 ..., etc. (Figure 3.24).

If the time intervals were 25 years, in 100 years the ratio of population to food would be 16:5. Lack of food is therefore argued to be the ultimate check on population growth.

Malthus's principles used **potential** and not actual growth figures for population and food production. Because there is a limit to the amount of food that can be produced, it determines a "ceiling" to the population growth in a given country. Malthus suggested preventive and positive checks as the two main ways to curb the population once this ceiling had been reached. Preventive checks include abstinence from marriage or a delay in the time of marriage and abstinence from sex within marriage, all of which would reduce the fertility rate. Malthus noticed strong negative correlations between wheat prices and marriage rate. Positive checks, such as lack of food, disease and war, directly affected death rates.

Malthus suggested that the optimum population exists related to resources and the level of technology. This is now related to the concept of overpopulation and underpopulation, rather than the optimum population. Optimum population is difficult to identify, and may vary as technology improves and attitudes change.

Even though the geometric rate of population increase is possible, it is rarely observed. The preventive and positive checks suggested by Malthus do not affect population growth, although contraception has since been introduced and should be considered a factor.

During the Industrial Revolution, agricultural production grew at a rapid rate (greater than the arithmetic rate), exceeding the rate of population growth. Industrial development affected agricultural production through

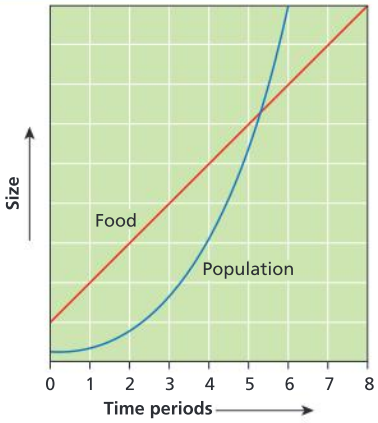


Figure 3.24: Malthus's views on the relationship between population growth and resources

intensification (labour and capital) and extension (more land); industry helped both. Malthus's ceiling limit on production was always ahead of and moving away from the population.

Since Malthus's time, people have increased food production in many ways. These include draining marshlands, reclaiming land from the sea, cross-breeding of cattle, growing high-yielding crop varieties, terracing steep slopes, growing crops in greenhouses, using more sophisticated irrigation techniques such as hydroponics, growing new foods such as soya, making artificial fertilizers, farming native crop and animal species, and fish farming.

▲ **Photo 3.12:** A marketplace in India

Since the 1950s there have been two main phases of agricultural production, namely extensification until the 1980s and, since then, intensification. These have created environmental issues such as loss of habitat, pollution from agrochemicals and high-energy farming.

Esther Boserup's theory of population

In 1965 Esther Boserup proposed a different theory of population. Unlike Malthus, she believed that people have the resources to increase food production. The greatest resource is knowledge and technology. When a need arises, someone will find a solution (Photo 3.13). Although she was researching very small pre-technological villages, her views are widely held to be applicable to modern societies.

Whereas Malthus thought that food supply limited population size, Boserup suggests that, on the contrary, in a pre-industrial society an increase in population stimulated a change in agricultural techniques so that more food could be produced. Population growth has thus enabled agricultural development to occur.

She examined different land-use systems, which were utilized according to their intensity of production. This was measured by the frequency of cropping. At one extreme was the forest fallow association with shifting cultivation; at its least intensive, any one piece of land would be used less than once every 100 years. At the other extreme was the multicropping system, which injected more than one harvest per year. She suggested that there was a close connection between the agricultural techniques used and the type of land-use system. The most primitive was shifting cultivation and fallow ploughing, with fallow reduction and increased cropping frequency occurring when higher yields were needed. She considered that any increase in the intensity of productivity by the adoption of new techniques would be unlikely unless population increased. Thus, population growth will lead to agricultural development and the growth of the food supply.

▲ **Photo 3.13:** The Boserup approach: human ingenuity is the key (sign at the Posco Iron and Steel Works, Pohang, Korea)

Boserup's theory was based on the idea that people knew the techniques required by a more intensive system, and adopted them when the population grew. If that knowledge was not available, the agricultural system would regulate the population size in a given area.

▲ **Photo 3.14:** Cultivating steep slopes using terracing

Emile Durkheim's theory of population

Emile Durkheim was a French sociologist who thought that an increase in population density would lead to a greater division of labour, which would allow greater productivity to be attained (1893). He even suggested that population pressure was necessary to increase the division of labour. Borrowing from the Malthusian theory of population density and observing the changes in labour around him at a time of increasing industrialization, he noted that labour differentiation tended to increase in proportion to the social complexity and size of the population.

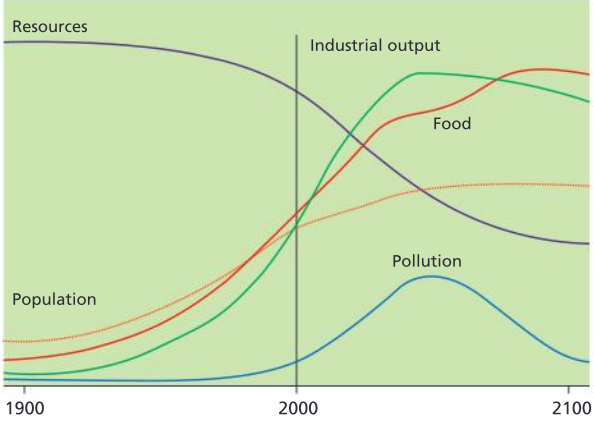
The Limits to Growth model

This study, also referred to as the Club of Rome model (1970), is a neo-Malthusian model in that it takes the same basic view as Malthus, although it suggests some potential solutions that Malthus would not have approved of. The study examined the five basic factors that determine and therefore ultimately limit growth on the planet:

- population
- agricultural production
- natural resources
- industrial production
- pollution.

The study observed that many of these factors grow at an exponential rate, such as food production and population, until the diminishing resource base forces a slowdown in industrial growth. However, positive factors, such as the rate of technological innovation, grow only at a constant (arithmetic) rate.

The authors of the model illustrated exponential growth by considering the growth of lilies on a pond. The lily patch doubles in area every day. When the pond is half covered by lilies, it will only be another day until the pond is covered totally. This emphasized the apparent suddenness with which the exponential growth of a phenomenon approaches a fixed limit. It also shows that there is only a short period of time within which to take corrective action. If the predicted growth of world population is correct, there is an alarmingly short time available for preventive action.



▲ **Figure 3.25:** The original limits to growth

The team then examined the limits of growth:

- physical necessities that support all physiological and industrial activity, for example food, raw materials and fuels
- social necessities such as peace, stability and education.

The team assumed that there would be no great changes in human values in the future (Figure 3.25).

The model suggests that food-induced output and population grow exponentially until the rapidly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate as a result of decreased food and medical services.

The team concluded that:

- if present trends continued, the limits to growth would be reached in the next 100 years, probably resulting in a sudden and uncontrollable decline in population and industrial capabilities
- it is possible to alter these growth trends and establish a condition of ecological and economic stability that is sustainable into the future.

Much of this is remarkably reminiscent of Malthus's predictions. However, there are a number of criticisms of the Limits to Growth model:

- It is a world model and does not distinguish between different parts of the world.
- It ignores the spatial distribution of population and resources, of agricultural and industrial activity, and pollution. People and resources do not always coincide with space; their distribution and size are part of the world's problem.
- The model emphasizes exponential growth and not the rate of discovery of new resources or of new users of resources.

Paul Ehrlich is an American biologist who in 1968 co-wrote with his wife Anne *The population bomb*. The opening sentence of the first edition stated:

> The battle to feed all of humanity is over. In the 1970s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now. At this late date nothing can prevent a substantial increase in the world death rate.

He was a modern neo-Malthusian who believed that population control is essential, an increase in food supply is necessary, and the redistribution of wealth is also needed to address the world's population problem.

He argued that the growth of the population was outstripping the growth of food and resources. In 1980 he had a bet with the economist Julian Simon. In the bet, Ehrlich argued that the cost of raw materials would rise in future, whereas Simon argued that their price would come down. They wagered over five raw materials – copper, chromium, nickel, tin and tungsten. The bet started in 1980 and lasted for a decade. Ehrlich lost the bet as all five commodities fell in price (adjusted for inflation) during the 1980s. However, had they chosen other commodities Ehrlich would have won. Moreover, had they chosen a 30-year period for the five commodities, Ehrlich would have won. Thus, it is possible to reach very different conclusions based on different commodities and different timescales.

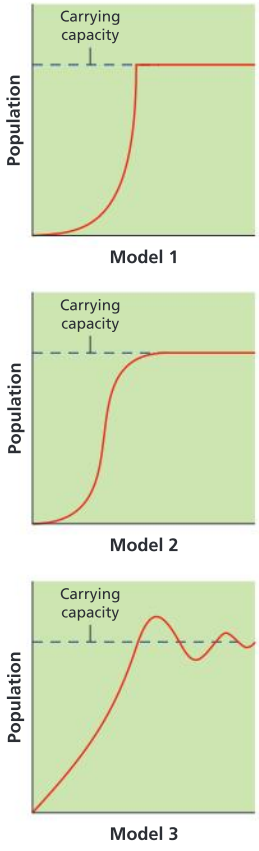
Common mistake

✗ Many students believe that the straight line for carrying capacity is correct.

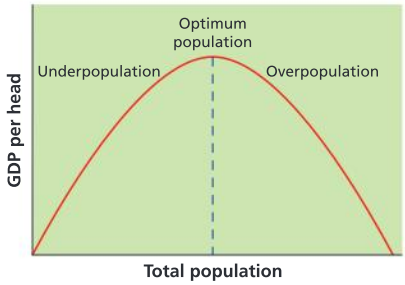
✓ Carrying capacity can increase due to improvements in technology and human adaptability.

Activity 10

1. Outline the principles of the neo-Malthusian view of population and resources.
2. Suggest how the message in Photo 3.13 relates to either the neo-Malthusian view of population and resources or the anti-Malthusian view.



▲ **Figure 3.26:** Carrying capacity



▲ **Figure 3.27:** Optimum, over- and underpopulation

Activity 11

Study Figure 3.25.

1. Describe the curve for the change in resources over time.
2. Suggest reasons to explain the nature of this curve.
3. Compare and contrast the curves for population and pollution.

Carrying capacity

The concept of a population ceiling, first suggested by Malthus, is of a saturation level where population equals the carrying capacity of the local environment. There are three models of what might happen as a population growing exponentially approaches carrying capacity (Figure 3.26):

- The rate of increase may be unchanged until the ceiling is reached, at which point the increase drops to zero. This highly unlikely situation is unsupported by evidence from either human or animal populations.
- The population increase begins to taper off as the carrying capacity is approached, and then to level off when the ceiling is reached. It is claimed that populations that are large in size, with long lives and low fertility rates, conform to this S-curve pattern.
- The rapid rise in population overshoots the carrying capacity, resulting in a sudden check, for example famine, birth control; after this, the population recovers and fluctuates, eventually settling down at the carrying capacity. This J-shaped curve appears more applicable to small populations with short lives and high fertility rates.

Optimum, over- and underpopulation

Optimum population is the number of people who, when working with all the available resources, will produce the highest per-capita economic return. It is the highest standard of living and quality of life. If the size of the population increases or decreases from the optimum, the standard of living will fall. This concept is dynamic and changes with time as techniques improve, as population totals and structures change, and as new materials are discovered.

Standards of living are a result of the interaction between physical and human resources and can be expressed as:

$$\text{Standard of living} = \frac{\text{Natural resources} \times \text{technology}}{\text{Population}}$$

Overpopulation occurs when there are too many people, relative to the resources and technology locally available, to maintain an adequate standard of living. Bangladesh, Somalia, and parts of Brazil and India are overpopulated as they have insufficient food and materials. They suffer from natural disasters such as drought and famine and are characterized by low incomes, poverty, poor living conditions, and a high level of emigration. Bangladesh has a population density of over 1,000 people per square kilometre, and is overpopulated.

Underpopulation occurs when there are far more resources in an area (such as food, energy and minerals) than can be used by the people living there. Canada could theoretically double its population and still maintain its standard of living. Countries like Canada and Australia can export their surplus food, energy and mineral resources, they have high levels of immigrants, and it is possible that their standard of living would increase through increased production if their population were to increase.

Resource stewardship

Resource stewardship is a concept that suggests that humans can use resources in such a way that they will be available to future generations. It suggests that there will be not only environmental sustainability but also social equity over access to resources.

The global commons refers to areas that lie outside the political reach of any nation state. According to the United Nations Environment Programme (UNEP), there are four global commons: the high seas, Antarctica, the atmosphere and outer space. The global commons require management and protection.

Renewable resources such as fish need not be depleted, provided that the rate of use does not exceed maximum sustainable yield; in other words, if the rate of use is within the limit of natural replacement and regeneration. If resources become over-exploited, depletion and degradation will lead to scarcity. If more than one nation is exploiting a resource, which is clearly the case in the fishing industry, resource degradation is often the result.

The tragedy of the commons

In 1968 Garrett Hardin, the American ecologist, suggested a metaphor, "the tragedy of the commons", to explain the lack of control over the way common resources are used and how the selfish acts of a few individuals can destroy the resource for others. In any given ocean, a number of nations may be fishing. Apart from the seas close to land, where there is an exclusive economic zone (EEZ), no country owns the oceans or the resources they contain. However, countries may use their resources and, if one country takes more fish from the oceans, their profits increase. Other countries do not benefit from this action. To maintain the same relative profitability, other countries may in turn increase their catch, so that they are not losing out relative to their competitors. (See Option B for a discussion of over-fishing.)

The "tragedy" is that other countries feel compelled to increase their catch in order to match the scale of the country that initiated the increase. Thus the rate of use may exceed maximum sustainable yield and the resources may become depleted. Although simplistic, the tragedy of the commons explains the tendency to over-exploit shared resources and the need for agreements over common management.

Case study

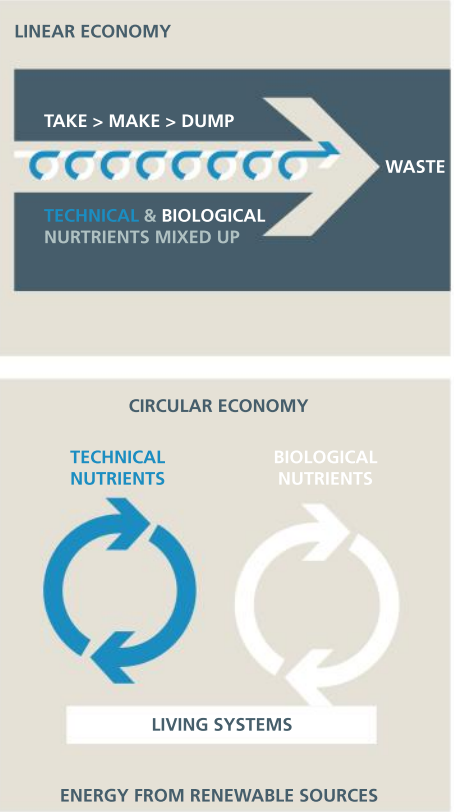
The IB and the circular economy

The Ellen MacArthur Foundation was established in 2010 to accelerate the transition to a circular economy. The Foundation's work focuses on four areas: insight and analysis, business and government, education and training, and communications. The Foundation works alongside Knowledge Partner and McKinsey and Company to quantify the economic potential of the circular economy. The Foundation also collaborates with global partners, including Google, to develop circular business initiatives. The Foundation is creating a global education initiative on the circular economy.

The IB has collaborated with the Ellen MacArthur Foundation to develop systems thinking and a perspective of the circular economy in the IB curriculum. The aim is to create an awareness of, and to take part in, future developments in the circular economy.

The circular economy framework as developed by the Ellen MacArthur Foundation is restorative and regenerative by design. According to Dame Ellen MacArthur, the links with education are clear, and her vision is to encourage young people to think differently, in circular ways. In 2016, most countries' economies were linear – her belief is that a circular economy requires advanced planning, so that materials used in a circular system will be recovered after use.

The IB believes that education is the key to developing the thinking needed to create a restorative and regenerative economy for generations to come. Given the right inputs, including education, young people inspire themselves, and embrace new ideas and a different way of thinking.



▲ **Figure 3.28:** Linear and circular economy, Ellen MacArthur Foundation

Activity 12

Describe the main differences between the linear economy and the circular economy in terms of energy source use.

ATL Research skills

To find out more about the Ellen MacArthur Foundation and the circular economy, visit www.ellenmacarthurfoundation.org.

The characteristics of a circular economy

A circular economy is one that preserves natural capacity, optimizes resource use and reduces loss through managing finite stocks and renewable flows. It is an economy that restores and regenerates resources, and keeps products, materials and components at their highest utility and value at all times. A circular economy aims to rebuild capital, whether it is financial, manufactured, natural, social or human. In a completely circular economy, consumption only occurs in bio-cycles, in which resources can be recovered and restored.

There are three principles behind the circular economy:

- Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.
- Optimize resource yields by circulating products, materials and components – this means designing for recycling and remanufacturing of products.
- Develop system effectiveness by eliminating negative externalities such as pollution and climate change.

In the circular economy, waste is minimized by the use of biological materials, which can be composted. Artificial (technical) materials, such as alloys and polymers, are designed for repeated use. Systems are designed to run on renewable energy. For example, agriculture could be run on solar energy, but modern intensive farming uses much fossil fuel in the form of fertilizers, distribution, and farm machinery. (See also Option G, Urban environments, for a discussion of the linear and circular models.)

The Sustainable Development Goals (SDGs)

The 17 SDGs were introduced in 2015, and are set to exist until 2030. They replaced the Millennium Development Goals (MDGs) that existed between 2000 and 2015.

Goal 1 calls for an end to extreme poverty by 2030. Poverty is widespread in sub-Saharan Africa, where over 40 per cent of the population lived on less than $1.90 a day in 2015. Globally in 2015, around 10 per cent of the world's population lived on less than $1.90 a day, compared with 28 per cent in 2000.

Goal 2 aims to end hunger and malnutrition by 2030, and seeks to achieve sustainable food production by 2030. The proportion of the world's population experiencing hunger fell by 4 per cent between 2000 and 2015, but there are still more than 800 million people who lack access to sufficient food. Over half the adult population in sub-Saharan Africa experiences food insecurity.

Goal 3 focuses on improving reproductive, maternal and child health, reducing epidemics of infectious diseases, lowering the incidence of degenerative diseases, and improving access to health care for all. Although the incidence of HIV, malaria and TB declined between 2000 and 2015, there were still more than 2 million new HIV infections in 2015, and 200 million cases of malaria. Sub-Saharan Africa accounted for nearly 90 per cent of malaria cases in 2015.

Case study

Resource use in three industries

Car manufacturing

The car industry accounts for 60 per cent of the world's lead use, which is predicted to run out by 2030. Remanufacturing and reconditioning employ 350,000 workers in the USA but only 35,000 in the EU, where some 12 million cars are "retired" each year. An example of where old cars have been remanufactured is the use of cars in Cuba, many of which have spare parts from other machines inserted to keep them viable (Photo 3.15).

▲ **Photo 3.15:** "Classic" cars in Cuba

At Choisy-le-Roi, in south-east Paris, the savings from the remanufacture of cars are impressive – the process uses 80 per cent less energy, 88 per cent less water, and 92 per cent fewer chemical products, and produces 70 per cent less waste. No materials are sent to landfill sites. Some 43 per cent of car bodies are reusable and 48 per cent are recycled for new parts.

Mobile phones

In North America, Western Europe and Japan, most people change their phone every two years. In 2010 the volume of waste electrical and electronic equipment (WEEE) in the EU was 750,000 tonnes. Generally, mobile phones are light (less than 160 g), but their materials and components have considerable economic value, since they contain many valuable resources such as gold, silver and rare earths. In the EU, some 160 million mobile phones are discarded annually, representing a loss of materials of $500 million a year.

Only about 15 per cent of phones are currently collected and recycled. Increasing collection rates to 50 per cent would make a huge difference: second-hand sales of phones would be profitable even after collection, processing and remarketing. Collecting reusable components and remanufacture could be made easier if the design of certain parts of a phone were standardized. The main parts that could be remanufactured include the charger, battery, camera and display.

The transition to a circular economy has major implications for material use and energy consumption, and offers major savings for both. Recycling of phones would generally occur close to the market and result in reduced imports of phones, which are mainly produced outside the EU.

Washing machines

More households in Europe own washing machines than cars. The typical household washing machine contains 30–40 kg of steel and will make around 100 wash cycles a year. In contrast, a hotel or launderette washing machine may make between 1,500 and 3,000 wash cycles a year. This trade-off between high-quality and low-quality machines has implications for energy consumption and use of materials. Energy efficiency could be improved if households used machines designed for hotels/launderettes.

Washing machines are generally recycled, although it is estimated that only 10 per cent of machines are refurbished. In many cases, old machines could be refurbished with replacement parts such as a new motor, pump or circuit board.

Goal 4 aims to improve education and training. In 2013, around 60 million primary school children did not attend school. Most of these come from the poorest households: children from the poorest 20 per cent of households are four times more likely to miss school compared with children from richer households.

▲ **Figure 3.29:** The UN Sustainable Development Goals (SDGs)

Goal 5 is to empower women and girls to achieve their full potential.

Goal 6 aims to ensure the availability and sustainable management of water and sanitation. In 2015 more than 660 million people were using unimproved sources of surface water, and water stress affects over 2 billion people around the world.

Goal 7 aims to promote access to affordable energy, and to increase the use of renewable energy sources. The proportion of people with access to electricity increased from 79 per cent in 2000 to 85 per cent in 2012, but there were still more than 1 billion people without access to electricity in 2012.

Goal 8 is to promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all. It also is attempting to eradicate forced labour, human trafficking and child labour.

Goal 9 plans to promote infrastructure development, sustainable industrialization and innovation. For example, while 89 per cent of urban areas had 3G mobile broadband coverage in 2015, only 29 per cent of rural areas had.

Goal 10 aims to reduce inequalities within and between countries. This includes inequalities in wealth, gender, age, race, class, ethnicity, religion and opportunity.

Goal 11 aims to make settlements more sustainable and to promote community cohesion, personal security, innovation and employment.

Goal 12 focuses on the need for sustainable consumption and production patterns, that is, the "circular economy" in which today's waste becomes tomorrow's raw materials and recycled products.

Goal 13 seeks to take urgent action to combat climate change and its impacts.

ATL Research and communication skills

Visit https://www.youtube.com/watch?v=1e8xgF0JtVg and watch "The girl effect: the clock is ticking".

Discuss the content of the film.

Goal 14 aims to promote the conservation and sustainable use of the oceans, seas and marine resources.

Goal 15 aims to manage forests sustainably, restore degraded lands, combat desertification, limit the degradation of natural habitats and reduce biodiversity loss.

Goal 16 aims to promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

Goal 17 calls for partnerships to strengthen the means of implementation of the SDGs, that is, the finance and technology.

ATL Research and communication skills

Study the SDG Progress Annual Report at http://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Explore the publication. Comment on the degree to which the goals are being met. Which have been the most and which the least successful goals?

Check your understanding

1. Outline the views of neo-Malthusians.
2. Suggest ways in which food production can be increased.
3. Explain the term "carrying capacity".
4. Distinguish between overpopulation and underpopulation.
5. Identify the four global commons.
6. Explain the meaning of the term "the tragedy of the commons".
7. Explain the benefits of the recycling of mobile phones or washing machines.
8. Outline the aims of the Sustainable Development Goals.
9. Suggest reasons why it may be difficult to achieve the SDGs.
10. Outline the main inequalities in gender as identified by the SDGs.

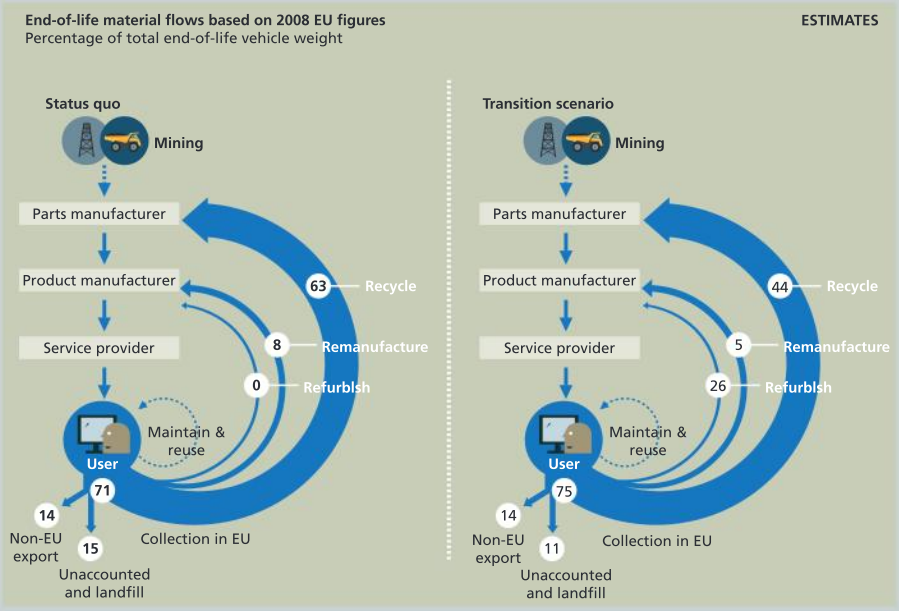
Concepts in context

There are many **possibilities** for how the world's resources may be used. Much depends on the **power** of the user; for example, large-scale TNCs as opposed to small-scale organizations and households. Some users will use resources wastefully, whereas others may attempt to conserve resources, and even create new ones. It is possible to use resources in a sustainable fashion. Resource stewardship promotes sustainable use of resources.

Synthesis and evaluation

- There are different views on global resource use and the effectiveness of management options. Some are pessimistic (such as those of Malthus and the Club of Rome) and others are optimistic (such as those of Boserup).
- In addition, there are variations in the scale of resource use, from the global scale to the regional and local scale.
- Resource use may have a negative impact in some areas but be managed carefully in others.
- There are calls by the UN and other organizations to use resources more responsibly, and to develop a circular economy that minimizes waste and reuses resources far more efficiently than previously.
- Geographers use decision-making skills to weigh up the potential impact of resource use and examine ways in which resources can be used in a more sustainable way. A geographical perspective takes into account variations in places, people, types of government, levels of wealth, and so on.

The diagram shows a model of recycling, remanufacturing and refurbishment for light commercial vehicles.

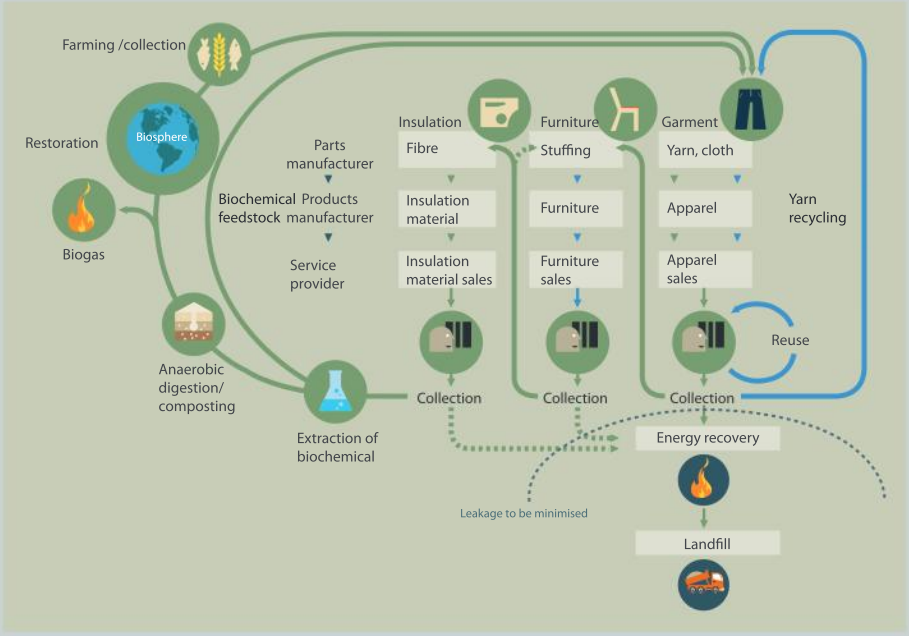


(a) (i) Define the term recycling (1 mark)

(ii) Suggest what is meant by the term "remanufacture" (1 mark)

(iii) Describe the changes in recycling, remanufacture and refurbishment between the Status quo model to the Transition scenario. (3 marks)

(iv) Outline the potential benefits of the Transition scenario over the Status quo model. (4 marks)



(b) Study the infographic on the textile industry and the circular economy.

(i) Identify three products are are made from textiles. (1 mark)

(ii) Outline two ways in which the textiles can be reused and recycled (2 + 2 marks)

(iii) Suggest two ways in which leakage is minimised. (2 marks)

(iv) Explain how textiles can contribute to the energy sector. (2 marks)

(c) Either

Discuss the value of the nexus approach with respect to food security. (10 marks)

Or

"The circular economy is the most effective way of planning resource us for the future." Discuss the implications of this statement. (10 marks)

UNIT 4
POWER, PLACES AND NETWORKS

Key terms

Foreign direct investment	The investment by a company into the structures, equipment or organizations of a foreign country. It does not include investment in shares of companies of other countries.
Globalization	"The growing interdependence of countries worldwide through the increasing volume and variety of cross-border transactions in goods and services and of international capital flows, and through the more rapid and widespread diffusion of technology" (International Monetary Fund).
Global village	The idea that the world (globe) has been transformed into a "village" by the almost instantaneous transmission of information, facilitated by improvements in ICT.
Offshoring	The process by which firms move production overseas.
Outsourcing	When a firm obtains inputs such as skills and services from separately owned suppliers instead of sourcing them internally.
Superpower	A nation or group of nations with a leading position in international politics.

The study of power, places and networks involves the study of global interactions arising from globalization. The concept of globalization developed in the 1960s after the Canadian academic Marshall McLuhan used the term "global village" to describe the breakdown of spatial barriers around the world. McLuhan argued that the similarities between places were greater than the differences between them, and that much of the world had been caught up in the same economic, social and cultural processes. He suggested that economic activities operated at a global scale and that other scales were becoming less important.

Global interactions are a multidimensional, complex set of processes in which societies and countries may adopt, adapt or resist goods, services and cultural traits from other societies and countries. The process is dynamic and is neither inevitable nor universal. Global interactions may increase or reduce the inequalities between places.

Key questions

1. How do global **power** and influence vary spatially?
2. How do different **places** become interconnected by global interactions?
3. How do political, technological and physical **processes** influence global interactions?

1 Global interactions and global power

Conceptual understanding

Key question

How do global **power** and influence vary spatially?

Key content

- Globalization indices showing how countries participate in global interactions.
- Global superpowers and their economic, geopolitical and cultural influence.
- The influence of global organizations and groups – the G7/8, the G20, the Organization for Economic Cooperation and Development (OECD) and the Organization of the Petroleum Exporting Countries (OPEC).
- The influence of global lending institutions, including the International Monetary Fund (IMF), the World Bank, and New Development Bank (NDB).

Globalization indices

Globalization refers to a range of processes and impacts that occur at a global scale. These are usually economic systems but can include physical systems (such as global warming) and sociocultural systems (such as fashion, music and the film industry). Globalization is not new – many countries had empires from which they sourced raw materials and labour – but the current form of globalization is more global, more integrated and has developed at a much faster rate than in the past.

There are three main forms of globalization:

- Economic: largely caused by the growth of transnational corporations (TNCs)
- Social: the impact of western culture, art, media, sport and leisure pursuits on the world
- Political: the growth of western democracies and their influence on poor countries, and the decline of centralized economies.

Global systems refer to organizations, groupings or activities that link different parts of the world. Transnational companies (TNCs), for example, operate in two or more countries, linking the economies of those countries. Such relations or activities have an effect on the people and the environment of the countries in which the TNC operates, and may provide opportunities but increase inequalities. Global governance refers to attempts to regulate these global systems, for example by the United Nations, the International Monetary Fund and the World Bank. Their interventions may also have an impact on people and the environment.

Globalization indices

There are a number of globalization indices, including the KOF Index of Globalization, Ernst and Young's (EY) Globalization Index and the New Globalization Index.

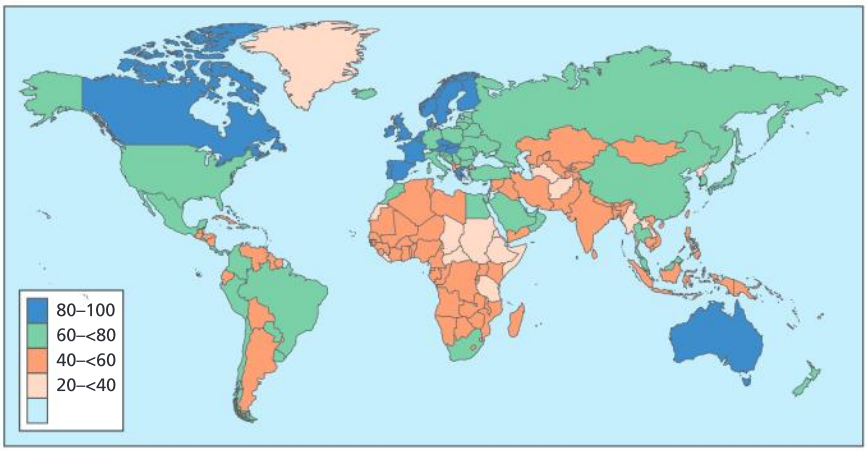
The KOF Index of Globalization

The KOF Index of Globalization, introduced in 2002, defines globalization as "the process of creating networks of connections among actors at multi-continental distances, mediated through a variety of flows including people, information and ideas, capital and goods. Globalization is conceptualized as a process that erodes national boundaries, integrates national economies, cultures, technologies and governance and produces complex relations of mutual interdependence".

Figure 4.1 shows that the most globalized countries are Canada, Australia, New Zealand and many European countries. The least globalized countries include many in sub-Saharan Africa, especially around the Horn of Africa, countries in conflict such as Afghanistan, and some low-income countries including Nepal and Myanmar.

The KOF Index covers the economic, social and political dimensions of globalization:

- The economic dimension – long-distance flows of goods, capital and services, as well as information and perceptions that accompany market exchanges (36 per cent of the Index).
- The social dimension – the spread of ideas, information, images and people (38 per cent of the Index).
- The political dimension – the diffusion of government policies (26 per cent of the Index).



▲ **Figure 4.1:** The KOF Index of Globalization, 2016 (based on data for 2013)

In addition to the indices measuring the three dimensions, the KOF Index calculates an overall index of globalization and sub-indices referring to actual economic flows, economic restrictions, data on information flows, data on personal contact, and data on cultural proximity. In 2016 the Netherlands was identified as the most globalized country in the world, followed by Ireland, Belgium and Austria. The KOF Index showed that advances were generally slowing down despite large increases in Eastern Europe and Asia-Pacific. The world's major economies (the USA, China, Japan, Russia and Germany) tend to be more inward-looking and less globalized.

Measures of economic globalization

Broadly speaking, economic globalization covers actual economic flows – usually taken to be measures of globalization – and restrictions to trade and capital. Since the financial crisis of 2008, economic globalization has made little progress.

Measures of social globalization

The KOF Index classifies social globalization in three categories:

- Personal contacts. This includes international telecom traffic (outgoing traffic in minutes per subscriber) and the degree of tourism (incoming and outgoing) a country's population is exposed to. Government and workers' transfers (such as remittances and foreign direct investment (FDI)) received and paid (as a percentage of GDP) measure whether and to what extent countries interact.
- Information flows. This includes the number of Internet users, cable television subscribers, and radios (all per 1,000 people), and international newspapers traded (as a percentage of GDP).
- Cultural proximity. This is arguably the dimension of globalization most difficult to grasp. According to one geographer (Tony Saich, "Globalization, Governance and the Authoritarian State"), it refers mostly to the dominance of US cultural products (see Photo 4.1). However, many global companies and products do not come from the USA: sushi, curry, Toyota and Sony spring to mind. The KOF

▲ **Photo 4.1:** Disney merchandise, Bandar water village, Brunei

▲ **Photo 4.2:** A sign for a McDonald's restaurant, Tokyo

ATL Research and communication skills

Study the detailed listings for the KOF Index at http://globalization.kof.ethz.ch/media/filer_public/2016/03/03/rankings_2016.pdf and examine the Index (and sub-indices) for five contrasting countries. Compare and contrast your chosen countries, and suggest reasons for the similarities/differences you have noted.

Index uses the number of McDonald's restaurants (Photo 4.2) and the number of IKEA stores per capita located in a country as measures.

In 2016 Austria had the highest social globalization, followed by Singapore, Switzerland and Ireland.

Measures of political globalization

Political globalization uses the number of embassies and high commissions in a country, the number of international organizations of which the country is a member and the number of UN peace missions in which a country has participated. In 2012 political globalization was highest in Italy, followed by France and Belgium.

Other globalization indices

The EY Globalization Index was developed by the Economist Intelligence Unit to measure the 60 largest countries/territories by GDP according to their level of globalization. The Index looks at each country's openness to trade, capital flows, exchange of technology and ideas, labour movements and cultural integration. As in the KOF Index, countries and territories such as Hong Kong, Singapore, Ireland, the Netherlands, Belgium and Switzerland are at the top of the table. However, it notes that the character of globalization is changing. Although trade in goods and services has largely returned to the pre-financial crisis (2008) level, it is technology and the flow of ideas that are the main areas of growth. Technology is very much the centre of the "digital" and interconnected world. However, the globalization of "talent" is limited; many businesses struggle to find workers with the right skills and experience, and such skilled labour tends to be clustered in cerain locations. In addition, the Index notes that some capital flows have shown a return to the USA and the EU.

The New Globalization Index tends to show similar results. It is based on finance, trade and politics, and social factors (Table 4.1).

▼ **Table 4.1:** The New Globalization Index: dimensions and weights

Finance 37%	Trade and politics 32%	Social factors 31%
FDI stock 19%	Trade in goods 11%	Trade in services 14%
FDI flow 13%	Trademarks 14%	Migration 9%
Portfolio stock 20%	Patents 14%	Tourism 15%
Portfolio flow 14%	Transfers 10%	Telephone 15%
Income payments 19%	Environmental agreements 16%	Books 11%
Internet 15%	International organizations 18%	Newspapers 14%
	Embassies 16%	Outgoing students 12%
		Peacekeeping 11%

Source: Petra Vujakovic. 2010. "How to measure globalization? A New Globalization Index". *Atlantic Economic Journal.*

The New Globalization Index differs slightly from the others in that it measures the distance of goods traded. Thus, for example, New Zealand and Argentina score higher on this measure than, for example, Hungary and the Czech Republic. In addition, it counts the number of refugees

in a country; hence Lebanon and Turkey would appear to be more globalized.

All of the indices show that small HICs, such as Singapore and the Netherlands, tend to be near the top of the list, whereas very large HICs, such as the USA, are located towards the bottom. Large rich countries such as Germany, France and Italy tend to be towards the middle of the rankings, while the major LICs are towards the bottom of the rankings.

Some critics argue that globalization is slowing down. They point to the growth in protectionism since the financial crisis of 2008, the growth in popularity of right-wing politicians such as Marine Le Pen and Donald Trump, the UK's decision to leave the EU ("Brexit"), and the development of more trade barriers by countries such as the USA, Germany and the UK.

Global superpowers

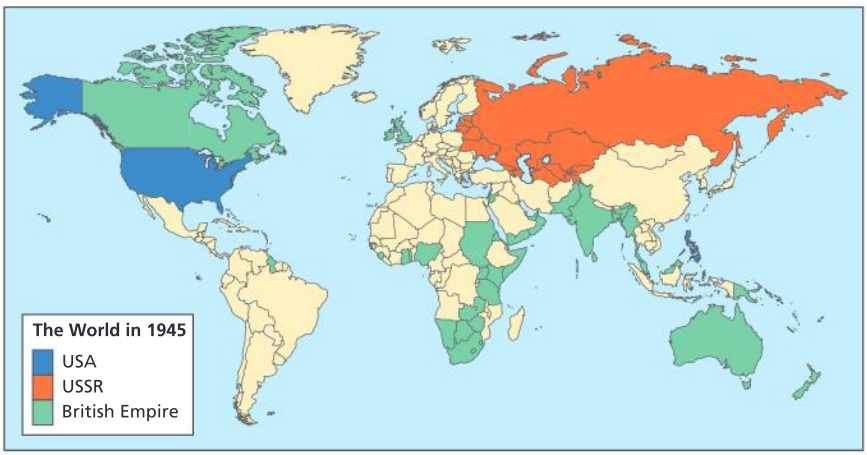
Superpowers are able to influence policy on a worldwide scale, and often in different regions at the same time. The concept of a superpower has developed to include its economic, cultural, military and geographical influence on the rest of the world, as seen, for example, in the USA and the former USSR and, more recently, in China, India and Brazil.

The term "superpower" was first used in 1944 by TR Fox in his book *The Superpowers: The United States, Britain and the Soviet Union – Their Responsibility for Peace*. These three nations fought on the same side in the Second World War, but afterwards became involved in a contest for economic, political and military power. At the end of the war, the British Empire still covered about a quarter of the world's land area and a quarter of its population, but in the following years most of its colonies gained their independence, joining the Commonwealth of Nations as independent states. As Britain's power declined, the USA and USSR were emerging as the new superpowers.

The USA, the USSR and the Cold War, 1947–91

The USA suffered less wartime damage to its territory than European and Asian countries and by the end of the war it had developed into a strong military and industrial power, as well as a major creditor for countries weakened by the war. Both the USA and the USSR sought to increase their dominance on the world scene. The competition between the two countries led to the development of the Cold War.

By the 1980s their respective powers had greatly increased, but there were a number of differences between the USA and the USSR. Politically, the USSR promoted communism and the economy was state controlled. In contrast, the USA was managed



▲ **Figure 4.2:** Map of world superpowers, 1945

as a democracy and had a free-market approach to the economy. Both countries were keen to support and extend their influence over other countries. The USSR developed strong links with Eastern Europe and developing countries. The USA, on the other hand, had firm relations with Western Europe, the Commonwealth, Latin America and key Asian countries. Post-war US policy was to contain the spread of Soviet influence, and to that end it supported a number of right-wing dictatorships in its attempt to reduce the spread of Soviet left-wing tendencies.

The two nations had shared characteristics in terms of population, land and resources. While the USSR was the world's largest country, with a land area of over 22 million km^2, the USA was the world's third-largest with over 9 million km^2. The USSR was the world's third-largest in terms of population size (over 285 million at the time of its break-up), while almost 250 million people resided in the USA. Both had many valuable economic resources; in particular the USSR had oil and gas, whereas the USA contained valuable minerals, metals, forests, and a modern agricultural and industrial system. The USA had the world's largest economy and the USSR the second largest. To complete the superpower checklist, the USSR had the world's largest land-based army and the world's largest stockpile of nuclear weapons. In contrast, the USA had the world's largest and most powerful navy and one of the two most powerful air forces in the world.

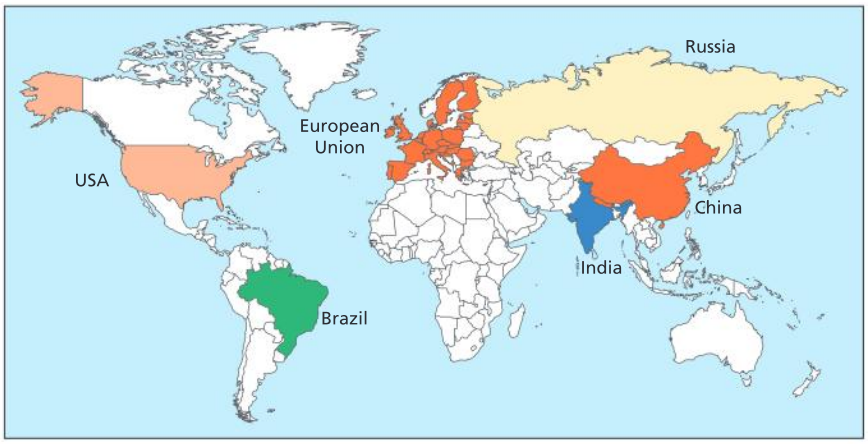
Culturally, both the USA and USSR affected large areas of the world. Conflict between the two superpowers was not just limited to military threats: the Cold War also affected the world of chess and basketball, and the respective countries and their allies did not attend the Olympic Games held in Moscow in 1980 and Los Angeles in 1984.

The term "soft power" is used to describe the ability to change individuals, communities and nations without using force or coercion. Many countries achieve soft power through their culture, political values and foreign policies such as aid and investment. Superpowers use soft power as well as hard power (force) to influence other countries. For example, the USA favours democracy and human rights, and US broadcasting into eastern Europe is partly credited for the rise of the Solidarity movement and the decline of Russian influence there. The USA has the largest number of foreign journalists based in a country, is a favourite destination for overseas students, and the distribution of American films and TV programmes, such as *Friends*, has led to the Americanization of other cultures and languages. Russia has also tried to spread its influence to other countries, but the lack of a popular culture, and language differences, have meant that it has had less influence than the USA overseas.

Rising superpowers after 1991

After the collapse of communism in the USSR and its break-up in 1991, the USA was left as the world's only superpower. However, US military involvement in Iraq and Afghanistan following the 2001 terrorist attacks on the USA has not achieved its desired ends and some critics argue that the USA is losing its superpower status. Since the 2008 financial crisis, the USA has lost economic strength (as have many countries that had been propped up by US money) and other nations are gaining

ascendancy. China, in particular, has experienced massive economic growth, as well as having a very large military – although whether it fulfills all the criteria to be called a superpower is debatable. The European Union, a group of 28 countries (at the time of writing, the UK had not left the EU), has also been described as a superpower, but internal differences between member countries reduce its cohesion. The economic rise of the BRICs nations (Brazil, Russia, India and China) and the oil-rich OPEC states brings benefits to many. Equally, there may be economic costs to the existing superpowers, and environmental and resource implications. In an increasingly globalized and interdependent world, it is likely that tensions will develop as power shifts.



▲ **Figure 4.3:** Potential and existing superpowers 2016

The USA: the military-industrial complex and the evolution of a superpower

After the Second World War, the USA had a greatly enhanced status and power. The Great Depression of the 1930s had been replaced by an economy stimulated by wartime production. Unlike Europe, the USA did not suffer from wrecked infrastructure. US involvement in the Second World War – the large-scale air and land campaigns in Europe and the "island-hopping" war against Japan in the Pacific – set a precedent for the global projection of US military strength.

It was not just economic and military strength: the USA encouraged the establishment of international institutions and international law. The UN headquarters were located in New York; the World Bank and the IMF were based in Washington. Although these were, and continue to be, international organizations, US institutions had greater access to them than if they had been located elsewhere.

The growth of US military influence worldwide grew out of a number of doctrines. These included:

- the Monroe Doctrine of 1823 – which declared that European colonial intervention in the western hemisphere would be resisted by force
- the Truman Doctrine of 1947 – which committed the US to support free peoples threatened by communist takeover
- the Nixon Doctrine of 1969 – under which arms shipments rather than US troops would be supplied to allies in the fight against communism
- the Reagan Doctrine of the 1980s – which provided US arms and training to groups seeking to overthrow Soviet-backed rulers.

The USA has by far the world's largest and most technologically advanced fleet of warplanes, ships, tanks and artillery systems.

These give it dominance over air, sea and land. Control of space and information are key aspects of US military strategy for the 21st century. The USA's global military presence includes overseas bases, ships and aircraft that allow the USA to apply force to any part of the globe, supply weapons and military training to a wide range of countries, and have a network of listening posts to gather and disseminate vital information.

The US defence industry employs over 2 million people, with local manufacturing plants or research and development facilities in most US states. Approximately one in six households in the USA have someone employed in the military-industrial complex. Annual spending on defence exceeds $100 billion a year. Federal funding for military research is $40 billion a year, twice what is spent on health, energy and the environment combined. The institutions and organizations that have developed over 50 years of intensive military spending have created vested interests with huge political influence.

For example, most US warplanes, bombs and missiles are made by a small group of very large contractors, including in particular Lockheed Martin, Boeing, Raytheon, TRW and Textron. In 1998–9, Lockheed Martin employed 130,000 people in the US and overseas and had over 900 facilities in 45 US states. Internationally, the company had business locations in 56 nations and territories. In the early 1990s, when defence spending dropped in the wake of the Soviet collapse, the US government urged defence contractors to merge in order to consolidate their strength and maintain America's defence capabilities. The outcome was a rapid series of mergers, which gave rise to a handful of giant groups.

Selling arms and military services worldwide

The US accounts for half of all international arms sales. Much US military equipment destined for export is manufactured abroad under licence. For example, Turkey has made F-16s since the mid-1980s. The US cooperates closely with certain allies, including the UK and Israel, on high-tech projects such as missile defence.

Apart from the huge ongoing requirement for production of new aircraft, tanks, ships and weapons systems, there is a vast procurement programme for spare parts, fuel, munitions and the myriad other supplies that sustain the US military machine. Huge amounts are spent on developing new weapons. Although the US is widely acknowledged to have the world's most advanced combat aircraft, it is busy making the next generation of fighter planes.

Case study

China – a rising superpower

Since 1978, the standard of living of most people in China has tripled. Market reforms have been introduced gradually, avoiding the "big bang" approach. Following the death of the Chinese leader Chairman Mao in 1976, a more moderate faction led by Deng Xiaoping gained control of the government. One of Deng's first acts was to inject an element of free enterprise into agriculture, allowing peasant families to keep for themselves anything they produced over the state quota. This responsibility system resulted in an almost immediate leap in food production.

Case study (continued)

A similar approach was later applied to the industrial sector.

In 1992 Deng gave official blessing to business entrepreneurship throughout China. After Deng died in 1997 and Jiang Zemin became the leader, China saw major improvements in its diplomatic standing and economic strength. Although disparities increased between urban and rural living standards, China's economic miracle has had an enormous impact on ordinary people, with village and township enterprises springing up all over the country. The Yangtze valley has become integrated into the Asia-Pacific trade bloc. Developments in the Pearl River Delta Region have built upon Hong Kong's success, to create a dynamic business region in southern China.

China's economic growth has also had a major impact on trade among the superpowers and the geographic regions of the world. The EU is the dominant trading region, followed by Asia and then North America. Despite the Asian financial crisis of 1997–8 – which saw the collapse of many Asian banks and the value of their stocks and shares, forcing many countries to restructure their economies and reduce their levels of debt – China's GDP has continued to grow by 8 per cent a year. China's demand for raw materials for this economic boom had a major impact on world markets in oil, iron ore, metals, petrochemicals and machinery. One of the largest of China's many infrastructure projects was the Three Gorges Dam, the world's largest hydroelectric plant. More giant projects are planned, including the diversion of river water from the south to the water-hungry north.

Despite rapid change, the structure of the Chinese economy still has the character of a poor developing country, with almost half the workforce employed in the primary sector. Industry accounts for 22 per cent of jobs but 51 per cent of output, with manufacturing 35 per cent. This reflects the fact that China has become the world's leading manufacturing centre, although much of the value-added output is from foreign-owned plants in China's special development zones. According to the IMF, in 2014 China produced 17 per cent of the world's gross domestic product, surpassing the USA's 16 per cent. However, China remains well below the USA in terms of GNI/head.

▲ **Figure 4.4:** A comparison of military might

▼ **Table 4.2:** Defence spending in ranked countries, 2015

Rank	Country	Spending, $ billion
1	USA	597.5
2	China	145.8
4	UK	56.2
5	Russia	51.6
6	India	48.0
11	Brazil	24.3

Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Table 4.3: The size of selected economies in 2014

Rank	Economy	GDP $ bn
1	USA	17,348
2	China	10,431
5	UK	2,992
7	Brazil	2,417
9	India	2,043
10	Russia	2.030

Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Activity 1

1. Describe and explain the main characteristics of a superpower.
2. Comment on the way superpower status changes over time.
3. Compare and contrast the characteristics of emerging superpowers with those of established superpowers.

Global organizations and groups

The G7 and the G8

The G7 (Group of Seven) is a powerful group of HICs – the USA, France, Germany, Italy, the UK, Japan and Canada – that meets annually to discuss matters such as the global economy, global governance, energy policy and international security. They were joined by Russia in 1998 to form the G8 (Group of Eight). However, Russia was suspended following its activities in Ukraine.

The G7 was initially established as a group of non-communist countries concerned about the rise in oil prices following OPEC's decision to exert greater control over the world's oil. The G7 is not a formal institution but acts in an advisory capacity. The small number of similar countries that make up the G7 should, in theory, enable decisions to be made, but critics argue that it does not follow through with its proposals and that it does not speak for any emerging economy.

Russia was admitted to the G7 when it was believed that the country would become more democratic. However, during the annual summit in 2013 the G7 leaders were keen to call for the Syrian leader Bashar al-Assad to leave office, but the Russian president declined to do so. Then, as the conflict between Ukraine and Russia escalated in 2014, the USA and EU imposed sanctions against Russia. When in July 2014 the Malaysia Airlines Flight MH17 crashed in east Ukraine, allegedly hit by anti-aircraft missiles fired by Russian-backed rebels, and killing all 298 passengers, the USA and the EU increased sanctions.

Without Russia, the G7 is able to speak unanimously. However, without Russia, the G7 represents a smaller proportion of the world's population, and without China, it cannot claim to be a truly global organization.

The G7 agenda has focused to a large extent on promoting economic recovery in Ukraine and in the EU. There are divisions among its members, with some countries wishing to impose austerity packages and others, such as the USA, preferring monetary policies to revive domestic demand and promote economic growth.

The G20

The G20 (G-20 or Group of Twenty) is an international assembly for the governments and central bank governors from 20 major economies. It was established in 1999 to discuss policy issues related to global financial stability. The G20 includes 19 countries – Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, South Korea, Mexico, Russia, Saudi Arabia, South Africa,

Turkey, the UK and the USA – and the EU. In addition, the G20's guests include Spain, the chair of ASEAN, two African countries, and one that is invited by the president of the G20. Several other people participate in G20 meetings, including the Chair of the IMF, the president of the World Bank, and the Chair of the Development Assistance Committee.

The G20 countries represent about 85 per cent of gross world product, 80 per cent of world trade, and about 65 per cent of the world's population. The G20's main interest is global economic governance, but it has also discussed the impacts of an ageing population, reform of the World Bank and the IMF, energy security and resource depletion. Given the nature of the countries involved, the G20 has an important bearing on global policy. It is likely that large Asian economies will play an increasingly important role in global governance in the future, on account of their population size and the size of their economies.

Following the financial crises of 2007–08, the G20 began to hold two summits a year, but since 2011 they have been held once a year. Although the G20 claims that its broad membership and high economic profile makes it legitimate, some critics question this, arguing that Africa is under-represented. Some 173 countries, many of them with large economies, are not represented in the G20. Norway is not represented, either by the EU or in its own right.

The OECD

After the Second World War, the Organization for European Economic Cooperation (OEEC) was established to run the US-financed Marshall Plan for the reconstruction of Europe. It recognized the need for cooperation between countries and their interdependence. In 1960 Canada and the USA joined the OEEC members to form the Organization for Economic Cooperation and Development (OECD). Other countries joined, and today the OECD has 35 members. The OECD aims to identify, analyse and discuss problems, and find policies to solve them. It provides a forum for countries to share experiences and to seek solutions for common problems. Its stated aim is to help countries around the world to:

- restore confidence in markets and the institutions that make them function
- re-establish healthy public finances as a basis for future sustainable growth
- foster and support new sources of growth through innovation, environmentally friendly "green growth" strategies and the development of emerging economies
- ensure that people of all ages can develop the skills to work productively and satisfyingly in the jobs of tomorrow.

(Source: http://www.oecd.org/about/)

The OECD also works with other global institutions such as the UN Food and Agriculture Organization (FAO), the IMF, the World Bank, the International Labour Organization and the G20.

OECD
BETTER POLICIES FOR BETTER LIVES

▲ **Figure 4.5:** The OECD logo

Activity 2

1. Study the list of countries in the OECD. Comment on the membership of the OECD.
2. Suggest one other country that should be a member of the OECD. Justify your choice.
3. Visit the OECD page on social and welfare issues, http://www.oecd.org/social/inequality-and-poverty.htm. Investigate some of the issues there (gender equality and development, families and children, poverty reduction and social development, income inequality and poverty). Make a brief presentation of your findings.

Table 4.4: Members of the OECD

Australia	France	Korea, South	Slovak Republic
Austria	Germany	Latvia	Slovenia
Belgium	Greece	Luxembourg	Spain
Canada	Hungary	Mexico	Sweden
Chile	Iceland	Netherlands	Switzerland
Czech Republic	Ireland	New Zealand	Turkey
Denmark	Israel	Norway	United Kingdom
Estonia	Italy	Poland	USA
Finland	Japan	Portugal	

Figure 4.6: OPEC members

ATL Research skills

To find out about the state of the world's oil reserves, demand levels and trends in the world economy, visit the OPEC home page at www.opec.org, where there is a monthly oil market report.

OPEC – an oil cartel

The Organization of Petroleum Exporting Countries (OPEC) was established in 1960 to counter oil price cuts by American and European oil companies. Founder nations included Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. Qatar, Indonesia and Libya joined in 1962 and the United Arab Emirates, Algeria, Nigeria, Ecuador and Gabon joined later. In 1979 the OPEC countries produced 65 per cent of world petroleum, but only 36 per cent by 2007. As early as 2003, concerns that OPEC members had little excess pumping capacity sparked speculation that their influence on crude oil prices would begin to slip. However, revenues from oil have allowed member countries to invest in and diversify their economies, generating wealth since the 1970s.

From a Western perspective, the development of OPEC and the control of oil has had important implications. As OPEC controlled the price of oil and much of the production in the 1970s and 1980s, Middle Eastern countries gained economic and political power. All world regions became increasingly dependent on the Middle East. Arguably, this has provided an incentive for the old industrialized countries to increase energy conservation or develop alternative forms of energy.

The importance of oil means that countries need to maintain favourable relationships with OPEC countries and that the Middle East will be involved in economic cooperation and development with industrialized countries. It also means that there needs to be political stability in the Middle East and a need to reassess coal and nuclear power as energy options.

Global lending institutions

The World Bank

The World Bank, established in 1944, is a source of financial and technical assistance to developing countries around the world. Its mission is to fight poverty by providing resources, sharing knowledge and building capacity. It is made up of two unique development institutions owned by 186 member countries: the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA).

The World Bank has its headquarters in Washington DC. It has more than 10,000 employees and over 100 offices worldwide.

Until 1967 the bank's original purpose was the reconstruction of post-war Europe, and it undertook a relatively low level of lending. From 1968 to 1980 the bank began to focus on the needs of the developing world and greatly increased the size and number of its loans. Bank policy shifted towards measures such as building schools and hospitals, improving literacy, and agricultural reform.

The period 1980–89 was dominated by lending to service third world debt. Structural adjustment policies (SAPs) aimed at streamlining the economies of developing nations were a large part of World Bank policy during this period.

Since 1989 World Bank policy has changed again, and its current focus is on the achievement of the Millennium Development Goals (MDGs), lending primarily to middle-income countries (MICs). The Bank's mission is to aid these countries and their inhabitants to achieve development and reduce poverty. This includes achievement of the MDGs, by helping countries develop an environment for investment, jobs and sustainable growth, thus promoting growth through investment and enabling the poor to share the fruits of that growth.

Extension work

Visit http://www.worldbank.org/en/news/press-release/2015/10/15/world-bank-new-end-poverty-toll-surveys-in-poorest-countries to see how conducting surveys in the world's poorest countries will help monitor ending poverty by 2030.

Critics of the World Bank

Non-governmental organizations and academics have long criticized the World Bank, claiming that its free-market reform policies are harmful to economic development. In *Masters of Illusion: The World Bank and the Poverty of Nations* (1996), Catherine Caufield argues that Western practices are adopted and traditional economic structures and values ignored or abandoned. A second contested assumption is that poor countries cannot modernize without money and advice from abroad.

Another criticism of the World Bank is the way in which it is governed. Although the World Bank represents 186 countries, it is run by a small number of rich countries. In addition, the World Bank has dual roles that are contradictory: that of a political organization and that of a practical organization. As a political organization, the World Bank must meet the demands of donor and borrowing governments. As a practical organization, it must be neutral, specializing in development aid, technical assistance and loans. Moreover, it focuses too much on the growth of GDP and not enough on living standards.

Some analyses show that the World Bank has increased poverty and been detrimental to the environment, public health and cultural diversity. It has also been suggested that the World Bank is an instrument for the promotion of US or Western interests in certain regions of the world.

One of the most significant criticisms of the World Bank has been the effect of structural adjustment programmes (SAPs) (see page 537).

The International Monetary Fund

The International Monetary Fund (IMF) is the international organization that oversees the global financial system by following the economic policies of its member countries, in particular those with an impact on

▲ **Figure 4.7:** The IMF logo

the exchange rate and the balance of payments. It is an organization formed with a stated objective of stabilizing international exchange rates and facilitating development.

The IMF was created in July 1944 with 45 members, and it now has 186 members. Countries contributed to a funding pool, which other countries with payment imbalances could borrow from on a temporary basis. The IMF was important when it was first created because it helped the world stabilize the economic system. The IMF's influence in the global economy steadily increased as it accumulated more members.

To deal with the 2008 global financial crisis, the IMF agreed to sell some of its gold reserves. In addition, in 2009 at the G20 London Summit it was decided that the IMF would require additional financial resources to meet the prospective needs of its member countries during the ongoing crisis. The G20 leaders pledged to increase the IMF's supplemental cash tenfold to $500 billion, and to allocate to member countries another $250 billion via Special Drawing Rights.

Member states with balance of payment problems may request loans to help fill gaps between what they earn and/or are able to borrow from other official lenders and what they must spend to operate. In return, countries must usually launch certain reforms such as SAPs.

Critics of the IMF

Critics claim that IMF policymakers supported military dictators friendly to American and European corporations, and that the IMF is generally unconcerned about democracy, human rights and labour rights.

One of the main SAP conditions placed on troubled countries is that the governments sell as much of their national assets as they can, normally to western corporations at heavily discounted prices. Moreover, the IMF sometimes advocates "austerity programmes" – increasing taxes even when the economy is weak – in order to generate government revenue. There is also often a considerable delay in the IMF's response to crises, and it tends only to respond to them (or even create them) rather than prevent them.

The IMF is for the most part controlled by the major Western nations. Historically, the IMF's managing director has been European and the president of the World Bank has been from the USA.

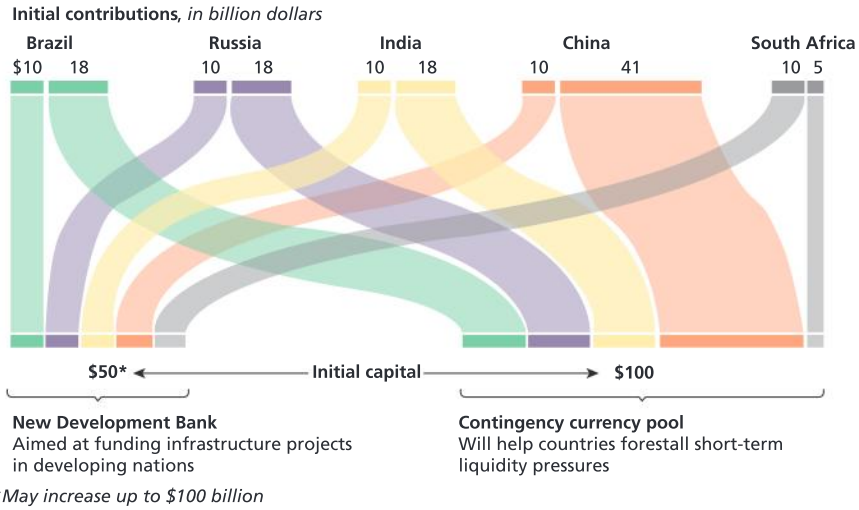
▲ **Figure 4.8:** The New Development Bank logo

The New Development Bank

The New Development Bank (NDB), formerly the BRICS Development Bank, was established by Brazil, Russia, India, China and South Africa in 2014. The NDB "shall support public or private projects through loans, guarantees, equity participation and other financial instruments". The bank has its headquarters in Shanghai.

Its main focus for lending will be infrastructure and sustainable development projects, such as clean energy. Brazil, Russia, India, China and South Africa initially contributed $10 billion to the fund (Figure 4.9). The bank plans initially to fund one project from each member.

New members are permitted to join, but the BRICS countries must always account for not less than 55 per cent of the shares. The bank represents an important step in cooperation among the BRICS. It will complement the assistance given by multilateral development banks, such as the World Bank. According to the NDB, although multilateral banks provide up to $100 billion/year, this is insufficient to meet the infrastructural development needs of emerging economies.



▲ **Figure 4.9:** Funding for the New Development Bank

Check your understanding

1. Outline the main components of the KOF Index.
2. In what ways does the New Globalization Index differ from other globalization indices?
3. Suggest why the UK declined as a superpower after the Second World War.
4. Comment on the importance to the USA of the military-industrial complex.
5. Compare the size of the defence industry in the USA, China and Russia.
6. Outline the main strengths and weaknesses of the G7 countries.
7. Explain what is meant by the term "cartel".
8. Suggest how OPEC influences energy policies.
9. Briefly explain two advantages and two disadvantages of the IMF.
10. Describe the sources of funding for the New Development Bank.

Concepts in context

Global **power** and influences vary spatially. This varies from the global scale to the regional and national level. Power and influence also vary over time – some superpowers and empires have declined over time. There are many groupings of countries, for example G7, G20, as well as international organizations such as the World Bank and the International Monetary Fund that wield considerable influence – not always to everyone's approval.

Synthesis and evaluation

There are many wealthy and powerful places around the world. Some of these are large and some are very small. Some smaller states are forced to interact with more countries because they do not have a varied range of resources. In contrast, some large countries may have a more varied resource base and may be less globalized. Over time, the importance of nations varies. Superpowers develop and wane. Some superpowers may be a collection of countries, which do not necessarily have to be geographical neighbours.

A number of international organizations, including banks, cartels and advisory forums, are shaping the economic and political development of many places. There has been criticism that sometimes these organizations are following an agenda that suits only themselves.

The use of tables and proportional symbols is a useful way to show variations in size/importance.

2 Global networks and flows

Conceptual understanding

Key question

How do different **places** become interconnected by global interactions?

Key content

- An overview of contemporary global networks and flows: trade in materials, manufactured goods and services.
- An overview of international aid, loans and debt relief, and international remittances from economic migrants.
- Illegal flows, such as trafficked people, counterfeit goods and narcotics.
- Foreign direct investment (FDI) and outsourcing by transnational corporations (TNCs), their global strategies and supply chains and the ways in which they network places and markets.

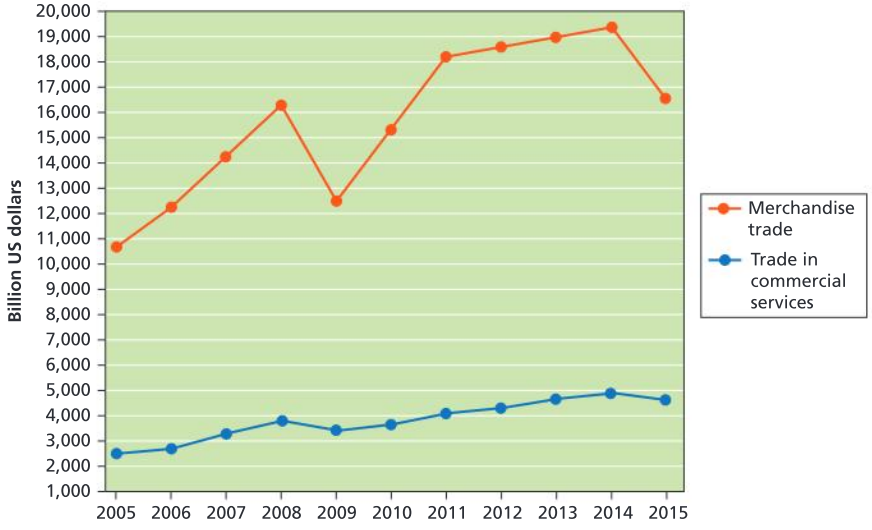
Global trade in materials, manufactured goods and services

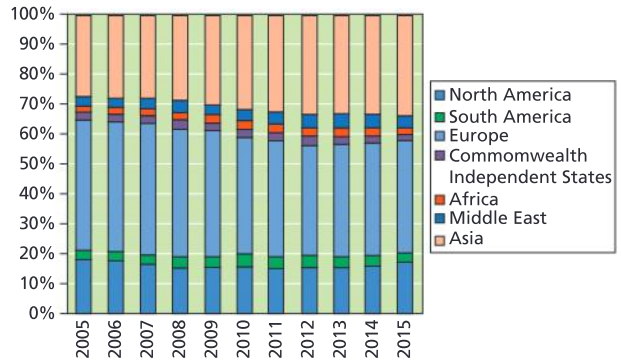
The value of world trade in materials, manufactured goods and services roughly doubled between 2005 and 2015. However, it declined in 2015 following reduced growth between 2012 and 2014 (Figure 4.10).

Asia, Europe and North America continue to account for the bulk of the merchandise, although the share in merchandise exports from emerging economies increased from 33 per cent in 2005 to over 40 per cent in 2015 (Figure 4.11). Moreover, the trade between emerging economies increased from just over 40 per cent to over 50 per cent of their global trade between 2005 and 2015 (Figure 4.12).

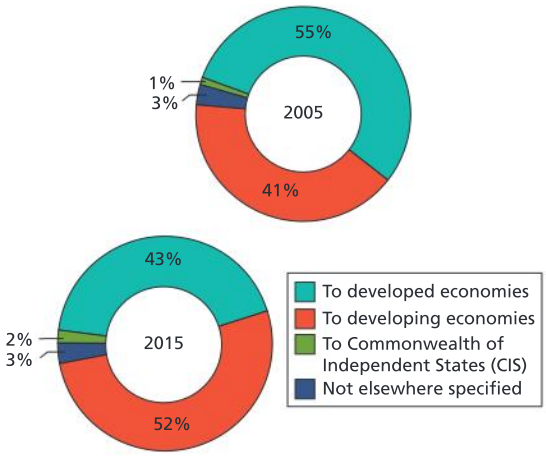
Merchandise trade was worth over $16 trillion in 2015, and was dominated by China, the USA, Germany, France, the UK and the Netherlands (Figure 4.13). The top 10 trading nations accounted for over half of the world's trade in 2015, and emerging economies accounted for over 40 per cent of the world's trade in merchandise.

▼ **Figure 4.10:** World merchandise trade and trade in services, 2005–15





▲ **Figure 4.11:** Merchandise trade by region, 2005–15 (% share)



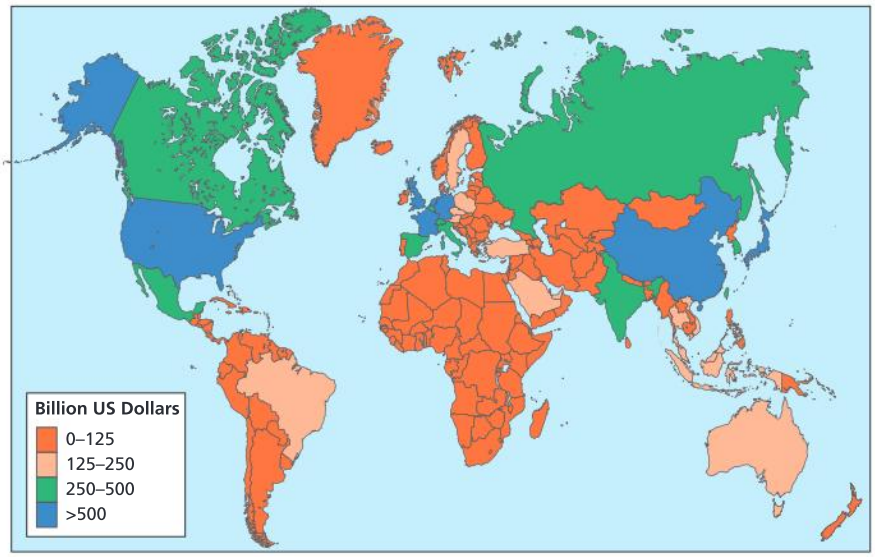
▲ **Figure 4.12:** Merchandise exports of emerging economies, 2005 and 2015

In contrast, emerging economies accounted for just over one-third of the trade in services in 2015. Countries that had trade in services worth over $50 billion included the BRICs, the USA and Canada, Australia and a number of European countries (Figure 4.14).

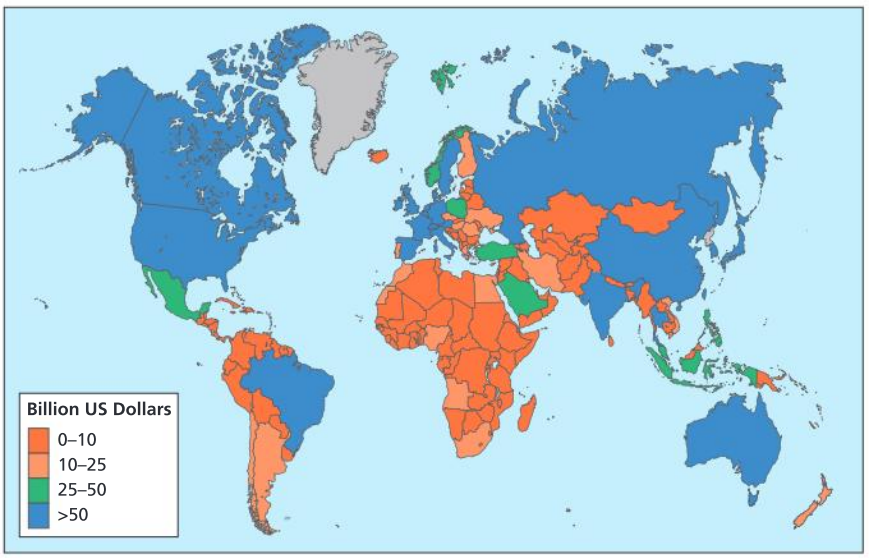
The slowdown in trade in 2015 was put down to a number of factors, including an economic slowdown in China, a recession in Brazil, falling commodity prices, including oil, and changes in exchange rates. Asia contributed more than any other region to the recovery of world trade after the financial crisis of 2008–09. "Factory Asia" continued to increase merchandise export volume growth between 2011 and 2014. However, the region's impact on global demand declined in 2015 as China and other Asian economies slowed down.

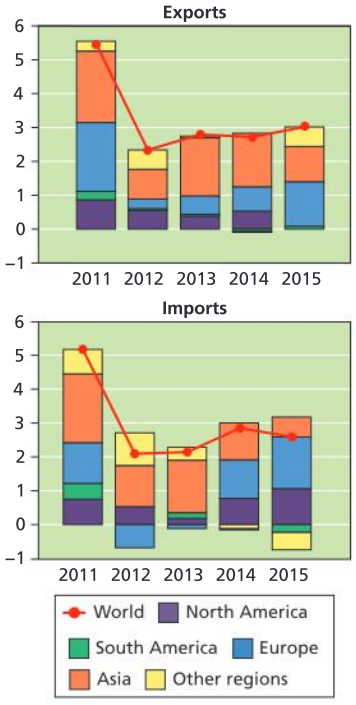
The share of manufactured goods in total merchandise exports increased from 67 per cent in 2014 to more than 70 per cent in 2015. The share of agricultural products increased slightly, whereas the share of fuels and mining products decreased. World

▼ **Figure 4.13:** Merchandise trade, 2015



▼ **Figure 4.14:** Trade in commercial, services, 2015





▲ **Figure 4.15:** Contribution to world trade volume growth by region, 2011–15

exports of iron and steel were badly affected by the fall in price for steel and a decline in demand.

In 2015, China remained the world's leading exporter and the USA the world's leading importer. China, the USA, Germany and Japan were the most important exporters and importers. China's exports in 2015 were valued at $2.17 trillion, followed by the USA at $1.5 trillion. The USA's imports were valued at $2.31 trillion, followed by China's, at $1.68 trillion.

Merchandise exports from a number of LICs were badly affected by the falling prices for energy and mining products. Many LICs depend to a large extent on the export of fuels and mining products. For the first time since 2005, the share of LICs merchandise exports fell to below 1 per cent of the global total.

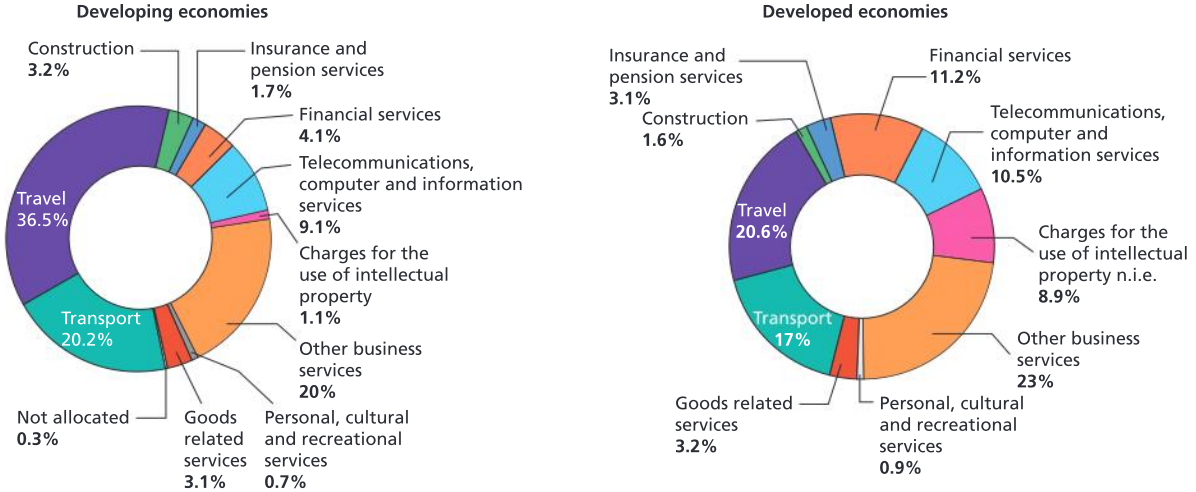
In contrast, developing countries' share in commercial services continued to rise, accounting for almost one-third of global exports. The increase was mainly due to China, India, Hong Kong, South Korea and Thailand. Travel and tourism account for the major share of commercial services in developing economies (Figure 4.16).

Activity 3

Find a copy of the latest *World Trade Statistical Review*, and update the information in this section.

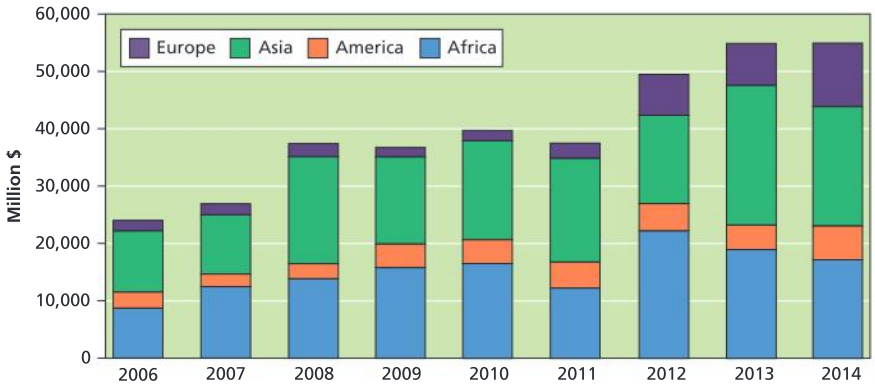
1. Describe and suggest reasons for the changes in merchandise exports of emerging economies between 2005 and 2015 (Figure 4.12).
2. Compare and contrast the structure of commercial services between developing and developed economies in 2015 (Figure 4.16).

▼ **Figure 4.16:** Structure of developing and developed economies' exports in commercial services, 2015



Aid for Trade

The Aid for Trade initiative attempts to help poor countries use trade as a means of achieving economic growth and reducing poverty. It plans to increase market access for poor countries. In 2014, over $50 billion was made available for Aid for Trade projects. Asia and Africa remain the main recipients.



▲ **Figure 4.17:** Aid for Trade financial commitments by region, 2006–14

ATL Research skills

Using the most up-to-date edition of the World Trade Statistical Review, update the information in this section. Identify the main changes that have occurred and suggest reasons for them.

ATL Research and communication skills

Use the WTO and OECD websites on Aid for Trade:

https://www.wto.org/english/tratop_e/devel_e/a4t_e/a4t_factsheet_e.htm

http://www.oecd.org/trade/aft/

and make a short presentation on the advantages and disadvantages of Aid for Trade.

International aid, loans and debt relief

There are a number of different types of aid, including emergency relief, development aid, and short- and long-term aid. Two of the most well known are top-down and bottom-up development (Table 4.5).

▼ **Table 4.5:** Top-down and bottom-up development

Top-down development	Bottom-up development
Usually large in scale.	Small in scale.
Carried out by governments, international organizations and "experts".	Labour intensive.
Done by people from outside the area.	Involves local communities and local areas.
Imposed upon the area or people by outside organizations.	Run by locals for locals.
Often well funded and quickly responsive to disasters.	Limited funding available.
Does not involve local people in the decision-making process.	Involves local people in the decision-making process.
Emergency relief can be considered top-down.	Common projects include building earthen dams, creating cottage industries.

Most aid organizations working in the field would say that bottom-up development is best. However, it is hampered by limited funding and political ties. There are occasions when top-down aid can be effective too.

Table 4.6: The effectiveness of different types of aid provision

When aid is effective	When aid is ineffective
It provides humanitarian relief.	It might allow countries to postpone improving economic management and mobilization of domestic resources.
It provides external resources for investment and finances projects that could not be undertaken with commercial capital.	It replaces domestic saving, direct foreign investment and commercial capital as the main sources of investment and technology development.
Project assistance helps expand much-needed infrastructure.	It might promote dependency rather than self-reliance.
It contributes to personnel training and builds technical expertise.	Some countries have allowed food aid to depress agricultural prices, resulting in greater poverty in rural areas and a dependence on food imports. It has also increased the risk of famine in the future.
It can support better economic and social policies.	Aid is sometimes turned on and off in response to the political and strategic agenda of the donor country, making funds unpredictable, which can result in interruptions in development programmes.
	The provision of aid might result in the transfer of inappropriate technologies or the funding of environmentally unsound projects.
	Emergency aid does not solve the long-term economic development problems of a country.
	Too much aid is tied to the purchase of goods and services from the donor country, which might not be the best or the most economical.
	Corruption may mean that a lot of aid does not reach those who need it – that is, the poorest people in the poorest countries.

Development aid

Table 4.9 shows that the main donors of development aid are the rich countries in North America, Europe, Australia, New Zealand and Japan. In contrast, the main recipients are in the poor countries. Highest levels of aid would appear to be go to much of sub-Saharan Africa, Eastern Europe and Russia and South East Asia.

The largest donors are the USA and Japan, although as a percentage of their GNP each donates less than 0.25 per cent of GNI. France and the UK are the next largest donors, donating less than 0.5 per cent of their GNI. The largest donors in relation to GNI are the Scandinavian countries, Norway, Denmark and Sweden.

Table 4.7: The largest recipients of bilateral and multilateral aid, $ million (2014)

1	Afghanistan	4,823.3
2	Vietnam	4,217.9
3	Syria	4,198.0
4	Pakistan	3,611.9
5	Ethiopia	3,585.1
6	Egypt	3,532.2
7	Turkey	2,3,4412.8
8	India	2,983.6
9	Jordan	2,699.1
10	Kenya	2,665.1

Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Table 4.8: The largest recipients of bilateral and multilateral aid, $ per head (2014)

1	West Bank and Gaza	579.0
2	Jordan	408.5
3	Kosovo	317.9
4	Guyana	208.5
5	Timor-Leste	203.8
6	Syria	189.5
7	Lebanon	180.3
7	Liberia	169.3
9	Bosnia & Herzegovina	165.5
10	South Sudan	164.9

Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Table 4.9: The largest bilateral and multilateral donors, $bn, 2014

1	USA	33
2	UK	19
3	Germany	17
4	Saudi Arabia	14
5	France	11
6	Japan	9
7	Sweden	7
8	The Netherlands	6
-9	Norway	5
-9	UAE	5

*China also provides aid, but does not disclose amounts.
Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Table 4.10: The largest bilateral and multilateral donors, % of GDP (2014)*

1	Saudi Arabia	1.8
2	UAE	1.26
3	Sweden	1.09
4	Norway	1.00
5	Denmark	0.86
6	UK	0.7
7	The Netherlands	0.64
8	Finland	0.59
8	Switzerland	0.5
10	Belgium	0.46
-17	USA	0.19

*China also provides aid, but does not disclose amounts.
Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

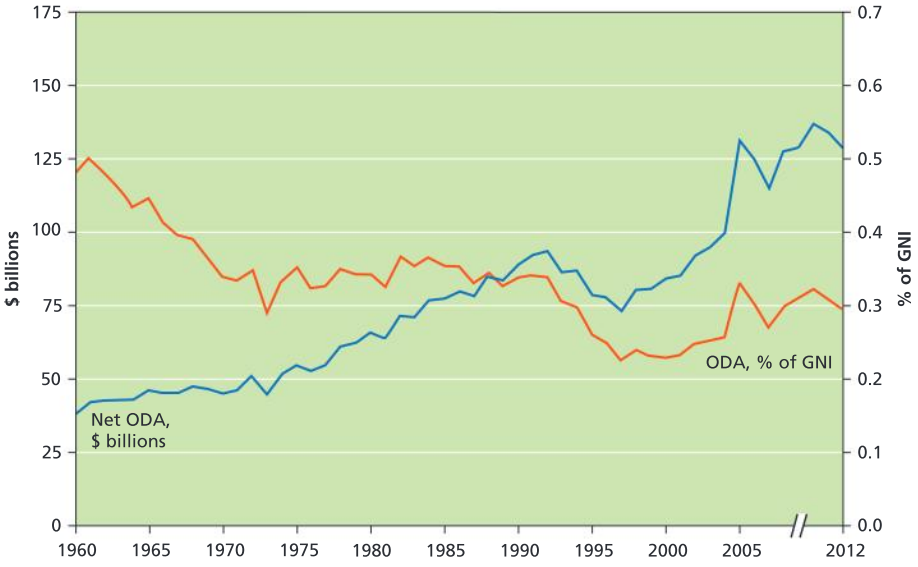
Case study

Aid and Bangladesh

Since its independence in 1971, Bangladesh has relied on foreign aid as a major source of foreign earnings. Between 1971 and 2011 Bangladesh received over $54.5 billion, much of it from the World Bank and IMF, on the condition that Bangladesh commit to several reforms. One was that Bangladesh privatize state-owned enterprises (SOEs). Between 2000 and 2014, 38 SOEs were privatized, but by 2014, 20 of these had closed. Levels of workers' compensation, job security, access to trade unions and leave entitlement are much lower in privatized companies compared with SOEs. Annual wage increases were smaller in the privatized firms compared with SOEs, and daily wages for casual workers were less than in SOEs.

Activity 4

Comment on the donation of aid by countries (a) in absolute terms and (b) as a proportion of their GNI.



▲ **Figure 4.18:** Changes in ODA, 1960–2012

Loans

Many countries provide loans for developing countries. The definition of a loan is that it is a transfer of money or skills that require repayment over a set time.

The main pattern of loans is a transfer from richer countries to poorer countries. In many poor countries, economic and social infrastructure – such as electricity, gas, transportation and communications services – is underdeveloped. In addition, there may be issues related to population growth, environmental degradation, disease and conflict. In theory, official development assistance (ODA) loans promote efficient use of the borrowed funds, since they require repayment and the donor is unlikely to provide loans for projects that may fail. Moreover, they place a relatively small financial burden on the donor government as they are paid back over time.

In 1970 the OECD adopted the target for donors to spend 0.7 per cent of their GNI on ODA, but by 2012 only five donors had met this target. Donors in the Development Assistance Committee (DAC), the body through which the OECD deals with matters related to cooperation with poor countries, achieved only 0.29 per cent of their GNI. The ODA is the largest international resource flow for over 40 countries and over 250 million people living in poverty. For example, ODA to Liberia in 2011 exceeded government expenditure, and in Rwanda it was equal to 80 per cent of government spending.

Sub-Saharan Africa receives the highest proportion of ODA, around 35 per cent, followed by South Asia (17 per cent). Afghanistan was the largest individual recipient, followed by the Democratic Republic of the Congo.

Activity 5

Describe the changes in ODA between 1960 and 2012, as shown in Figure 4.18.

Debt relief

Sub-Saharan Africa includes most of the 42 countries classified as heavily indebted, and 25 of the 32 countries rated as severely indebted. In 1962 sub-Saharan Africa owed $3 billion (£1.8 billion). Twenty years later it owed $142 billion. Today its debt is about $235 billion. The most heavily indebted countries are Nigeria ($35 billion), Côte d'Ivoire ($19 billion) and Sudan $18 billion).

Many developing countries borrowed heavily in the 1970s and early 1980s, encouraged to do so by Western lenders, including export credit agencies. They soon ran into problems, including:

- low growth in industrialized economies
- high interest rates between 1975 and 1985

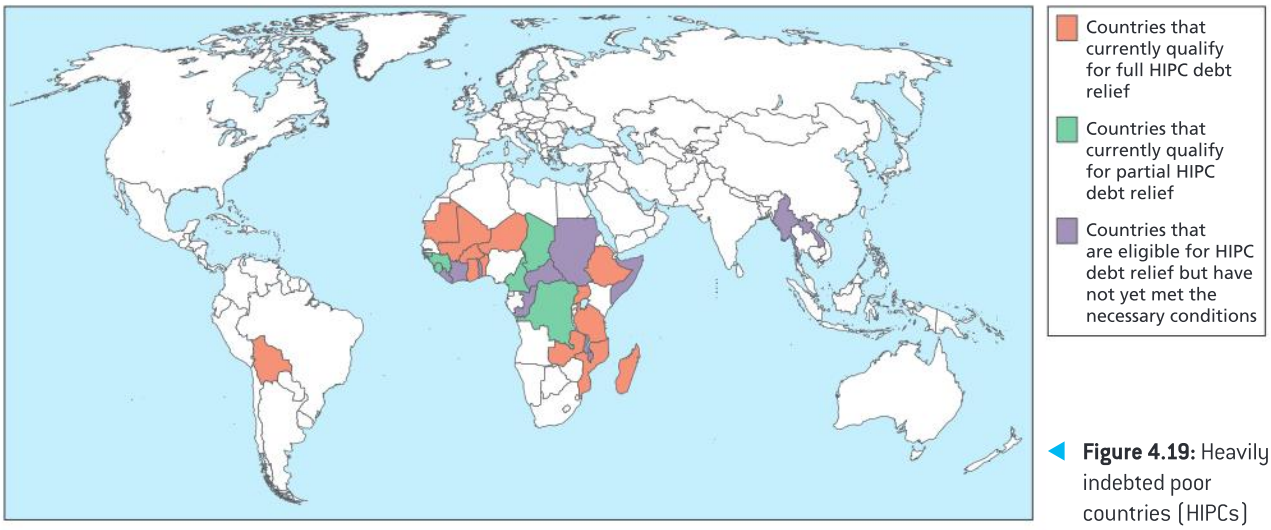


Figure 4.19: Heavily indebted poor countries (HIPCs)

- oil price rises
- falling commodity prices.

Since 1988 the Paris Club of government creditors has approved a series of debt relief initiatives. In addition, the World Bank has lent more through its concessional lending arm, and the International Development Agency has given loans for up to 50 years without interest but with a 3–4 per cent service charge. Lending has risen from $424 million in 1980 to $2.9 billion, plus a further $928 million through the African Development Bank. The IMF has also introduced a **soft loan facility**, conditional on wide-ranging economic reforms.

Structural adjustment programmes

Structural adjustment programmes (SAPs) are loans requiring the borrowing country to cut its government expenditure, reduce the amount of state intervention in its economy, and promote liberalization and international trade. SAPs are explicit about the need for international trade and long-term economic growth. They have four main requirements:

- greater use of a country's resource base
- reforms to increase economic efficiency
- generation of foreign income through diversification of the economy and increased trade
- a reduction in the active role of the state.

The measures are sometimes divided into two main groups:

- the stabilization measures, short-term steps to limit any further deterioration of the economy (such as a wage freeze and reduced subsidies on food, health and education)
- adjustment measures, longer-term policies to boost economic competitiveness (tax reductions, export promotion, downsizing of the civil service, privatization and economic liberalization).

However, some people argue that these measures have made many countries' situations worse.

The Heavily Indebted Poor Countries (HIPC) initiative

The Heavily Indebted Poor Countries (HIPC) initiative, launched in 1996 by the IMF and the World Bank and endorsed by 180 governments, has two main objectives:

- to relieve certain low-income countries of their unsustainable debt to donors
- to promote reform and sound policies for growth, human development and poverty reduction.

Debt relief occurs in two steps:

- At the decision point, the country gets debt **service relief** after having demonstrated adherence to an IMF programme and progress in developing a national poverty strategy.
- At the completion point, the country gets debt **stock relief** on approval by the World Bank and the IMF. The country is entitled to at least 90 per cent debt relief from bilateral and multilateral creditors to make debt levels sustainable.

"Debt service" is required over a given period for the repayment of interest and principal on a debt – monthly mortgage payments are a good example. "Stock relief" is the cancelling of specific debts; this achieves a reduction in debt service over the life of a loan.

Of the 42 countries participating in the initiative, 34 are in sub-Saharan Africa. None had purchasing power parity (PPP) above $1,500 in 2001, and all rank low on the HDI. Between 1990 and 2001, HIPCs grew by an average of just 0.5 per cent a year. HIPCs have been over-indebted for at least 30 years: by poor-country standards their ratios of debt to exports were already high in the 1980s. At the same time, HIPCs have received considerable official development assistance. Net transfers of such aid averaged about 10 per cent of their GNP in the 1990s, compared with about 2 per cent for all poor countries. To date, 16 HIPCs have reached the decision point and eight have reached the completion point (Benin, Bolivia, Burkina Faso, Mali, Mauritania, Mozambique, Tanzania and Uganda).

Expanding market access

Expanding market access is essential to help countries diversify and expand trade. Trade policies in rich countries remain highly discriminatory against developing country exports. Average OECD tariffs on manufactured goods from developing countries are more than four times those on manufactured goods from OECD countries. Moreover, agricultural subsidies in rich countries lead to unfair competition. Cotton farmers in Benin, Burkina Faso, Chad, Mali and Togo have improved productivity and achieved lower production costs than their richer country competitors. Still, they can barely compete. Rich-country agricultural subsidies total more than $300 billion a year, nearly six times official development assistance.

To expand market access, HICs should set targets to:

- increase ODA to fill financing gaps (estimated to be at least $50 billion)
- remove tariffs and quotas on agricultural products, textiles and clothing exported by developing countries

TOK

Should the debt be cancelled?

There is debate about whether or not to cancel the debt of the poorest African countries. In 2000 a coalition of groups under the Jubilee 2000 banner called on the G7 summit meeting to cancel the debt. As a result, a number of countries received full or partial debt relief. These countries were then able to use the money saved to improve conditions for their people. For example, Tanzania introduced free schooling, built more schools and employed more teachers.

In 2006 a new agreement called the Multilateral Debt Reduction Initiative (MDRI) came into force, writing off the entire $40 billion debt owed by 18 HIPCs to the World Bank, the IMF and the ADF. The annual saving in debt payments amounts to just over $1 billion. However, countries outside Africa are not included in this agreement.

Rich countries have now promised to cancel the debt of 42 countries and give an extra £5 million of aid by 2050.

Critics of debt relief state that it does not help the poor; that it does not help countries that do not get into debt; and that it encourages countries to overspend.

- remove subsidies on agricultural exports from developing countries
- agree and finance, for HIPCs, a compensatory financing facility for external shocks, including collapses in commodity prices
- agree and finance deeper debt reduction for HIPCs that have reached their completion points, to ensure sustainability.

Remittances

Figure 4.20: Main flows of migrants, 2005–10

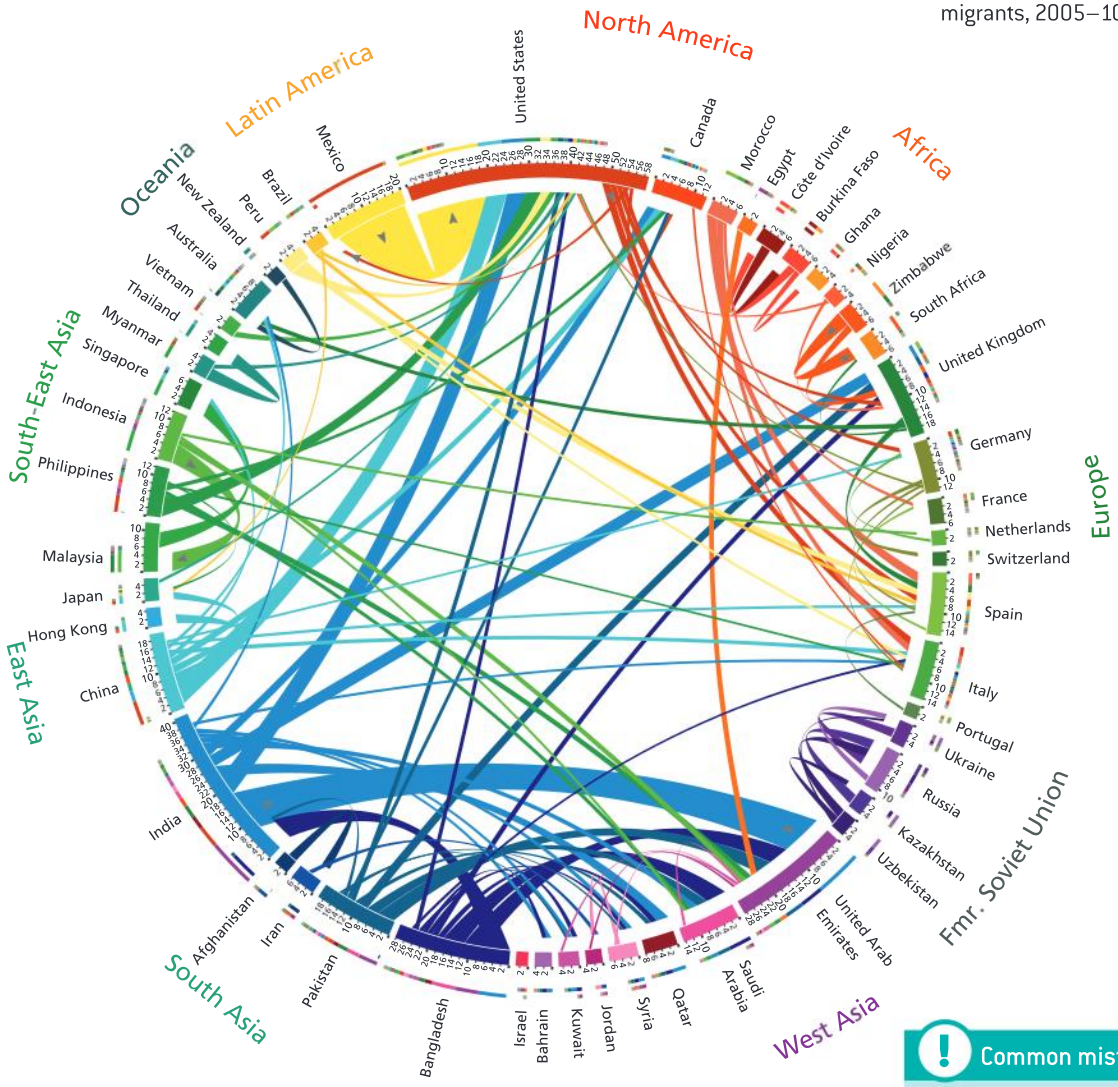
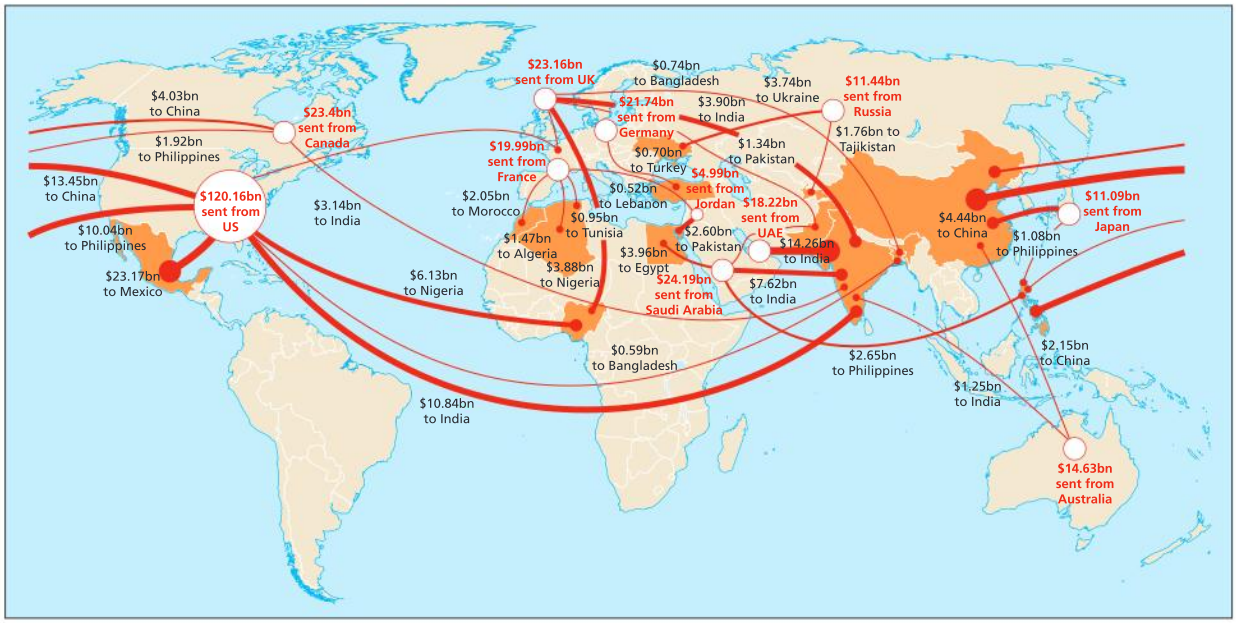


Figure 4.20 shows the main migrant flows between 2005 and 2010. The diagram shows some 75 per cent of migration between those years (only flows of over 50,000 are shown). It is not just people from poor countries who are migrating to richer countries. Many of the world's migrants come from emerging economies, but people from rich countries also migrate, to oil-rich countries, for example. The largest regional migrations are from South East Asia to the Middle East, drawn to the oil economy and the boom in the construction industry. The largest flow between two single countries is from Mexico to the USA. (See also Unit 1.)

Common mistake

✗ Many people believe that remittances only transfer money from rich countries to poor countries.

✓ Many high-income countries also receive remittances, including France and Germany, as shown in Table 4.11.



▲ **Figure 4.21:** Main flows of remittances, 2011

▼ **Table 4.11:** The value of remittances, $ million, 2014

1	India	70.389
2	China	62,332
3	The Philippines	28,403
4	France	24,968
5	Mexico	24, 460
6	Nigeria	20,921
7	Egypt	19,570
8	Germany	17,629
9	Pakistan	17,066
10	Bangladesh	14,969

Source: The Economist. 2017. *Pocket World in Figures*. London, UK. Profile Books.

Illegal flows

There are many forms of illegal flows, such as trafficked people, counterfeit goods and narcotics.

Trafficked people

Trafficking of people is a crime of "global scope". The UN Office on Drugs and Crime 2014 Report stated that between 2010 and 2012 there were over 27,000 victims of trafficking, from data provided by 83 countries. Trafficking can be domestic or international. About 70 per cent of victims are international, although fewer than 30 per cent are inter-regional. Most trafficking occurs within the same geographical sub-region. Frequently, victims come from relatively poorer countries and are exploited in relatively richer countries. Most trans-regional victims are trafficked into affluent areas such as Europe, North America

and the Middle East. One of the key aspects of inter-regional trafficking is its complexity, requiring passports, visas, international transport, local transport, accommodation and supervision of victims. In contrast, domestic trafficking requires less preparation and organization.

The Middle East has the highest share of inbound trafficked people from other regions (Figure 4.22).

Victims from East Asia have been detected in all regions and sub-regions of the world, often in large numbers. Other significant numbers of trafficked people are from South Asia, sub-Saharan Africa, and South America. (See also Unit 1 for anti-trafficking measures.)

Activity 6

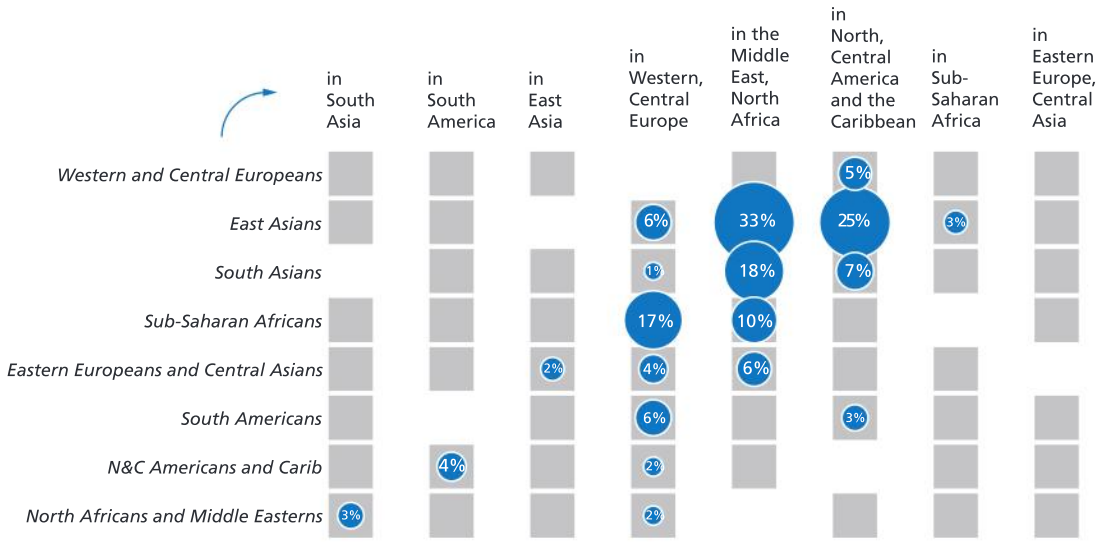
Comment on the source and destinations of trafficked people as shown in Figure 4.23.

Counterfeit goods

Counterfeit goods generate more than $250 billion each year, and are responsible for labour exploitation, environmental damage and health implications for consumers. In addition, there are links between counterfeit goods, money laundering, illicit drugs and corruption. Major criminal groups, such as the Mafia and Camorra in Europe and the Americas and the Triad and Yakuza in Asia, have become involved with trafficking of counterfeit goods.

Corruption and bribery are linked to the trade in counterfeit goods, especially when they are transported internationally. In an inspection of shipping containers by the UNODC and Container Control Programme (CCP), over one-third of containers were carrying counterfeit goods among their loads.

The trade in counterfeit goods reduces tax revenues for governments. It may raise extra costs with the need for more policing and surveillance. The size of the market for online sales of counterfeit goods is unknown, but likely to be substantial and increasing.



Note: the values below 1% are not shown.

▲ **Figure 4.22:** Citizenship of foreign victims of trafficking by sub-region, shares of the total number of detected victims, 2010–12

There are a number of environmental impacts of the trade in counterfeit goods, such as the unregulated use of dyes and toxins, and their illegal disposal. Labour exploitation in the trade is believed to be widespread. Jobs are low paid, unregulated and may have limited safety measures in place. Many trafficked migrants are forced to work in such jobs. The International Labour Organization (ILO) believes that there is a link between counterfeiting and labour exploitation. It describes workshops in the textiles industry, where illegal migrants copy and pirate well-established brand names.

▼ **Table 4.12:** The diverse nature of illicitly produced goods

Automotive	Scooters, engines, engine parts, body panels, airbags, windscreens, tyres, bearings, shock absorbers, suspension and steering components, automatic belt tensioners, spark plugs, disc brake pads, clutch plates, oil, filters, oil pumps, water pumps, chassis parts, engine components, lighting products, belts, hoses, wiper blades, grilles, gasket materials, rings, interior trim, brake fluid, sealing products, wheels, hubs, anti-freeze, windscreen-wiper fluid
Chemicals/ pesticides	Insecticides, herbicides, fungicides, non-stick coatings
Consumer electronics	Computer components (monitors, casings, hard drives), computer equipment, webcams, remote control devices, mobile phones, TVs, CD and DVD players, loudspeakers, cameras, headsets, USB adaptors, shavers, hair dryers, irons, mixers, blenders, pressure cookers, kettles, deep fryers, lighting appliances, smoke detectors, clocks
Electrical components	Components used in power distribution and transformers, switchgears, motors and generators, gas, and hydraulic turbines and turbine generator sets, relays, contacts, timers, circuit breakers, fuses, distribution boards and wiring accessories, batteries
Food, drink and agricultural products	Fruit, conserved vegetables, milk powder, butter, ghee, baby food, instant coffee, alcohol, drinks, candy/sweets, hi-breed (high-yielding) corn seeds
Pharmaceuticals	Medicines used for treating cancer, HIV, malaria, osteoporosis, diabetes, hypertension, high cholesterol, cardiovascular disease, obesity, infectious diseases, Alzheimer's disease, prostate disease, erectile dysfunction, asthma and fungal infections; antibiotics, anti-psychotic products, steroids, anti-inflammatory tablets, painkillers, cough medicines, hormones and vitamins; treatments for hair and weight loss
Tobacco	Cigarettes, cigars and snuff
Toiletries and other household products	Home and personal care products, including shampoos, detergents, fine fragrances, perfumes, feminine protection products, skincare products, deodorants, toothpaste, dental care products, shaving systems, razor blades; shoe polish; non-prescription medicine

Source: UNODC, "Focus on the Illicit Trafficking of Counterfeit Goods and Transnational Organised Crime", https://www.unodc.org/documents/counterfeit/FocusSheet/Counterfeit_focussheet_EN_HIRES.pdf

Fraudulent medicines

According to the UNODC, the sale of fraudulent medicines from East Asia and the Pacific to South East Asia and Africa is worth about $5 billion a year. The World Health Organization believes that about 1 per cent of medicines in HICs and up to 30 per cent in LICs are fraudulent. *The Lancet* reported in 2012 that one-third of malaria medicines in sub-Saharan Africa and East Asia were fraudulent. Among the most commonly produced fraudulent drugs were those for treating high blood pressure, high cholesterol, depression, diabetes and schizophrenia.

Counterfeit food and drink

According to the UK Food Standards Agency, up to 10 per cent of the food bought in the UK involves fraudulent activity. For example, "wild" salmon could be produced by aquaculture. In 2008, in China, thousands of babies became ill after drinking formula milk contaminated with melamine. Similarly, in the Czech Republic 20 people died after drinking liquids containing industrial methanol. They had been disguised as brand-named alcoholic drinks. In 2013 the European "horse meat scandal" broke out, as meat passed off as beef was found to be horse meat.

Flows of drugs

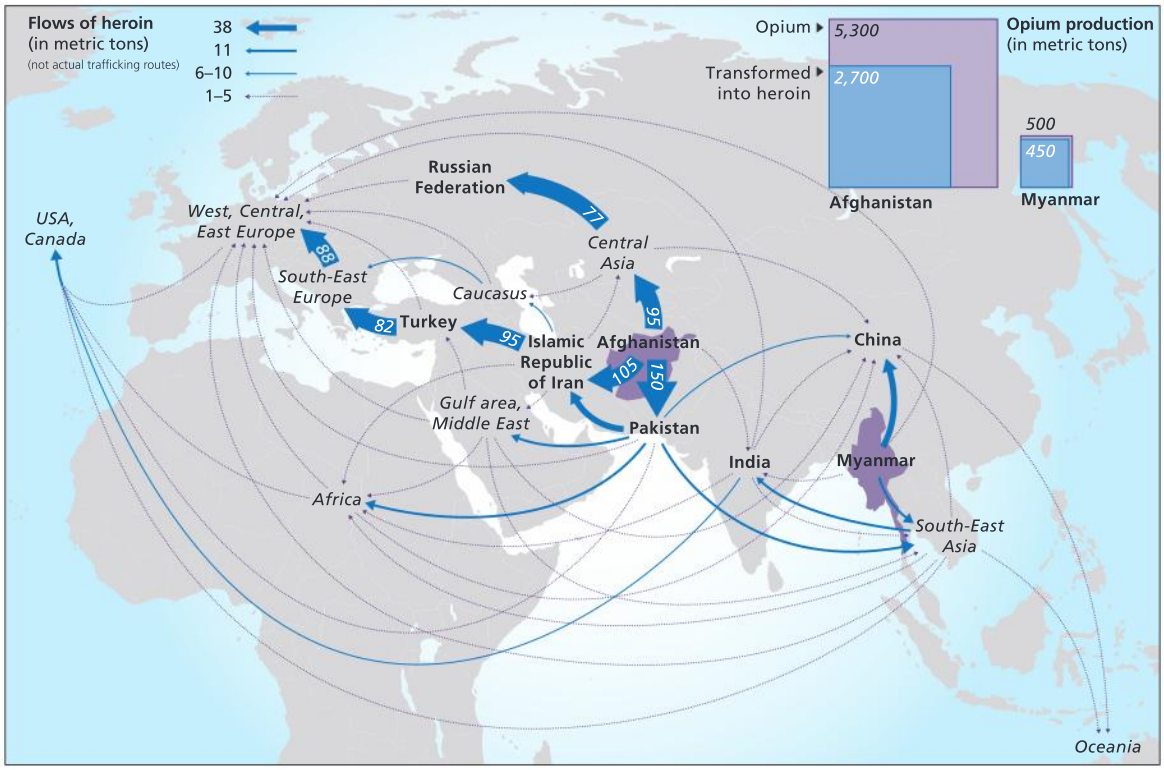
Drug trafficking is a major global trade involving the cultivation, manufacture, distribution and sale of substances that are subject to drug prohibition laws (UNODC). The global drug trade is estimated to be worth more than $300 billion, or 1 per cent of total global trade. For example, about 410 tonnes of heroin come on to the world market each year, of which about 345 tonnes are produced in Afghanistan and a further 45 in Myanmar and Lao PDR. Afghanistan is believed to make about $60 billion/year from the heroin trade. The heroin market in Western Europe and Russia is believed to be worth around $33 billion. In 2008, over 60 tonnes of heroin were seized. Most (39 per cent) was seized in the Near East, the Middle East and south-west Asia, about a quarter in south-eastern Europe and one-tenth in Western and Central Europe.

The drugs trade is associated with violence. Nearly 80 per cent of the cocaine destined for the USA passes through Honduras, which has one

ATL Research and communication skills

Find out about the UN Convention against Transnational Organized Crime. What are its aims? How successful has it been? Make a short presentation of your findings.

Investigate also the European horse meat scandal. Which countries were involved? Why was it a "scandal"? What was done to deal with it?



▲ **Figure 4.23:** Global heroin flows from Asian points of origin

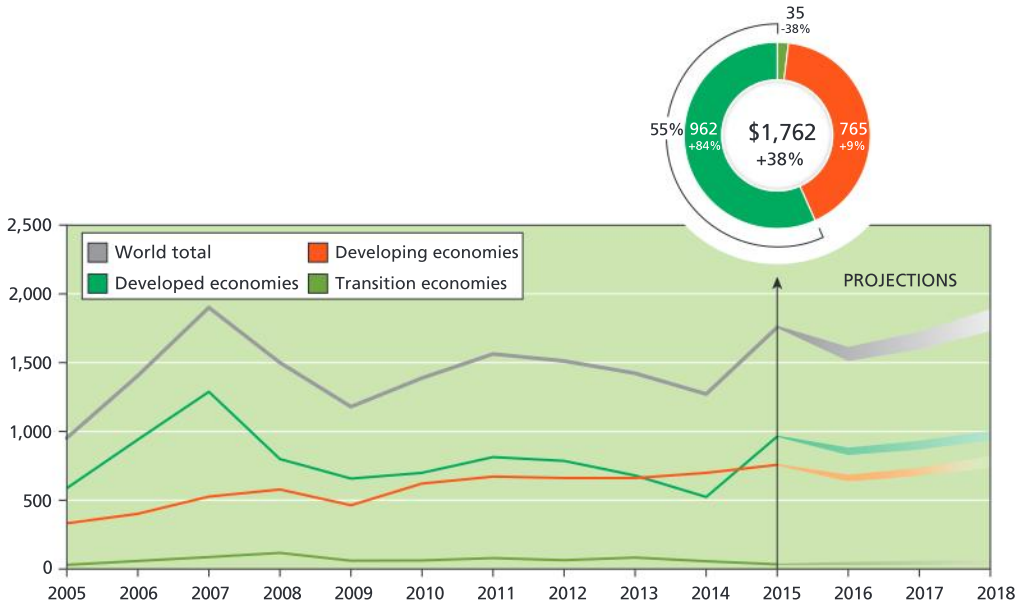
of the highest murder rates in the world. In the USA, the FBI believes that 5 per cent of murders are drug-related. In the UK, the cost of crime committed to support drug users' habits is believed to be about £16 billion per year.

As globalization has proceeded and international borders become more open, the ability to detect and capture drug traffickers has decreased.

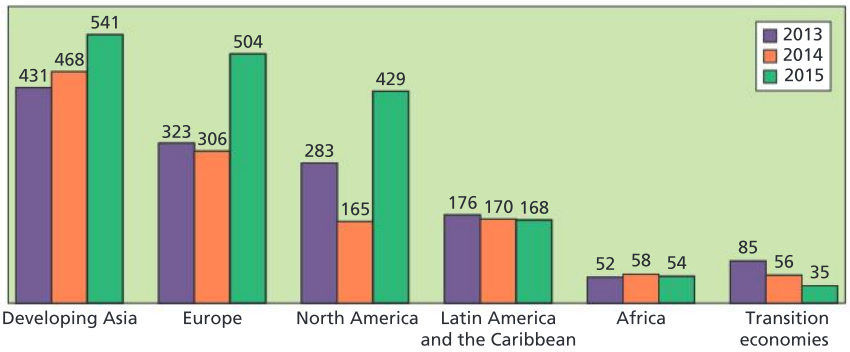
Foreign direct investment (FDI)

FDI is the investment by a company into the structures, equipment or organizations of a foreign country. It does not include investment in shares of companies of other countries.

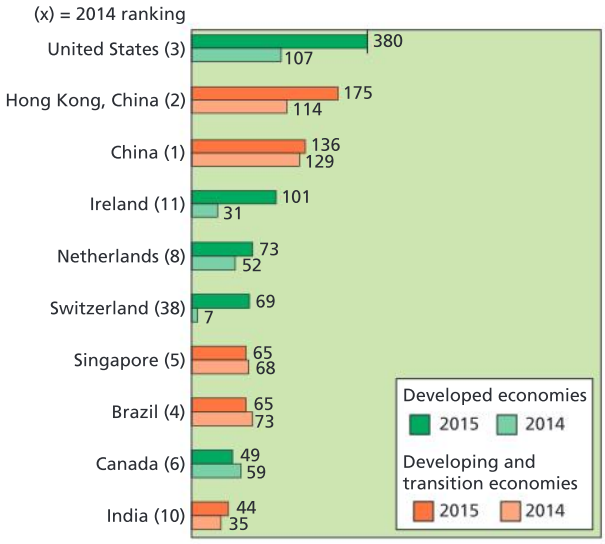
FDI fell after the financial crisis of 2008–9 but by 2015 had improved. Much of the growth was due to investment in HICs, especially in the USA and Europe. In addition, FDI in NICs reached a new high in 2015 (Figure 4.24). Asia remained the main focus for FDI in NICs/LICs, whereas FDI into Africa, Latin America and the Caribbean slowed (Figure 4.25). One exception was Cuba, which re-established diplomatic ties with the USA, and FDI there is expected to increase.



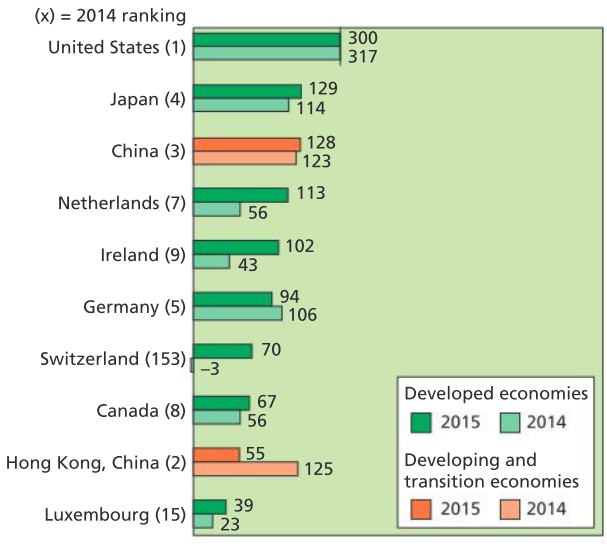
▲ **Figure 4.24:** Global FDI inflows by groups of economies, 2005–15, and projections to 2018



▶ **Figure 4.25:** FDI inflows by region, 2013–15



▲ **Figure 4.26:** FDI inflows ($ billion), the top 10 host economies, 2014 and 2015



▲ **Figure 4.27:** FDI outflows ($ billion), the top 10 home economies, 2014 and 2015

Outward FDI flows from HICs increased by a third in 2015. Neverthless, this was still 40 per cent short of the peak in 2007. Europe became the world's largest investing region. Investment in agriculture declined while that in manufacturing increased. FDI to Africa fell by 7 per cent in 2015, partly because of low commodity prices. In contrast, FDI to Asia increased but is predicted to slow down as many economies mature. FDI to transition economies such as the CIS remained low because of low commodity prices, declining domestic markets and the impact of restrictive measures (such as sanctions) and geopolitical tension. Flows to landlocked LICs and developing small-island states had major declines.

▼ **Table 4.13:** The positive and negative impacts of the global shift

	Positive	Negative
In HICs	Cheaper imports of all relatively labour-intensive products can keep the cost of living down and lead to a buoyant retailing sector. Greater efficiency in surviving outlets can release labour for higher-productivity sectors (this assumes low unemployment). Growth in LICs may lead to a demand for exports from HICs. Promotion of labour market flexibility and efficiency, and greater worker mobility to areas with relative scarcities of labour should be good for the country. Greater industrial efficiency should lead to the development of new technologies and promote entrepreneurship, and should attract foreign investment. Loss of industries can lead to improved environmental quality (e.g. Consett).	Rising job exports lead to inevitable job losses. Competition-driven changes in technology add to this. Job losses are often of unskilled workers. Big gaps develop between skilled and unskilled workers, who may experience extreme redeployment differences. Employment gains from new efficiencies will only occur if industrialized countries can keep their wage demands down. Job losses are invariably concentrated in certain areas and certain industries. This can lead to deindustrialization and structural unemployment in certain regions. Branch plants are particularly vulnerable as, in times of economic recession, they are the first to close, often with large numbers of job losses.

	Positive	Negative
In NICs and LICs	Higher export-generated income promotes export-led growth, which promotes investment in productive capacity and potentially leads to a multiplier effect on the national economy. The effects can trickle down to local areas with many new, highly paid jobs. Negative trade balances can be reduced. The shift can lead to exposure to new technology, improvement of skills and higher labour productivity. Employment growth in relatively labour-intensive manufacturing spreads wealth, and does redress global injustice (the development gap).	Inequality is unlikely to decrease – as jobs tend to be concentrated in the core region of urban areas – and in-migration may increase. Disruptive social impacts arise if TNCs are exploitative and establish sweatshops. Also branch plants may move on in NICs too, leading to instability (as in the Philippines). Overdependence on a narrow economic base can result. Food supplies may be destabilized as people give up agriculture. Environmental issues associated with over-rapid industrialization can occur. Health and safety issues may arise because of tax legislation.

Source: Warn, S., 2004. "The global shift". *Geo Factsheet 161*. Birmingham, UK., Curriculum Press.

Activity 7

1. Compare the top 10 FDI inflows and outflows as shown in Figures 4.26 and 4.27.
2. Suggest why landlocked LICs and developing small-island states saw a decline in their FDI.
3. Update the data on FDI by looking at the World Investment Report at http://unctad.org/en/PublicationsLibrary/wir2016_Overview_en.pdf.

Transnational companies

A transnational company (TNC) is an organization that operates in a large number of countries. Generally, TNC headquarters are in HIC cities, with research and development (R&D) and decision-making concentrated in growth areas of HICs, and assembly and production located in LICs and NICs.

TNCs provide a range of advantages and disadvantages for their host countries (Figure 4.28).

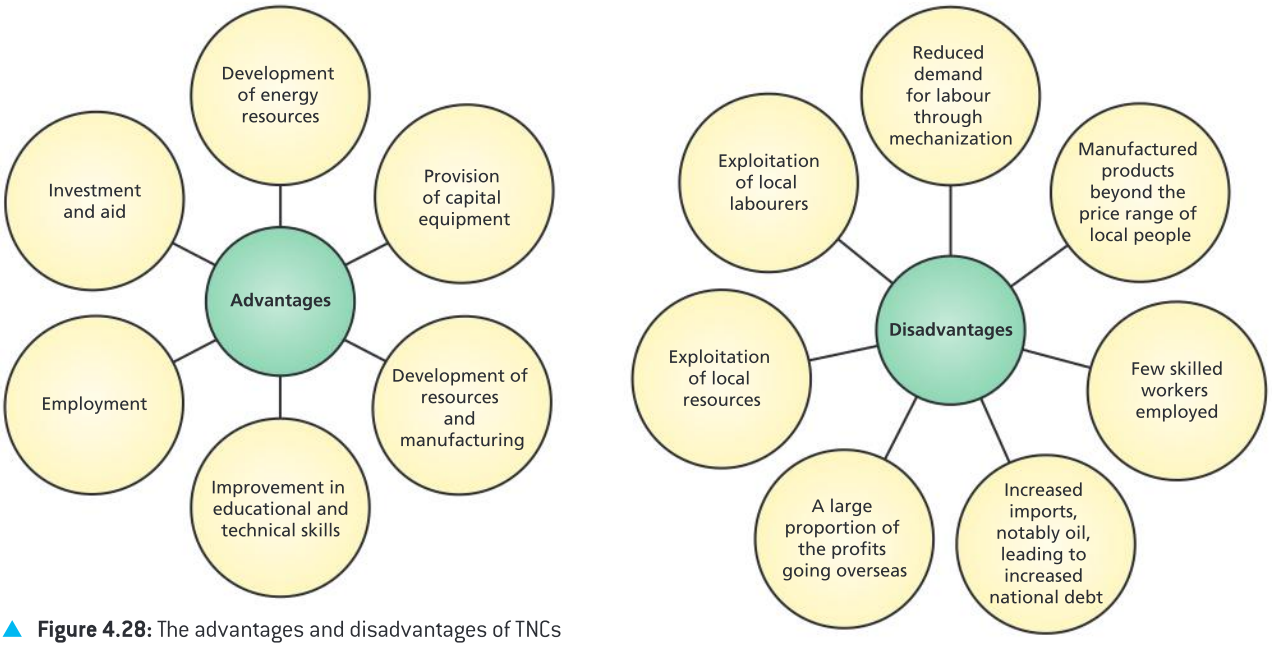
TNC power

The sheer scale of the economic transactions that TNCs make around the world and the effect they have on urban, regional and national economies give them tremendous power. Thus TNCs have become planned economies with vast **internal markets**.

- Up to a third of all trade is made up of internal transfers of TNCs. These transfers produce money for governments via taxes and levies.
- Economic power comes from the **ownership of assets**.
- Over 50 million people are employed by TNCs.
- Although many governments in developing countries own their own resources, TNCs still control the marketing and transport of goods.

Reduced demand and increased competition create unfavourable economic conditions. In order to survive and prosper, TNCs have used three main strategies:

- Rationalization – slimming down the workforce, which involves replacing people with machines
- Reorganization – improvements in production, administration and marketing, such as increased subcontracting
- Diversification – developing new products.



▲ **Figure 4.28:** The advantages and disadvantages of TNCs

Globalization has brought much employment and economic growth to low-wage countries. The transfer of employment from HICs has led to declining wages and increased job insecurity in HICs (see Table 4.13). Nevertheless, there have been a number of campaigns to improve workers' rights and employment conditions, and TNCs have been reminded of their responsibilities to their workers and to the environment.

The supply chain describes the "full range of activities which are required to bring a product or service from conception, through the intermediary phases of production, delivery to final consumers, and the final disposal after use" (Kaplinsky and Morris, 2001). Sustainable management of supply chains means improving workers' conditions, ensuring safe environmental practices, and making long-term economic improvements in the companies involved. Critics argue that TNCs in NICs and LICs have been too concerned with the exploitation of workers to be truly sustainable. However, many TNCs are increasingly aware of their corporate social responsibility (CSR).

Common mistake

✗ Many students think that TNC investment and takeovers are only from HICs to LICs. This is not always the case.

✓ TNCs from emerging economies may invest in HICs and take over some of their companies, as illustrated by the Tata Group.

Case study

The Tata Group

◀ **Photo 4.3:** The Tata Group logo

The Tata Group comprises over 100 companies, encompassing cars and consulting, software and steel, tea and coffee, transport and power, chemicals and hotels. Tata Consultancy Services (TCS) is Asia's largest software company. Tata Steel is India's largest steelmaker and number 10 in the world. Taj Hotels Resorts and Palaces is India's biggest luxury hotel group by far. Tata Power is the country's largest private electricity company. Tata Global Beverages is the world's second-largest maker of branded tea.

Tata operates in over 80 countries and employs about 600,000 people. Overall, the group earned 7 trillion rupees, or $108 billion, in revenues in 2015 and 45 billion rupees in profits. Nearly

Case study (continued)

▲ **Photo 4.4:** Tata's Ramanujan IT city

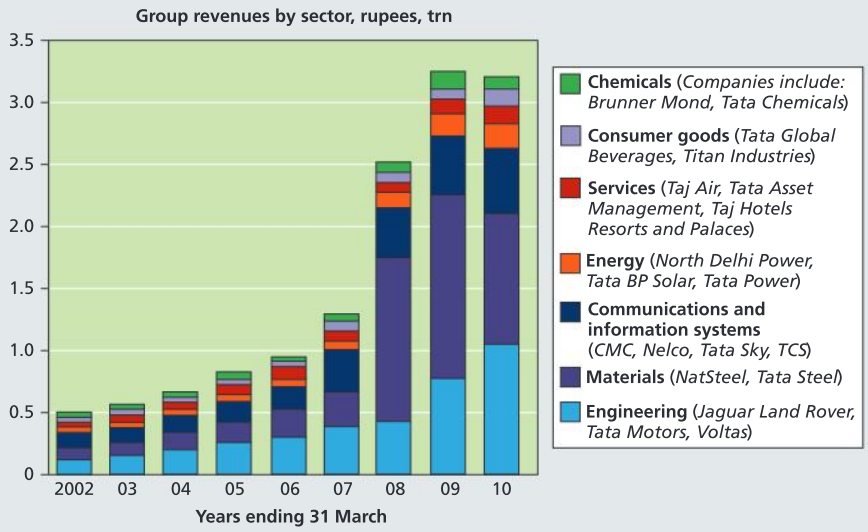
60 per cent of its revenue comes from outside India. Just as Tata played a leading role in nation building from its foundation in 1868, creating India's first Indian-owned steel plant, power station, luxury hotel, domestic airline and sundry other firsts, it is now one of the stars of India's globalization.

Liberalization and globalization

Economic liberalization was both an opportunity and a threat for Tata. It was an opportunity because it enabled Tata to compete in the international arena. It was a threat because Tata was vulnerable to competition. Its companies were uncoordinated, overmanned and undermanaged. Ratan Tata (Chairman of the Tata Group 1991–2012) set about streamlining the company. For example, Tata Steel has more than doubled its output since 1994 (from 3 million to 6.4 million tonnes) while cutting its workforce in India by more than half (from 78,000 to 30,000). He focused the group on six industries that have provided most of its revenues since 2000 – steel, motor vehicles, power, telecoms, information technology (IT) and hotels – and increased its shareholding in these core businesses.

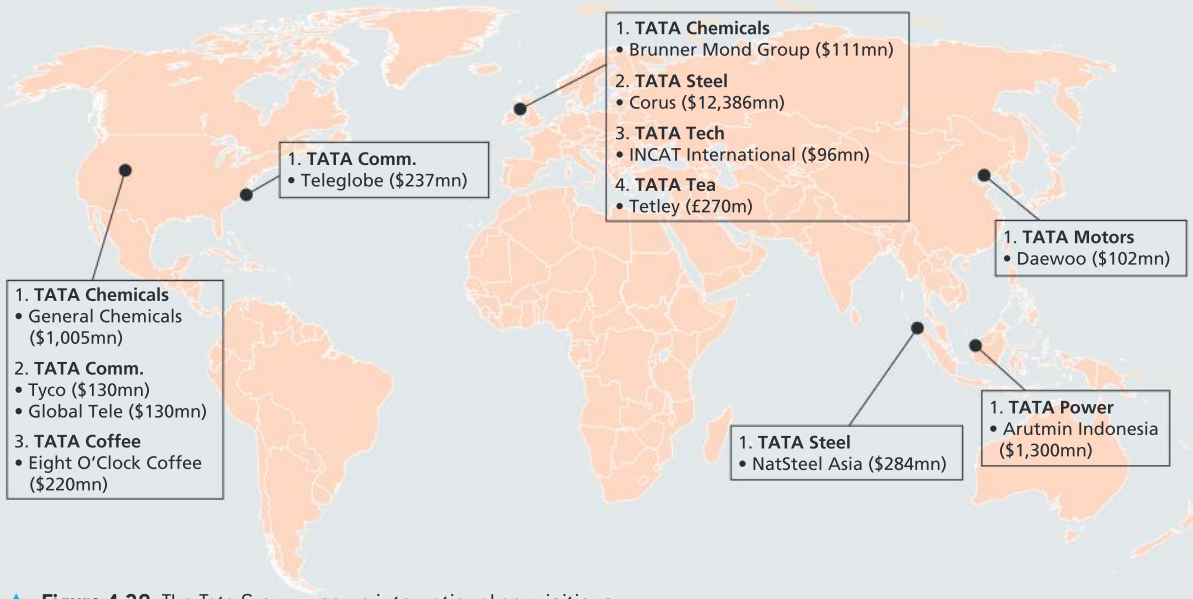
The group has embraced globalization. The pace of foreign acquisitions has grown dramatically: in 1995–2003 Tata companies made, on average, one purchase a year; in 2004 they made six; and in 2005/6 more than 20. The scale has also grown. Tata Tea's takeover of Tetley Group, a British company, for $450 million in 2000 was the first of several acquisitions of well-known brands that announced the group's arrival in the global arena. In 2007 Tata Steel bought Corus, Europe's second-largest steelmaker, for $12.1 billion. A year later Tata Motors paid $2.3 billion for Jaguar Land Rover (JLR).

In all, Tata has spent around $20 billion on foreign companies. Today it earns about three-fifths of its revenue abroad and employs more British workers than any other manufacturer, and two of its biggest companies, Tata Motors and Tata Communications, are listed on the New York Stock Exchange.



▲ **Figure 4.29:** Tata's revenue by source and year

Case study (continued)



▲ **Figure 4.30:** The Tata Group – some international acquisitions

In emerging markets, Tata Steel and Tata Motors have bought out or bought into several Asian companies, such as Thailand's Millennium Steel and South Korea's Daewoo trucks. Diversified groups are the "dominant" form of business in many emerging markets, including Chile, Indonesia, Mexico, Pakistan and Thailand. In India, Tata Motors makes the first Indian-designed car, the Indica, and the world's cheapest, the Nano.

Tata created many of India's greatest institutions, such as the Indian Institute of Science, the Tata Institute of Fundamental Research and the Tata Memorial Hospital. Tata prides itself above all on its culture, which it argues is defined by three things: loyalty, dignity and what is now called corporate social responsibility (CSR). Tata trusts fund worthy causes, from clean-water projects and literacy programmes to the various Tata institutions, all of which cost $97 million in 2010.

Jamshedpur, the home of Tata Steel, is, perhaps, the world's most successful company town. Tata Steel runs almost all the city's institutions: these include a 980-bed hospital, a zoo, a giant sports stadium, academies for football, archery and athletics, golf courses, and the local utility company. Some critics claim that Tata is now focusing on profit at the expense of its once ahead-of-its-time philanthropy. For example, in 1912 the company introduced an eight-hour working day (the norm in the UK was then 12 hours). It introduced paid leave in 1920 (which became legally binding in India in 1945), and started a provident fund for its employees in 1920, which became law for all Indian employers in 1952.

The group is pursuing innovation on two levels. At the high end, Tata Chemicals is conducting research in nanotechnology and food science. But what has caught more attention is the group's commitment to "frugal innovation": new products designed to appeal to poor people and the rising middle class. These include the Tata Nano (a 150,000 rupee car), a cheap water filter using rice husks, and a prototype of a $500 house that can be bought in a shop. The hotel company is building $20-a-night billets for India's commercial travellers. After the Asian tsunami in December 2004, TCS and Tata Teleservices developed a weather-alert system for fishermen.

But the group nevertheless faces serious problems. One is the parochialism that afflicts big countries (and companies): the upper management is still dominated by Indians who know only life within Tata.

Activity 8

1. Describe, and comment on, the revenue by sector for the Tata Group (Figure 4.29).
2. Comment on the pattern of international acquisitions made by the Tata Group (Figure 4.30).

ATL Research and communication skills

Visit the Tata Group website at www.tata.com.

Read about the Tata Trusts in their corporate brochure, *Leadership with Trust* (www.tata.com/ebook/tata_brochure/index.html). How do their current trusts compare with their earlier philanthropy?

Read about the Tata Code of Conduct: www.tata.com/ebook/tcoc/index.html. To what extent do you think the company still follows the values and principles set out in the code?

Case study

Apple Inc. and its supply chain

Apple Inc. is one of the richest corporations in the world, valued at $247 billion in 2015. However, the Apple supply chain has received much criticism on account of human rights, environmental and ethical issues in China. These issues emerged around 2006, and Apple has attempted to deal with them. Arguably, as the market leader, Apple Inc. has a particular duty to ensure responsible and ethical practices.

For the manufacture of the iPhone, Apple has some 785 suppliers in over 230 countries worldwide – 349 of them in China (Table 4.14). Apple, therefore, outsources much of its production and, arguably, its CSR towards workers. In its Supplier Code of Conduct, Apple states that "suppliers are required to provide safe working conditions, treat workers with dignity and respect, act fairly and ethically, and use environmentally responsible practices wherever they make products or perform services for Apple".

Table 4.14: The location and number of Apple suppliers internationally, 2015

China 349	Malaysia 23
Japan 139	Philippines 21
USA 60	Singapore 17
Taiwan 42	Germany 13
South Korea 32	Vietnam 11

Foxconn, the world's largest electronic manufacturing services (EMS) company, employing approximately 1.6 million people in China, is Apple's principal supplier. Since 2006, there have been allegations of poor working conditions at Foxconn, where workers would earn just $50/month but be expected to work 15 hours a day. In 2010 demands for better working conditions and higher wages culminated in 18 attempted suicides, 13 of which were successful. After the suicides, Foxconn put up mesh netting around its buildings to prevent people jumping from them, provided counselling for its workers and increased wages.

However, in 2014 an investigation for the BBC's programme *Panorama* revealed ongoing issues with Apple's supply chain. Apple's social and environmental actions have been described as "reactive". However, Chinese labour laws and lack of enforcement do little to protect workers. Indeed, China has actively encouraged inward investment from overseas TNCs. The sales of Apple products seem to be unaffected by the supply chain controversies. Sometimes consumers and civil society can be powerful in bringing about social and economic change, but not in this case.

Activity 9

1. Compare the different strategies of Apple and the Tata Group. Suggest reasons that explain which is the more successful company.
2. Contrast the Tata Group and Apple in terms of workers' rights and conditions.

Check your understanding

1. Describe the changes in world merchandise trade and trade in services, 2005–15 (Figure 4.10).
2. Comment on the contribution to world trade volume growth by region, 2005–15 (Figure 4.15).
3. Compare the advantages and disadvantages of top-down and bottom-up development.
4. Outline the conditions when aid is effective and when it is ineffective.
5. Identify the main aid donors (a) in terms of per cent GDP and (b) in absolute terms.
6. Briefly explain the role of structural adjustment plans (SAPs).
7. Outline the main flows of migrants' remittances.
8. Outline the main flows in the heroin trade.
9. Comment on the range of activities that the Tata Group is involved in.
10. Explain why Apple Inc. has experienced criticism over the treatment of workers in its supply chain.

Concepts in context

Different places become interconnected by global interactions. These interactions include the trade in materials, manufactured goods and services, aid, loans and debt relief, remittances, FDI and illegal flows of people, counterfeit goods and drugs. TNCs also connect different places through the locations of their operations.

Synthesis and evaluation

- Different places are interconnected by a range of flows – some legal, some beneficial, some exploitative and some illegal. These include such varied flows as trade, aid, remittances, trafficked people, drugs, illegal goods and investment by TNCs, to name but a few. Many stakeholders are involved – from multi-government organizations down to individual workers – and their power and their rights vary enormously. Managing and policing global flows is extremely difficult.
- Geographers use many methods for showing global flows, one of the most important being flow diagrams (for example, Figure 4.21). However, new methods have been developed, which remove geographical location but focus on size of flow (for example, Figure 4.20).

3 Human and physical influences on global interactions

Conceptual understanding

Key question

How do political, technological and physical **processes** influence global interactions?

Key content

- Political factors that affect global interactions: multi-governmental organizations (MGOs) and free trade zones; economic migration controls and rules.
- Our "shrinking world" and the forces driving technological innovation.
- Changing global data flow patterns and trends; transport developments over time; patterns and trends in communication infrastructure and use.
- The influence of the physical environment on global interactions: natural resource availability and the potentially limiting effect of geographic isolation, at varying scales.

Multi-government organizations

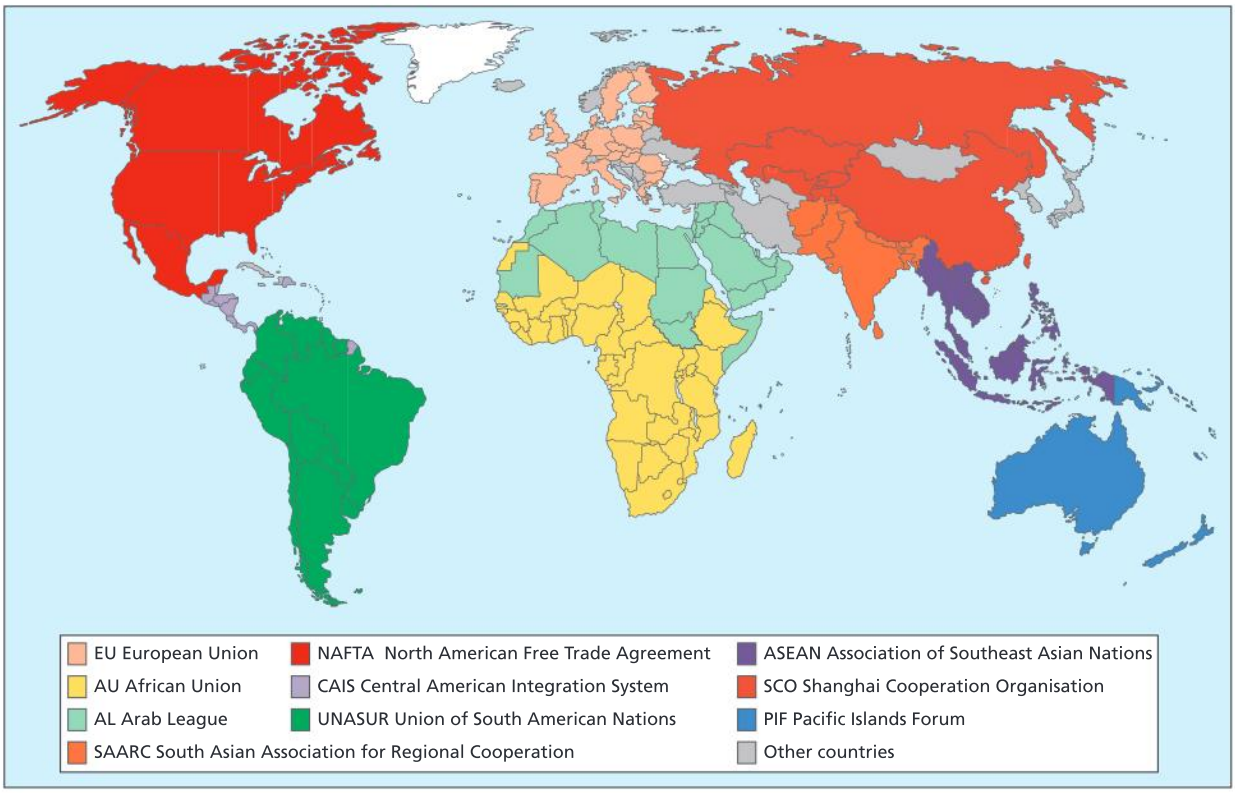
Multi-government organizations (MGOs) are those that operate across a number of different states. Some are international, such as the World Bank, the IMF and the UN, whereas others are regional, such as the North American Free Trade Agreement or the European Union. Most MGOs focus on economic matters in an attempt to increase trade and interactions, although there may be some protectionism from external states.

Trading blocs

A trading bloc is an arrangement among a group of nations to allow free trade between member countries but to impose tariffs (charges) on other countries that may wish to trade with them. Examples of trading blocs include the European Union (EU), the Association of South East Asian Nations (ASEAN), the North American Free Trade Agreement (NAFTA) and the Union of South American Nations (UNASUR) (Figure 4.31). A trading bloc is protected from external trade to some degree. Since the Second World War there has been an increase in the number of trading blocs. However, not all trading blocs have the same function and level of integration:

- **Free trade areas** are where members abolish tariffs and quotas on trade between themselves but restrict imports from non-member countries. NAFTA is a good example of a free trade area.
- **Customs unions** are a closer form of economic integration. As well as having free trade between members, all members operate a common external tariff on imports from abroad. Mercosur is a good example of a customs union.
- **Common markets** are customs markets which, as well as the free trade in goods and services, allow free movement of people and capital.
- **Economic unions** are groups of nations that not only allow free trade and free movement of people and capital, but also require members to have common policies on such sectors as agriculture, industry and regional development. The European Union is an example of an economic union. When the UK joined in 1973, it joined a common market. With increasing integration, the common market became the European Economic Community (EEC), then the European Community, and finally the European Union in 1993. In 2016, the UK voted to leave the EU.

Many trading blocs were established after the Second World War, as countries used political ties to further their economic development. Within a trading bloc, member countries have free access to each other's markets. Therefore, in the EU, France has access to Spanish



▲ **Figure 4.31:** The world's main trading blocs

markets, German markets, and so on. In return, Spain, Germany and other countries of the EU have access to France's market. Being a member of a trading bloc is beneficial because it allows greater market access – in the case of the EU, this amounts to over 500 million wealthy consumers. Some critics believe that trading blocs are unfair as they deny non-members access to certain markets. For example, developing countries have more limited access to the rich markets of Europe, which makes it harder for them to trade and develop. In order to limit protectionism, the WTO tries to promote free trade, which allows all producers in the world equal access to all markets.

Case study

NAFTA: the North American Free Trade Agreement

The North American Free Trade Agreement (NAFTA) between the USA, Canada and Mexico was signed in 1994, creating one of the largest free trade zones in the world. The population of the NAFTA countries is approximately 456 million, with an average per capita GNP of $35,490. This was the first free trade zone to join HICs with an LIC. It is an agreement to phase out restrictions on the movement of goods, services and capital between the three countries.

Its aim is to:

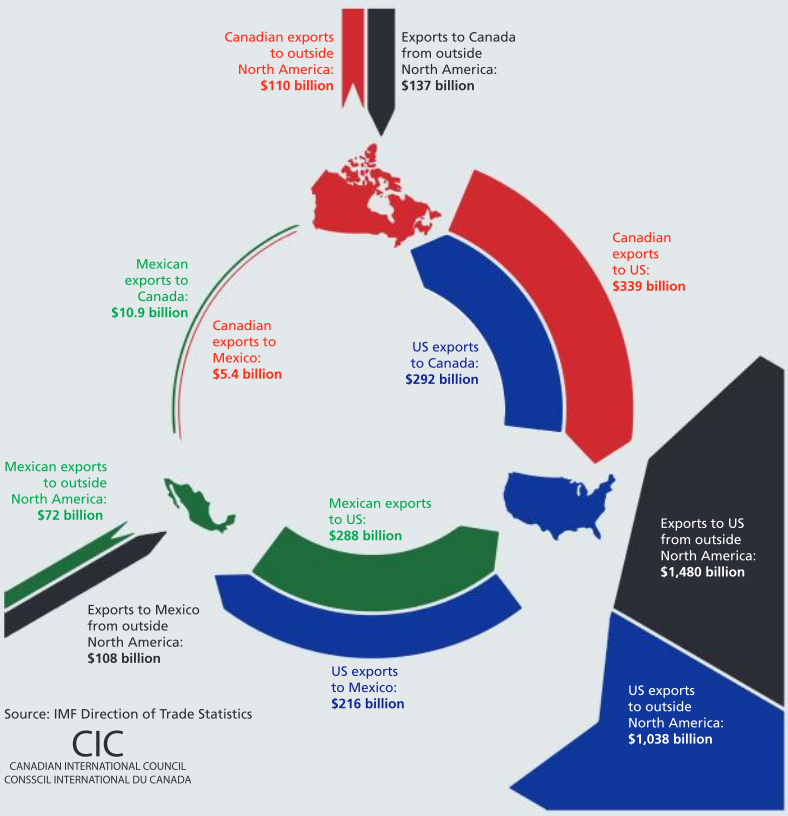
- eliminate trade barriers
- promote economic competition
- increase investment opportunities
- improve cooperation between the USA, Canada and Mexico.

Case study (continued)

Until 1982, Mexico followed a policy of government-sponsored industrialization based on import substitution industries (ISIs). However, financial crises through overspending during the 1970s and 1980s forced the Mexican government to seek aid from the USA, the World Bank and the IMF. Aid was provided, at a price: Mexico was forced to rearrange its economy along free market lines.

The government was keen to agree, partly to receive the aid and partly for fear of being ignored by the USA. Mexico hoped that, by joining NAFTA, economic growth would follow and employment would increase, and it would take off as an NIC. The USA managed to include clauses to protect American workers, and agricultural treaties were arranged bilaterally between the countries. US critics warned that assembly jobs would be lost to low-cost locations in Mexico.

▼ **Figure 4.32:** The state of North American trade, 2012 merchandise trade between North American countries and beyond



However, there has been opposition to NAFTA. Critics argue that it will not necessarily bring economic growth. Experience in Canada has shown that:

- many small firms have closed as a result of competition with lower-cost US firms
- many firms left Canada for lower-cost areas in the USA
- mergers and takeovers have increased unemployment.

With respect to Mexico:

- US industries move to Mexico to take advantage of its ultra-cheap labour. Along the USA–Mexican border there are about 2,000 US-owned, labour-intensive, export-orientated assembly plants, employing about 500,000 Mexican labourers. This has increased unemployment in the USA and reinforced a low-wage mentality in Mexico – incomes in this *maquiladora* sector have risen by only 15 per cent since 1994. Many of the workers are children and working conditions are unsafe.
- Up to 15 million farmers are affected by the removal of subsidies, decline in communal ownership of the land and the removal of border restrictions on trade. US and Canadian grain producers can dump their surpluses in Mexico, forcing uncompetitive Mexican peasants out of agriculture. On the other hand, Mexico has become an important meat market for the USA. This is partly due to the rise in its GDP per capita.

According to NAFTA, poverty rates in Mexico have fallen and there has been a rise in real income. Mexico's rural areas will become

Case study (continued)

export-orientated: industrial and service growth has replaced agriculture. However, where there has already been growth, its value has been questioned, and critics argue that Mexico could be exploited even more as a huge ultra-cheap labour supply.

Environmentalists point to Mexico's poor record of enforcing environmental laws. They fear that Mexico may become a dumping ground for hazardous material and show that Mexico's rivers and air are already heavily polluted.

Export processing zones and free trade zones

Export processing zones (EPZs) and free trade zones (FTZs) are important parts of the so-called new international division of labour, and they represent what are seen as relatively easy paths to industrialization. By the end of the 20th century more than 90 countries had established EPZs as part of their economic strategies.

The popularity of EPZs is due to three groups of factors that link the economies of LICs with those of the world economy in general and the advanced economies in particular. These are:

- problems of indebtedness and serious foreign exchange shortfalls in LICs since the 1980s
- the spread of new liberal ideas in the 1990s that encouraged open economies, foreign investment and non-traditional exports
- the search by TNCs for cost-saving locations, particularly in terms of wage costs, in order to shift manufacturing, assembly and component production from locations in the advanced economies.

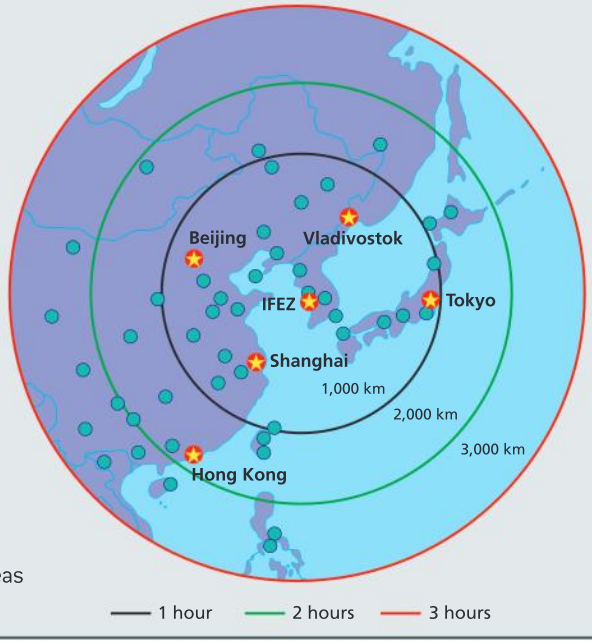
Activity 10

1. Study Figure 4.32, which shows the composition of exports from the three NAFTA countries and exports as a percentage of GDP.
2. Compare and contrast the composition of exports of the three countries. Comment on the relative contribution of exports by value.
3. Visit http://news.bbc.co.uk/1/hi/business/3077610.stm and www.ftaa-alca.org/view_e.asp.
   a. What are APEC and the FTAA?
   b. What is the Cairns group? What commodity does it trade in? What is unusual about the Cairns group?

Case study

The Incheon Free Economic Zone (IFEZ), South Korea

South Korea's national government started the north-east Asian countries' business hub project in April 2002. Free economic zones were created to attract more direct foreign investment. Incheon is one of these special economic zones with minimized regulation and maximized business incentives and opportunities for foreign investment. Compared to the rest of the country, the IFEZ offers tax breaks and other incentives to attract foreign investment and expand foreign exchange circulation. It also offers a foreign language service, labour flexibility, and foreign



▶ **Figure 4.33:** The accessibility of Incheon: areas within three hours' flight time

Case study (continued)

education and medical institutions. Its aim is to provide foreign-invested enterprises with an optimal business and living environment in order to attract their investment in high-end industries and global services.

Overview of the IFEZ

The north-east Asian region is one of the fastest-growing economic blocs in the world. Three countries of the region – Korea, China and Japan – are the driving force for this growth and development. Korea is strategically located in the centre of the vast markets between China and Japan. The best strategy for Korea's survival is therefore to make the best use of this economic and geopolitical location, and to fulfil the role of "facilitator" or "intermediary" between China and Japan as an economic hub in north-east Asia.

Incheon is located to the west of Seoul and is partly built on land reclaimed from the sea. The Incheon FEZ covers an area of over 200 square kilometres, and will be completed by 2020. The IFEZ project comprises three separate districts within Incheon Metropolitan City – the Cheongna reclaimed area, Songdo and Yeongjong, which surrounds Incheon International Airport. The total cost of the scheme is over $21 billion and over 510,000 people are expected to live there. IFEZ's goal is "to create the most desirable conditions for both living and business".

SWOT (strengths, weaknesses, opportunities and threats) analysis of the IFEZ

Incheon has many advantages ideal for establishing a free economic zone:

- It is a coastal city with an internationally competitive seaport and an airport that is the main entry point to Korea.
- Two billion people, or 32 per cent of the world's population, and 61 cities each with over a million people live within 3.5 hours flight time from Incheon. Sixty-nine airlines serve 160 cities in 49 countries.
- Incheon is adjacent to Korea's capital, Seoul, so it has a well-qualified workforce.

However, it has some disadvantages:

- Some of the incentives offered in the IFEZ may lead to expensive foreign schools, which would widen the education gap between rich and poor.
- North Korea is detrimental to the development of the IFEZ because foreign investors perceive a possible threat from the north of a second Korean War.

▲ **Photo 4.5:** The IFEZ at Incheon

Activity 11

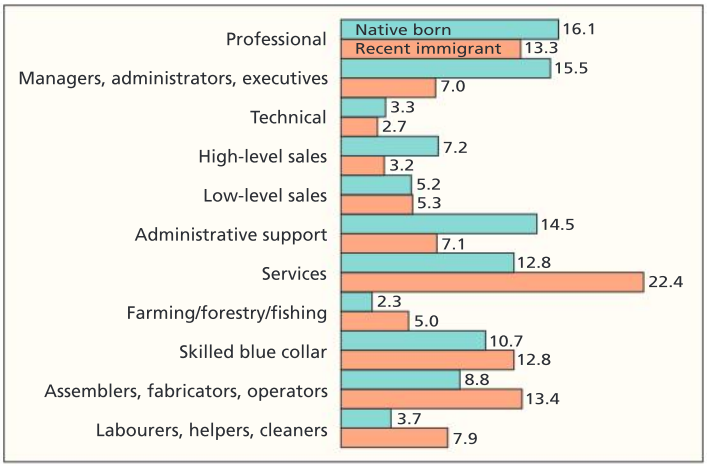
1. Distinguish between an export processing zone and a free trade zone.
2. Study Figure 4.33.
   a. Approximately how far are Tokyo and Beijing from the IFEZ?
   b. Name a location within two hours flight time of Korea.
   c. What does this map suggest about Korea and the IFEZ?

Economic migration controls and rules

International migration has changed much in recent years. Four general trends can be identified:

- Migration is becoming more global, in the sense that more countries are affected at the same time and the diversity of areas of origin is increasing.
- Migration is accelerating, with the number of movements growing in volume in all major regions.

- Migration is becoming more differentiated, with no one type of movement dominating a country's flows but instead combinations of permanent settlers, refugees, skilled labour, economic migrants, students, retirees, arranged marriages, and so on.
- Migration is increasing among women, who are not only moving to join earlier male migrants but now playing a much fuller part in their own right, notably as economic migrants as well as often being dominant in refugee flows.



▲ **Figure 4.34:** Migrants and jobs in the USA

These trends have implications for policymakers. There are new challenges for governments to provide for migrants, but there is also increased hostility in receiving countries. Increasing globalization and the growing diversity of migrants make it harder for governments to restrict migration.

Migration is important for the growth of an economy. In the USA, economic prosperity is associated with the country's ability to attract labour – both skilled and unskilled. Due to the USA's ageing population, the immigrant population accounted for more than 50 per cent of the growth in the labour market in the 1990s. Nevertheless, many people in the USA want to control migration.

Case study

Migration control in the USA

Illegal immigration to the USA refers to foreign nationals voluntarily residing in the country in violation of US immigration and nationality laws. Illegal immigration carries a civil penalty. Punishment can include fines, imprisonment and deportation.

It is estimated that there are around 12 million illegal immigrants in the US. Their mode of illegal entry into the country is believed to break down as follows:

- After entering legally with inspection: non-immigrant visa overstayers, 4–5.5 million; border crossing card violators, 250,000–500,000.
- After entering illegally without inspection: evading immigration inspectors and border patrol, 6–7 million.

A traveller is considered a "visa overstayer" once he or she remains in the USA after the period of admission has expired. Visa overstayers tend to be somewhat more educated and better off financially than those who cross the border illegally. People have long used sham marriages as a way to enter the USA.

Each year, an estimated 200,000 to 400,000 illegal immigrants try to make the 24–48 km hike through the Mexican wilderness to reach cities in the USA. Often, the people who choose to sneak across the border employ expert criminal assistance – smugglers who promise a safe passage into the United States.

Indian, Russian, Thai and Chinese women have reportedly been brought to the USA under false pretences to be then used as sex slaves. As many as 50,000 people are illicitly trafficked into the United States annually. Trafficking in women plagues the USA as much as it does underdeveloped nations. Organized prostitution networks have migrated from metropolitan areas to small cities and suburbs.

Immigration and enforcement

Illegal migration over the US–Mexico border is concentrated around big border cities such as

Case study (continued)

El Paso and San Diego, which have extensive border fencing and enhanced border patrols. Stricter enforcement of the border in cities has failed significantly to curb illegal immigration, instead pushing the flow into more remote regions and increasing the cost to taxpayers of each arrest from $300 in 1992 to $1,700 in 2002. The cost to illegal immigrants has also increased: they now routinely hire coyotes, or smugglers, to help them get across.

In 2005, the US House of Representatives voted to build a separation barrier along parts of the border not already protected by separation barriers. A later vote in 2006 included a plan to blockade 860 miles (1,380 km) of the border with vehicle barriers and triple-layer fencing along with granting an "earned path to citizenship" to the 12 million illegal aliens in the US and roughly doubling legal immigration (from their 1970s levels). In 2007 Congress approved a plan calling for more fencing along the Mexican border, with funds for approximately 700 miles (1,100 km) of new fencing. In 2017, US president Donald Trump called for the wall to be completed – and to be paid for by Mexico.

ATL Research and communication skills

For information on the globalization of migration control, see http://www.opendemocracy.net/people-migrationeurope/article_1274.jsp. Comment on the views expressed in the article.

For the International Organization for Migration, see http://www.iom.int/jahia/jsp/index.jsp Outline the main concerns of the IOM.

See http://www.open2.net/blogs/society/index.php/2009/06/12/paradox_migration_control?blog=10 and outline the paradoxes of migration control.

Visit http://www.open2.net/immigrants/migrantmap.html for an interactive map showing migrants in many parts of the world. Describe the migration of population in an area that interests you.

Australia's migration laws and regulations set the criteria and standards that foreign nationals must meet if they wish to travel to and remain in Australia for a period of time.

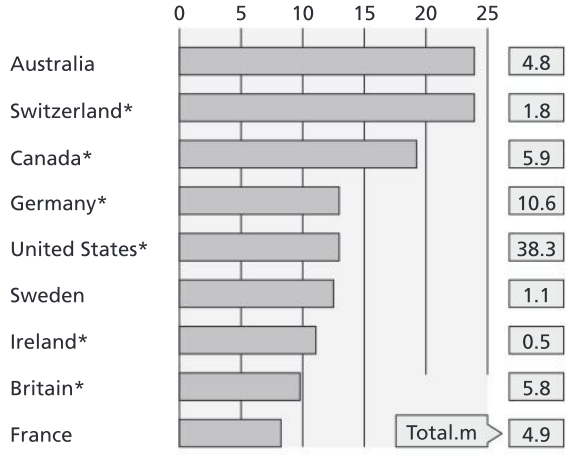


Figure 4.35: The foreign-born population in selected OECD countries

Activity 12

1. Which is the most common job sector for (a) native-born workers and (b) foreign-born workers in the USA?
2. Compare and contrast the employment structure of native-born workers with those of foreign-born workers, as shown in Figure 4.35.
3. Suggest reasons why a country would want to limit the amount of in-migration within its borders.

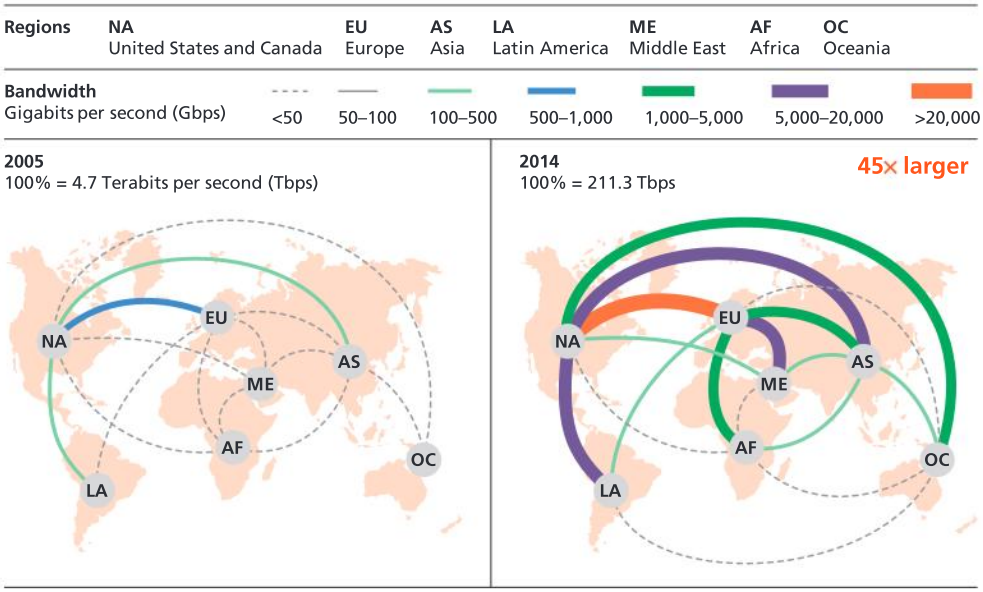
The "shrinking world": data flow patterns and trends

The world has become more interconnected than ever before. The physical flow of goods and services was the hallmark of the 20th century, but it is flows of data and information that characterize the 21st century. Digitization has changed globalization in many ways. It is driving down the cost of cross-border communications and transactions, allowing businesses to connect with other businesses and customers in almost any part of the world. HICs are the most globally connected countries, although NICs and LICs are closing the gap slowly.

The digital age poses some challenges. Companies may be subject to pricing pressures, there are potentially more aggressive competitors, and security is a major issue. Social media may create new communities but it is also a means for the spread of extremism.

When trade was dominated by physical goods, it was largely confined to TNCs in HICs but, now that global data flows are escalating, more countries and smaller enterprises are increasingly able to compete on the global market. The volume of data being transmitted across borders has surged, connecting countries, companies and individuals. These flows mainly consist of information, searches, communications, video, sales and inter-company traffic. Although container ships are responsible for moving products to the markets, goods are ordered, tracked and paid for online.

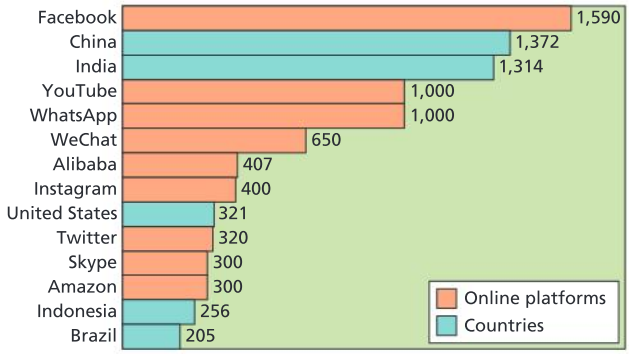
▼ **Figure 4.36:** The surge in cross-border data flows connecting countries



NOTE: Lines represent inter-regional bandwidth (for example between Europe and North America) but exclude intraregional cross-border bandwidth (for example connecting European nations with one another).

Digital platforms are central to the new era of globalization. These include social networks, operating systems, digital media platforms and e-commerce websites – some of them with hundreds of millions of users.

About one-eighth of the global goods trade is carried out by international e-commerce, and about half of the world's traded services are already digitized. Digitization allows the instantaneous exchange of virtual goods such as e-books, apps, online games,

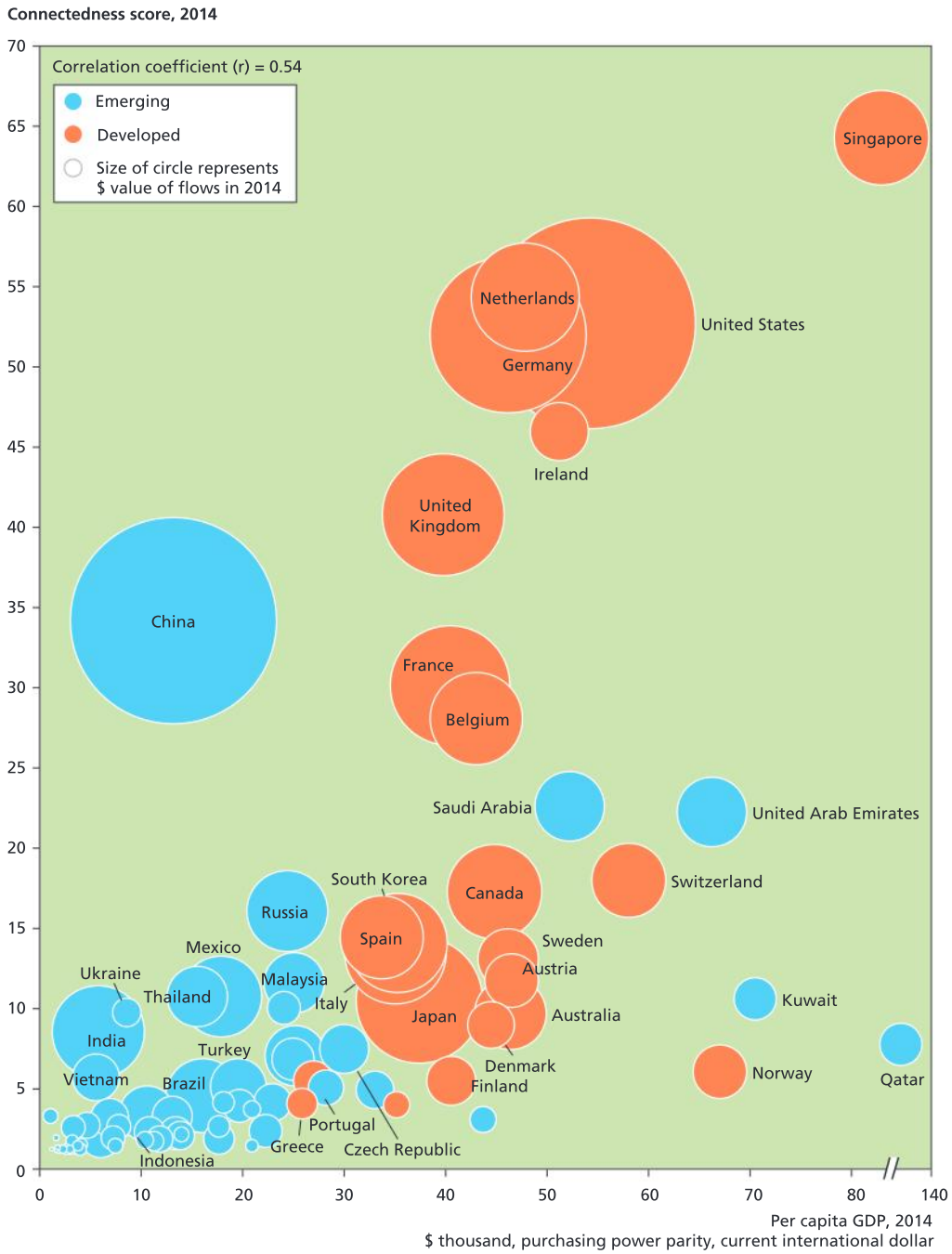


▲ **Figure 4.37:** Users of the largest online platforms vs population of the world's largest countries (million)

MP3 music files and streaming services, and software. For example, when Netflix expanded its business model from mailing DVDs to online streaming, it increased its market to over 190 countries. Facebook suggests that there are 50 million small and medium enterprises (SMEs) on its platform, up from 25 million in 2013. Digital platforms allow companies to reach beyond the constraints of a small local market and reach a global audience.

Although more countries are participating in digital networks, global flows are concentrated among a comparatively small number of users. The USA, Europe and Singapore are at the centre of the world's digital networks. Singapore became South East Asia's main shipping port decades ago. It also became a regional hub for finance and services by attracting skilled international labour and FDI. In a similar way, the Netherlands is a major shipping hub and a hub for data traffic.

Figure 4.38 shows that a small number of countries are much more connected than the rest of the world. Within some countries there are "world cities". According to the McKinsey Global Institute, there are only eight truly global cities, with strong connections in four of the five flows (goods, services, finance, people and data). Within countries, there are very different patterns of globalization. In the UK and Germany, for example, the pattern of globalization is more even, compared with, for example, China, which has a highly connected coastal region and largely unconnected inland/western provinces.



▲ **Figure 4.38:** Country connectedness and level of income

Activity 13

1. Describe the change in the size and pattern of cross-border data flows, as shown in Figure 4.36.
2. Comment on the size of online platforms, as shown on Figure 4.37.
3. Study the graph that shows level of connectedness, purchasing power parity (PPP), and value of flows, 2014 (Figure 4.38).
   a. Describe the relationship between PPP and level of connectedness.
   b. Identify two contrasting exceptions to the pattern you have identified in (a).
   c. Identify the five countries with the largest value of flows in 2014.
4. Visit www.mckinsey.com.business-functions/digital-mckinsey/our-insights/digital-globalization-the-new-era-of-global-flows.
   a. Describe, and suggest reasons for, changes in globalization between the 20th and 21st centuries.
   b. Study the table on page 12 of the report, which shows how the MGI Connectedness Index is measured. Choose two contrasting countries and compare their overall level of connectedness and their component scores.

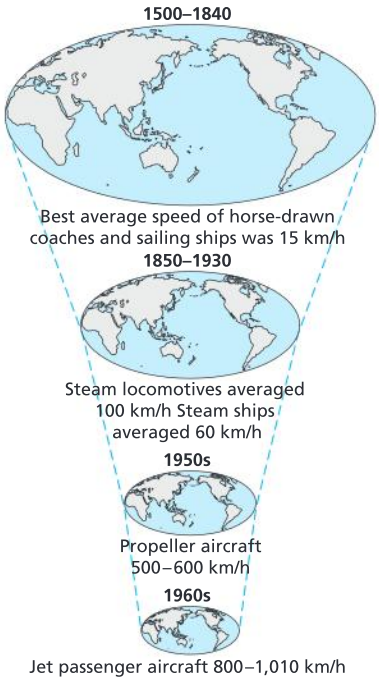
Transport developments over time

The **frictional effect of distance**, or **distance decay**, suggests that areas that are close together are usually more likely to interact with one another, whereas areas far apart are less likely to interact with one another. However, there has been a reduction in the frictional effect of distance, as improvements in transport have allowed people to travel greater distances in less time. In addition, improvements in ICT bring places in different parts of the world together almost instantaneously.

Time–space convergence

A basic requirement for the evolution of international trade and the development of transnational corporations (TNCs) is the development of technologies that overcome the frictional effect of distance and time. The most important of these *enabling* technologies are transport and communications. Neither of these technologies caused international trade or the development of TNCs, but they allowed such developments to occur. Without them, today's complex global economic system simply would not exist.

Transport systems are the means by which materials, goods and people are moved between places. Communication systems are the means by which information is transmitted between places. Before the development of electricity in the 19th century, information could move only at the same speed, and over the same distance, as the prevailing transport system would allow. Electricity broke that link, making it increasingly necessary to treat transport and communication as separate, though closely related, technologies. Developments in both have transformed the world, allowing unprecedented mobility of materials and goods and a globalization of markets.



▲ **Figure 4.39:** Time–space convergence

The world has "shrunk" in the time it takes to get from one part of the world to another (Figure 4.39). For most of human history, the speed and efficiency of transport were low and the costs of overcoming the frictional effect of distance high. Movement over land was especially slow and difficult before the development of the railways. The major breakthrough came with the invention and application of steam power and the use of iron and steel for trains, railway tracks and ocean-going vessels. The railway and the steamship enabled a new, much enlarged, scale of economic activity.

The mid–late 20th century saw an acceleration of this process of space – time convergence. The most important developments have been the introduction of commercial jet aircraft, the development of much larger ocean-going vessels (superfreighters) and the introduction of containerization, which greatly simplifies trans-shipment from one mode of transport to another. Of these, the jet aircraft had the most influence, especially on the development of TNCs, which coincided with the take-off of commercial jets during the 1950s.

Both the time and relative cost of transporting materials, goods and people have fallen dramatically as a result of changes in transport technology. However, these developments have depended, to a large extent, on parallel developments in communications technology. In the 19th century rail and ocean transport needed the electric telegraph and, later, the oceanic cable, for their development. Similarly, the far more complex global transport system of the present depends fundamentally on telecommunications technology.

Communications technologies are the key technology in all economic activities but they are especially vital to those sectors and activities whose primary function is to collect, transform and transmit information. One of the most important catalysts to enhanced global communications has been the development of satellite technology. Satellite technology has made possible remarkable levels of global communication of conventional messages and also the transmission of data. Its key element is the linking together of computer technologies with information-transmission technologies over vast distances. Not only are transmission costs by satellite insensitive to distance, but also user costs have fallen dramatically. Optical fibre cables are now challenging satellite communications: these systems have a very large carrying capacity, and transmit information at very high speed and with a high signal strength.

However, only very large organizations – whether business or government – have the resources to utilize fully the new communications technologies. For the TNC, they have become essential to its operations. For example, Texas Instruments, the electronics TNC, has approximately 50 plants located in some 19 countries. It operates a satellite-based communications system to coordinate, on a global scale, production planning, cost accounting, financial planning, marketing, customer services and personnel management. The system consists of almost 300 remote job-entry terminals, 8,000 inquiry terminals and 140 distributed computers connected to the network.

According to Peter Dicken, in his book *Global Shift* (2010), technological developments in communications have transformed time–space

relationships between all parts of the world. However, not all places are equally affected. In general, the places that benefit most from innovations in the communications media are the "important" places – the core areas. In contrast, the peripheral areas have benefited much less from new communications technologies. New investments in communications technology are market related; they go to where the returns are likely to be high. The cumulative effect is to reinforce both certain communications routes at the global scale and to enhance the significance of the nodes (cities/countries) on those routes.

The jet engine

An estimated 320 million people meet annually at professional and corporate events after travelling by air. Of the world's $12 trillion of merchandise trade, 35 per cent by value was shipped by air in 2006. The jet engine is perhaps the most significant innovation in long-distance transport ever. The jet is safer, easier to maintain, better suited for longer distances, and more fuel efficient than the propeller. Jet aircraft have a much higher power-to-weight ratio, which enables longer range, faster travel and bigger payloads. For example, the Airbus A380, the world's largest passenger plane, can carry about 555 people.

While most global trade is by maritime shipping, air transport fills an important niche in just-in-time production systems. In Brazil, known for its primary goods exports, air cargo in 2000 accounted for 0.2 per cent of total export volume by weight, but almost 19 per cent by value. Important sectors benefiting from air transport are semiconductors and fashion.

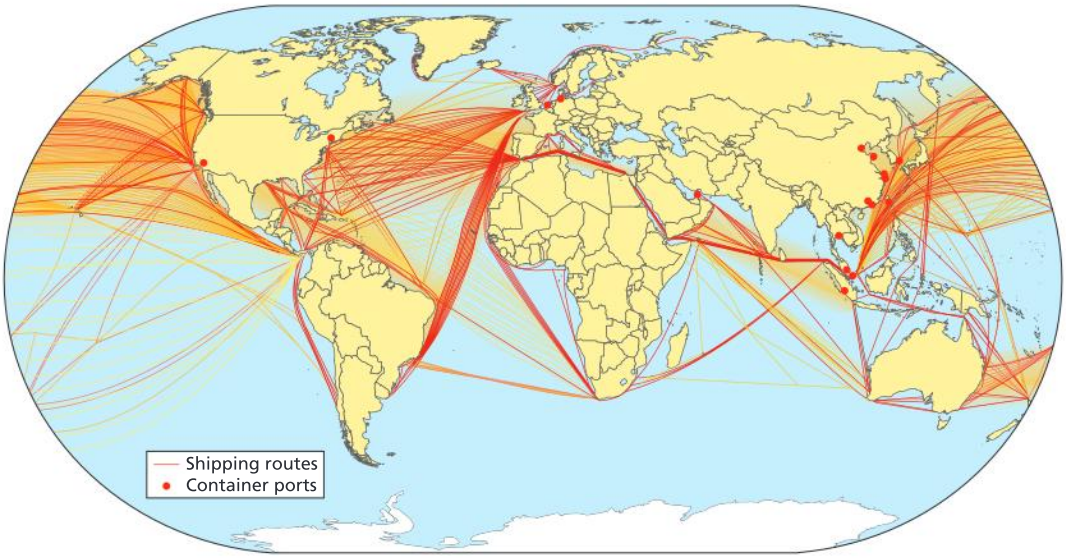
Inexpensive and frequent air services have allowed countries like Chile, Colombia and Kenya to sell agricultural and horticultural products to markets in Europe, the Middle East and North America. A prime example is Kenya, which today has a third of the global market for cut flowers. By contrast, Bangladesh's lack of cold storage facilities and refrigerated air cargo capacity has reduced its opportunities to export high-value fruits and vegetables to the Middle East.

Containers

Containers are the backbone of the modern global economy. About 90 per cent of non-bulk cargo worldwide is transported in containers stacked on trucks, rail wagons and freight ships. In 2007 more than 18 million containers made more than 200 million trips. Cargo shipped is now measured in TEUs (20 foot equivalent units) or FEUs (40 foot equivalent units). A TEU is the measure of a box 20 feet long and 8 feet wide, with a maximum gross mass of 24 metric tons.

The Japanese government was the first to support the expansion of containerization. It built the world's first container terminals in the Tokyo-Yokohama and Osaka-Kobe areas in 1967. Once the infrastructure facilities were in place, container traffic took off; by the end of 1968, the Japan–US route was crowded with container ships. Since then, container transport has increased at enormous rates. The boxes keep getting larger, with the standard FEU size giving way to 48 foot and 53 foot boxes that allow trucks to haul more freight on each trip. The world's fleet is

▲ **Photo 4.6:** Containers at Tokyo port



▲ **Figure 4.40:** Shipping routes and the world's main container ports

expanding steadily, as is the size of the vessels.

Only geography and topography limit the ever-increasing size of ships: their absolute size is restricted by the depth of the Straits of Malacca, linking the Indian Ocean to the Pacific Ocean. This limits a ship to dimensions of 470 metres long and 60 metres wide. The Panama Canal is being expanded to allow ships up to 12,000 TEUs to pass, and there were talks about China building a new canal through Nicaragua or building two ports in Columbia and a new railway to link them. Many of the larger container ships can now carry 17,000 TEUs and there are plans to build containers that can carry 25,000 TEUs, but the number of ports that can accommodate these ships is limited.

Activity 14

Watch a video on the role of containers in global trade, at http://ed.ted.com/lessons/how-containerization-shaped-themodern-world

and "ship-shipping ships": http://geographyeducation.org/2013/10/14/ship-shipping-ships/

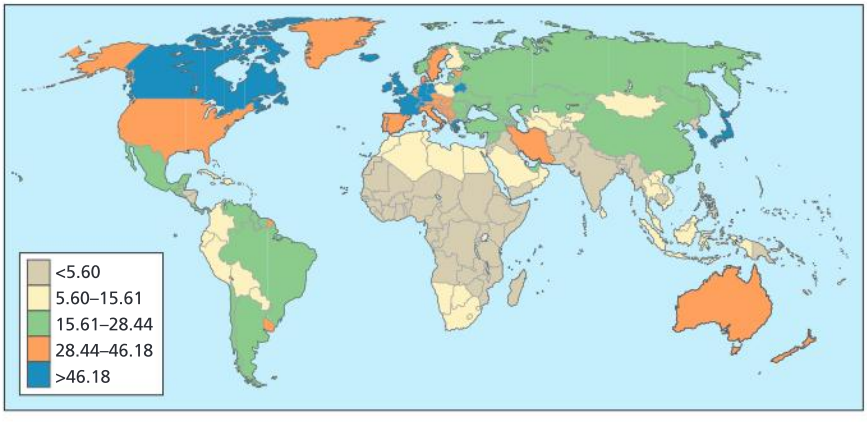
and https://www.youtube.com/watch?v=wEGNDQraUzY.

Patterns and trends in communication infrastructure

There are striking variations in international access to fixed telephone lines, mobile subscriptions, the Internet and broadband (Figures 4.41–4.44).

Changing trends

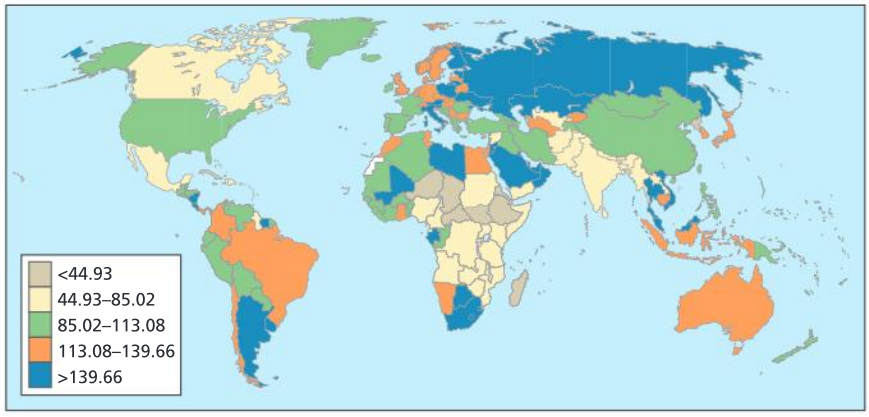
It took radio 38 years to reach its first 50 million users, television 13 years, and the Internet three years. Facebook had 50 million users in just one year, and Twitter took even less time to reach that number. Every year, ICT technology brings faster processing speeds, greater storage capacity and more advanced software. Many trends reflect the dominance of the internet. Consumers and businesses expect to find any information via a search engine; health care, education and government services are available over the Internet, and can be accessed from most places in the world.

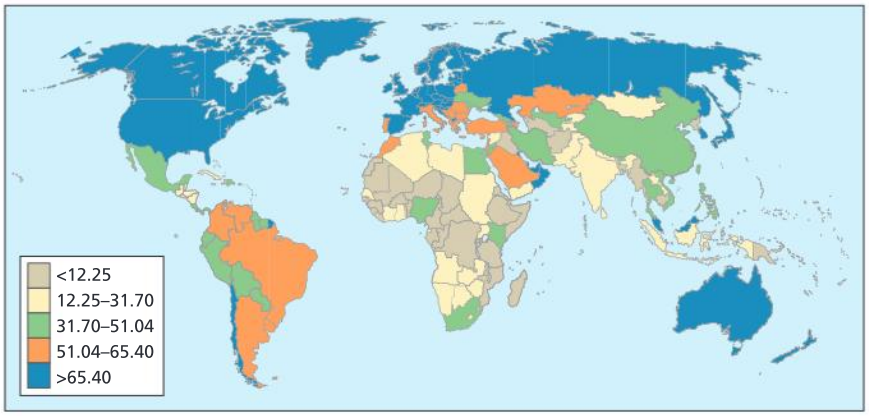


▲ **Figure 4.41:** Fixed telephone landlines per 100 people

The McKinsey Global Institute estimates that half of growth in mobile Internet until 2025 will occur in NICs and LICs. It suggests that there will be 3 billion new users connected by 2025. By 2015, some 1.8 billion people will move up to the global consumer

▼ **Figure 4.42:** Mobile cellular subscriptions per 100 people





▲ **Figure 4.43:** Internet users per 100 people

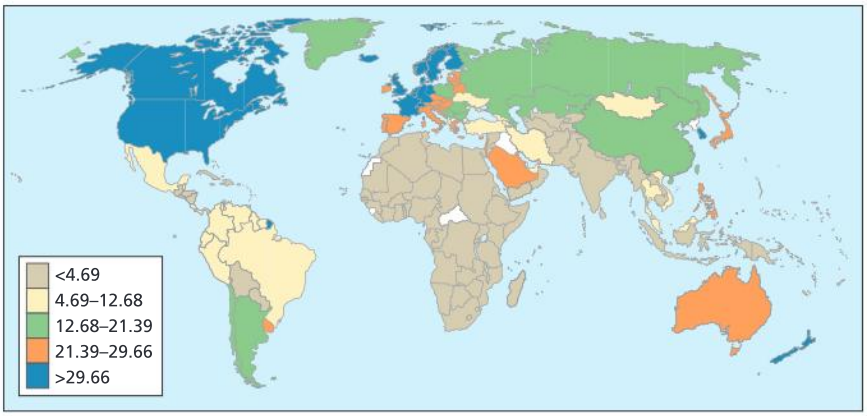
Activity 15

1. Describe the variations in landlines as shown in Figure 4.41.
2. Go to the World Bank's interactive sites for each of the maps: http://data.worldbank.org/indicator/IT.MLT.MAIN.P2?view=map.
   a. Choose three or more contrasting countries and find out their data for landlines, mobile phones, Internet use and access to broadband. Hover over a country to read its value.
   b. To what extent is there still a digital divide between HICs and LICs? Use evidence from the website to support your answer.

class – those with enough money to purchase goods and services, having met their basic needs.

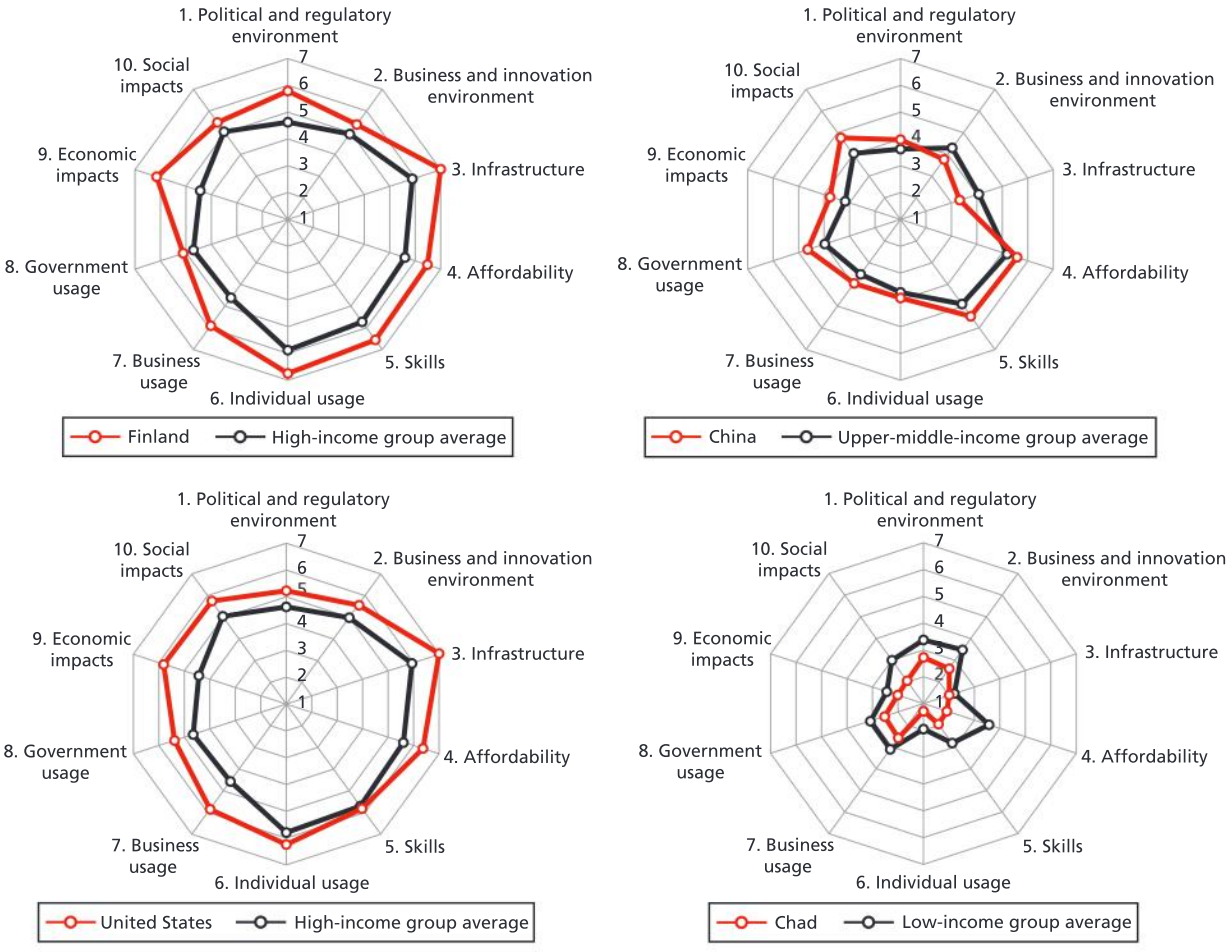
It is expected that the biggest rise will be in smartphones. Since 2005, sales of mobile handsets have increased by 20 per cent per year in Africa and by 15 per cent per year in Asia and Latin America. China and India each have more than 1 billion mobile handsets. Smartphones enable people to have access to financial services such as Safaricom's M-Pesa. Launched in 2007, the service doubled the number of its subscribers in just two years, and now has 15 million accounts in Kenya and 9 million in Tanzania. In South Africa, around half a million people have opened bank accounts with Standard Bank using mobile phones.

Mobile phones can improve access to health care. For example, in Bangladesh, where 90 per cent of births occur outside hospitals and clinics, a scheme to notify midwives when labour starts has resulted in almost 90 per cent of births taking



▶ **Figure 4.44:** Fixed broadband subscriptions per 100 people

Figure 4.45: The quality of Internet provision in four selected countries
Source: World Economic Forum 2016



Activity 16

Study Figure 4.45.

1. Compare the quality of Internet provision and Internet use between the four countries.
2. Using an atlas, suggest reasons why China and Chad may find it difficult to improve their Internet service and usage.

place with a midwife present. Education courses can also be delivered over the Internet. MOOCs (massive open online courses) are creating learning opportunities for people of all ages.

Nevertheless, despite all these advances, many people still do not have access to the Internet. This includes large numbers of poor people, the elderly, those with certain disabilities, and those living in areas with no service. There are also major differences between countries. The best Internet provider is Finland, followed by Singapore, and the worst is said to be Chad. Figure 4.45 shows Internet profiles for Finland, the USA, China and Chad.

The influence of the physical environment on global interactions

Natural resource availability

The availability of natural resources is a significant factor in world trade. For example, the Middle East countries dominate the export of oil. Countries endowed with other raw materials, such as food products, timber, minerals and fish, also have the potential to trade.

Australia and Canada are rich in mineral resources and they continue to exploit these. Other countries may have used the bulk of their resources, but have since diversified. The UK and Germany were major coal and steel producers, but have diversified their economies so as not to depend on those resources. Many HICs have been built to a considerable extent on their export of raw materials in demand on the world market. MICs and LICs rich in raw materials, such as Brazil and South Africa, have been trying to follow a similar path – using the wealth from exporting their raw materials to diversify and produce a more broadly based economy. Countries with a single resource product – for example, St Lucia with bananas and Malawi with tobacco – are more vulnerable to climate extremes, disease and currency fluctuations because they have fewer alternative ways to earn foreign currency.

Geographic isolation

Isolation from world markets can be a major limiting factor. Increased transport costs and times may reduce access to markets. Countries that are landlocked may also have to pay substantial tariffs to export their goods. For example, South Sudan has to pay either Sudan or Kenya to get its oil to the coast. Landlocked countries may also have to pay for the use of another country's air space. Access to market has long been a theme in geography, and models of agriculture and industry have considered location in relation to markets and labour. This occurs at a local scale as well as at a regional and international scale.

Synthesis and evaluation

- Processes that influence spatial interactions are interlinked in complex ways that accelerate global interactions. For example, places that have good Internet connections are much more able to communicate with other areas than isolated locations lacking Internet connectivity. Deep-water ports facilitate shipping and trade, whereas landlocked countries find it difficult to trade. Developments in ICT facilitate global interactions, but there are political and environmental limits to these interactions.
- Flow diagrams and choropleth maps are often used to show the volume of interactions and their pattern of use, but other forms of diagrams, such as polar graphs (Figure 4.45), may be used to show the complexity of a network.

EXAM PRACTICE

(a) Using examples, explain the geographic pattern of one or more illegal flows. (12 marks)

(b) Examine how global interactions can lead to increased inequalities. (16 marks)

Check your understanding

1. Explain the term "trading bloc".
2. Distinguish between a customs union and a common market.
3. Distinguish between an export processing zone and a free trade zone.
4. Outline the ways in which migration may be controlled.
5. Describe the changes in cross-border data flows between 2005 and 2014 (Figure 4.36).
6. Explain the term "distance decay".
7. Outline the advantages of containers for transport of goods.
8. Compare the global distribution of fixed landlines with that of mobile cellular phones.
9. Outline the global variations in Internet use.
10. Briefly explain how the physical environment affects global interactions.

Concepts in context

Political, technological and physical **processes** influence global interactions in a variety of ways. For example, trading blocs, free economic zones and free trade zones encourage trade between areas. Improvements in ICT speed up and increase the volume of global interactions. Transport developments have led to a smaller world – a global village. Physical processes and conditions, such as resource endowment and location, also influence global interactions.

UNIT 5
HUMAN DEVELOPMENT AND DIVERSITY

Key terms

Civil society	Any organization or movement that works in the area between the household, the private sector and the state to negotiate matters of public concern. Civil societies include non-governmental organizations (NGOs), community groups, trade unions, academic institutions and faith-based organizations.
Culture	A system of shared meanings used by people who belong to the same community, group or nation, to help them interpret and make sense of the world. These systems of meanings include language, religion, custom and tradition, and ideas about "place".
Cultural diffusion	The spread of cultural ideas, from their place of origin to other regions, groups or nations.
Cultural imperialism	The practice of promoting the culture, values or language of one nation in another, less powerful one.
Diaspora	The forced or voluntary dispersal of any population sharing a common racial, ethnic or cultural identity, after leaving their settled territory and migrating to new areas.
Resource nationalism	When a country decides to take all, or a part, of one or a number of natural resources under state ownership.
Glocalisation	The adaptation of a product or service to the locality or culture for which it is marketed.
Protectionism	Any economic policy that limits trade between countries so as to protect trade in the home country.
Affirmative action	An economic policy of favouring members of a disadvantaged group. It is sometimes described as positive discrimination.

Human development is a multidimensional process. The Sustainable Development Goals (SDGs) are an attempt to achieve a high level of human development for all by 2030. Human development can be measured by the human development index, a composite index which takes into account a number of features of human development. Other methods of measuring human development include the Gender Development Index. Certain populations, notably women and indigenous groups, are discriminated against. Partly as a result of increased global interactions, some cultural traits are changing, and parts of the world are becoming more homogeneous. Cultural change may be through choice (diffusion) or imposed (imperialism). Diaspora groups may attempt to preserve their culture. There are many communities that resist globalization and globalized production. The rise of anti-immigration groups, nationalism and protectionist policies have slowed global interactions.

Key questions

1. What are the ways of supporting the **processes** of human development?
2. How do global interactions bring cultural influences and changes to **places?**
3. How does the **power** of local places and actors to resist or accept change vary?

1 Development opportunities

Conceptual understanding

Key question

What are the ways of supporting the **processes** of human development?

Key content

- The multidimensional process of human development and ways to measure it, such as the UN Sustainable Development Goals (SDG) criteria.
- The validity and reliability of development indicators and indices, including the Human Development Index (HDI) and Gender Inequality Index (GII).
- Empowering women and indigenous or minority groups.
- The importance of social entrepreneurship approaches for human development: the work of microfinance organizations and their networks; alternative trading networks such as "Fair Trade"; TNC corporate social responsibility frameworks and global agreements.

The UN Sustainable Development Goals

The UN Sustainable Development Goals (SDGs) were agreed in 2016, although they are still subject to refinement and improvement as

methods and data availability improves. There are 17 goals and a number of sub-goals (Table 5.1).

Table 5.1: The UN Sustainable Development Goals

Sustainable Development Goal	Status (2015 unless specified)
1. End poverty in all its forms everywhere.	• Poverty remains widespread in sub-Saharan Africa, where over 40% of the population live on less than $1.90/day. • A tenth of the world's workers and their families are living on less than $1.90/day. • Young people aged 15–24 are most likely to be among the working poor. • Only 20% receive any type of social assistance or social protection benefits in LICs, compared with 66% in HICs.
2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.	• Nearly 800 million people worldwide lack access to adequate food. • Over half the adult population in sub-Saharan Africa face moderate or severe food insecurity.
3. Ensure healthy lives and promote well-being for all ages.	• Nearly 6 million children died, mostly from preventable causes. • 2.1 million people became newly infected with the HIV virus, and over 200 million people had malaria. Sub-Saharan Africa accounted for nearly 90% of malaria cases.
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	• In 2013, some 59 million children of primary school age did not attend school. • In 2013, over 750 million adults were unable to read or write – 66% of them were women.
5. Achieve gender equality and empower all women and girls.	• Women spend about twice as much time on unpaid labour compared with men.
6. Ensure availability and sustainable management of water and sanitation for all.	• Over 90% of the world's population has access to an improved water source. • 2.4 billion people do not have access to improved sanitation. • Water stress affects over 2 billion people worldwide.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.	• Over 1 billion people do not have access to electricity. • Some 3 billion people rely on polluting and unhealthy fuels for cooking.
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.	• Gender disparities in unemployment are most marked in Western Asia and North Africa, where women are almost twice as likely as men to be unemployed.
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	• HICs invested about 2.4% of their GDP in R&D, whereas for LICs it was less than 0.3%. • 3G mobile broadband covered almost 90% of the urban population but less than 30% of the rural population.

Sustainable Development Goal	Status (2015 unless specified)
10. Reduce inequality within and among countries.	• In about 60% of countries the per capita income of the poorest 54% of households increased faster than the national average.
11. Make cities and human settlements inclusive, safe, resilient and sustainable.	• In 2014, 30% of the global urban population lived in slums. • Around half of the urban population is exposed to urban air pollution that is more than 2.5 times higher than the WHO's recommended safety level.
12. Ensure sustainable consumption and production patterns.	• In 2010, the total material footprint (amount of primary material used) was 23.6 kg per unit of GDP in HICs, and 14.5 kg per unit of GDP in LICs.
13. Take urgent action to combat climate change and its impacts.	• On average, over 80,000 die and a further 200 million are affected each year (2000–2013) by natural disasters.
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.	• Fewer than 70% of global marine fish stocks are biologically sustainable.
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss.	• The average annual loss of forests fell from over 7 million ha in the 1990s to 3.3 million ha per year, 2010–15. • Over 23,000 species of plants, fungi and animals were identified as facing a high risk of extinction. • Since 1999, more than 7,000 species of plants and animals have been found in illegal trade.
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.	• Between 2008 and 2014, the murder rate in LICs was twice that in HICs. • At the peak in 2011, over one-third of victims of trafficking were children. • Up to a quarter of all births in LICs are unregistered.
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.	• ODA totalled $131 billion in 2015. • The share of LIC merchandise exports is just over 1% of total merchandise exports.

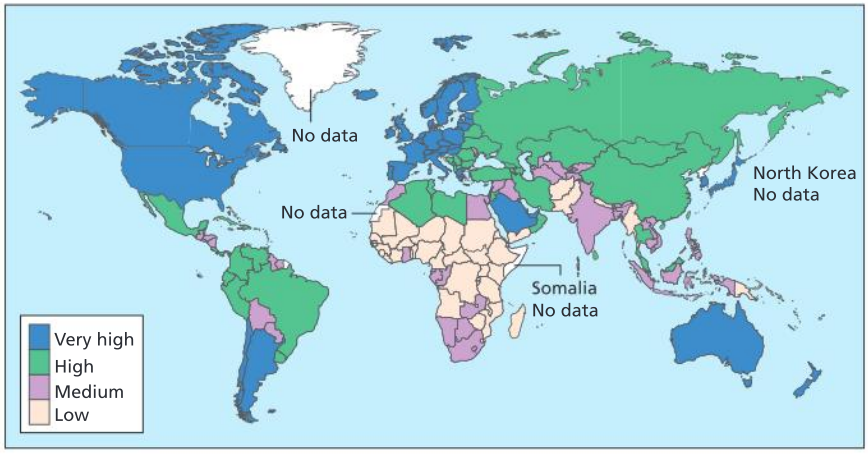
Source: Adapted from the UN *Sustainable Development Goals Annual Report 2016*

The Human Development Index

The Human Development Index (HDI) is a composite measure of development. It includes three basic components of human development:

- longevity (life expectancy)
- education index – mean years of schooling, expected years of schooling
- standard of living – income adjusted to local cost of living, that is, purchasing power.

The United Nations (UN) has encouraged the use of the HDI, as it is more reliable than single indicators such as gross national income (GNI) per head. (GNI was previously known as gross national product – GNP.) It is a composite index so that the importance of any one factor is reduced.



▲ **Figure 5.1:** Global HDIs for 2014
Source: Based on data in *The Human Development Report 2015*

Countries with a very high human development index have to have a relatively high index for each component. A country with a high purchasing power, for example, but a low life expectancy and low education index, will only have a medium HDI.

The HDI varies theoretically between 1.0 (maximum) and zero. Considerable progress has been made in the HDI since 1990. The number of people living in countries ranked very high on the Index has more than doubled, from 0.5 billion in 1990 to 1.2 billion in 2014. In addition, the number of people living in countries with a low HDI fell from 3.2 billion in 1990 to 1.2 billion in 2014. However, improvements in the HDI are slowing down. The HDI for LICs increased on average 1.2 per cent per year between 2000 and 2010, but only by 0.7 per cent per year between 2010 and 2014.

The five countries at the top of the HDI are Norway (0.944), Australia, Switzerland, Denmark and the Netherlands – which are separated by just 0.022. In contrast, the five countries at the bottom of the HDI – namely Niger (0.348), Central African Republic, Eritrea, Chad and Burundi – have a range of 0.052, more than twice that of the range of countries at the top. This suggests that countries at the top of the HDI have a similar level of development whereas those at the bottom have more varied levels. Although sub-Saharan Africa has the most countries ranked low on the HDI, a number of countries there, such as Namibia and Zambia, have moved up to the medium level. In 2014, the countries with the greatest relative drop in HDI rank were Syria and Libya.

Comparing the ranking of developing countries by their HDI and gross national income shows some interesting patterns. Many oil-producing countries, for example, have much lower HDI rankings than their GNI rank, while some poor countries rank relatively high in the HDI because they have deliberately devoted scarce resources to human development. Cuba, Costa Rica, Vietnam and Sri Lanka fall into this category. Similarly, some countries with a similar income, such as Equatorial Guinea and Chile, have very different rankings, whereas other countries with a similar ranking, such as Indonesia and Gabon, have different income levels. Other countries, such as New Zealand, have a much higher rank for HDI (9) than for GNI (32).

TOK

How can we measure poverty?

Many of the world's poorest people live in poverty so acute that it is difficult for those fortunate enough to live in MICs to comprehend what it means to be poor. The UN Development Programme's **Human Poverty Index** (HPI) (Table 5.2) is based on three main indices: the percentage of the population not expected to survive beyond the age of 40; the adult illiteracy rate; and a deprivation index based on an average of three variables – the percentage of the population without access to safe water, the percentage of the population without access to health services, and the percentage of children under the age of five years who are underweight through malnourishment. The United Nations Development Programme (UNDP) has calculated that the cost of eradicating poverty across the world is relatively small compared to global income – not more than 0.3 per cent of world GDP – and that political commitment, not financial resources, is the real obstacle to poverty eradication. While the HDI measures overall progress in a country in achieving human development, the HPI reflects the distribution of progress and measures the backlog of deprivations that still exists.

ATL Research skills

Use the data in the 2015 *Human Development Report* to investigate the HDI in a range of contrasting countries of your choice. Visit http://hdr.undp.org/sites/default/files/hdr_2015_statistical_annex.pdf and look at differences in the HDI, composition of the HDI and changes in the trends.

The Human Poverty Index

The Human Poverty Index (HPI) measures deprivation in the same dimensions of basic human development as the HDI. It is divided into two indices, HPI-1 and HPI-2.

HPI-1

The HPI-1 measures poverty in LICs. It focuses on deprivations in three dimensions:

- Longevity – as measured by the probability at birth of not surviving to age 40
- Knowledge – as measured by the adult illiteracy rate
- Living standards, public and private – as measured by the percentage of people without sustainable access to drinking water, without access to health services, and the percentage of children underweight for their age.

HPI-2

Because human deprivation varies with the social and economic conditions of a community, a separate index, the HPI-2, has been devised to measure human poverty in selected OECD countries, drawing on the greater availability of data. The HPI-2 focuses on deprivation in the same three dimensions as the HPI-1 and one additional one, social exclusion:

- Longevity – as measured by the probability at birth of not surviving to age 60
- Knowledge – as measured by the adult functional illiteracy rate
- Living standards – as measured by the percentage of people living below the income poverty line
- Social exclusion – as measured by the long-term unemployment rate (12 months or more).

Measuring gender inequality

The Gender-related Development Index (GDI)

The GDI measures achievements in the same dimensions and using the same indicators as the HDI, but examines inequalities between women and men. It is simply the HDI adjusted for gender inequality.

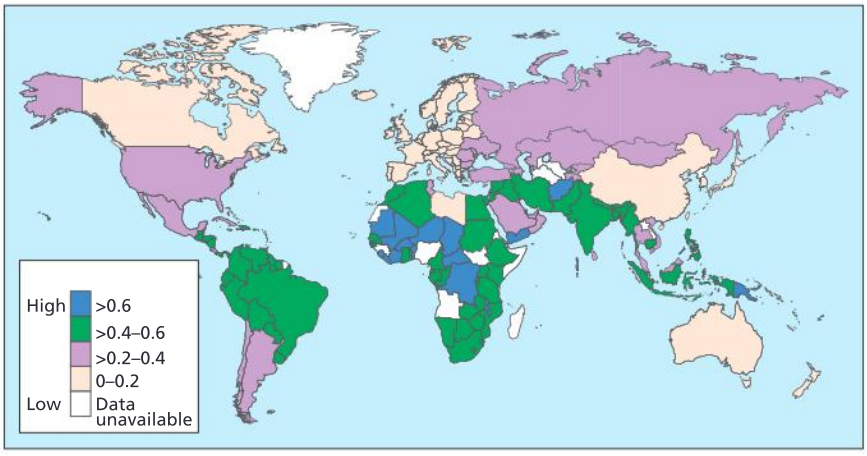
The Gender Empowerment Measure (GEM)

The GEM reveals whether women can take an active part in economic and political life. It exposes inequality in opportunities in selected areas. It focuses on participation, measuring gender inequality in economic and political participation and decision-making. It tracks the percentages of women in parliament, among legislators, senior officials and managers and among professional and technical workers, and the gender disparity in earned income, reflecting economic independence. Norway is ranked first in the GEM (0.837) and Yemen 70th (0.127).

▼ **Table 5.2:** HDI, HPI-1, HPI-2, GDI – same components, different measurements

Index	Longevity	Knowledge	Decent standard of living	Participation or exclusion
HDI	Life expectancy at birth	Adult literacy rate Combined enrolment ratio	GDP per capita (PPP $)	-
HPI-1	Probability at birth of not surviving to age 40	Adult illiteracy rate	Deprivation in economic provisioning, measured by: • percentage of people without sustainable access to an improved water source • percentage of children under five underweight for age	-
HPI-2	Probability at birth of not surviving to age 60	Percentage of adults lacking functional literacy skills	Percentage of people living below the income poverty line (50% of median-adjusted disposable household income)	Long-term unemployment rate
GDI	Female and male life expectancy at birth	Female and male adult literacy rates Female and male combined primary, secondary and tertiary enrolment ratios	Estimated female and male earned income, reflecting women's and men's command over resources	-

The Gender Inequality Index (GII)

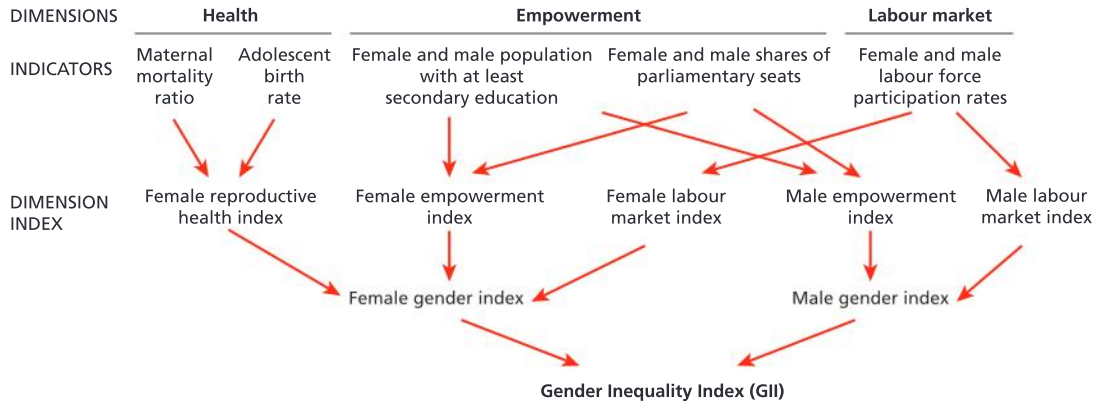


▲ **Figure 5.2:** The Gender Inequality Index, 2014
Source: Based on data in *The Human Development Report 2015*

In 2010, the UNDP introduced the Gender Inequality Index. The countries with the lowest gender inequality (meaning women are better off) in 2014 were, in rank order, Slovenia, Switzerland and Germany (Figure 5.2). The USA, ranked 8 on the HDI, was ranked 55 on the GII, and Qatar, ranked 32 on the HDI, was ranked 116 on the GII. In contrast, at the bottom end of the scale (lowest first) were Niger, Chad, Afghanistan, Côte d'Ivoire and Mali.

The GII measures gender inequalities in three aspects of human development (Figure 5.3):

- Reproductive health – as measured by maternal mortality ratio and adolescent birth rates
- Gender empowerment – as measured through the proportion of parliamentary seats held by women, and the proportion of adult



▲ **Figure 5.3:** Measuring gender inequality
Source: UNDP Gender Inequality Index

females and males aged over 25 years with some experience of secondary school

- Economic status – as measured by labour force participation by males and females aged 15 and over.

According to the UNDP:

- 70 per cent of the world's hungry people are women and more than 30 million girls are out of school
- women have comprised only 8 per cent of negotiating delegations in UN-mediated peace processes since 1992
- in 2010 and 2011, only 22 per cent of peace agreements signed contained women's peace and security provisions
- women, boys and girls are 14 times more likely to die during a natural disaster than men (UNDP Fast Facts).

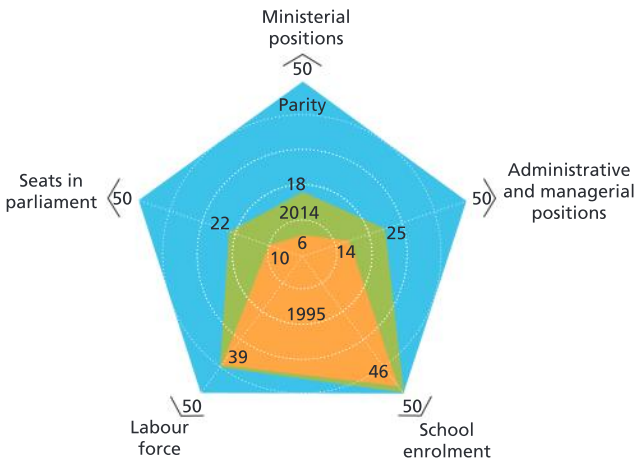
Moreover, former New Zealand Prime Minister Helen Clark, who became Administrator of the UNDP, in 2009 stated that:

- on average, women earn 24 per cent less than men
- around half of all women are in informal or precarious work that limits their social protection
- women do a disproportionate amount of unpaid work, including care work
- women make up over 40 per cent of the agricultural workforce in LICs but often have limited access to resources and financial services.

She has called for greater employment generation for women in rural areas, improved access to land and credit, and more provision of care by governments.

Activity 1

1. Describe the pattern of variations in the global Gender Inequality Index, as shown in Figure 5.2.
2. Compare and contrast the pattern of the GII with that of the HDI. Suggest reasons for the differences.
3. Study Figure 5.4. Compare the progress towards gender equality between 1995 and 2014.



▲ **Figure 5.4:** Progress made towards gender equality between 1995 and 2014

ATL Research and communication skills

Use the Human Development Report http://hdr.undp.org/sites/default/files/hdr_2015_statistical_annex.pdf and go to Table 5 (pp 224–7). Choose contrasting countries – an HIC, an NIC, an MIC, an LIC and an oil-rich country – and investigate the composition of their gender inequality (maternal mortality ratio, adolescent birth rate, share of seats in parliament, population with at least some secondary education and labour force participation ratio). Make a presentation of your results – which you could show on a series of diagrams like the radar chart in Figure 5.4.

Empowering women

UN Women and UN Global Compact have developed the following Women's Empowerment Principles:

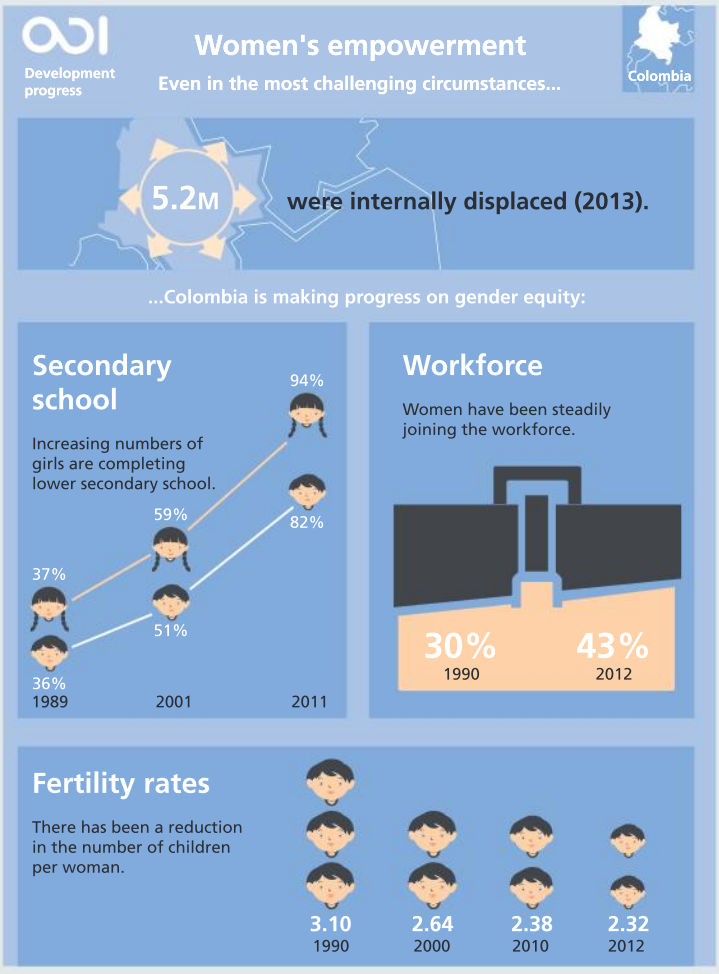
- Establish high-level corporate leadership for gender equality.
- Treat all women and men fairly at work – respect and support human rights and non-discrimination.
- Ensure the health, safety and well-being of all women and men workers.
- Promote education, training and professional development for women.
- Implement enterprise development, and supply chain and marketing practices that empower women.
- Promote equality through community initiatives and advocacy.
- Measure and publicly report on progress to achieve gender equality.

Case study

Empowering women in Colombia

One of the longest armed conflicts in Latin America took place in Colombia. During the conflict, women became mobilized and they have influenced new laws and policies. Colombia now has more women in decision-making positions than ever before – by 2011, 32 per cent of cabinet members were women, up from just 12 per cent in 1998. Girls' enrolment in secondary and tertiary education exceeds that of boys, and women's participation in the labour force increased from 30 per cent in 1990 to over 40 per cent in 2012.

A number of factors have helped to bring about these changes: legal reform and greater political opportunities for women, including a Bill of Rights based on equality and



▶ **Figure 5.5:** https://oxfamblogs.org/fp2p/what-are-the-drivers-of-change-behind-womens-empowerment-at-national-level-the-case-of-colombia

Case study (continued)

non-discrimination; the growth of women's social movements; international support for women's organizations, including negotiations between donor agencies and other stakeholders; and improvements in social and economic conditions in Colombia.

Nevertheless, there are still challenges ahead. The peace process signed in 2016 remains fragile. The root causes of the conflict are inequality, access to land, and political, class and generational divisions, and these remain. Progress has benefited well-educated, urban women, whereas many rural women are illiterate and poor, and continue to experience gender-based discrimination and violence.

Empowering indigenous and minority groups

There are some 370 million indigenous people around the world, accounting for 5 per cent of the world's population but 15 per cent of its poor. Indigenous people are generally marginalized and isolated, in worse health than the general population, and much less able to participate in economic and political processes. Most live in rural areas and depend on agriculture and related activities for their livelihoods.

The International Fund for Agricultural Development (IFAD) is a UN agency that aims to eradicate rural poverty by financing projects to aid agricultural development in developing countries. In Panama, for example, IFAD established a sustainable rural development project for the Ngobe–Bugle Territory to define territorial boundaries and restore land rights to the indigenous communities. It provided financial and technical support to the communities involved, and improved local leaders' planning and administrative skills. The ultimate aim of the project is to support natural resource management based on traditional practices.

Another IFAD initiative was the Western Uplands Poverty Alleviation Project in Nepal. Its aim was to reduce the high level of discrimination against women and ethnic minorities. It also planned to revive and strengthen the indigenous women's traditional health care system based on the use of locally grown plants.

ATL Research and communication skills

Read the Oxfam Report "Women's empowerment in Colombia: from poverty to power". For the summary report, go to https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9744.pdf.

For the full report, go to https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9743.pdf.

Make a presentation on the successes so far and the challenges ahead for women's empowerment in Colombia.

ATL Research skills

Use the Government of Nepal's Western Uplands Poverty Alleviation Project (WUPAP) website – www.wupap.gov.np – and IFAD publications on WUPAP to find out about the challenges facing the region, and the success of the project. Make a presentation of your findings.

Case study

Mapajo Lodge, Bolivia

Mapajo Lodge is an ecotourism project that started in 1999 as a community income-diversification scheme. It has become a model for increasing income, improving standards of living and ensuring environmental protection. Profits are used to finance small community projects to improve the quality of life for the indigenous community with as little impact as possible and based on respect for their natural and cultural heritage. Initiatives have focused on land rights, crafts (Photo 5.1), education, culture and microfinance.

Case study (continued)

The Mapajo Ecolodge is located in the 400,000 ha Pilon Lajas Indigenous Territory Biosphere Reserve in the Amazonian rainforest. The community consists of around 300 people from the Moseten and Chiman indigenous groups. The local community provided materials and labour for the project, with financial support from Canada, the UK and France. The Mapajo Lodge is one of several ecolodges that are part of http://www.madidi.com, a company founded by a US biologist to promote indigenous ecotourism in the region. The communities receive approximately 20 per cent of the tourism income, and other costs for transport, food, taxes and travel agents.

▲ **Photo 5.1:** Sharing weaving skills at the Mapajo Ecolodge

ATL Research and communication skills

Find out about the Mapajo ecotourism project at http://www.madidi.com/mapajo.html.

Read about its impacts at http://www.ipsnews.net/2012/09/ecotourism-helps-amazon-jungle-communities-survive/.

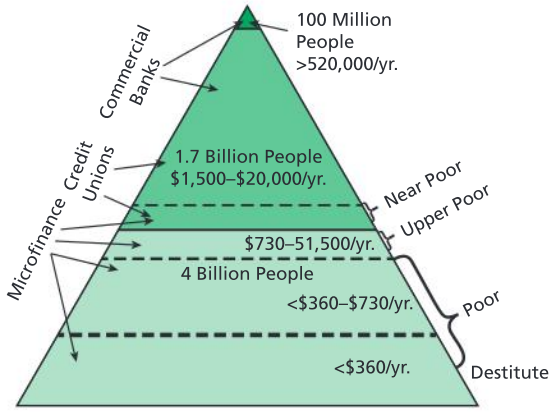
Social entrepreneurship and human development

Microfinance

Around 2.5 billion adults have no access to financial services, and 80 per cent of people living on less than $2 a day have no bank account, so microfinance has grown to meet the needs of these people. Microfinance lending schemes aim to reduce poverty, address social issues including gender discrimination, and enable market access for the poor. Microfinance has grown dramatically since 1974, when Muhammad Yunus made a small loan to women in Bangladesh. This led to the development of the Grameen Bank and other organizations that provide small business loans to poor people.

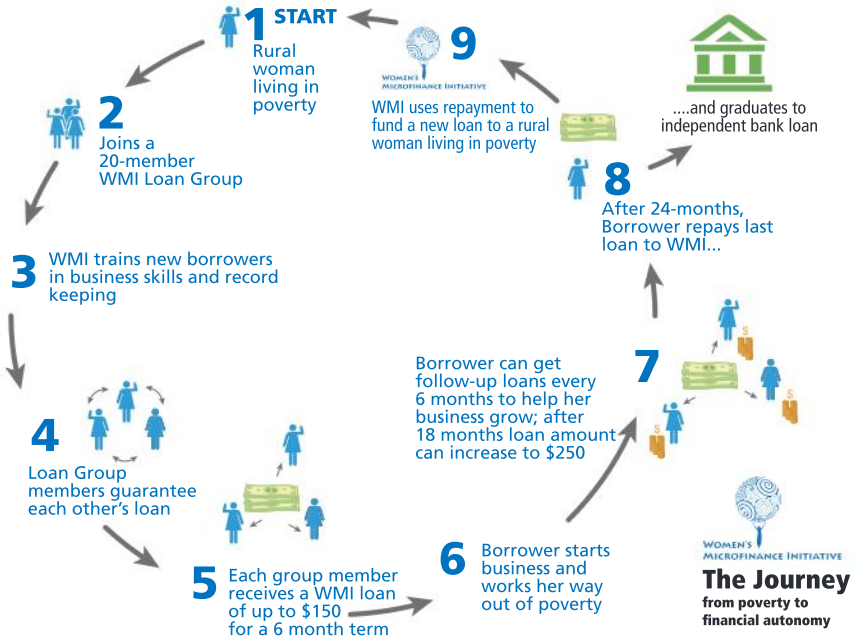
Most people who use microfinance are people in rural areas, mainly farmers, who cannot access other forms of finance. They need to borrow money to improve their farms, and buy seeds and fertilizers and so on. In the past, their lack of access to banks may have forced them to use "loan sharks" (money lenders charging very high rates of interest).

Microfinance schemes often focus on women, who in some societies are unable to own land or borrow money. In most microfinance schemes, the members are part of a community, and the community lends



Source: VISA International, World Bank, C.K. Prahalad

◀ **Figure 5.6:** The hierarchy of banks and their customers



◀ **Figure 5.7:** Microfinance schemes – the theory

out money to its members. This makes repayment of the loan much more likely.

There is no doubt that microfinance schemes have the potential to improve living standards for many poor people. However, the schemes have their critics:

- Their interest rates are higher than those of commercial banks – but lower than those of loan sharks.
- Some people will use the loans to pay for food or health care rather than for starting or improving their business.
- Not all poor people are entrepreneurs and so the loans may be wasted.
- Microfinance loans may be used to pay off other loans rather than for business purposes.

Some also claim that microfinance does not tackle the root causes of poverty but actually makes poverty worse. In their book *Microcredit and Women's Empowerment* (2012), the authors (Faraizi et al.) argue that microcredit is a tool to subjugate and discipline women, and that it just enables poor people to be seduced and exploited by capitalism. They argue that women in Bangladesh do not control their own resources, and that microcredit has not empowered or transformed their roles.

Fair trade

Fair or ethical trade can be defined as trade that attempts to be socially, economically and environmentally responsible. It is trade in which companies take responsibility for the wider impact of their business.

! Common misconceptions

✗ Some students confuse fair trade with free trade. Free trade occurs when countries are able to trade with each other without any tariffs or restrictions. In most cases, the main aim is to maximize profits.

✓ In fair trade, producers do not seek to maximize profits, but seek to make a profit and improve the wages and working conditions of their workers.

▲ **Photo 5.2:** A fair trade rugby ball

Case study

People Tree

People Tree is a textiles company that follows the principles of fair trade as set out by the WFTO. For every garment People Tree makes, there is a positive impact somewhere in the world. Working closely with 50 fair trade groups in 15 countries, People Tree brings benefits to people at virtually every step of the production process – from growing cotton to weaving, dyeing, embroidery and stitching – helping to alleviate poverty in some of the world's most marginalized communities.

People Tree uses ecologically sound methods of production, designing garments to be produced by hand wherever possible to minimize their environmental impact. Most of its cotton is certified organic as well as fair trade, and dyed using safe and natural dyes. It sources as many products as it can locally, choosing natural and recycled products over toxic, synthetic and non-biodegradable materials.

The People Tree Eco Policy is to:

- promote natural and organic farming
- avoid polluting substances
- protect water supplies
- use biodegradable substances where possible
- recycle materials where possible.

▲ **Photo 5.3:** People Tree, a socially responsible textiles company

ATL Research skills

Visit the World Fair Trade Organization, at www.wfto.com, and People Tree, at http://www.peopletree.co.uk. Find out about People Tree's latest social review.

Ethical trading is an attempt to address failings of the global trading system. Fair trade aims to ensure that producers in poor countries get a fair deal. A fair deal includes a fair price for goods and services, decent working conditions and a commitment from buyers so that there is reasonable security for the producers.

Some retailers appear to be the driving force behind fair trade as they seek out good practice in their suppliers in terms of health and safety at work, employment of children, pay and conditions, and even the freedom of association of workers.

Corporate social responsibility

(See also the case studies in Unit 4 on the Tata Group, pages 547–549, Apple Inc., page 550, and People Tree, above.)

Corporate social responsibility (CSR) refers to the attempts of companies to assess the social, economic and environmental impacts of their activities, and take action to reduce these impacts if necessary. Companies vary widely in their responsibilities towards workers and the environment. In general, companies involved in fair trade take more care of their workers and the environment than some large transnational companies. Most transnationals have a code of CSR, but whether they follow that code is another matter.

In 2014 McDonald's Corp. announced its 2020 Corporate Social Responsibility Framework. Its goals include:

- supporting sustainable beef production
- sourcing only coffee, palm oil and fish that are sustainably produced
- procuring fibre-based packaging only from certified or recycled sources
- serving 100 per cent more fruit, vegetables, low-fat dairy or grains in nine of its top markets
- increasing in-restaurant recycling to 50 per cent and minimizing waste in nine of its top markets
- increasing energy efficiency in company-owned restaurants by 20 per cent in seven of its top markets.

Activity 2

1. Comment on the goals of McDonald's CSR Framework. Outline the potential advantages of the goals and any potential omissions.
2. Choose a company that operates in your country of residence. Research its CSR. Have a class discussion to see how it could improve on its CSR.

Case study

The Rana Plaza disaster, Bangladesh

On 24 April 2013 an eight-storey garment factory in Rana Plaza on the outskirts of Dhaka collapsed, killing more than 1,100 people. Over half the victims were women and children. It was one of the worst industrial accidents in South Asia since the Bhopal disaster of 1984. Local police had warned that the building was unsafe but the owners allegedly threatened to fire those who did not carry on as usual (*The Economist*, 4 May 2013). The government was criticized for not enforcing building regulations – some two dozen factory owners are members of Bangladesh's parliament. Planning permission had been given for a five-storey building, not an eight-storey building.

Bangladesh is the world's second largest textile manufacturer, producing clothes for many global brands such as Primark, Gap and Walmart, and the industry is worth $20 billion. As production shifts from China, Bangladesh is likely to become an even larger textile manufacturer. Bangladesh's main advantage is its low-cost labour – the monthly minimum wage is 3,000 taka (about $38), about 20 per cent of China's minimum wage.

As a result of the Rana Plaza disaster, many clothing companies have made efforts to improve their CSR. Some critics argue that the CSR may sound good on paper, but making sure that all the details are covered in every single supplier is difficult to achieve.

Following the disaster, Nike and Gap had to deal with allegations of using child labour. Walmart launched a fire-safety training academy there. Gap announced plans to help factory owners upgrade their plants and improve safety. Primark provided long-term compensation to the workers, or their dependents, of its supplier, New Wave Bottoms, and an additional $1 million to the Rana Plaza Donors Trust Fund.

According to the Worker Rights Consortium, a pressure group, audits had looked at working hours and child labour, but not the structural soundness of buildings or fire exits. It believes that it would cost $3 billion to make all the garment factories in Bangladesh safe. Spread over a few years, it would raise the cost of each garment produced by only a few cents, but would safeguard the workers.

▲ **Photo 5.4:** The collapse of the Rana Plaza (Dhaka Savarbuilding), Bangladesh 2013

Activity 3

1. Explain why CSR is likely to become a greater issue in Bangladesh over the next decade.
2. Outline the advantages and disadvantages of outside companies using Bangladesh as a source of cheap labour.

Check your understanding

1. Outline the main aims of the UN Sustainable Development Goals.
2. Describe the main global patterns of the Human Development Index.
3. How is the Gender Inequality Index measured?
4. Outline the progress made in reducing gender inequalities between 1995 and 2015.
5. Outline the geographic variations in gender empowerment in Colombia.
6. Outline the benefits of microfinance.
7. Examine the critics' view of microfinance.
8. Briefly explain People Tree's eco policy.
9. Outline the reasons for the growth of the textile industry in Bangladesh.
10. Examine the advantages and disadvantages of corporate social responsibility (CSR).

Concepts in context

The Sustainable Development Goals are a set of goals that are designed to improve the **processes** of human development by 2030. These aim to reduce inequalities as highlighted by the Human Development Index and the Gender Development Index. There are many ways in which human development can be increased, such as empowering women, indigenous and minority groups, and using microfinance schemes.

Synthesis and evaluation

- There are many aspects of human development, with clear inequalities around the world and within countries. The Sustainable Development Goals build on the MDGs in their attempt to raise global living standards but also to protect the environment.
- Certain people are more likely to be discriminated against than others, including women, children, indigenous groups, minorities and refugees. There have been many attempts to reach out to these people – through microfinance schemes, fair trade and CSR. However, critics of these schemes argue that they do not benefit the poor and that they maintain the status quo.
- Geographers need to develop empathy, so that they can understand the impacts of projects on different stakeholders, notably the poor.

2 Changing identities and cultures

Conceptual understanding

Key question

How do global interactions bring cultural influences and changes to **places**?

Key content

- The global spectrum of cultural traits, ethnicities and identities, and ways in which the spectrum of diversity is widening or narrowing at different scales.
- The effects of global interactions on cultural diversity in different places: the diffusion of cultural traits; cultural imperialism; glocalization of branded commodities; and cultural hybridity.
- Cultural landscape changes in the built environment.
- How diasporas influence cultural diversity and identity at both global and local scales.

▲ **Photo 5.5:** Cultural diversity in London

Cultural traits

Culture gives us a sense of "who we are" and where we belong. It gives us a sense of our own identity and how we identify with others. Culture is a process rather than a thing, and it is constantly shifting and changing rather than fixed.

Cultural diffusion, the spread of cultural traits, occurs in many ways. It may occur when two cultures intermingle, which occurred historically when members of different cultures interacted with one another through trade, intermarriage or warfare, and it happens today when, for example, different countries share an interest in a particular sport. Cultural diffusion may also be forced, as when one culture defeats another and forces its beliefs and customs on to the conquered people. An example of this is cultural imperialism (see page 586), when the culture of one nation is promoted in another. It reflects an assumption that the culture being imposed is somehow superior to the one being supplanted.

Cultural diffusion today is taking hold around the world as cultural ideas spread through communications technology and the mass media. Globalization is regarded as a key process in driving culture towards a global model. Media TNCs and the movement of workers and tourists aid this process.

An emerging global culture

It is commonly accepted that the world is changing fast, and the rate of this change is probably greater than ever before. New technologies such as the Internet and satellite communications mean that the world

TOK

What is "culture"?

Culture is an increasingly important concept within geography. It is a complicated concept with a range of meanings, and it is important to all human populations. Culture varies from region to region, with some areas being relatively similar and others offering greater diversity. Cities are often culturally diverse, which is reflected in the population, services and the built environment. In spite of cultural diffusion, localized cultures survive and new cultures can still be generated.

Culture is the way of life of a particular society or group of people. Among other factors, it includes beliefs, behaviours, customs, traditions, rituals, dress, language, art, music, sport and literature.

is becoming more global and more interconnected. The increased speed of transport and communications, the increasing intersections between economies and cultures, the growth of international migration, and the power of global financial markets are among the factors that have changed everyday lives in recent decades.

Proponents of the idea of an emerging global culture suggest that different places and cultural practices around the world are converging and becoming ever similar. A global culture might be the product of two very different processes:

- The export of supposedly "superior" cultural traits and products from advanced countries, and their worldwide adoption ("westernization", "Americanization", "modernization").
- The mixing, or hybridization, of cultures through greater interconnections and time–space compression (the shrinking of the world through transport links and technological innovation), leading to a new universal cultural practice.

Language

A number of languages have more than 100 million native speakers. These include English, Mandarin, Spanish, Portuguese, Hindi, Arabic, Russian and Bengali. English has become one of the dominant world languages, but it has major variations in vocabulary and accents from country to country and also from region to region. The United Nations has six official languages: Arabic, Chinese, English, French, Russian and Spanish.

Language evolves over time, and new words come into use just as others disappear. Some languages, such as Inuktan, the language of the Inughuit people of north-west Greenland, are likely to disappear by 2025, while others, such as Irish, have undergone a major revival since the 1970s when interest in Irish culture and identity increased. New variations, such as SMS language, have also developed.

Common misconception

✗ Global maps are a huge simplification. This map suggests that all people in Europe are Catholics and Christians. This is not the case.

✓ It is true to say that the most common religions in Europe are Catholicism and Christianity, just as the most common religion in North Africa and the Middle East is Islam.

Religion

There are five major global religions: Christianity, Islam, Hinduism, Chinese folk religion and Buddhism. While Christianity and Islam can claim to be truly global, the remaining three are more regional in their distribution.

Christianity and Islam have both used political networks and military strength to expand their spheres of influence. The spread of Christianity across the globe can be linked to the expansion of European colonies throughout Africa, Asia and the Americas. Christianity gave a shared culture to areas linked by colonial powers, so that economic and political integration (domination) coincided with cultural integration (domination). In the case of the British Empire, improvements in communications – such as the telegraph with its submarine cables that connected the colonies to the mother country – allowed more effective links than had been previously possible and enabled the transmission of cultural information. The development of an education system based on

British curricula and textbooks further pushed the British culture into its colonies.

As some religions expand, others fade over time. Zoroastrianism – the philosophy and religion based on the teachings of the prophet Zoroaster – was once the dominant religion in Persia. It may have been the world's first monotheistic (one God) religion; and many Jewish, Christian and Muslim beliefs are said to derive from Zoroastrianism. There are now probably fewer than 200,000 followers of Zoroastrianism, mostly in parts of India.

In other areas, notably China, there are many folk religions that draw on aspects of mythology. There are believed to be nearly 400 million followers of Chinese folk religion, which is a combination of religious practices, worship of ancestors, Taoism and Buddhism. There are also remnants of Neolithic religions such as the worship of the Sun, the Moon, the Earth and the stars.

Music

Music lends itself to globalization because it is one of the few popular modes of cultural expression that does not depend on written or spoken language for its primary impact. The production, distribution and consumption of music have a particular geography. Transnational corporations control the global music industry, with the USA and the UK dominating domestically generated popular music. "World music" is now a significant component of the marketing strategies of these corporations, and it exposes global audiences to local musical traditions from around the world. Migrations of people have also had cultural impacts on music, evidenced in increasingly "hybridized" forms.

Television

Until recently, television programmes tended to be produced primarily for domestic audiences within national boundaries, and could be subjected to rigorous governmental control. However, with the advent of cable, satellite and digital technologies, in addition to political and legal deregulation in many states, several television channels are now globally disseminated, and to some extent circumvent national restrictions. The USA, France, Germany and the UK are major exporters of television programmes, but Brazil, Mexico, Egypt, Hong Kong and Spain are increasing their output. Companies such as Al Jazeera, BBC, CNN and ABC have an international reach.

Sport

Sports are forms of cultural expression that are becoming increasingly globalized, as well as increasingly commodified. Football/soccer is the most obvious example, but similar trends can be observed in US major league baseball. The New York Yankees are a global icon. Many major league players hail from countries such as Cuba, the Dominican Republic, Puerto Rico and Costa Rica; the sport is becoming increasingly globalized through television coverage and its inclusion as an Olympic sport.

Activity 4

1. Explain the meaning of the term "culture".
2. Examine the ways in which the international movement of workers, migrants and commodities can lead to cultural diffusion.

ATL Research skills

Visit http://geography.about.com/od/culturalgeography/a/culturehearths.htm for a discussion of culture hearths and cultural diffusion and some useful links to other sites.

TOK

What is cultural imperialism, and how has it changed over time?

Proponents of the cultural imperialism thesis date its inception to the industrial colonialism phase. It was during this phase that colonialism reached its zenith, peaking just prior to the First World War, when the British Empire reached its maximum territorial extent. It is usually the case that the cultural imperialist is a large, economically or militarily powerful nation (like Britain during this period) and the victim country is a smaller or less affluent one (like India). However, the end of formal colonialism in the second half of the 20th century did not spell the end of cultural imperialism.

The world is becoming more uniform and standardized, through a technological, commercial and cultural synchronization emanating from the West, and globalization is tied up with modernity. Cultural imperialism has become an economic process as well as a political one. It is forged by TNCs that represent the interests of the elite, especially those of the USA.

Tourism

Tourism is one of the most obvious forms of globalization. Once again, the geography of tourism is skewed, since it is dominated by people of all classes from rich countries. It can also be exploitative, particularly through the growth of international sex tourism and the dependency of some poor countries on the exploitation of women. However, it is a form of international cultural exchange that allows large numbers of people to experience other cultures and places. It also locks specific destinations into wider international cultural patterns.

Cultural imperialism

Global cultural imperialism today has resulted from economic forces, as when the dominant culture (usually the USA) captures markets for its commodities and thereby gains influence and control over the popular consciousness of other cultures. The export of entertainment is one of the most important sources of capital accumulation and global profits, displacing manufacturing exports. In the political sphere, cultural imperialism plays a major role in dissociating people from their cultural roots and traditions of solidarity, replacing them with media-created needs that change with every publicity campaign. The political effect is to alienate people from traditional community bonds and from one another. As countries are attracted by and brought under the influence of the dominant world system, they are pressured and sometimes bribed into shaping their social institutions to correspond to, or even promote, the values and structures of the dominant system. Some of the means by which this happens occur through language, tourism, global brands, the media and democracy.

Language

There are around 6,000 languages in the world, and this figure may drop to 3,000 by 2100. Approximately 60 per cent of these languages have fewer than 10,000 speakers; a quarter have fewer than 1,000. English is becoming the world language. Although Mandarin is more widely spoken as a first language, if second-language speakers are taken into account the total number of English speakers is close to a billion. English is the medium of communication in many important fields including air travel, finance and the Internet. Two-thirds of all scientists write in English; 80 per cent of the information stored in electronic retrieval systems is in English; 120 countries receive radio programmes in English; and at any given time over 200 million students are studying English as an additional language. It is an official language in much of Africa, the Pacific, and south and South East Asia.

Tourism

Tourism is now the world's largest industry. British holidaymakers on the Costa del Sol, Spain, where they practise cultural traits such as drinking beer and eating fish and chips while lying on crowded beaches surrounded by tall buildings, represent a stereotype that captures the essence of this type of standardization. Another example of stereotyping is the action of German tourists securing the sunbeds by swimming pools early in the morning.

Global brands

Behind the growth in the influence of TNCs is the rise of global consumer culture built around world brands. McDonald's, for example, operates over 35,000 outlets in more than 100 countries. In 1997 it opened one outlet every four hours. Coca-Cola is sold in nearly every country. It is a transcultural item, yet it is very much linked with US culture. (See pages 590–592 for more on branded commodities.)

The media

Global media complexes are superseding national media systems. Around 20 to 30 large TNCs dominate the global entertainment and media industry, all of which are from the West, and most from the USA. These include giants such as Time-Warner, Disney, News Corporation, Universal and the BBC.

Democracy

The spread of liberal democracy has been profound and it is now practised in the vast majority of nation states across the planet. Underlying this diffusion is the Western enlightenment belief that it is the most desirable form of governance.

Criticisms of cultural imperialism

It has been argued that the concept of cultural imperialism ascribes to globalization too much determining power. The power of locality, and of local culture, is thus overlooked. Moreover, a variation on the cultural imperialism argument sees the creation of a universalized hybrid culture. This type of culture is homogeneous but not entirely Western in nature. The impact of contact is not one way. For example, the British drink tea because of the British imperial connection with India, where tea is grown, and a number of words in the English language, such as *bungalow, shampoo, thug,* and *pyjamas,* are borrowed from languages of the subcontinent. Further examples of universalized hybrids are the influence of Black American and Hispanic dialects on rap, the most popular music globally in 2015, and the fact that football (soccer), thought to have been invented in China, spread throughout the British Empire.

Activity 5

1. Outline ways in which culture may become diluted and/or homogenized.
2. With the use of examples, explain what is meant by the term "cultural imperialism".

ATL Research and communication skills

Visit www.culturalpolitics.net/popular_culture.

This site raises questions about American culture in a global context. Click on "Cultural imperialism".

To what extent is there an American (or other specified) culture in your country?

Have a class debate over the advantages and disadvantages of this external influence.

Activity 6

Briefly explain how Chinese activities are affecting Tibetan culture.

Research skills

Visit http://news.bbc.co.uk/1/hi/world/asia-pacific/6940182.stm.

How have conditions changed since the building of the railway?

Research skills

Visit www.survivalinternational.org, the website of Survival International, the movement for tribal peoples. Click on "Tribes and campaigns" and look up the Jarawa.

Visit http://www.guardian.co.uk/world/2010/feb/04/ancient-language-extinct-speaker-dies to read an article about the death of the last person to speak the Andaman language, Bo.

Activity 7

Describe and explain how Jarawa culture could be affected by tourism and other developments.

Cultural diffusion and indigenous groups

Case study

Cultural change in Tibet

Tibet is one of the most remote and isolated places on Earth. It is high up in the Himalayas and often described as "the roof of the world". For much of the early 20th century (1911–49), it functioned like an independent country. However, following the 1949 Chinese Revolution and the creation of the People's Republic of China, Tibet's independence largely vanished. China invaded Tibet in 1950, and in 1951 compelled Tibet to sign an agreement giving China control over Tibet's external relations and the establishment of the Chinese military in Tibet, in return for guaranteeing Tibet's political system and religious freedom.

However, Tibet's population believes that the Chinese colonial rule of their country has eroded their culture. Their desire for political self-determination and an end to Chinese rule led to an uprising in 1959, when Tibet's Buddhist spiritual leader, the Dalai Lama, was forced to flee and seek refuge in northern India. About 80,000 Tibetans followed him. In 1965 the Chinese government created the Tibetan Autonomous Region (TAR) as part of the People's Republic of China.

The Chinese government has encouraged migration of the ethnic Han Chinese population into the region, changing the culture of Tibet. The building of the China–Tibet railway, finished in 2005, has speeded up this migration of the Han people from China. The railway was almost exclusively built using Han labour, and many see it as a political tool, not only allowing for increased migration of the Han into Tibet, but also allowing China to increase its military presence in the area. The railway lets China exploit Tibet's resources and move them to China's urban-industrial complex. Many Tibetans claim that the ethnic Han are given more of the better-paid jobs in the area.

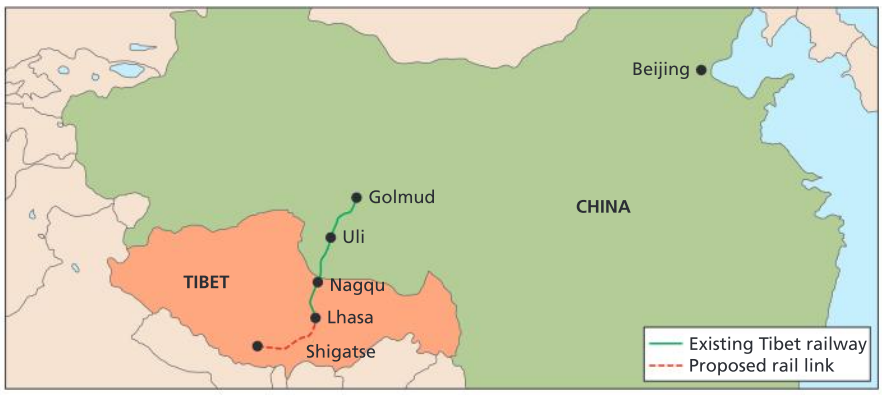


Figure 5.8: The route of the Chinese railway into Tibet

Case study

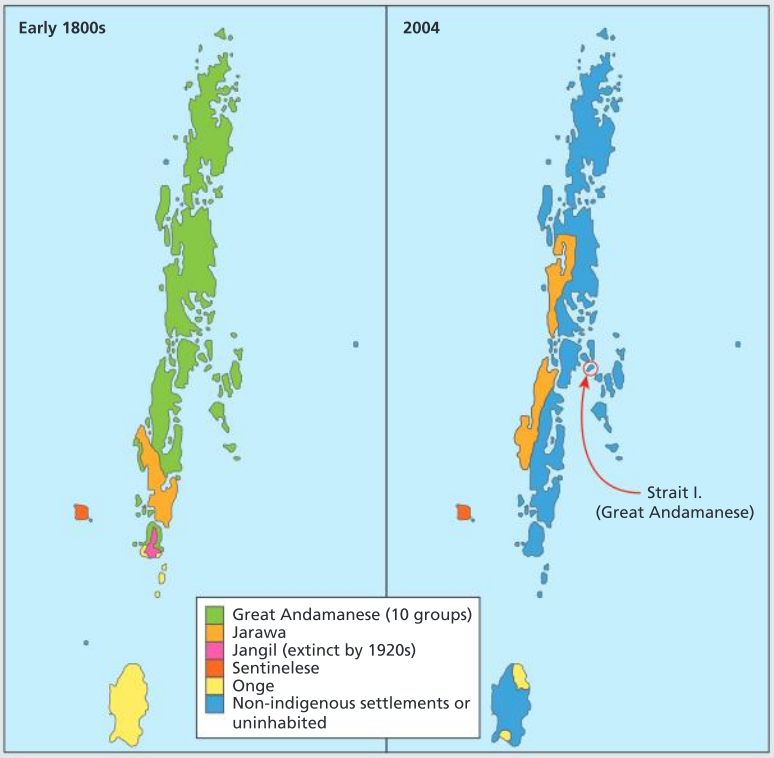
Cultural change in the Andaman Islands

The Andaman Islands, lying just off the coast of Thailand in the Bay of Bengal, are governed by India. The indigenous population has steadily declined from about 5,000 in the 18th century, at the time of first outsider contact, to about 1,000 today. The island chain was colonized by British settlers in 1858 and used for most of the next century as a penal colony. There are around 500 islands, 38 of which are inhabited. Indian settlers have poured in since independence, increasing the population to around 356,000.

One of the indigenous tribes, the Sentinelese, still lives uncontacted on a remote island. They were filmed firing arrows at a helicopter that went to check whether they had survived the 2004 tsunami. Tribes on some islands have retained their distinct culture by dwelling deep in the forests and resisting (with arrows) colonizers, missionaries and documentary makers. However, the construction of trunk roads since the 1970s has opened up the region to new forms of development.

These unspoilt islands are becoming a fashionable upmarket destination, as a result of which the Jarawa tribe is under serious threat. Until 1998 the tribe was protected by its ferocious reputation and it had little real contact with the outside world. But since then, not only have many Indian settlers moved into their forest home but the number of tourist trips into their jungle reserve has grown rapidly since 2000. Although notices at the entrance to the forest instruct visitors not to stop or allow the Jarawa into their vehicles, take photographs, or give them food or clothing, there is evidence that these practices are happening. The influx of tourists poses a potentially deadly danger for the 320 surviving Jarawa.

Moreover, plans for a luxury resort hotel at the edge of the Jarawas' protected forest were approved in 2009. The company building it, Barefoot, which already has a much-praised Andaman Islands eco-resort, says that it practises socially responsible tourism. Critics insist that the new resort has been deliberately chosen because it is near the Jarawa reserve, so that



▲ **Figure 5.9:** Distribution of the indigenous peoples of the Andaman Islands, early 1800s and 2004

Case study (continued)

holidaying guests can enjoy the thrill of seeing the tribespeople at close quarters. Two attempts to halt the new hotel development, brought by Andaman Islands' own regional government officials in the Indian courts, have failed.

The resort will bring an influx of workers and settlers to the area, increasing the pressure on the Jarawa and their land, exposing them to diseases such as swine flu, to which they have no immunity, and to alcohol, which has ravaged other tribes. Trips to see the Jarawa – officially on the pretext of visiting mud volcanoes that lie within the reserve – have become big business on the islands. Visitors are allowed to use the road through the reserve and, although they are not supposed to stop, invariably they do. The number of visitors from mainland India has increased as cheap flights to the Andamans have replaced the four-day boat journey that was once the only cost-effective way to get there.

▲ **Photo 5.6:** The Jarawa of the Andaman Islands

Glocalization of branded commodities, and cultural hybridity

Case study

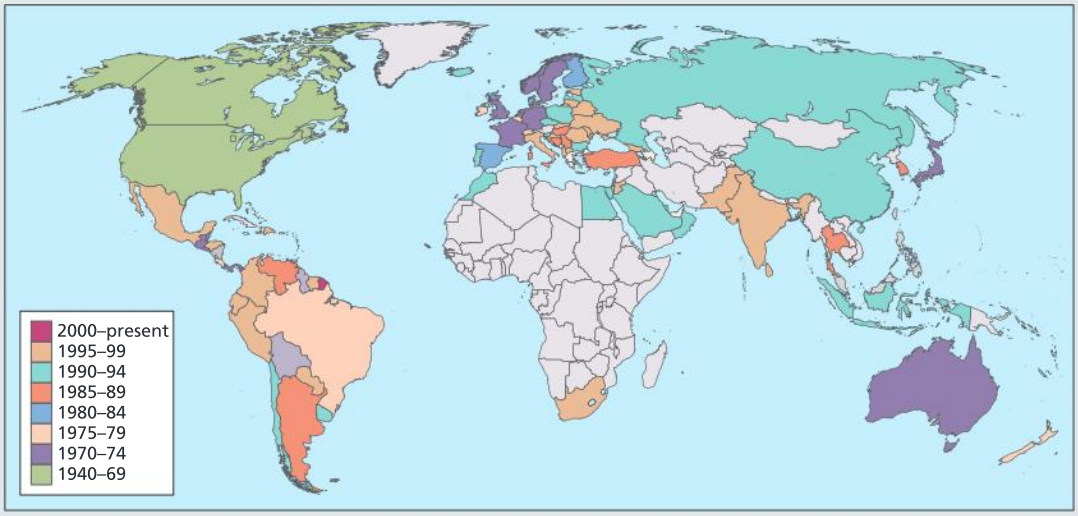
McDonald's restaurants

On an average day, more than 70 million customers are served at one of 35,000 McDonald's restaurants in more than 100 countries. Over 1.9 million people work in McDonald's and its franchises. The first McDonald's restaurants were located in the USA and Canada and more opened in Europe, Australia and Japan during the early 1970s (Figure 5.10). By the end of the 1970s McDonald's was consolidating its position in Europe and New Zealand and had opened restaurants in South America, namely in Brazil. The 1980s saw further expansion and consolidation in South America, Mexico, parts of Europe and South East Asia. China, Russia and parts of the Arab world were reached in the 1990s. Over half these restaurants are in the United States, but the UK has over 600 outlets, Brazil over 250, China nearly 200 and Thailand nearly 50.

McDonald's has been considered an emblem of globalization. *The Economist* uses the Big Mac Index to compare the cost of a Big Mac in different countries (Switzerland's is the most

▲ **Photo 5.7:** McDonald's restaurant in Tokyo, Japan

Case study (continued)



▲ **Figure 5.10:** McDonald's map

expensive, India's the cheapest). McDonald's is famed for its corporate uniformity; it has the same decor and the same service style the world over. Nevertheless, McDonald's has been localized, indigenized and incorporated into traditional cultural forms and practices. Exactly how this has happened varies across East Asia, for example:

- In Beijing, McDonald's has lost its American role as a place of fast and cheap food, and become a middle-class consumption place, somewhere for a special family outing, somewhere "customers linger ... for hours, relaxing, chatting, reading, enjoying the music". Many people perceive McDonald's as American, but Americana means something stylish, exotic and foreign, and as such actually results in the meanings and experiences of McDonald's in Beijing being very un-American.
- In Japan, while there is a similar leisurely use of McDonald's, here it is not a place of exotic social prestige but a youth hangout, a place where someone in a business suit would be out of place.
- In Hong Kong, McDonald's was likewise marketed to the youth market and McDonald's restaurants in Hong Kong are filled with people of all ages, few of whom are seeking an American cultural experience. The chain has become a local institution (glocalized) in the sense that it has adapted and blended into the urban landscape.

McDonald's menus vary around the world. The basic menu is similar but there are national specialities. South Korea's McDonald's offers shrimp burgers and bulgogi burgers, consisting of pork marinated in bulgogi. Japanese McDonald's offers green tea-flavoured milkshakes, as well the gratin korokke burger – a sandwich of mashed potato, filled with shrimp, macaroni and shredded cabbage.

In 2014, McDonald's began testing a new service, "Create your taste" (CYT), in which customers could use a dedicated kiosk to choose all the ingredients, which are then individually cooked. The meal is not fast food, but delivered on wooden boards, with fries in wire baskets and salads in china bowls. Cutlery is provided.

ATL Research skills

Find out about the food chain Subway. How does it compare with McDonald's in terms of number of restaurants and number of countries it operates in?

Use http://www.subway.com/

Look in the section "About us" and use the "History", "Our World" and "Social Responsibility" tabs to build up your own case study.

Activity 8

1. Using the data in Figure 5.11, and on a blank map of the world's countries, produce a map to show variation in consumption of Coca-Cola in the selected countries.
2. Comment on the distribution and pattern you have produced.
3. Which statistic from the countries do you find most surprising? Give reasons for your answer.

Case study

Coca-Cola

Founded in 1886 by pharmacist John Styth Pemberton in Atlanta, Georgia, the Coca-Cola Company is the world's leading manufacturer, marketer and distributor of non-alcoholic beverage concentrates and syrups, used to produce nearly 400 brands. When Coca-Cola was first launched, its two key ingredients were cocaine, sourced from the coca leaf, and caffeine, from the kola nut. This led to the name Coca-Cola (the k in kola replaced by a c for marketing reasons).

The biggest-selling soft drink in history and one of world's best-known products, Coca-Cola was first offered as a soda fountain beverage in Atlanta. Coca-Cola arrived in Britain in 1900, where it was first sold through soda fountain outlets, including Selfridges and the London Coliseum. The Coca-Cola trademark is now the most recognized in the world and the word "Coca-Cola" itself is thought to be the second most widely understood word in the world after "OK".

The Coca-Cola Company continues to be based in Atlanta but it employs 49,000 people worldwide, operating in over 200 countries. The production and distribution of Coca-Cola uses a franchising model, so that *local* people with *local* resources produce the drinks. Coca-Cola produces a syrup concentrate, which it sells around the world, in brands that embrace distinct tastes and local preferences.

A number of variations on the original Coca-Cola formula include:

- Coca-Cola with lime – available only in the USA, Canada, Singapore, the UK, Belgium and the Netherlands
- Coca-Cola Blak (2006–8) – available only in the USA, Canada, France, the Czech Republic, Bosnia and Herzegovina, Bulgaria and Lithuania
- Coca-Cola Citra (2005–present) – available only in Bosnia and Herzegovina, New Zealand and Japan
- Coca-Cola clear (2016) – available only in Canada, France and Australia.

Since June 2012, Coca-Cola has been officially available in every country of the world except Cuba and North Korea.

▼ **Figure 5.11:** Coca-Cola consumption snapshot

based on U.S. 8 fluid ounces of a finished beverage

India	12	Thailand	93	Bolivia	244
Mali	12	Colombia	127	South Africa	247
Indonesia	14	Philippines	129	Austria	253
Pakistan	17	Italy	137	Canada	259
Nigeria	27	France	149	Spain	287
China	38	Turkey	173	Australia	309
Kenya	40	Japan	179	Belgium	340
Egypt	53	El Salvador	180	Argentina	345
Russia	73	Germany	190	Panama	379
South Korea	84	Peru	208	United States	403
Morocco	88	Great Britain	210	Chile	460
Worldwide	92	Brazil	230	Mexico	728

92 servings
consumed per person worldwide in 2011

The changing urban cultural landscape

The evolution of uniform urban landscapes is the result of a variety of factors:

- improvements in communications technology (television, Internet, etc.), so that people in cities around the world are aware of opportunities and trends in other cities
- increased international migration and the spread of ideas and cultures
- time–space convergence, which allows faster interactions between places
- the desire of global brands (TNCs) such as McDonald's, Coca-Cola and Starbucks to reach new markets
- improvements in standards of living and aspirations to be part of a global network of urban centres
- globalization of economic activity, culture (art, media, sport and leisure activities) and political activity.

Are urban areas around the world converging in form? Many urban landscapes in different countries today look very similar. Tall towers are a feature of many cities, such as Toronto, Kuala Lumpur, Beijing and New York. Industrial estates and science parks are increasingly globalized, as TNCs outsource their activities to access cheap labour, vital raw materials and potential markets. Many cities have pedestrianized shopping centres, open markets and out-of-town supermarkets (Photos 5.10–5.12). Much appears to have changed since the mid-1970s, when cities underwent dramatic transformations in their physical appearance, economy, social composition, governance, shape and size.

Are we seeing a globalized urban pattern, or do local and national characteristics still prevail? In Los Angeles, for example, there is a wide array of sites in compartmentalized parts of the inner city: Vietnamese shops and Hong Kong housing in Chinatown; a pseudo-Soho of artists' lofts and galleries; wholesale markets; urban homelessness in the Skid Row district; an enormous barrio (shanty town) stretching eastwards toward East Los Angeles; and the intentionally gentrifying South Park redevelopment zone. Many large cities have their Chinatowns and other ethnic or racial areas. Individual cities are anything but homogeneous. Cities are increasingly globalized, increasingly heterogeneous, and, as a result, cities are more similar now because they are all more diverse.

▲ **Photo 5.8:** Seoul city centre

▲ **Photo 5.9:** McDonald's restaurant, Ulsan, South Korea

▶ **Photo 5.10:** City centre, pedestrianized shopping mall, Bandar Seri Begawan, Brunei

▲ **Photo 5.11:** Out-of-town shopping centre, Bandar Seri Begawan, Brunei

◀ **Photo 5.12:** Market, Bandar Seri Begawan, Brunei

▼ **Photo 5.13:** The Cheong GyeCheon, Seoul

▲ **Photo 5.14:** Sultan Omar Ali Saifuddien Mosque, Bandar Seri Begawan

Case study

Seoul, South Korea

Seoul is a good example of the debate on the homogenization of urban landscapes. On the one hand, it fits the theory of a homogenized landscape – global firms (such as McDonald's) are located in Seoul, just as Korean firms like Hyundai and Samsung are located in other countries. The CBD is characterized by skyscrapers and international firms such as Barclays and Tesco. There are high-rise apartments and edge-of-town developments, and decentralization, such as at Gyeonggi-do and Pangyo on the south side of Seoul.

On the other hand, a massive urban redevelopment project has centred on the restoration of the Cheong Gye Cheon River in downtown Seoul. This restoration has not been just of a river but also has historical, cultural and economic value. Murals along the side of the river recount some of the most important events in Seoul over the last 600 years, and the river has become an important focus for Seoul residents and visitors – rather like Trafalgar Square in London – partly because it is stressing the individuality and uniqueness of Seoul, and of Korea.

TOK

What type of urban area is unique?

All urban areas have something in common. All have something unique. Urban areas that are less westernized or less globalized might be expected to be more different from one another than those that are more globalized. Perhaps Arab cities are different in structure and environment from western cities? Perhaps most large western cities are becoming more Arabic? Western and Arabic cultures may be merging in some urban areas, or co-existing peacefully. For example, a mosque dominates the urban landscape of Bandar Seri Begawan, the capital of Brunei (Photo 5.14). Equally unusual is that a high proportion of the country's people live in the traditional stilt houses of Bandar's water village (Kampong Ayer), yet there is evidence of western culture even there.

Diasporas and cultural diversity

The scattering of a population, or diaspora, originally referred to the dispersal of the Jewish population from Palestine in 70 CE. It is now used to refer to any dispersal of a population formerly concentrated in one place. Examples include:

- the forced resettlement of Africans in the slave trade
- imperial diasporas during colonial expansion, such as Indian labourers who migrated to the sugar plantations of South Africa
- professional and business diasporas, such as the movement of Indians and Japanese overseas today
- cultural diasporas, such as the movement of migrants of African descent from the Caribbean.

The Chinese diaspora

Approximately 40 million people of Chinese origin live in sizeable numbers in at least 20 countries. Large concentrations are in Singapore (2.6 million), Indonesia (7.6 million), Malaysia (6.2 million), Thailand (7 million) and the USA (3.4 million). Historically, Chinese migration began in the 10th century with the expansion of maritime trade. During periods of colonialism, large numbers of Chinese moved into Singapore and Mauritius – the latter encouraged by the French. With globalization, Chinese migration for professional and business reasons has increased.

The Chinese diaspora has significant economic power, through remittances, as well as financial power invested in the host countries. The growth and development of Chinatowns throughout the world illustrate the assimilation of the Chinese into the societies in which they exist. Chinatowns are an important symbol of Chinese culture and identity.

The Irish diaspora

The Irish diaspora consists of Irish migrants and their descendants in countries such as the USA, the UK, Australia, New Zealand, Canada and those of continental Europe. The Irish diaspora contains more than 80 million people, more than 14 times the population of Ireland.

The USA was the most popular destination for the Irish in the 19th century, and Irish migration there reached a peak of 1.8 million in 1891. By 1951 the number of Irish in Britain overtook the US figure and by 1981 there were four times as many there as in the USA. Since 1981 there have been major fluctuations in the figures. There was an increase in Irish migrations to the US during the 1980s, a drop in the numbers going to Britain and a rise in numbers going to other EU countries. There were also high rates of return and an overall fall in absolute numbers of emigrants.

With improvements in Ireland's economic situation and a fall in Irish birth rates (since the 1980s), the period of high emigration is fast becoming part of Irish history. Nowadays, fewer than 18,000

Activity 9

1. Explain the evolution of uniform urban landscapes.
2. To what extent are urban landscapes uniform?

ATL Research skills

Visit http://news.bbc.co.uk/1/hi/magazine/4602953.stm for an article on clone towns – the extent to which high streets are all the same – and http://www.rgs.org/OurWork/Schools/Fieldwork+and+local+learning/Local+learning/Fieldwork+in+the+local+area/Clone+town+survey.htm for guidance on how to do fieldwork on clone towns.

▲ **Photo 5.15:** Irish and US flags in New York

Irish people leave each year, and many of these will eventually return to Ireland.

- Of all Irish-born people living abroad, 75 per cent are in Britain.
- About 1.7 million people in Britain were born to Irish parents.
- The third-generation Irish community in Britain could number as many as 6 million people.
- Of the total US population, 10.8 per cent claim Irish ancestry – the equivalent of seven times the population of Ireland itself.
- Irish-born people in the US number 156,000.
- US states with the largest Irish-American populations are California, New York, Pennsylvania, Florida and Illinois.
- Irish-Americans were the largest ancestral group in Washington DC, Delaware, Massachusetts and New Hampshire.

Emigration has been a constant theme in the development of the Irish nation, and has touched the lives of people in every part of Ireland. The economic and social prosperity of the country has been affected positively, through monies sent home from abroad, and negatively, through the loss of so many talented young Irish people. Irish emigrants have also had an enormous impact on the development of the countries in which they settled.

Activity 10

Using examples, explain what is meant by the term "diaspora".

In the USA, the Irish are largely perceived as hard workers. Most notably, they are associated with the positions of police officers, firefighters, Roman Catholic Church leaders, and politicians in the larger eastern seaboard metropolitan areas. Irish Americans number over 44 million, making them the second largest ethnic group in the country, after German Americans. The largest Irish-American communities are in Chicago, Boston, New York City, Baltimore, Philadelphia, Kansas City and Savannah, Georgia. Each city has an annual St Patrick's Day parade, with Savannah having the largest. At state level, Texas has the greatest number of Irish Americans. According to the 1990 US Census, Arkansas listed 9.5 per cent of the population as of Irish descendent, primarily located in the south-eastern part of the state. In percentage terms, Boston is the most Irish city in the USA and Massachusetts the most Irish state.

Various aspects of Irish culture, such as sport (hurling and Gaelic football), traditional Irish music and dance (popularized by *Riverdance*), food (colcannon – cabbage or kale and potatoes), and drink (Guinness), are commonplace throughout many of the areas where the Irish have settled.

ATL Research skills

Visit www.newyorkirishcenter.org for the New York Irish centre. The newsletter is a good source of information.

What aspects of Irish culture does the New York Irish Centre offer and support?

The Syrian diaspora

There are believed to be between 8 million and 15 million Syrian diaspora. Increasingly, more of them are refugees whereas earlier diaspora were economic migrants. There have been three main waves of Syrian migration. In the late 19th century, many were attracted by adverts for jobs in South America. Many Syrians went to Brazil and Argentina, and both countries have a significant number of Syrian diaspora. During the late 19th and early 20th centuries, many Syrians went to the USA, in particular to New York, Boston and Detriot. Most were Christians fleeing

persecution and in search of a better life. Many in New York lived in Manhattan in what was to become known as Little Syria. However, as they prospered they moved into more affluent neighbourhoods. Due to changes in legislation few Syrians moved to the USA between 1924 and 1965, but since then there has been an increase, notably in Muslim Syrians going to the USA. Since the 1970s there has been an increase in the Syrian diaspora in the Middle East, firstly due to the oil economies of the region, and latterly due to refugees fleeing Syria into neighbouring states.

In 2002 the Syrian goverment established the Ministry of Expatriate Affairs, to encourage the diaspora to return (at least for a visit) and to invest in the country. Tourism and remittances are the main source of foreign exchange for Syria, worth $1–$2 billion annually. Some younger diaspora populations are reluctant to return, fearing conscription to National Service. Conflict and civil war in Syria has had a negative impact on the number of diaspora returning for a holiday.

Check your understanding

1. Define the term "culture".
2. Explain the term "cultural imperialism".
3. Identify three major global media complexes.
4. Comment on the view that there is a global culture.
5. Describe the dispersion of the Syrian diaspora.
6. Comment on the consumption of Coca-Cola as shown in Figure 5.11.
7. Identify two examples of how Coca-Cola have adapted to local markets.
8. Briefly explain how and why urban areas are becoming homogenized.
9. Explain the term "diaspora".
10. Outline how diaspora help spread and preserve culture.

Concepts in context

Global interactions bring cultural influences and changes to **places**. Some cultural traits are disappearing, such as some indigenous languages, whereas others are becoming stronger. As more people move around the world, and global interactions increase, there is a diffusion of culture. In other cases, culture may be imposed – which may or may not be possible to resist.

Synthesis and evaluation

- There is much evidence that global interactions are changing the culture of places. New forms of culture are emerging, and to an extent there is a global culture. The spread of a dominant culture is facilitated by the increase in ICT, notably the Internet. On the other hand, some societies try to preserve their own culture, while diaspora groups help to spread and preserve their native culture.
- Certain branded commodities adapt to local cultures, such as food tastes. Variations in the acceptance of a changing culture often depend on the age, wealth and education of people.
- Many cities are becoming more similar in their characteristics – for example, in their buildings, brands and transport systems.
- Geographers use many skills (comparative, empathetic) to understand how identities are changing and how different people feel about these changes.

3 Local responses to global interactions

Conceptual understanding

How does the **power** of local places and actors to resist or accept change vary?

Key content

- Local and civil society resistance to global interactions: rejection of globalized production, including campaigns against TNCs and in favour of local sourcing of food and goods by citizens; the rise of anti-immigration movements.
- Geopolitical constraints on global interactions: government and militia controls on personal freedom to participate in global interactions.
- National trade restrictions, including protectionism and resource nationalism.
- The role of civil society in promoting international-mindedness and participation in global interactions, including social media use and campaigning for Internet freedom.

The rejection of globalized production

Globalized production has many advantages and disadvantages (Table 5.3). Views vary widely between stakeholders. Jobs may be outsourced to LICs, which may favour workers in LICs despite their poor pay and working conditions, and provide cheap goods for consumers in HICs. With increased globalization, there is more trade, transport and release of greenhouse gases.

▼ **Table 5.3:** The benefits and costs of globalized and localized food production

Local commercial production	Globalized production
Benefits	Benefits
Producer • Increased market access and sales • Possibly more farm-gate sales	*Producer* • Ability to produce foods cheaply and to a uniform standard
Consumer • Fresh food • Local products "in season" • Reduced air miles • Smaller carbon footprint	*Consumer* • Cheap food available year round • All types of products available year round • Competition between producers keeps main costs down

Local commercial production	Globalized production
Local economy • Improved local farming economy • Multiplier effects, e.g. demand for fertilizers, vets, farm equipment	*Local economy* • May be able to provide large amounts of a single product to a major TNC • Specialization, allowing intensification and increased production
Costs	Costs
Producer • Increasing cost of oil, making cost of inputs higher • Greater emphasis on quality, making production less profitable	*Producer* • Increased air miles • Higher costs of inputs, especially fertilizers and oil • Profit margins increasingly squeezed
Consumer • Higher cost of local farm products • Less choice "out of season"	*Consumer* • Increased costs likely to be passed on to the consumer • Indirect costs, such as pollution control, eutrophication of streams, soil erosion, declining water quality
Local economy • Cost of subsidies to maintain farming, e.g. payments to encourage farming in environmentally friendly ways	*Local economy* • Undercuts local farmers who may quit farming • Producers vulnerable to changes in demand and at the mercy of TNCs

Alternatives to globalization

Global civil society is extraordinarily heterogeneous. Groups that comprise it can be liberal, democratic and peaceful, or illiberal, anti-democratic and violent. Some civil societies are very large organizations, such as Oxfam, whereas others are relatively small, such as Operation Hunger in South Africa. Furthermore, even those global civil society groups that advocate progressive values – development non-governmental organizations (NGOs), for example – may sometimes act in ways that run counter to those values.

The rise of NGOs

The perception that global institutions, such as the World Bank and the IMF, are undemocratic and do not help all people equally has led to a global civil society movement that is attempting to regulate the global system from below. This has witnessed a massive rise in NGOs representing the needs of many "victims" of globalization. The statistics are impressive:

- A survey of NGOs in 22 nations showed that they employed 19 million workers, recruited 10 million volunteers and generated $1.1 trillion in revenue.
- In 1960 every country had citizens participating in 122 NGOs – by 1990 the number had increased to over 500.

- In Western Europe, 66 per cent of NGOs have been formed since 1970.
- There are over 2 million NGOs in the USA, 75 per cent of which have been formed since 1968.
- In Eastern Europe, 100,000 non-profit organizations appeared between 1989 and 1995.
- In Kenya, over 250 NGOs appear every year.
- In 1909 there were just 176 international NGOs; by 2000 there were over 29,000, 60 per cent of them formed since the 1960s.

However, caution is required. Evidence from South Africa suggests that many small-scale NGOs and local bottom-up development schemes fold after a short time. The figures must be treated with care.

Several broad alliances have emerged within NGOs, such as the global environmental movement, the anti-globalization movement and the global women's movement. Well-known individual NGOs include Greenpeace, The Fair Trade Network, Stop The War Coalition, Globalize Resistance, Oxfam, CAFOD, Amnesty International and Médicins sans Frontières. Each of these has different aims and methods, but all agree that major globalizing bodies such as the World Bank, the IMF and the G8 countries are pushing an agenda that favours rich western countries at the expense of others.

At an individual level, some people have decided to boycott GM crops. Others, during the increase in oil prices in 2013–2014, boycotted garages owned by Shell and BP. Others choose to do something positive such as buying Fair Trade products, as a way of helping producers in poor countries at the expense of large TNCs.

While the role of global civil societies should not be overstated (they are generally much less powerful than governments, international organizations, and the private sector), there are plenty of recent examples of where global civil society groups have been a force for progressive social change. The International Campaign against Landmines and the Jubilee 2000 campaign for debt relief are two of the best known and most successful. More generally, parts of global civil society have succeeded in putting new issues and ideas on the international agenda, and in effecting changes in national and international policies. They have helped to improve the transparency and, to some extent, the accountability of global institutions, and to mobilize public awareness and political engagement.

Important areas where global civil societies are trying to have an impact include:

- creating a more level playing field for the global South
- supporting free media and access to information
- making global civil society more accountable and transparent
- establishing a new relationship with global institutions.

Case study

The role of civil societies – Shell and Ogoniland, Nigeria

Shell's activities in Nigeria have been described as a neo-colonial resource grab, with Shell profiting from the suffering of local communities and a complicit Nigerian government using military force to allow oil exploitation.

In 1979 Nigeria was at the peak of an oil boom. Oil brought in $25 billion that year and external debt was less than $10 billion. Within a few years, however, Nigeria had gone from boom to bust, and has yet to recover. Shell is by far the largest oil company in Nigeria, operating mainly in the Niger Delta, and has long been the focus of protests. The Ogonis are one of many ethnic groups living in the Niger Delta, and members of their community are calling for a greater say in how their land is used.

Shell is responsible for nearly half the country's output of 2 million barrels a day, and Nigeria is as dependent on oil as it ever was. It accounts for 80 per cent of export earnings and 90 per cent of government revenue. Additionally, Shell is the leading partner in a proposed liquefied natural gas (LNG) project. This promises to be the most important source of foreign exchange in Nigeria since the development of the oil industry.

The text below is taken from the newspaper advertisements taken out by Greenpeace, The Body Shop International, Friends of the Earth and Chaos Communications. It raises a broad spectrum of issues:

- Economic – should the public buy Shell products?
- Environmental – degradation and pollution
- Social – poor people unable to defend themselves
- Cultural – the chances for the Ogoni people to continue as farmers and fishermen.

DEAR SHELL, THIS IS THE TRUTH. AND IT STINKS.

For over 30 years, the activities of the Nigerian government, Shell and other multinational oil companies have led to the widespread degradation and pollution of the region's lakes, rivers, land and air. The Ogoni are mostly farmers and fishermen, who need their land and water to live. The oil spills and pollution must be cleared up and the lands restored.

Shell must take responsibility for their part in this pollution. We believe that Shell has an obligation to operate to the highest environmental and social standards. We do not believe that Shell has done so in Nigeria.

Please heed the words of Ken Saro-Wiwa himself, writing from his prison cell before his execution on 10 November 1995: "I believe that only a boycott of Shell products and picketing of garages can call Shell to their responsibility to the Niger Delta. I remain hopeful that men and women of goodwill can come to the assistance of the poor deprived in Ogoni and other parts in the Niger Delta who are in no position to defend themselves against a multinational such as Shell."

THE BODY SHOP, WATERSMEAD, LITTLEHAMPTON, WEST SUSSEX

FRIENDS OF THE EARTH, 26-28 UNDERWOOD STREET, LONDON N1 7JQ

GREENPEACE, GREENPEACE HOUSE, CANONBURY VILLAS, LONDON N1 2PN

THIS MESSAGE WAS FUNDED BY THE BODY SHOP INTERNATIONAL, FRIENDS OF THE EARTH, GREENPEACE AND CHAOS COMMUNICATIONS LIMITED

▲ **Figure 5.12:** The case against Shell

Case study (continued)

CLEAR THINKING IN TROUBLED TIMES

There are certainly environmental problems in the area, but as the World Bank's Survey has confirmed, in addition to the oil industry, population growth, deforestation, soil erosion and overfarming are also major environmental problems there.

In fact, Shell and its partners are spending US$100 million this year alone on environment-related projects, and US$20 million on roads, health clinics, schools, scholarships, water schemes and agricultural support projects to help the people of the region. And, recognizing that solutions need to be based on facts, they are sponsoring a $4.5 million independent survey of the Niger Delta.

But another problem is sabotage. In the Ogoni area – where Shell has not operated since January 1993 – over 60 per cent of oil spills were caused by sabotage, usually linked with claims for compensation. And when contractors have tried to deal with these problems, they have been forcibly denied access.

It has also been suggested that Shell should pull out of Nigeria's Liquefied Natural Gas project. But if we do so now, the project will collapse … A cancellation would certainly hurt the thousands of Nigerians who will be working on the project, and the tens of thousands more benefiting in the local economy. The environment, too, would suffer, with the plant expected to cut greatly the need for gas flaring in the oil industry. It's only the people and the Nigerian Government of that time who will pay the price.

And what would happen if Shell pulled out of Nigeria altogether? The oil would certainly continue flowing. The business would continue operating. The vast majority of employees would remain in place. But the sound and ethical business practices synonymous with Shell, the environmental investment, and tens of millions of dollars spent on community programmes would all be lost. Again, it's the people of Nigeria that you would hurt.

It's easy enough to sit in our comfortable homes in the West, calling for sanctions and boycotts against a developing country. But you have to be sure that knee-jerk reactions won't do more harm than good.

Some campaigning groups say that we should intervene in the political process in Nigeria. But even if we could, we must never do so. Politics is the business of governments and politicians. The world where companies use their economic influence to prop up or bring down governments would be a frightening and bleak one indeed.

We'll keep you in touch with the facts.

▲ **Figure 5.13:** The case for Shell

▶ **Photo 5.16:** A contaminated fish farm in the Niger Delta

Case study (continued)

In 2011 an independent report by UNEP revealed that many areas of the Niger Delta were severely contaminated. In at least 10 communities, drinking water was contaminated with hydrocarbons, and at Nisisoken Ogale, levels of benzene, a carcinogen, were over 900 times the World Health Organization's safe limit. The impact on mangrove trees was described as disastrous. Trees had lost their leaves and stems, and no longer functioned as a nursery for fish. Fish tend to leave polluted areas in search of clean water, so local fisheries were badly affected.

Emergency measures requested by UNEP

1. Ensure that all drinking water wells where hydrocarbons were detected are marked and that people are informed of the danger.
2. Provide adequate sources of drinking water to households whose drinking water supply is affected.
3. People in Nisisoken Ogale who have been consuming water with benzene over 900 times the WHO guideline are recorded on a medical registry and their health status assessed and followed up.
4. Initiate a survey of all drinking water wells around those wells where hydrocarbons were observed and arrange measures 1–3 as appropriate based on the results.
5. Post signs around all the sites identified as having contamination exceeding intervention values warning the community not to walk through or engage in any other activities at these sites.
6. Post signs in areas where hydrocarbons were observed on surface water warning people not to fish, swim or bathe in these areas.
7. Inform all families whose rainwater samples tested positive for hydrocarbons and advise them not to consume the water.
8. Mount a public awareness campaign to warn the individuals undertaking artisanal refining that such activities are damaging their health.

UNEP also found that artisanal refining (illegal theft of oil from pipelines and then refining it in primitive stills) was causing much damage. Remote sensing revealed that in Bode West, artisanal refining between 2007 and 2011 had led to a 110 per cent decline in healthy mangrove trees.

UNEP concluded that control and maintenance of the infrastructure in Ogoniland was inadequate. It stated that all sources of ongoing pollution needed to be cleared up before the clean-up operation could begin. It estimates that the clean-up will take between 25 and 30 years to accomplish. Much of the work will be done by young Ogoni people, who will then be able to clean up other parts of the delta. However, the clean-up could be affected by the dramatic fall in the price of oil and falling profits for Shell. The proposed clean-up is a step in the right direction but it is not a victory – the health, lives and livelihood of many people in the region have been ruined for decades, and for some forever.

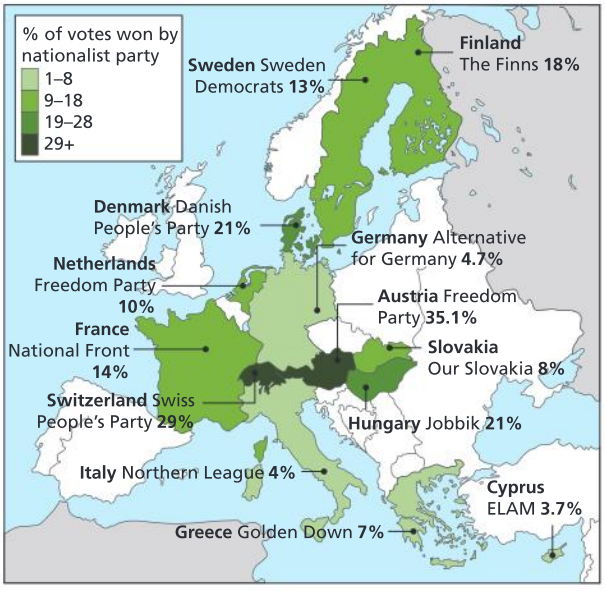
In 2015 the community of Bodo received a US$83 million settlement from Shell over two oil spills that destroyed their homes and livelihoods.

ATL Research skills

Visit the UNEP Environmental Assessment of Ogonil and study images of the impacts, at http://www.unep.org/disastersandconflicts/CountryOperations/Nigeria/EnvironmentalassessmentofOgonilandreport/Downloadimages/tabid/54433/Default.aspx.

The rise of anti-immigration groups

There are many reasons for the rise of anti-immigration groups. The main concerns of those opposed to immigration are the perceived threats over competition for jobs, and the cost of housing, education and health



▲ **Figure 5.14:** The rise of nationalism in Europe

care. In some cases, notably in LICs and NICs, environmental issues may also be a concern, as a result of rapid population growth. Some argue that certain immigrant groups isolate themselves from society and refuse to integrate into mainstream society. If migrants are unable to assimilate into society, they may form ghettos. Other concerns include increased crime rates and the spread of infectious diseases.

On the other hand, plenty of evidence suggests that migration benefits the host country. A 2014 study by economists at University College London suggested that the UK benefited from EU migrants to the amount of £20 billion/year. However, the 2008 economic crisis, the euro crisis and the increase in the number of migrants from Syria, the Middle East and North Africa have combined to make many Europeans anxious about migration. This has led to an increase in right-wing political parties opposed to immigration in many European nations, including Austria, Hungary, Germany, France and the UK (Figure 5.14).

Many of these parties have existed for a long time, such as the Danish People's Party, France's National Front and Italy's Northern League. However, some of them have different agendas: UKIP campaigned successfully for the UK to leave the EU, although it has limited representation in parliament.

Case study

Denmark's immigration laws

Denmark has some of the tightest immigration laws in Europe, even though it is party to the Schengen Agreement, which removed border checks within the EU. Denmark has introduced a points system designed to make it more difficult for "family reunions" that allow foreigners into the country for marriage, imposing a minimum age of 24 years for both the Danish spouse and the immigrant, proof of financial independence, and evidence of an active commitment to Danish society. A spokesperson for the British Institute of International and Comparative Law claimed that such measures are likely to be in breach of EU law in terms of ethnic and age discrimination. In 2008, changes to migration policy prevented state-funded hostels from accepting foreigners who did not have permanent residence status. Part of the explanation for these changes has been pressure from the Danish People's Party. The Party receives about 15 per cent of the national vote, enough for it to be a member of the coalition government.

In 2016 the Danish government voted in favour of seizing asylum seekers' assets in order to help pay for their stay while their application for asylum is considered. Valuables worth over about $1,000 would be seized on entry to the country to cover housing and food costs. In addition, "family reunions" would be possible only after three years rather than one year. The UN condemned the measures, claiming that they were illegal and inhumane. The Danish government claimed that it was not just asylum seekers that were being targeted but anyone who wanted to qualify for social benefits. Indeed, Denmark is not alone in claiming assets. Switzerland takes 1,000 francs (around $700), and some German states take funds from asylum seekers.

In 2015, Denmark received 21,300 asylum seekers. Denmark is a small nation with a population of about 6 million. In one survey, 70 per cent of Danes felt that migration was the main issue facing the country.

Activity 11

Comment on the rise of right-wing political groups in Europe, as shown in Figure 5.14.

Case study

The "Jungle" in Calais, France

The "Jungle" is the term given to an encampment of asylum seekers and migrants outside Calais, in northern France. There have been a number of camps around Calais since 1999, with a population of up to 7,000 at certain times. Many of the migrants have attempted illegally to enter the UK from these camps by stowing away on lorries, cars, trains and boats.

Conditions in the camps are poor. The camps have been described as a shanty town in an HIC. At different times, the French authorities have destroyed the camps but the residents find new locations. In 2016 the French authorities provided 125 shipping containers for 1,500 migrants to live in. These were used on the sand dunes as no permanent housing could be built there. Some migrants have resisted living in the containers, preferring to try to get to Britain.

In 2016 the French Minister of the Economy warned that if the UK were to leave the EU, as it has voted to do, British immigration officials might not be allowed to operate in Calais, and the Jungle would have to relocate to the UK.

In July 2016 the Jungle contained over 7,000 migrants, more than 750 of them minors, and the camps were growing by 50 people each day. The majority of migrants come from conflict-affected countries, around two-thirds of them from non-European countries such as Syria, Sudan, Eritrea, Ethiopia and Kurds from Iraq. Most were attempting to reach Britain rather than stay in France.

The camps are considered to be dangerous, especially for women. There is some access to water but sanitation is poor. Educational aids have been provided to the migrants by organizations such as Jungle Books.

As the camps have grown, the popularity of French right-wing groups has risen. There has been evidence of arson at the camps, racial abuse, and shopkeepers refusing to serve some asylum seekers.

In October 2016 French authorities began the relocation of the migrants and the demolition of the Jungle. By then charities suggested the population was up to 10,000 with around 1,300 lone children (no parents with them). Under the Dubs Agreement, the UK government had agreed to allow lone children safe refuge in the UK.

However, the process was said to be extremely bureaucratic, taking up to 10 hours of legal work for each child. Under the 2003 Treaty of Le Touquet, between the UK and France, part of the UK's border was placed in Calais, enabling UK officials to carry out passport controls in Calais rather than in the UK. Despite the UK's decision to leave the EU, the UK government rejected the suggestion that they move the border control from Calais to the UK. The demolition of the jungle is unlikely to resolve the issue of migrants stranded in Calais trying to reach the UK.

▲ **Photo 5.17:** Part of the Calais "Jungle"

Activity 12

1. Using an atlas, suggest why many migrants have travelled to Calais.
2. Outline the potential (a) advantages and (b) disadvantages for Calais and the UK in allowing uncontrolled movement of migrants.
3. Suggest why residents in Calais or in the UK may have fears about the number of migrants.

Geopolitical constraints on global interactions

Government and militia control

In general, Internet access is highly controlled in communist countries such as China, North Korea, Cuba and Vietnam. Eritrea and North Korea are the most censored countries worldwide.

China has a "Great Firewall" in which human censors and technological tools block critical websites and social media. In 2014 a government paper, Document 9, was leaked. It stated that the role of the media was to support government's rule. It also stated that it was essential for China's censors to be vigilant when keeping watch over China's 642 million Internet users, more than 20 per cent of the world's online users.

Eritrea has banned independent journalists. A UN enquiry into human rights in Eritrea claimed that there were systemic human rights violations, widespread detention and indefinite military service. Fearing the spread of uprisings following the Arab Spring, Eritrea scrapped plans for mobile Internet access for its citizens. The Internet is available only through slow dial-up connections, and less than 1 per cent of the population go online. In 2009, the UN placed an arms embargo on Eritrea after allegations were made that it was supporting the Somali Islamist group al-Shabab.

Eritrea also has the lowest figure worldwide for cellphone users, at 5.6 per cent. Some Eritrean exiles try to provide independent online websites and broadcasts, although these are blocked by the state-run telecommunications company EriTel. Most Eritreans in national service earn $1–$2 per day. Up to 320,000 Eritreans have fled the country, many making the dangerous journey to Europe to start a new life away from the "pervasive state control". In 2015 they were the second largest nationality, after the Syrians, to arrive on Italian shores.

North Korea largely prevents its population from travelling around the country or abroad, and only the political elite own vehicles. Emigration and immigration are strictly controlled. Only political supporters and the healthiest citizens are allowed to live in Pyongyang. Less than 10 per cent of the population have cellphones, although some phones are believed to be smuggled in from China. Some schools and other institutions have access to a highly controlled intranet. According to Reporters Without Borders, radio and TV sets bought in North Korea are only able to receive government frequencies. The TV systems in North Korea differ from those in South Korea.

ATL Research skills

Read about China's Document 9 at http://www.chinafile.com/document-9-chinafile-translation.

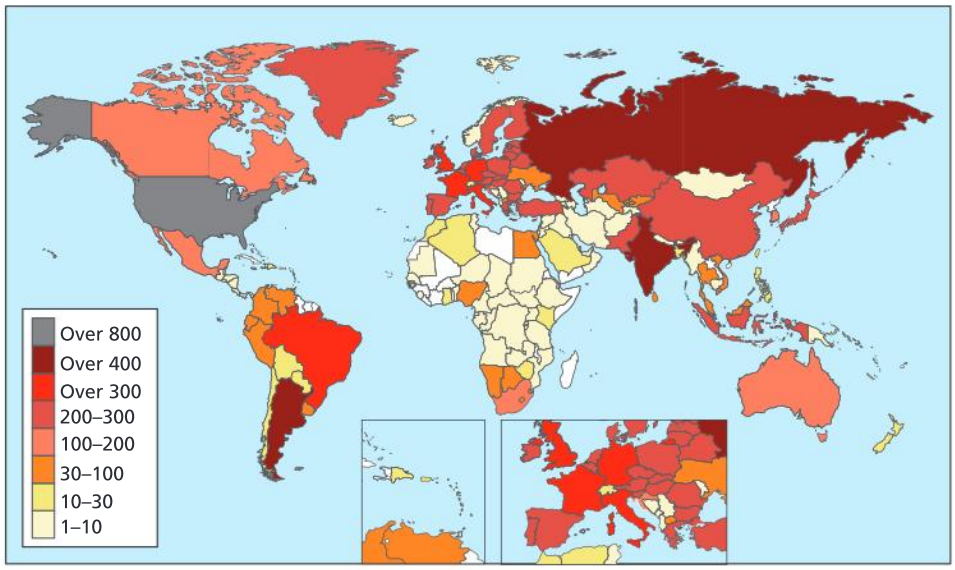


Figure 5.15: Protectionist policies by country, 2008–13

National trade restrictions

Trade restrictions are a form of protectionism: most trade restrictions place an additional charge on traded goods to make home goods more competitive. In extreme cases there may be trade wars between countries. Most economists would argue that trade restrictions increase inefficiency and lead to less choice for consumers, although they may help a country to industrialize. Trade barriers have been criticized as well, as they often affect LICs. Taxes on imports and subsidies to HICs producers may result in overproduction in HIC and dumping in LICs.

Protectionism reduces trade between countries. This may be achieved through taxes on imports (tariffs), limits on the volume of imports (quotas), administrative barriers (for example, food safety, environmental standards), subsidies to home producers as well as anti-dumping legislation and campaigns to buy nationally produced goods.

Since the end of the Second World War, most HICs have eliminated protectionist policies and tried to embrace free trade, or at least free trade within a trading bloc. However, according to the Global Trade Alert, 70 per cent of the 20 OECD nations have imposed restrictive trade policies in response to the global economic slowdown since 2008 (Figure 5.16).

For example, in 2015 the USA imposed a 256 per cent tariff on Chinese steel and a 522 per cent tariff on cold-rolled steel used in vehicle manufacturing. Protectionist policies have been on the increase in many OECD countries (Figure 5.16).

Almost all G20 countries have introduced protectionism in basic metals (Figure 5.17).

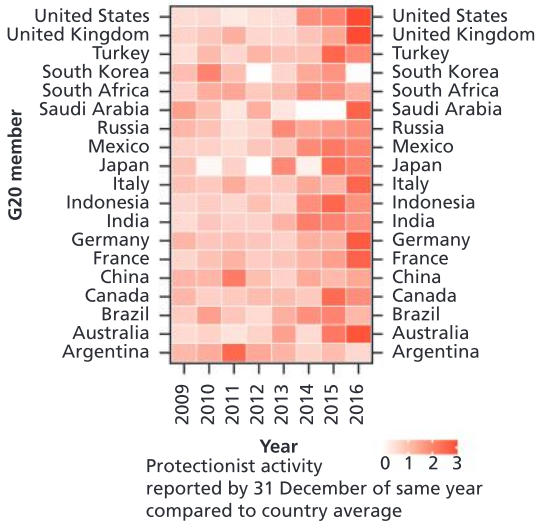


Figure 5.16: Changes in protectionist policies among OECD countries, 2009–16

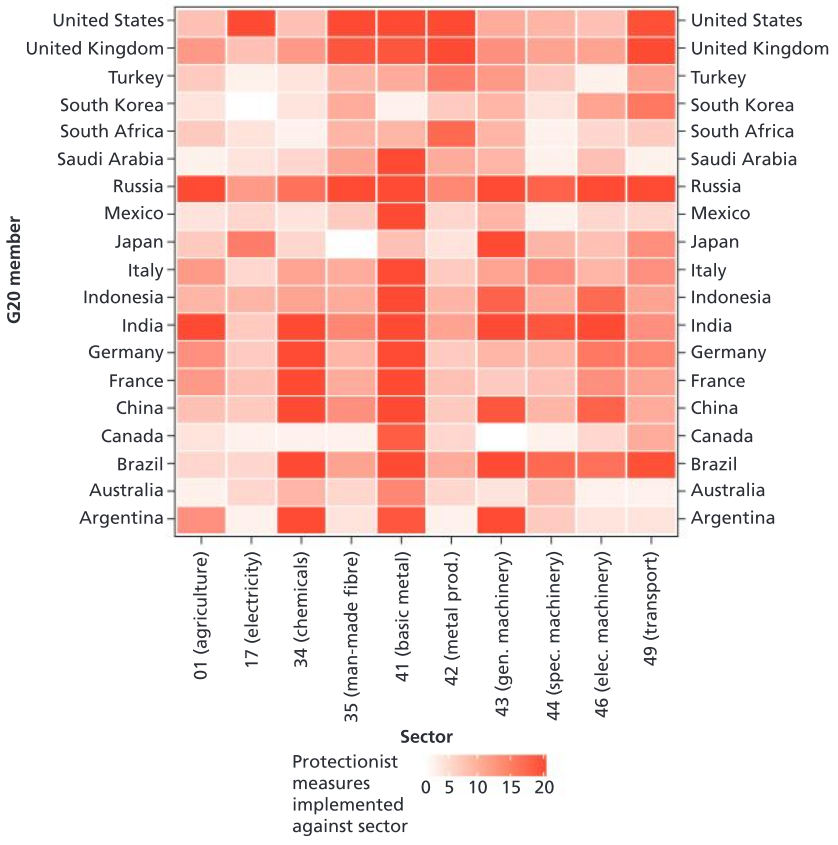


Figure 5.17: Protectionism among G20 members by economic sector

Activity 13

1. Study Figure 5.16.
   a. State two examples of countries in which protectionism has increased.
   b. Identify two countries in which protectionism has decreased.
2. Figure 5.17 shows protectionism and economic sector.
   a. Which country has the greatest number of protectionist policies?
   b. Identify the two economic sectors with the most protectionist policies.
3. Comment on the global pattern of protectionist policies as shown in Figure 5.15.

ATL Research skills

Visit the Global Trade Alert website at http://www.globaltradealert.org/.

Click on the map that shows measures taken (protectionist and liberalizing). Find examples of countries that are implementing protectionist policies, as well as those trying to liberalize their economies.

Resource nationalism

Resource nationalism occurs when a country decides to take all, or a part, of one or a number of natural resources under state ownership. Across much of Africa, governments have attempted to gain a larger share of the profits from mining. In South Africa, mineral wealth is estimated at $2.5 trillion, and the government is considering a 50 per cent windfall tax on mining profits and a 50 per cent capital gains tax on the sale of prospecting rights.

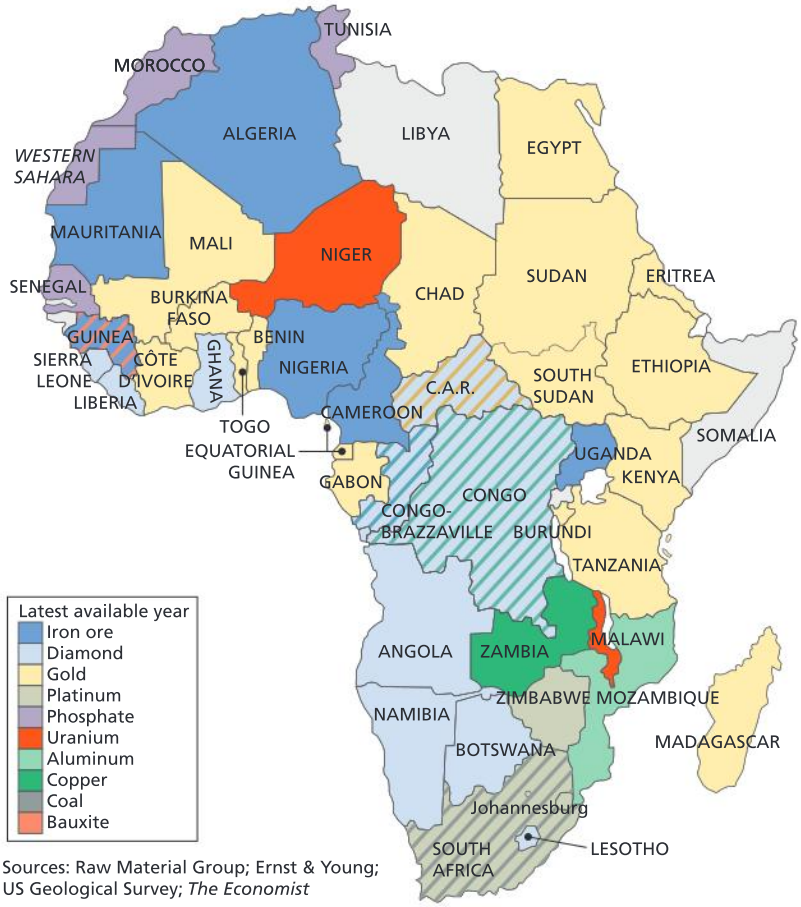
In 2012 Ghana announced a review and possible renegotiation of all mining contracts, to ensure that mining profits are maximized for the benefit of the country. It intends to raise taxes on mining from 25 to 35 per cent, with a windfall tax of 10 per cent. In Zambia, the government doubled its royalties on copper to 6 per cent. In Guinea, which contains some of the world's largest bauxite reserves, the government takes 15 per cent of all profits from mining, and in Namibia, all new mining has been transferred to a state-owned company. Zimbabwe's "indigenization" policy forces companies to cede a 51 per cent stake to local communities. In South Africa, following the end of the apartheid era, black-economic-empowerment laws required mining firms to sell stakes of at least 26 per cent to black shareholders by 2014.

Some global mining companies are worried about resource nationalism. Mining is a capital-intensive industry and much of the equipment is extremely expensive. Companies worry that investments may cost billions of dollars, and take up to a decade to get a return. If countries change the

terms of contracts, many companies, and their workers, would suffer.

One of the most successful mining operations in Africa is the Debswana venture, a joint 50:50 diamond operation between De Beers and the government of Botswana. The De Beers Botswana Mining Company was founded in 1969, with the Botswana government having a 15 per cent share in the company. Over the next five years it increased its share to 50 per cent. Debswana is now the world's leading diamond firm. It accounts for about 30 per cent of Botswana's GDP, 50 per cent of government revenue and about 75 per cent of export earnings. Some 80 per cent of the profits go directly to the government. Conditions in Botswana are different to elsewhere in Africa. The country has a stable government, rich and productive mines, and a small population.

Although resource nationalism holds many benefits for countries, the state must be prepared to help out those industries when they face tough times. It is important for the countries to give companies enough return on their investments that they will continue to invest in the future.



Sources: Raw Material Group; Ernst & Young; US Geological Survey; *The Economist*

▲ **Figure 5.18:** Major resources mined in Africa

The role of civil society

Civil society is composed of all the civic and social organizations or movements that form the basis of a functioning society, and work in the area between the household, the private sector and the state to negotiate matters of public concern. Civic societies include non-governmental organizations (NGOs), community groups, trade unions, academic institutions and faith-based organizations.

Activity 14

Briefly explain the advantages and disadvantages of resource nationalism for countries.

People's Global Action

People's Global Action (PGA) is a network for spreading information and coordinating actions between grassroots movements around the world. These diverse groups share an opposition to capitalism and a commitment to direct action and civil disobedience as the most effective form of struggle. The PGA grew out of the international Zapatista gatherings in 1996 and 1997, and was formed as a portal for direct and unmediated contact between autonomous groups.

Its first conference took place in 1998, when movements from all over the world met in Geneva and launched a worldwide coordination of resistance against the global market economy and the World Trade

ATL Research and communication skills

Visit the PGA website at https://www.nadir.org/nadir/initiativ/agp/en/. Find out their current hallmarks.

Visit http://www.avaaz.org/en, the website of Avaaz, an international civic organization that promotes activism on issues such as human rights, climate change and religious conflict. Its stated mission is to "ensure that the views and values of the world's people inform global decision-making". The organization operates in 13 languages, and claims more than 3 million members worldwide. The word "avaaz" means "voice".

▲ **Photo 5.18:** The Avaaz logo

What issues is Avaaz currently involved in?

Use the campaigns icon to investigate one or more campaigns that Avaaz has been involved in. Consider signing up as a member and getting involved in issues that are important to you.

Organization (WTO). Later that year, hundreds of coordinated demonstrations, actions and street parties took place on all five continents, against the meeting of the G8 and the WTO. From Seattle to Genoa, many of the groups and movements involved with PGA have been a driving force behind the global anti-capitalist mobilizations.

A second international conference took place in Bangalore, India, in 1999 and the third in Cochabamba, Bolivia, in 2001. There have been regional conferences in Latin America, North America, Asia and Europe, and three caravans of movements: the Intercontinental Caravan, the Colombian Black Communities tour, and the Peoples' Caravan from Cochabamba to Colombia.

PGA is not an organization and has no members, but it does aim to be an organized network. Contact points for each region are responsible for disseminating information and convening the international and regional conferences; an informal support group helps with fundraising; and there is a website, numerous email lists and a secretariat. The basis of unity and political analysis is expressed in the constantly evolving manifesto and hallmarks.

Challenging restricted freedom

Case study

Political change in Myanmar/Burma

There has been considerable political change in Myanmar, from the decades of authoritarian military rule to the democratic election of Aung San SuuKyi of the National League for Democracy party in November 2015, and her swearing in as president in March 2016. Nevertheless, there are still many important challenges ahead, notably for Myanmar's ethnic Rohingya community and for minority religious groups. The military still have a disproportionate share of parliamentary seats. Many important, difficult decisions have been left for the new government, and there is no guarantee that they will succeed.

In the elections, over 6,000 candidates represented more than 90 political parties, However, 75 candidates were disqualified for failing to meet citizenship or residence criteria, including all the Rohingya candidates and most Muslims. Ahead of the elections, former president Thein Sein signed a ceasefire agreement with eight ethnic groups but a further seven failed to sign the agreement.

In July 2015 Myanmar's parliament debated four laws to "protect race and religion" but Amnesty International and the International Court of Justice condemned them all. The laws were:

- the Religious Conversion Bill – to make anyone who wants to change their religion have to go through a state-governed body
- the Buddhist Women's Special Marriage Bill – to specifically target and regulate the marriage of Buddhist women with men from other religions
- the Population Control Healthcare Bill – to establish a three-year "birth spacing" interval for women between births
- the Monogamy Bill – to criminalize extramarital relationships.

Case study (continued)

▼ **Photo 5.19:** The Rohingya – Asia's new boat people

Fears have been raised that the population control bill could be used to enforce population control on the largely stateless Rohingya population. The Rohingya remain the thorn in the new government's side.

According to the Myanmar government, the Rohingyas only entered the area after 1948. However, a census during British colonial rule identified over 50,000 Muslim people in Rakhine state. Some believe that they have been in the state since the fifteenth century.

The Rohingyas are one of the world's most persecuted minorities without citizenship. Over 30,000 of them are living in two refugee camps in Bangladesh, in Cox's Bazaar and Kutupalong. In 1982 Burma's Citizenship Act created three categories of citizen: national, associate and naturalized. Full citizenship was only for national ethnic groups such as Burmans, Mons and Rakhines, and for those whose ancestors had been in Burma since before the first Anglo-Burma war (1824). Thus the Rohingyas became stateless in 1982. Initiatives since then have generally failed to protect the Rohingyas, and many have suffered persecution. In 2014 the Myanmar government expelled humanitarian groups, thus preventing health care and aid for the Rohingyas.

Case study

Challenging restrictive freedom: the Arab Spring

The Arab Spring refers to the range of demonstrations, protests, riots and civil wars that spread through countries in the Middle East and North Africa after 2010. Most of the revolutions and protests were over by 2012, although the ongoing conflict in Syria is an important exception. By September 2016, the only country involved in the Arab Spring to become a democracy was Tunisia.

Numerous factors lay behind the Arab Spring: dissatisfaction with governments, dictatorships, corruption, economic decline, unemployment, inequalities in wealth, food shortages and escalating food prices. Widespread access to social media networks made the Arab Spring possible in countries such as Tunisia and Egypt, whereas in Yemen and Libya people communicated through the traditional forms of media.

In Tunisia, the Arab Spring began when the street vendor Mohamed Bouazizi set himself alight in Sidi Bouzid in December 2010, in response to the confiscation of his wares and harassment by officials. This event sparked street protests that eventually led to the removal of President Ben Ali, after 23 years in office. Prior

Activity 15

Read this article about the Rohingyas, trafficking and forced migration: http://www.bbc.co.uk/news/world-asia-32740637. Use it to update your notes on restricted freedom.

▲ **Photo 5.20:** The Tunisian street vendor Mohamed Bouazizi, who set himself on fire, December 2010

Case study (continued)

to the demonstrations there had been high unemployment, corruption, a lack of freedom of speech, poor living conditions and rising food prices. By October 2011 there were the first post-revolution elections, and in January 2014 a new constitution increased human rights and gender equality. During Tunisia's Arab Spring around 330 people were killed.

In contrast, around 40,000 people were killed in Libya's Arab Spring and over 300,000 in Syria's. Protests began in Libya in 2011, and quickly reached the capital, Tripoli. As fighting intensified between government and rebel forces, the USA, France and the UK began a bombing campaign against Libyan forces. In August, anti-government forces captured Tripoli, and in October, the deposed Libyan leader Colonel Gaddafi was killed. The Arab Spring in Syria is ongoing and has seen multi-sided armed conflict, the formation of ISIS and the use of Russian forces to support the Syrian leader President Bashar al-Assad. Thousands have fled Syria, leading to humanitarian crises in Lebanon and Jordan, and a swell of migrants seeking refuge in Europe.

Following the protest and changes associated with the Arab Spring came the so-called Arab Winter, a wave of violence, instability and economic decline. The Arab Spring has thus had mixed success. For some, there has been greater freedom compared with the restrictions before, as in Tunisia and Egypt. For others, the Arab Spring has led to a collapse of law and social order, as in Syria and Libya.

A number of reasons have been put forward to explain what has determined success in some areas but not others. They include:

- strong civil societies – countries with strong civil societies such as Tunisia were more successful than those without because they were able to transform the country after political change
- the degree of state censorship – in countries where Al Jazeera and the BBC provided widespread coverage, such as Egypt, mass violence by the government and the military was supressed, in contrast to countries such as Libya and Syria, where there was less television reporting
- social media – countries with greater access to social media were more able to mobilize support for the protests
- support of the national military – in Egypt and Tunisia, the military supported the protesters in removing the government, whereas in Libya and Syria the military have contributed to civil war
- the mobilization of the middle class – countries with a strong, vocal middle class were more likely to see political change than countries with a weak or limited middle class.

Activity 16

Suggest how the Arab Spring has led to greater freedom for some but less freedom for others.

Check your understanding

1. Explain the rise of anti-immigration policies in Europe.
2. Suggest reasons for the links between controls on personal freedom in Eritrea and the migration crisis in Europe.
3. Describe the range of protectionist measures.
4. Explain why protectionism is on the rise among OECD countries.
5. Explain why Debswana is considered to be an ideal mining venture.
6. Outline the potential advantages and disadvantages of resource nationalism.
7. Outline the five hallmarks of People's Global Action.
8. Comment on how political changes in Myanmar have brought benefits for some people but not for others.
9. Explain how the Rohingyas have become a stateless people.
10. Briefly explain why the Arab Spring succeeded in some countries but not in others.

Concepts in context

Local places and players sometimes have the **power** to resist or accept change. Some anti-globalization movements resist change. The rise of anti-immigration groups, protectionist policies, resource nationalism and the challenging of restricted freedom are all examples of the ways in which people and places have responded to change.

Synthesis and evaluation

- Acceptance of or resistance to global interactions takes many forms. They may be passive or aggressive, violent or non-violent, positive or negative, political or non-political.
- Many organizations are actively involved in global interactions, from MGOs such as the World Bank and the IMF, championing increased interactions, to NGOs and civil societies working towards eliminating the negative impacts of global interactions.
- Improvements and changes in ICT have facilitated increased global interactions and also enabled political change. Although some of the changes are very small-scale, they link into much larger-scale global interactions.
- Geographers use many skills – ICT skills, social-media skills – to be aware of the potential advantages and disadvantages of global interactions, and to do something about them.

EXAM PRACTICE

(a) Examine the progress in reducing gender inequalities. (12 marks)

(b) Examine the reasons for the rejection of globalized production. (16 marks)

UNIT 6
GLOBAL RISKS AND RESILIENCE

Key terms

Crowdsourcing	The process of sourcing ideas, services, funding or content from the public in order to maximize the benefit of a large group's collective assets.
Cybercrime	Criminal activity using the internet/computers/computing.
Cyber security	The protection of information systems, hardware and software from theft or damage.
Drone	Unmanned aerial vehicle (UAV).
e-passport	Passports containing a computer chip with details about the owner.
Geopolitics	The influence of physical and human geography (for example, location, access to resources) on politics and international relations.
Profit repatriation	The return of a company's foreign-earned profits or financial assets to that company's home country.
Reshoring	The relocation to the home country of a business's or company's operations that were overseas.
Resilience	The ability of individuals, communities or environments to respond to shocks and changes while continuing to operate and/or improve under the new circumstances.
3D printing (or additive manufacturing)	The creation of a physical object from a digital model by laying down a sequence of layers.

As well as offering advantages, globalization has increased geopolitical and economic risks. For example, improvements in ICT have led to many negative impacts on people, communities and even nations, including cybercrime, disruptions in supply chains, and tax avoidance. New technologies such as drones and 3D printing may also bring risks: drones have been linked with civilian deaths in war and increased insensitivity among military personnel, while 3D printing has created new weapons.

Global interactions have many impacts on the natural environment, from climate change and ocean acidification to localized pollution and waste. Global interactions may also threaten manufacturing industry and employment, particularly in HICs.

Many international civil society organizations are trying to deal with these environmental and social risks, although their efforts may be compromised by their association with large corporations. New technologies are facilitating new ways of fundraising and information sharing, such as crowdsourcing.

Key questions

1. How do technological and globalizing **processes** create new geopolitical and economic risks for individuals and societies?
2. How do global interactions create environmental risks for particular **places** and people?
3. What are the new and emerging **possibilities** for managing global risks?

1 Geopolitical and economic risks

Conceptual understanding

Key question

How do technological and globalizing **processes** create new geopolitical and economic risks for individuals and societies?

Key content

- Threats to individuals and businesses: hacking, identity theft and the implications of surveillance for personal freedoms; political, economic and physical risks to global supply-chain flows.
- New and emerging threats to the political and economic sovereignty of states: profit repatriation and tax avoidance by TNCs and wealthy individuals; disruptive technological innovations, such as drones and 3D printing.
- The correlation between increased globalization and renewed nationalism/tribalism.

Threats to individuals and businesses

According to the 2015 "Cost of Cybercrime" study, global cybercrime is increasing and costs countries millions of dollars every year. The study defines cybercrime as criminal activity using the Internet, and it includes stealing an organization's intellectual property, seizing online bank accounts, creating and distributing computer viruses, posting confidential material on the Internet, and disrupting computing services. Surveys of over 250 large companies (those with more than 1,000 direct connections to the network system) in seven countries, found that the average cost of cybercrime to them was $7.7 million/year, ranging from $0.31 million to $65 million, with the larger companies experiencing the higher costs. All industries were found to be at risk, some more than others: financial services and utility and energy companies experience more cybercrime than health care and agriculture. Insiders carried out many of the cyber attacks.

The highest total average cost of cybercrime is in the USA, at $15 million, while Russia has the lowest, at $2.37 million. The decrease in cost in Germany, Australia and Japan is believed to be due to exchange-rate differences, with a strong dollar compared with other currencies. The cost of cybercrime is about 0.13 per cent of GDP in the UK, 0.64 per cent in the USA and 1.6 per cent in Germany.

As more areas of people's lives become computerized or digitized, the risks of cybercrime increase. The computing company Symantec ranked the 20 countries that generate most cybercrime. It found the worst-affected countries to be the USA, China, Germany, the UK and Brazil. The least affected were Argentina, Australia and Israel. Fighting cybercrime has become an extremely important issue in most countries – and a big business.

ONLINE FINANCIAL FRAUD

HOW CYBERCRIMINALS STEAL MONEY FROM USER'S BANK ACCOUNTS

Users are soft targets for financial cybercrime

Hacking banks is difficult–that's why criminals prefer to attack their customers

~1 900 000

users worldwide encountered banking malware attacks in 2013[1]

98% of users regularly access online financial services[2]

28% don't check website security when they enter confidential data[2]

38% carry out financial operations from mobiles and only 42% use mobile protection[2]

How can cybercriminals steal money from users?

Holders of online bank accounts can be targeted in a number of ways:

When visiting sites, reading emails

When using unprotected connections or Wi-Fi hotspots

When using infected sites, outdated software, suspicious links and attachments

Internet dangers:
PHISHING

FAKE BANKING FORMS

A fake letter from a bank or other payment system asking for account credentials

30% of users received suspicious emails like this[2]

FAKE BANKING WEBSITES

A fake site invites users to submit their account credentials. The link imitates a real URL but leads to a phishing website.

21% of phishing sites mimic banking, financial and e-pay organizations[1]

Connection dangers:
INTERCEPTION

TRAFFIC INTERCEPTION

On unprotected Wi-Fi networks all data can be intercepted. Data on the screen can also be modified

34% of public Wi-Fi users take no specific measures to protect themselves[2]

DNS/PROXY SPOOFING

URL to IP mapping is vital to web security. Modifying these settings can result in trusted URLs directing users to phishing sites

23M users faced phishing attacks in 2013[1]

Computer dangers:
TROJANS

COLLECTING DATA WHEN IT'S ENTERED

Trojans intercept keystrokes or take screenshots, capturing sensitive info from regular or virtual keyboards. The Zbot is one of the most prominent examples.

8M attacks with Zbot were recorded by kaspersky Lab in 2013[1]

USING WEB INJECTION

Trojans prompt users to enter data into rogue fields on legitimate pages. They can also imitate screens such as a list of user transactions or a simple "Blue screen"

$250M was stolen by cybercriminals using the Carberp Trojan in 2013[3]

BYPASSING TWO-FACTOR AUTHENTICATION

Many mobile Trojans work in tandem with their big brothers to intercept data from phones. Carberq-in-the-Mobile. Zeus-in-the-Mobile, etc.

268% more unique malware samples for Android OS were detected in 2013[1]

▲ **Figure 6.1:** Some types, and impacts, of cybercrime.

Hacking

Hacking is a major threat to all Internet users, from individuals up to national governments, Internet providers and TNCs. For example, in October 2016 there was a major attack on companies such as Twitter and Paypal, and many websites were affected including the New York Times, CNN and the Wall Street Journal. All were customers of Dyn, a US company that operates as a switchboard of Internet traffic. Hackers used thousands of interconnected devices that had been infected with a malicious code, known as a "botnet", to disable the Internet. It was one of the largest Internet attacks ever. Security experts working for Dyn linked it to a Chinese company, XiongMai Technologies. The complexity of the attack made it difficult to deal with. Such attacks are becomming more common although not all are on such a scale. One expert suggested that it could be another nation trying to find weaknesses in the USA's Internet system.

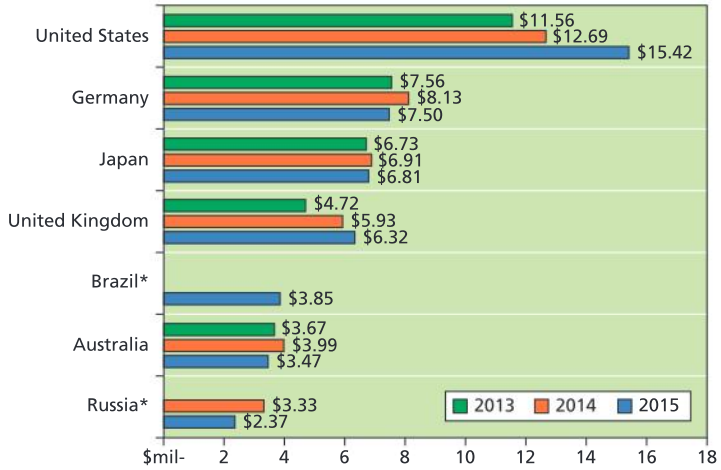
At the other end of the scale, mobile devices and PCs are also vulnerable to attack. Often the source of the attack is a PDF or JPEG graphic that appears harmless until it is opened. It is likely that such attacks will increase in complexity in future, since "criminals will always go to where the money (or advantage for them) is" (US bank robber, Slick Willie Sutton).

Identity theft

Identity theft is one of the fastest-growing white-collar crimes in the USA. Cybercrime differs from traditional crimes in that the offender and the victim can be geographically separate. Nevertheless, in a study of identity theft in the USA, regional differences and hotspots were identified. Since 2001, the Federal Trade Commission (FTC) has logged increasing incidents of identity theft. By 2006, more than a million complaints had been registered.

The incidence of identity theft is expected to rise in the future because of the increase in the number of databases, many of which have insufficient protection. In addition, the very low prosecution rates and lenient sentencing make identity theft appealing to some criminals.

A number of populations are more at risk of identity theft than others. They include people in close groups such as university students and military personnel, medical patients and even the deceased. In a study of urban areas in Florida, whites were most likely to be the victims of identity theft (72 per cent) and Hispanics the least (1 per cent), and blacks were the most likely offenders (69 per cent).



▲ **Figure 6.2:** The total cost of cybercrime in seven countries ($ millions)

Source: Ponemon Institute©

Maps of identity theft show clear regional variations. The south-western and western states of the USA had much higher rates than the Midwest and the east coast (Figure 6.2).

The pattern for identity theft was found to be similar to that for larceny (the stealing of valuable property). While larceny is considered to be a blue-collar crime and identity theft a white-collar crime, both forms of crime are generally non-violent and involve the direct theft of valuable goods from a victim. The increase in identity theft (benefit fraud) in 2006 is believed to have been triggered by Hurricane Katrina, which affected parts of the Gulf Coast during 2005. After the hurricane, there was a chaotic period with increased opportunities for crime, including looting, theft and violence, and eventually some forms of identity theft.

Case study

Forms of identity theft in the UK

Identity crime is a major global problem. In the UK alone, identity crime costs taxpayers about $1.5 billion annually, and the costs are rising each year. Identity crime includes extortion (blackmail), cyber-bullying (trolling) and defamation (libel).

There are a number of types of identity theft.

- Trashing is the retrieval of documents from rubbish bins or obtained during a burglary. Internet technology has provided criminals with a global reach.
- Phishing relies on emails to trick people into revealing personal and financial information. Spear phishing occurs when highly personalized e-mails are sent to specific targets.
- Pharming or spoofing refers to information that appears relevant to the recipient, and encourages them to open an email.
- Smishing is the sending of text messages to potential victims.
- Vishing refers to messages sent by voice that are designed to corrupt the recipient's voicemail and phone.
- Data can also be collected from lost or stolen laptops or from discarded laptops that have not been wiped clean.

Social media sites, such as Facebook, have been used by individuals for criminal activity. There are cases where people have been tricked into sending photos of themselves, only to be blackmailed after doing so. Cyber-bullying or trolling is the practice of posting abusive and inflammatory messages online. In extreme cases it has contributed to the suicide of the victims of such messages.

A CareerBuilder survey claimed that over one-third of employers use social media to investigate prospective employees before deciding upon a job offer.

ATL Research and communication skills

Visit the Federal Trade Commission at http://www.ftc.gov/bcp/edu/microsites/idtheft/ and update the data on identity theft in the USA. Write a brief report on your findings.

Activity 1

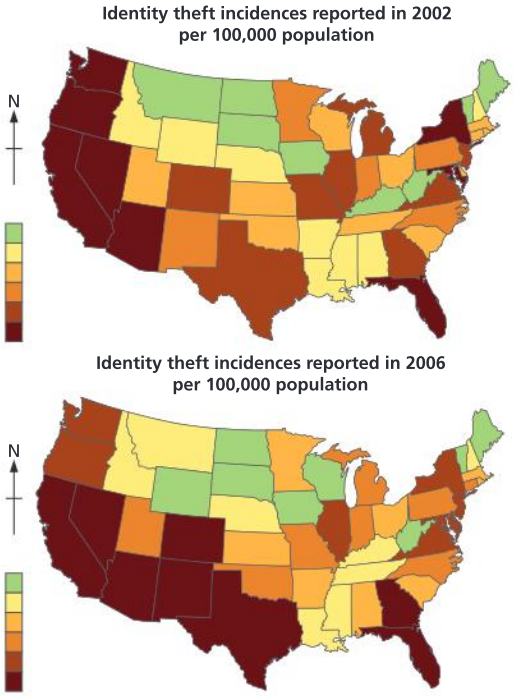
1. Choose an appropriate graphic technique for showing the data in Table 6.1.
2. Comment on your findings.
3. Study Figure 6.3. Describe how the main pattern of identity theft has changed over time.

▼ **Table 6.1:** Cybercrimes in the USA

Category	% of total 2002*	% of total 2006*
Credit card identity theft	42	25
Phone or utilities fraud	22	16
Bank fraud	17	16
Employment-related	9	14
Government documents or benefit fraud	8	10
Loan fraud	6	5
Other identity theft	16	24

*Percentage sums exceed 100 due to individuals reporting multiple victimizations.

Source: Lane,G and Sui, D "Geographies of identity theft in the US"GeoJournal. Vol 75. Pp 43 @ 55



▲ **Figure 6.3:** Identity theft in the USA, 2002 and 2006, per 100,000 population

Implications of surveillance for personal freedom

In 2013 the United Nations published a report, "The link between state surveillance and freedom of expression", concerning the threat of state surveillance to the right to privacy. According to the report:

> "State surveillance of communications is ubiquitous, and such surveillance severely undermines citizens' ability to enjoy a private life, freely express themselves and enjoy their other fundamental human rights." (https://www.privacyinternational.org/node/392)

It was the first time the UN has emphasized the centrality of "the right to privacy to democratic principles and the free flow of speech and ideas".

In 2009 there were concerns about the growing tide of surveillance used by states following the 9/11 attacks on the USA, and the UN was called upon to take action to update its understandings of the right to privacy in the face of the Internet and new technologies. Since then, new technologies have been adopted and surveillance techniques have proliferated. As the methods by, and frequency with which, people are able to communicate has expanded and evolved, so too have the means by which states have sought to monitor private communications. Modern surveillance technologies enable states to intrude into individuals' private lives.

Furthermore, technological advancements mean that the effectiveness of states in conducting surveillance is no longer limited by scale or duration. For example, by placing taps on the fibre optic cables, states can achieve almost complete control of telecommunications and online communications. Such systems were reportedly adopted, for example, by the Egyptian and Libyan governments in the lead-up to the Arab Spring.

Increasingly, the private sector collects more and more data that contain information about people's daily lives. Individuals and businesses choose to store the content of their communications, such as voicemails, emails and documents, with third-party service providers. Access to such communications data is an increasingly valuable surveillance technique employed by states. Vague and unspecified notions of "national security"

have become an acceptable justification for access to communications in many countries. Legislation has not kept pace with the changes in technology, creating gaps that deprive individuals of protection and allow for the increased use of surveillance.

The UN report believes that one of the greatest dangers to surveillance and the loss of personal freedom is the global industry that has developed around the sale of surveillance technologies to governments. The industry is virtually unregulated and often operates outside existing legal standards. Repressive regimes are commonly the buyers of the technology. The report highlights surveillance technology designed by the private sector and utilized in Libya, Bahrain, Syria, Egypt and Tunisia.

The report makes a number of recommendations including:

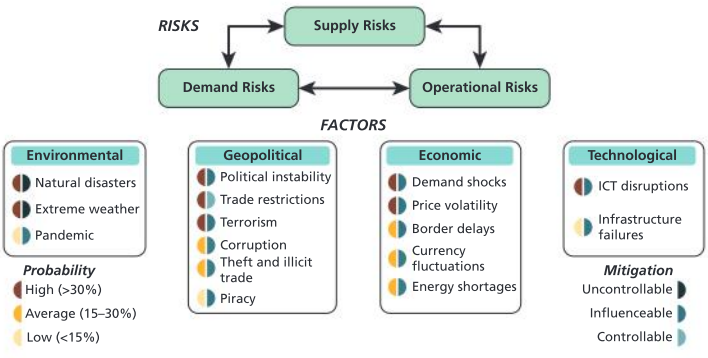
- communications surveillance must be regulated by legal frameworks and must be strictly and demonstrably necessary to achieve a legitimate aim
- illegal surveillance by public or private actors should be criminalized
- the provision of communications data by the private sector to the state should be sufficiently regulated and monitored by an independent authority
- anonymity online should not be outlawed, nor should encryption
- measures must be taken to prevent the commercialization of surveillance technology.

Risks to global supply-chain flows

There are many risks to global supply-chain flows. For example, there are risks on the supply and demand sides and operational risks (Figure 6.4).

Supply risks refer to the ability to meet the demand for goods in terms of quantity, quality and timing. Demand risks refer to the changes in demand, possibly as a result of currency fluctuations or political relations. Operational risks refer to the transport infrastructure responsible for delivering the goods.

Supply-chain risks are influenced by a number of factors, which might be environmental, geopolitical, economic, or technological:



▲ **Figure 6.4:** Risks to global supply-chain flows

- Physical environmental factors include natural disasters (earthquakes, floods), extreme weather events and epidemics. Floods in Bangladesh regularly disrupt the supply chain there, and the outbreak of Ebola in West Africa limited the movement of people and goods to and from the region. The 2011 tsunami that affected Japan had a major impact on the motor industry: up to 150,000 fewer cars

were produced in the USA as a result of disruption of the supply chain for parts. Likewise, the 2011 floods in Thailand led to shortages of hard drives after up to 1,000 factories were forced to close, leading to economic losses of some $20 billion.

- Political factors include protectionism, trade restrictions, and conflict, all of which have a major impact on the supply chain. Supplies of goods from the Middle East and North Africa were severely disrupted at times following the Arab Spring protests. The conflict in Ukraine has led to sanctions against Russia, and these reduce flows of goods. Governments with poor political or economic stability may take decisions (such as resource nationalism) that cause much uncertainty among investors.
- Economic factors include currency fluctuations and trade restrictions imposed by governments. Rising interest rates can cause havoc for firms that require goods at cheap prices. Debt crises in Europe among the PIIGS countries (Portugal, Ireland, Italy, Greece and Spain) provided much economic uncertainty to risk managers. Countries with strong trade unions and/or a history of strikes may threaten global supply chains.
- Technological factors include disruption to transport networks and ICT networks. Transport infrastructure failures are unusual, but ICT reliability is an issue.

Managing supply chains is a difficult business and many companies do not take out adequate insurance to cover potential losses. A survey in 2013 found that more than three-quarters of companies had experienced supply-chain disruption within the previous two years.

Activity 2

Study Figure 6.4.

1. Briefly explain how each of the environmental factors may influence global supply chains.
2. Comment on the ways in which geopolitical factors may influence global supply chains.

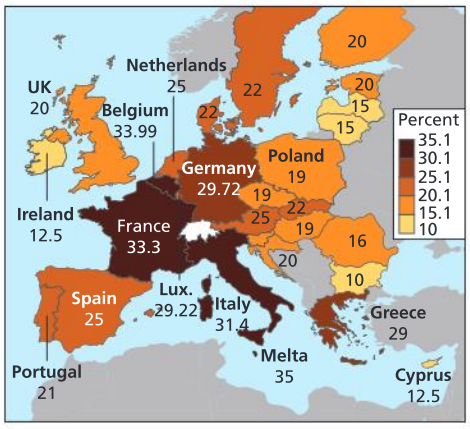
New and emerging threats to the sovereignty of states

Profit repatriation and the avoidance of tax

Repatriation of profits is the movement of profits made in a business or investment in a foreign country back to the country of origin. Profits are normally repatriated to protect against expropriation or to take advantage of currency fluctuation. Profit repatriation is an important factor in determining whether foreign direct investment (FDI) in another country is actually profitable for the parent firm.

Profit repatriation laws vary from country to country. For example, when the Volkswagen Group earns huge profits anywhere in the world, it takes a share back home to Germany, after converting it into euros. China is the global business hub today and ranked very high on the FDI targets list. This is because China has slowly and successfully liberalized its economy and laws to suit FDI needs. It is possible legally to repatriate up to 90 per cent of annual profits from China, provided certain norms are fulfilled, such as setting up local offices in China and creating a reserve account of at least 10 per cent of total net profit.

Some companies choose to open subsidiaries in other countries. They do this because the corporation tax in their home country is extremely high, and significant savings can be made by being based elsewhere.



▲ **Figure 6.5:** Corporation tax in the European Union

Case study

Tax avoidance: the case of Apple

In 2016 Apple Inc. was ordered by the European Union to pay €13 billion worth of back taxes to Ireland. Apple claimed that such a move could lead to less investment in the EU by TNCs. The European Commission ruled that the tax deal between Apple and the Irish government was illegal, since the same deal was not open to other companies. Irish corporation tax is normally 12.5 per cent, one of the most competitive in Europe (Figure 6.5), but Apple had an arrangement whereby the maximum tax rate it paid in Ireland was just 1 per cent; in 2014 it paid 0.005 per cent.

The Commission argued that Apple's deal with the Irish government had allowed the company to attribute sales to a "head office" that existed only on paper. Consequently, Apple avoided paying tax on most of its profits from sales of its iPhone and other goods. It transferred the profits to Ireland rather than the country in which the phones were sold. It does not repatriate the money to the USA as it would have to pay US corporation taxes of around 35 per cent.

Somewhat bizarrely, the Irish government announced that it did not want to claim the money back as it wanted to maintain its reputation as a low-tax base for foreign TNCs, and that thousands of jobs would be at risk if foreign-owned companies in Ireland relocated. Apple employs around 6,000 people in Cork, Ireland. According to some commentators, the Commission's ruling was a serious attempt at limiting the power of large multinationals to avoid their tax liabilities. According to Christian Aid, tax avoidance is a damaging "race to the bottom", in which governments are competing to be able to offer TNCs the lowest tax bill.

It is not just Apple that has entered into agreements with national governments. Tax deals between Luxembourg and Fiat, and between the Netherlands and Starbucks, have been found to be unlawful. The deals between Luxembourg and both McDonald's and Amazon are continuing.

Activity 3

1. Compare the variations in corporation tax around the European Union (Figure 6.5).
2. Comment on Apple's tax deal with Ireland, with respect to the information shown in Figure 6.5.

Activity 4

Suggest how large TNCs are able to negotiate low tax deals.

Tax avoidance is not confined to HICs. Oxfam estimates that LICs could be losing up to $124 billion each year as a result of tax avoidance by TNCs and the "super-rich". Action Aid reported on tax avoidance by Associated British Foods (ABF) in Zambia. ABF is Britain's second-largest food and drink manufacturer, with operations in 46 countries and an annual turnover of around £11 billion.

Between 2007 and 2012, Zambia Sugar, a subsidiary of ABF, made profits of $123 million but paid less than 0.5 per cent tax. It also repatriated over one-third of its profits to countries such as Ireland, Mauritius and the Netherlands, which offer very low tax rates. The Zambian government estimates that it loses over $2 billion per year from tax avoidance by TNCs and a few extremely wealthy people.

Action Aid estimates that ABF should have paid about $18 million in tax to Zambia. This amount of money is 14 times larger than all UK aid given to Zambia during the same period. Christian Aid estimates that LICs are losing out on about $160 billion per year, and that the money could be better used for health and education. The "If" campaign claims that tackling tax avoidance could end world hunger.

Tax avoidance by the wealthy

There are a number of ways in which wealthy people avoid paying tax. One way is to live in countries with lower rates of tax. For example,

the former Formula 1 world champion Jensen Button lives in Monaco where there is zero income tax. The businessman Philip Green manages his various businesses through a holding company, Taveta Investments. The company is registered in his wife's name, and she is a South African who lives in Monaco. The company has managed to avoid tens of millions of pounds of tax.

Most of the world's wealthy individuals pay someone to sort out their finances. Many form their own businesses and arrange to pay a spouse a wage below the maximum threshold. They attempt to spread the same income among two people rather than one, as they can then claim two tax allowances. Some arrange to pay themselves a small salary but then take a higher proportion of their income as dividends. These are generally taxed at a lower rate than salaries.

Others will invest in firms or small businesses. By donating assets to charity, a person is able to claim tax relief on the entire value of the assets.

The Panama Papers

The Panama Papers is the name given to 11.5 million files that were leaked from the database of the world's fourth largest offshore law firm, Mossack Fonseca. The records show the complex ways in which wealthy individuals can exploit secretive offshore tax regimes. Twelve national leaders were among 143 politicians, their families and close associates known to have been using offshore tax havens. They included Vladimir Putin, Pakistan's prime minister Nawaz Sharif, Iraq's former vice-president and ex-interim prime minister Ayad Allawi, the Ukrainian president Petro Poroshenko, the son of Egypt's former president, and the prime minister of Iceland.

Disruptive technological innovations

Drones

Drones are unmanned aerial vehicles (UAVs) operated by remote control, either by an operator or by an on-board computer. Drones have a number of advantages: they can be used for surveillance in natural and man-made disasters, to survey damage, locate victims, help the police search for lost children and monitor large crowds. They can be used to make structural surveys of buildings, to monitor environmental conditions and to provide farmers with information (Photo 6.1).

Growth of the drone industry will generate major profits. Growth between 2015 and 2018 is expected to generate over $13 billion, and by 2025 over $80 billion. Moreover, it is expected that the industry will create some 30,000 manufacturing jobs and more than 70,000 technical jobs.

However, concerns exist about the use of drones for military manoeuvres and for surveillance. Drones used in war are operated far from the conflict zone and may thus desensitize armed personnel to war and killing. In addition, drones have caused many civilian fatalities. It has also been found that, just like other military personnel, some drone operators have experienced post-traumatic stress disorder.

ATL Research and communication skills

Find out about the Panama Papers at https://www.theguardian.com/news/2016/apr/03/what-you-need-to-know-about-the-panama-papers.

Have a class discussion about the ethics of wealthy individuals having so much wealth and trying to avoid paying tax.

ATL Thinking skills

Most people would prefer to pay less tax. Do you consider the tax avoidance by Apple and ABF to be ethical? Justify your position.

ATL Research and communication skills

Find out more about the "If" campaign. Visit http://www.christianaid.org.uk/ActNow/if-enough-food/if.aspx and https://www.theguardian.com/global-development/2013/jan/23/anti-hunger-campaign-if-g8-act.

Comment on your findings.

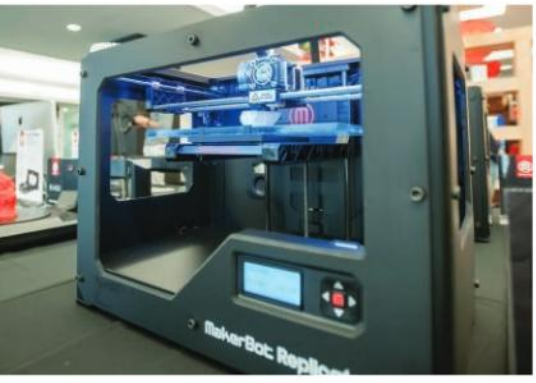
Activity 5

Watch the short video on drones at https://www.youtube.com/watch?v=PeCjkA7OA-k. Briefly explain how drones could improve your lifestyle.

▲ **Photo 6.1:** Drones – the future of agriculture

Activity 6

Outline the advantages and disadvantages of drones.



▲ **Photo 6.2:** A 3D printer

Activity 7

Outline the advantages and disadvantages of 3D printing.

Drones have also been linked with an invasion of personal privacy. Their powerful cameras and remote sensing imagery can be used to "spy" on people. The USA's law enforcement agency, the FBI, has used drones in law enforcement since 2006.

Other problems include cost, especially with the drones used for military operations, breakdown or malfunction of computer software, and human error in their operation.

3D printing technology

3D printing technology, or "additive manufacturing", allows for the creation of physical objects from a digital model, by building them up in a sequence of layers. The technology is said to have great potential in engineering, medicine, the military, construction, architecture, education and the computing industries. In 3D printing it is possible to use a variety of different materials.

3D printing allows manufacturers to create complex 3D objects in a short time. There is little waste involved, as products are built up rather than reduced in size. In addition, designs can be transferred over the Internet. 3D printing has been used to create prosthetics, parts of the human body, organs and tissues. It has been used to create a 5cm long blood vessel and an eagle's beak destroyed by a hunter. Those in favour of 3D printing argue that it could counter globalization, as many users will do much of their own manufacturing rather than outsource or engage in trade to obtain the products they need. 3D printing technology could lead to the development of localized, customized production that responds to actual rather than anticipated demand. Some believe that 3D printing could lead to a resurgence of US manufacturing as highly skilled companies will be needed to develop the technology and access large amounts of capital to develop the technology needed for the the industry.

However, 3D printing technology poses risks. The lack of legislation and regulations concerning the technology means that it can be used to create weapons, parts of weapons, guns, knives and counterfeit goods. Internationally, where gun controls are strict and real firearms less easily available, the impact of this may be great. Critics argue that 3D printing will replace labour in increasingly complex tasks, as technology already has with ATMs, online banking, mobile payment systems and so on. A member of a German lock-picking group managed to create a key using a 3D printer to unlock handcuffs carried by Dutch policemen. He even put the model online for anyone to print off. There are also concerns that 3D printing can enable gangs to steal money from ATM machines.

ATL Research and communication skills

Investigate Jingdong's use of drones in retailing, ahead of Amazon's plans to use drones for delivering goods, at http://www.mirror.co.uk/news/world-news/chinese-company-beats-amazon-deliver-8230920 and http://www.bbc.co.uk/news/technology-25180906.

Comment on these stories and look for other links.

Increased globalization and renewed nationalism

By 2014–15 it was clear that the increase in globalization had been matched by an increase in nationalism. There had been an increase in international tension and a decrease in multilateral cooperation. The cause of the increase in nationalism was due, in part, to poor economic growth following the financial crash of 2008, rising inequality, and, in Europe, rising immigration. The changes brought about by globalization led many people to look for stability in national or local features, such as a shared culture, history or language. The rise in nationalism is not confined to Europe: China, Japan and India all have charismatic nationalistic leaders. This new nationalism takes many forms: protectionist policies such as trade barriers, policies favouring domestic workers, ant-immigration measures and resource nationalism. In some locations, access to social media has been restricted. In the most extreme cases, economic failure and a lack of opportunities for young people are fuelling extremism, resentment of globalization and the West, and, in extreme cases, terrorism.

Japan and China's changing relationship

Economic integration and interdependence have been characteristics of Japan and China since the 1990s. In 2014 Sino–Japanese trade reached $340 billion; China was Japan's leading trade partner and Japan was China's second-largest trade partner. Japan was the leading investor in China, investing more than $100 billion in 2014.

Since the financial crisis of 2008, China has been more assertive in its economic dealings. For example, China's "weaponization" of trade, through banning the export of rare earths to the Philippines and restricting imports of bananas from that country, followed disputes in the East and South China Seas. China's economy has matured, and it is now exporting more high-value goods. China's outbound investment increased from $2 billion in 2004 to $80 billion in 2014 and $120 billion in 2015. It is showing a similar trend to Japan's outward investment in the 1980s. Japan has been diversifying its investments around Asia, including Vietnam, the Philippines, Indonesia and Myanmar.

China and Japan have become investment competitors within Asia. Both are striving to invest in transport infrastructure around Asia. Although China has a cost advantage, Japan promises to hire local workers. The competition to build transport infrastructure has become a symbol of the rivalry between the two nations for industrial supremacy in Asia.

In addition, both countries have built up their defence export industries. China is now the world's third-largest exporter of arms. There is a possibility of this competition spilling over into military conflict. Both China and Japan have increased their military capacity to protect their overseas investments. There is growing concern that China's military might respond to a perceived threat in the South China Sea and initiate a conflict in the region. Whether Western nations would become involved remains to be seen.

Check your understanding

1. Define cybercrime.
2. Describe the main forms of identity theft.
3. Identify the main population groups that are victims of identity theft in the USA.
4. Outline the main factors that affect global supply chains.
5. Explain the term "profit repatriation".
6. Suggest why certain TNCs have avoided paying tax.
7. Briefly outline the advantages and disadvantages of drones.
8. Briefly outline the advantages and disadvantages of 3D printing.
9. Briefly explain why globalization has led to increased nationalism.
10. Suggest why relations between China and Japan may lead to military conflict in the future.

The Ukrainian crisis

The crisis in Ukraine began in November 2013, with protests in Kiev following President Yanukovych's rejection of a deal for greater integration with the European Union. State forces tried to stop the protests but, in the weeks that followed, the protesters increased in number. In March 2014 Russian troops gained control of the Crimean region following a disputed referendum in which Crimea voted to join Russia. The Russian president Vladamir Putin had said that Crimea needed to be part of a "strong and stable sovereignty" and that could only be Russia.

In May 2014 pro-Russian separatists in Donetsk and Luhansk, in eastern Ukraine, declared independence from Ukraine. In the conflict that followed, over 9,000 people were killed and 1.1 million Ukrainians became refugees. The Ukraine government and NATO reported the build-up of Russian troops and artillery close to Donetsk, and Russian shelling of locations close to its border.

By July 2014, the conflict had become an international crisis, with the EU and the USA speaking out against Russia. Dutch air accident investigators concluded that the shooting down of a Malaysian Airlines flight over Ukrainian airspace was carried out with Russian-built surface-to-air missiles provided by Russia to the separatists.

The conflict has increased tensions between Russia and both the EU and the USA. These tensions may intensify if Russia expands its presence in Ukraine or into a NATO country. Economic sanctions are said to have cost Russia some €100 billion.

Concepts in context

Many technological and globalizing processes are creating geopolitical and economic risk for individuals and societies. For example, there are threats to individuals and businesses, such as hacking, identity theft and the implications of surveillance for personal freedoms. There are also new and emerging threats to the political and economic sovereignty of states, including profit repatriation and tax avoidance by TNCs and wealthy individuals, and disruptive technological innovations, such as drones and 3D printing. Moreover, there is a link between increased globalization and renewed nationalism.

Synthesis and evaluation

- Globalization has led to increased geopolitical and economic risks. For example, improvements in ICT have led to many negative impacts including cybercrime, disruptions in supply chains and tax avoidance. Many people, communities and even nations feel disadvantaged by such activities.
- Some new technologies such as drones and 3D printing bring many benefits, but may also bring risks, some new, some old. Drones have been linked with civilian deaths in war and increased insensitivity among military personnel, while 3D printing has created new organs and tissues, but also new weapons.
- Geographers must look at different perspectives and consider both the advantages and the disadvantages of globalization from various viewpoints.

2 Environmental risks

Transboundary pollution (TBP)

Acid rain – or, more precisely, acid deposition – is rainfall that is more acidic than normal as a result of human activity. The term "acid rain" was introduced as long ago as the 1850s for rain with a pH of less than 5.65. Rainfall is naturally acidic because it absorbs carbon dioxide in the atmosphere and becomes a weak carbonic acid, with a pH between 5 and 6. The pH scale is logarithmic, so a decrease of one pH unit represents a tenfold increase in acidity. Thus pH 4 is 10 times more acidic than pH 5. The pH of acid rain can be as low as 3.0.

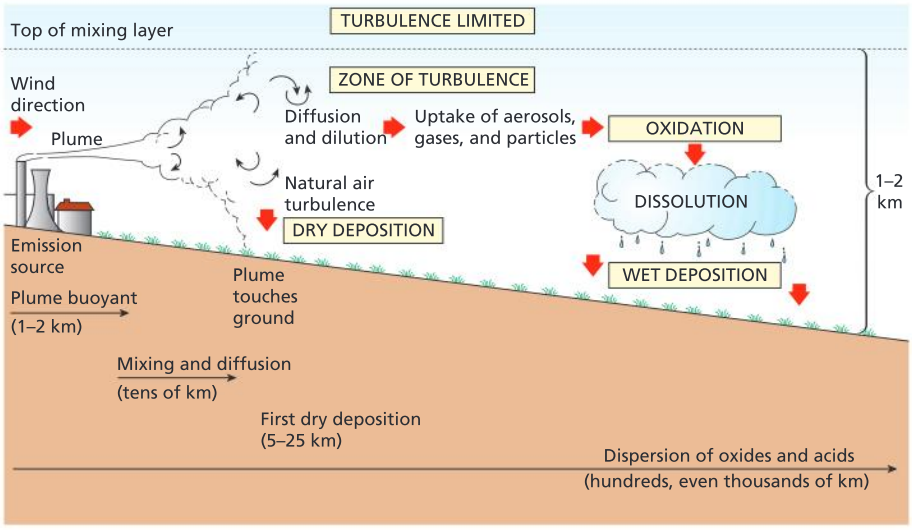
Rain becomes more than usually acid because of air pollution. The major causes of this pollution are the sulphur dioxide and nitrogen oxides produced by burning fossil fuels such as coal, oil, and gas. When sulphur dioxide and nitrogen oxides are released into the atmosphere, they can be absorbed by the moisture and become weak sulphuric and nitric acids. Most natural gas contains little or no sulphur and causes less pollution.

Coal-fired power stations are the major producers of sulphur dioxide, although all processes that burn coal and oil contribute. Vehicles, especially cars, are responsible for most of the nitrogen oxides in the atmosphere. Some come from the vehicle exhaust itself, but others form when the exhaust gases react with the air. Exhaust gases also react with strong sunlight to produce poisonous ozone gas, which damages plant growth and, in some cases, human health.

Dry and wet acid deposition

Acidic deposition can be wet or dry. **Dry deposition** of pollutants occurs typically close to the source of emission and damages nearby buildings and structures. **Wet deposition**, by contrast, occurs when the pollutants are dissolved in precipitation, and may fall at great distances from the sources (Figure 6.6). Since wet deposition crosses international boundaries with disregard, it is a form of transboundary pollution.

Snow and rain in north-eastern USA have been known to have pH values as low as 2.1. In the eastern USA as a whole, the average annual acidity values of precipitation tend to be around pH 4 (Figure 6.7). As a general rule, sulphur oxides have the greatest effect and are



▲ **Figure 6.6:** Dry and wet deposition

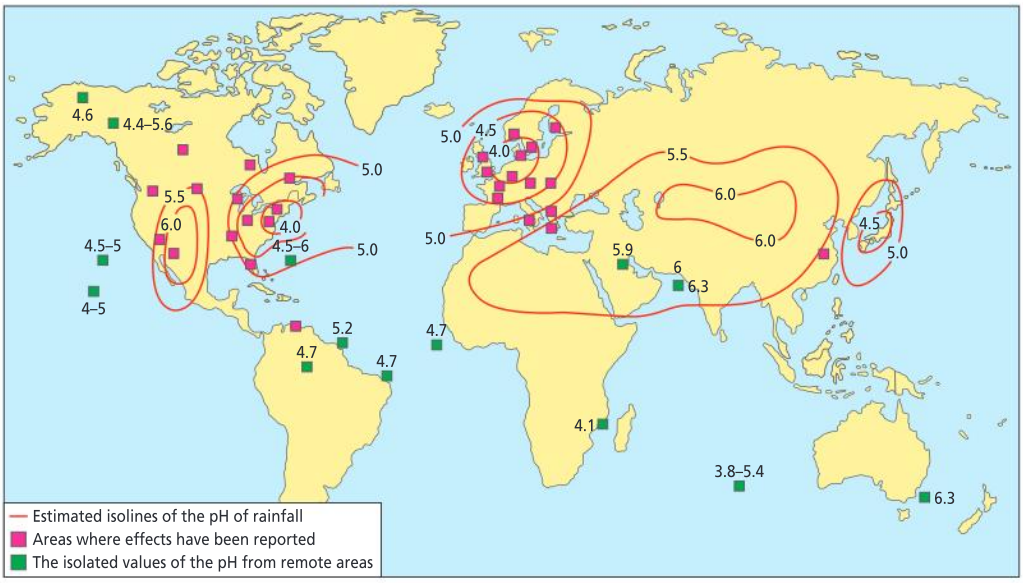
Conceptual understanding

Key question

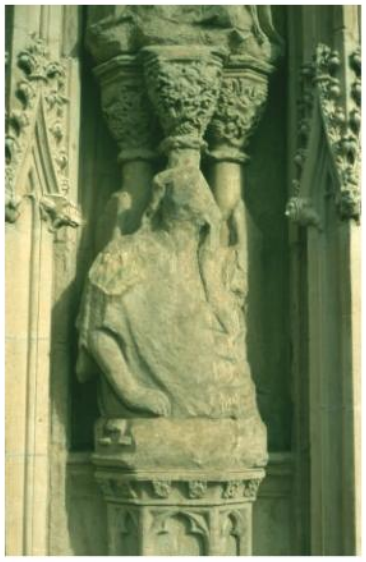
How do global interactions create environmental risks for particular **places** and people?

Key content

- Transboundary pollution (TBP) – pollution affecting a large area or more than one country.
- The environmental impacts of global flows at varying scales: localized pollution, including along shipping lanes; carbon footprints for global flows of food, goods and people.
- Environmental issues linked with the global shift of industry: polluting manufacturing industries; food production systems for global agribusiness.



▶ **Figure 6.7:** Map of world acidification



▲ **Photo 6.3:** The impact of acid rain on stonework

responsible for about two-thirds of the problem. Nitric oxides account for most of the rest. However, in some regions, such as Japan and the west coast of the USA, the nitric acid contribution may be of relatively greater importance. Worldwide emissions of SO_2 are declining while those of NOx are increasing, partly as a result of increased car ownership.

Acidification has a number of effects:

- Buildings are weathered (Photo 6.3).
- Metals, especially iron and aluminium, are mobilized by acidic water and flushed into streams and lakes.
- Aluminium damages fish gills.
- Forest growth is severely reduced.
- Soil acidity increases.
- Lakes become acidic and aquatic life suffers.
- There are possible links (as yet unproven) to the rise in cases of senile dementia.

The effects of acid deposition are greatest in areas with high levels of precipitation (causing more acidity to be transferred to the ground) and those with base-poor (acidic) rocks that cannot neutralize the deposited acidity.

- Rainfall is naturally acidic.
- There are natural sources of acidification, such as volcanoes (Photo 6.4).
- No single industry/country is the sole emitter of SO_2/NOx.
- Cars with catalytic convertors have reduced emissions of NOx.
- Different types of coal have variable sulphur content.

! Common mistake

✗ Acid deposition in the USA or China might not necessarily be transboundary, depending upon where the SO_2 and NOx originated from. However, some of the SO_2 and NOx may have originated outside of each of these countries; it is impossible to state exactly where all of the pollutants originated from.

✓ Acid deposition is a form of transboundary pollution when it crosses from one country (source) to another (destination).

Reducing the impacts of acid deposition

Various methods are used to try to reduce the damaging effects of acid deposition. One of these is to add powdered limestone to lakes to increase their pH values. However, the only really effective and practical long-term treatment is to curb the emissions of the offending gases. This can be achieved by:

- reducing the amount of fossil fuel combustion
- using less sulphur-rich fossil fuel
- using alternative energy sources that do not produce nitrate or sulfate gases (such as hydropower or nuclear power)
- removing the pollutants before they reach the atmosphere.

▲ **Photo 6.4:** A natural source of acidification – Soufrière volcano, Montserrat

Case study

Acid rain in eastern Canada

Acid rain has had a major impact in eastern Canada. Provinces that are part of the Canadian Precambrian Shield, including Ontario, Quebec, New Brunswick and Nova Scotia, are hardest hit. The Precambrian Shield consists of areas of hard rock – granite – that cannot neutralize the effects of acid deposition. Even if the pH of lakes and groundwater returns to a more normal level, the ecosystems may have changed dramatically. For example, many of these areas have lost much of their calcium, which is required for the survival of tiny, plankton-like crustaceans, *Daphnia* – an important basis of the food chain. Their place has been taken by a plankton species that does not require much calcium, *Holopedium*. It is larger than *Daphnia* and its jelly-like coating largely protects it from predators, so some other species have lost their food supply. *Holopedium* have begun to clog up water filtration stations on account of their jelly coating. Scientists believe that it could take thousands of years for weathering of local rocks to return lake water calcium to its previous levels.

Some lakes have recovered but many have not. A survey of 202 lakes revealed that 33 per cent of them have reduced levels of acidity since the 1980s, 56 per cent were unchanged and 11 per cent were more acidic. The **critical loads** for Nova Scotia are low, and the area continues to exceed the critical load for both land and water ecosystems.

▲ **Photo 6.5:** The impacts of acid rain on rivers in Nova Scotia

Activity 8

1. What are the main gases responsible for acid deposition?
2. What is the difference between wet deposition and dry deposition?
3. Outline the natural causes of acid deposition.
4. Describe the main impacts of acidification.
5. Suggest how it is possible to manage acidification.

Environmental impacts of global flows

Shipping

Shipping has been one of the most important factors in the growth of globalization. However, it is now known that there are high rates of pollution along certain shipping routes (Figure 6.8). Scientists monitoring pollution have identified an NO_2 track in the Indian Ocean between Singapore and Sri Lanka, and others in the Red Sea, the Gulf of Aden, the Mediterranean Sea and along the route from Singapore to China. Such tracks are less evident in the Pacific and Atlantic Oceans, where ships are not concentrated in narrow zones.

Shipping causes considerable pollution and environmental damage, including:

- oil and chemicals released in deliberate discharges and accidental spills
- waste dumping, including sewage and garbage
- air pollution through the release of greenhouse gases
- physical damage through the use of anchors
- noise pollution, which disturbs large mammals such as whales.

The potential for pollution is highly concentrated along the world's main shipping routes. Approximately 50,000 merchant ships are sailing these routes, carrying about 90 per cent of the world's trade between countries. Regulations to protect the oceans are set by the International Maritime Organization and the UN Convention on the Law of the Sea. These organizations have been criticized as slow and reactive rather than pushing for tighter environmental controls.

Rising levels of CO_2 are leading to increased acidification of the oceans. Ships also release sulphur and nitrogen oxides in their exhaust gases, which also lead to acidification. Controls on the sulphur content of marine fuel exist in parts of Europe and North America. Estimates suggest that the deposition from sulphur dioxide from shipping ranges from around 10 per cent to more than 25 per cent along the Atlantic Ocean, the Gulf of Mexico, and the Pacific Ocean. (See Option B for more on ocean acidification.)

Activity 9

Study Figure 6.8.

1. Describe the distribution of particulate matter overlaid on the world's major shipping routes.
2. Suggest possible links between shipping routes and particulate matter pollution.

ATL Research and communication skills

For a map of ship tracks, go to http://earthobservatory.nasa.gov/IOTD/view.php?id=80375.

Describe the distribution of the tracks. How do you account for the grey area in the Arctic?

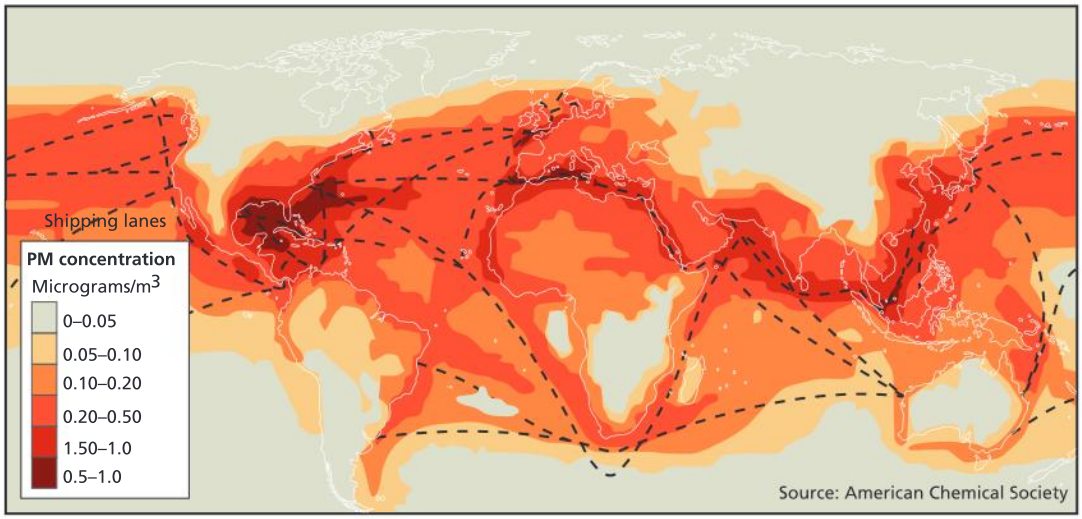


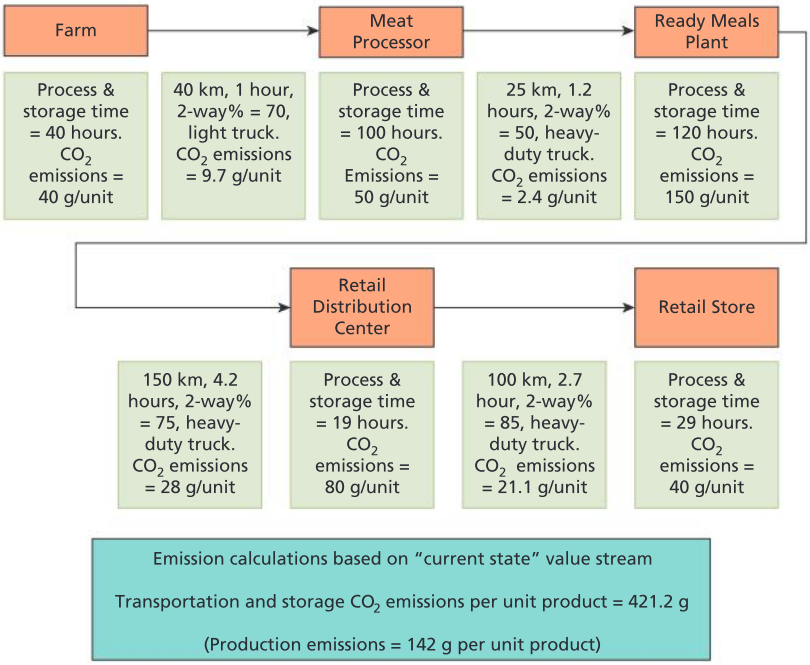
Figure 6.8: Shipping pollution and the world's main shipping routes

Carbon footprints for global flows of food and other goods

Food

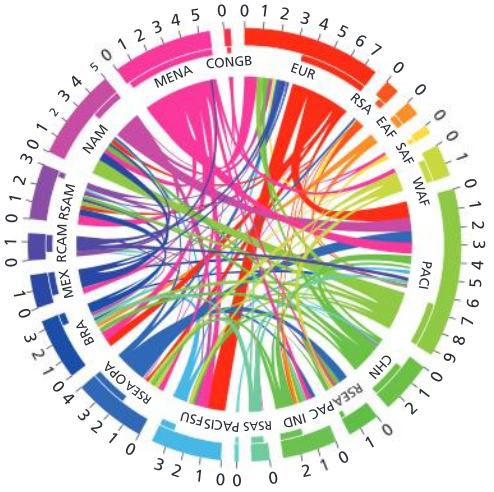
The carbon footprint associated with food production is complex. Figure 6.9 shows a model for food production, distribution and retailing.

The flow of foodstuffs around the world has its own carbon footprint and the flows shown in Figure 6.10 link the main producers and consumers. The carbon footprints will depend on such factors as volume of produce, method of transport, the need to keep products refrigerated, type of packaging, storage, distribution and sales. However, this is not the only environmental impact of the trade in food. Producing the food may involve the use of machinery, chemicals and pesticides, and these, too, can have an environmental impact.



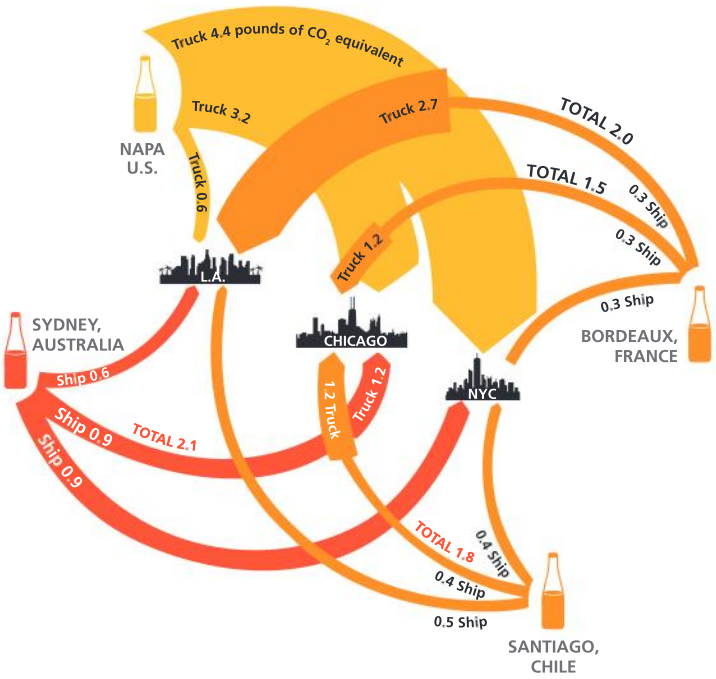
▲ **Figure 6.9:** Carbon emissions in the food trade

Figure 6.11 shows the carbon footprint of transporting wine from four wine-producing areas – the Napa Valley, Bordeaux, Santiago and Sydney – to three markets in the USA – New York, Los Angeles and Chicago.



Source: GLOBIOM model projections.
Note: BRA = Brazil; CHN = China; CONGB = Congo Basin; EAF = Eastern Africa; EUR = Europe; FSU = Former Soviet Union; IND = India; NAM = North America; MENA = Middle East and North Africa; MEX = Mexico; PACI = Pacific Industrialized; PACIS = Pacific islands; RCAM = Central America and Caribbean; RSA = South Africa; RSAM = Rest of South America; RSAS = Rest of South Asia; RSEA OPA = Rest of South East Asia / Other Pacific Asia; RSEA PAC = Rest of South East Asia / Planned Asia; SAF = Southern Africa; WAF = Western Africa.

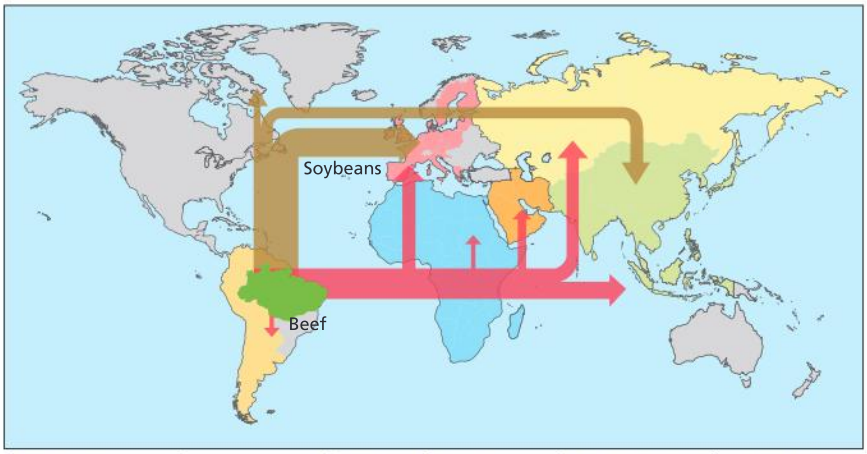
▲ **Figure 6.10:** Global flows of trade in agricultural emissions, in 100 Mt/CO_2eq/year. The white part of the inner bar represents what the region produces, and the coloured part represents emissions from their imports.



▲ **Figure 6.11:** Desire lines comparing the carbon footprint of wine transport

Activity 10

1. Study Figure 6.10, showing global flows of trade.
   a. Identify the main destinations of food exports from North America.
   b. Identify the sources of food imports into Europe.
   c. Which regions depend most on imports of food?
2. Study Figure 6.11, showing carbon flows associated with the transport of wine.
   a. Identify (i) the largest and (ii) the smallest carbon flow.
   b. Suggest why the carbon flows to Chicago from Santiago and Bordeaux are much greater than those to New York.
   c. Suggest why the carbon flows from Los Angeles are generally higher than those from France, Chile and Australia.
3. Study Figure 6.13, showing carbon flows in exports from Brazil. Describe the carbon flows associated with the trade in soybeans and beef from Brazil.
4. Comment on the strengths and weaknesses of the three types of diagram used in Figures 6.10, 6.11, and 6.12.

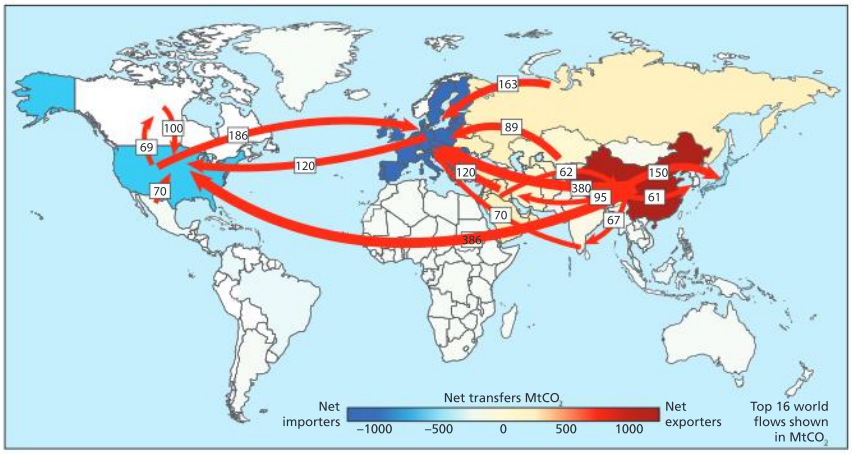


Soybeans	Embodied Carbon ($TgCO_2e$)	% of Total	Beef	Embodied Carbon ($TgCO_2e$)	% of Total
Asia	31.0	12.1%	Africa	7.3	3.0%
EU	80.3	31.2%	EU	29.6	12.3%
Rest of world	17.2	6.7%	E. Europe	29.9	12.5%
Brazil	128.4	50.0%	Mideast	18.8	7.8%
			Rest of world	34.5	14.4%
			Brazil	120.0	50.0%

▲ **Figure 6.12:** Carbon flows from Brazil due to exports of beef and soybeans

Other goods

The flow of goods shows a very different carbon footprint from the flow of food. By convention, these emissions are considered to belong to the producing nation, despite the fact that the consuming nations generate the demand for the products. Figure 6.13 shows only the 16 largest flows and identifies net exporters and importers of CO_2. The importance of China as an exporter of goods is clearly seen, as is the importance of the USA and the EU as importers of goods.



▲ **Figure 6.13:** Flows of CO_2 associated with the export of goods

Population flows

Human migration is at an all-time high. The migration of people from LICs to HICs will normally lead to an increase in global emissions. In the UK, population growth between 2008 and 2033 will add 7 million

people through net migration, and will increase the UK's greenhouse gas emissions by almost 125 million tonnes of CO_2 by 2020 and by over 500 million tonnes CO_2 by 2033. Migration from "low carbon" to "high carbon" countries will lead to an increase in greenhouse gas emissions, especially if the migrants' standard of living increases following the migration.

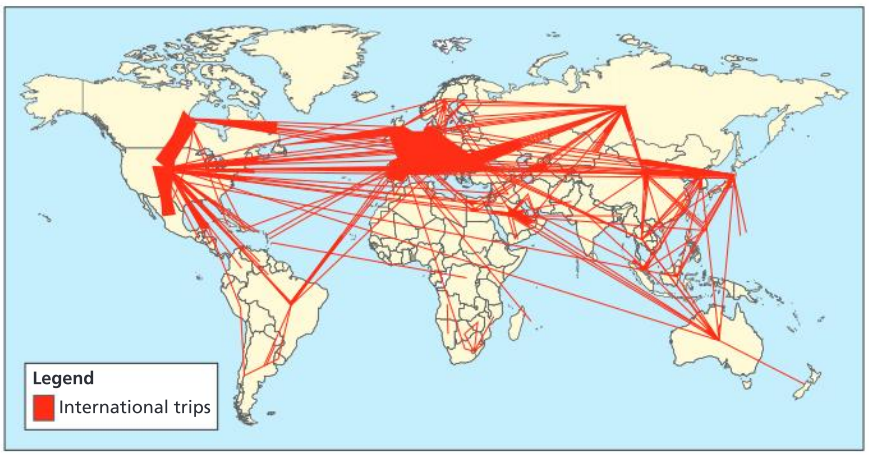
Immigrants to the USA

Research into the environmental impact of immigrants in the USA concluded that:

- CO_2 emissions of the average immigrant (legal or illegal) in the USA are 18 per cent lower than those of the average native-born American.
- Immigrants in the USA produce four times more CO_2 in the USA than they would have in their countries of origin.
- The impact of immigration to the USA on global emissions is equal to approximately 5 per cent of the increase in annual worldwide CO_2 emissions since 1980.
- Legal immigrants have a much larger impact than illegal immigrants because they have higher incomes and higher resulting emissions, and are more numerous.

Tourism flows and carbon footprints

The carbon footprints generated by tourism are likely to vary greatly between types of travel and destinations – reflecting climate, culture, energy sources, available technology and activities undertaken. Most tourism-related activities require energy directly in the form of fossil fuels or indirectly in the form of electricity, which is often generated from petroleum, coal or gas.



▲ **Figure 6.14:** The main international flows of tourists

In 2003 the World Tourism Organization (WTO) acknowledged the two-way relationship between tourism and climate change. Climatic change will have impacts on a number of tourist destinations and tourist flows. In turn, tourism is a major contributor to climate change by its use of fossil fuels and emissions of greenhouse gases.

Environmental issues linked with the global shift of industry

Polluting manufacturing industries

Western nations have long been siting their polluting industries in developing countries, often with disastrous consequences. In 1984 the American-owned Union Carbide company released toxic gas from

Case study

Maquiladora development in Mexico

Mexico has attracted many US-owned companies to build low-cost assembly plants in places such as Cuidad Juarez, Nuevo Laredo and Tijuana. These factories, called *maquiladora* operations, are foreign-owned but employ local labour. Since 1989, more than 2,000 US firms have set up in Mexico's border cities. The main attractions are low labour costs, relaxed environmental legislation and good access to US markets.

Although Mexican law requires firms to transport hazardous substances back to the USA, illegal dumping in Mexico is common. Air and water pollution are increasing as a result. Despite the environmental problems, many Mexicans are in favour of the *maquiladoras* because they bring investment, money and jobs to northern Mexico. Over 500,000 people are employed in these factories.

its pesticide plant in Bhopal, India, killing thousands. The shift of manufacturing industries from HICs to emerging economies, including the BRICS, has resulted in widespread pollution of air, water and soil, and impacts on the health of residents who live there. HICs have more robust green laws, greater social supervision and more effective governments; pollution emissions are higher in NICs, where environmental regulations and their enforcement are weaker. These less regulated environments give richer nations a chance to export their waste and pollution. The environmental vulnerability of LICs and NICs to pollution is as a result of their underdeveloped systems as well as their need for the economic benefits of the polluting industries.

Food production systems for global agribusinesses

The food market is truly global. Farming has become increasingly intensive, large in scale and globalized in the drive for cheaper food. Advances in technology and communications have combined with falls in transport costs to transform the way in which food is sourced. The concentration of power in retailing and food processing has affected those at the other end of the scale, namely farmers in LICs and small farmers in MICs. Increasingly, modern farming methods are having a negative impact on the environment. The term "agro-industrialization" refers to the large-scale, intensive, high-input, high-output, commercial nature of much modern farming.

Since the 1950s, a revolution has taken place in the food industry. Every step in the process – how food is grown, harvested, processed, distributed, retailed and cooked – has changed. Until the Second World War, farmers were the major players in the food industry. After the war they were given grants and subsidies, but these were merely to stop them going out of business. Many therefore intensified, increased efficiency and adopted labour-saving technologies such as agro-chemicals, machinery and high-yielding varieties (HYVs) of plants.

Agro-industrialization has increased food production but is a major consumer of energy and a contributor to greenhouse gas emissions, air pollution, water pollution, land erosion and loss of biodiversity.

TOK

Is the relocation of polluting industries the main cause of pollution in Mexico?

A study that investigated the relationship between *maquiladoras*, air pollution and human health in Paso del Norte found that particulate emissions from *maquiladoras* undoubtedly have significant impacts on human health, in particular respiratory disease. However, it found that particulate emissions generate health damage of similar magnitudes regardless of the source, and that *maquiladoras* are clearly not the region's leading sources of particulates. Unpaved roads, vehicles and brick kilns were the main sources of particulate emissions. Given that vehicles and brick kilns emit far more combustion-related fine particulates than *maquiladoras*, they inflict more health damage. The study found no evidence that health damage attributable to *maquiladoras* disproportionately affected the poor. However, brick kilns were far more likely in poor areas.

Improved yields and environmental impacts

Food processors usually want large quantities of uniform-quality produce or animals at specific times. This is ideally suited to intensive farming methods. In HICs, since the 1960s, with increased inputs of fertilizers, insecticides and pesticides; for example, wheat yields have increased from 2.6 to 8 tonnes per hectare, barley from 2.6 to 5.8 tonnes. In just two decades, new production methods have increased a dairy cow's average yield from 4,000 litres to 5,800 litres a year.

Unfortunately, intensive farming requires the heavy use of synthetic chemicals and methods that lead to land degradation and animal welfare problems. Air pollution and greenhouse gas emissions from farming cost more than £1.1 billion annually in the UK. About 10 per cent of the UK's greenhouse gas emissions come from the methane from livestock digestion and manure and nitrous oxide from fertilized land. Animals are reared on production lines. The spread of disease is a problem. Cox's apples receive an average of 16 pesticide sprays. Lettuces imported to the UK from Spain, Turkey, Zimbabwe and Mexico are sprayed on average 11.7 times.

Cleaning up the chemical pollution and repairing the damage to habitats caused by industrial farming cost up to £2.3 billion a year in the UK alone. It now costs water companies £135–£200 million to remove pesticides and nitrates from drinking water. In the USA it is estimated that the costs of agriculture (pesticides, nutrient run-off, soil loss and so on) could be as high as $16 billion ($96 per hectare) for arable farming and $714 million for livestock. Soil erosion alone – not all caused by farming – costs up to $6 billion in sedimentation of dams, harbours and fish farms.

The global food industry has a massive impact on transport. Food distribution now accounts for between a third and 40 per cent of all UK road freight. The food system has become almost completely dependent on crude oil. This means that food supplies are vulnerable, inefficient and unsustainable. It is estimated that a kilogram of blueberries imported by plane from New Zealand produces the same emissions as boiling a kettle 268 times.

Between 1978 and 1998, the distance food was transported increased by 50 per cent. In order to be transported long distances, food must be heavily processed, packaged or chemically preserved. Transporting animals long distances to slaughter has made it almost impossible to contain outbreaks of serious diseases such as foot and mouth. Journeys of 300–600 kilometres to slaughter are not unusual for animals today, and the average journey to abattoir has been estimated at 160 kilometres.

Land-use change and loss of biodiversity

Farmland makes up the greatest use of land on earth. It is also increasing in cover. In Brazil, for example, the Amazon Basin, the *cerrado* (savanna woodland) and the Atlantic forest (with a high number of endemic species) are at risk of conversion to farmland. In 2004 soya production in areas of the Amazon and the Atlantic forest amounted to over 21 million tonnes. The expansion of cocoa in the 1970s and soya in the 1990s and biofuels in the 2000s has reduced the Atlantic forest to less than 10 per

ATL Research skills

Visit www.worldanimalprotection.org and go to the "Our work" section and "Animals in farming", for farm animal welfare reports. Find out what the reports say about the environmental impact of industrialized animal agriculture. Organize a class debate about the issues regarding animal welfare and the need to feed to world's population.

▲ **Photo 6.6:** Food display – global food in a supermarket

▼ **Table 6.2:** The role of livestock in GHG emissions

Gas	Contribution to climate change (%)	Livestock emissions (billion tonnes carbon dioxide equivalent)	Livestock emissions as % of total anthropogenic
Carbon dioxide	70	2.70	9
Methane	18	2.17	37
Nitrous oxide	9	2.19	64

cent of its original size. The *cerrado* is threatened by the expansion of cattle ranching, which is also closely related to soya production.

Food miles and a Christmas dinner

The concept of food miles describes how far food has travelled before it appears on a plate. However, it is also important to consider how the food has been transported and even packaged; frozen food, for example, has higher energy costs. Critics also argue that transport cost is only part of the environmental impact of food production – there could be other costs such as reduction in biodiversity, eutrophication, decreased water quality and increased risk of flooding.

The ingredients of a traditional Christmas meal bought from a supermarket may have cumulatively travelled more than 23,000 miles, or 38,000 kilometres, according to the report *Eating Oil* (2004). Buying the ingredients in a London supermarket, the report found that poultry could have been imported from Thailand and travelled nearly 17,000 kilometres, runner beans could have come from Zambia (nearly 8,000 kilometres), carrots from Spain (1,600 kilometres), mangetout from Zimbabwe (over 8,000 kilometres), potatoes from Italy (2,400 kilometres), and sprouts from Britain, where they were transported around the country before reaching the shop (200 kilometres) (Figure 6.15). By the time trucking to and from warehouses to stores was added, the total distance the food had travelled was more than 38,000 kilometres – the equivalent of travelling around the world once. Transporting ingredients such great distances makes food supplies vulnerable.

Case study

Water problems and flower farming in Kenya

In Kenya, British and European-owned flower companies grow vast quantities of flowers and vegetables for export, but the official Kenyan water authority, regional bodies, human rights and development groups, as well as small-scale farmers, have accused flower companies near Mount Kenya of "stealing" water from Kenya's second largest river, the Ngiro. The river is a life-sustaining resource for nomadic farmers, but it also sustains the flower farms supplying UK supermarkets. According to the head of the water authority, the 12 largest flower farms may be taking as much as 25 per cent of the water normally available to more than 100,000 small farmers.

Since a flower is 90 per cent water, the flower companies are thereby exporting Kenyan water as "virtual water". Kenya is one of the driest countries in the world and is exporting water to some of the wettest. The flower companies, which employ 55,000 labourers, are in direct competition with the peasant farmers for water,

Case study (continued)

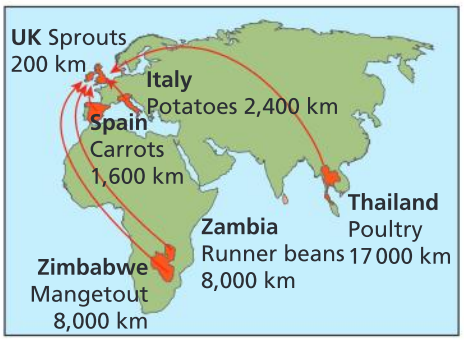
and the biggest companies pay the same as the smallest peasant for water.

The greatest impact is being felt by the nomadic pastoralists in the semi-arid areas to the north and east of Mt Kenya. Not only do the flower farms take the water, but they have also taken over land that the pastoralists used. The shores of Lake Naivasha in the Happy Valley area of Kenya are covered with flower farms, which use excessive amounts of water from the lake. Environmentalists also note problems of pollution from pesticides and deforestation caused by migrant workers from the growing shanty towns foraging for fuel.

In 2010, as a result of the eruption of the volcano under the Eyjafjallajökull in Iceland, flights from Kenya to Europe were shut down. Around a million kilograms of fresh produce is normally shipped out of Kenya every night, three-quarters of it to Europe and more than a third of this to Britain. With most European airports closed, an estimated $8 million-worth of flowers had to be destroyed. It is estimated that the Kenyan horticultural industry lost an average of $3 million a day. Kenya Airways also lost about $1 million a day.

▼ **Table 6.3:** Litres of water needed to produce 500 grams of various foods and selected items

Meat	Processed food	Fruit	Vegetables	Common goods
Beef 8,442	Sausages 6,283	Figs 1,723	Avocados 700	Pair of jeans 13,184
Pork 3,437	Processed cheese 2,678	Plums 877	Corn 495	Hamburger 3,482
Chicken 2,132	Eggs 1,818	Bananas 468	Beans 195	Glass of milk 241
	Fresh cheese 1,687	Apples 382	Potatoes 141	Cup of coffee 168



▲ **Figure 6.15:** The wastefulness of a Christmas dinner

◀ **Photo 6.7:** Flowers grown for HIC supermarkets in an LIC

TOK

Which is best for the environment – organic food that has been flown a long distance or locally produced food treated with fertilizers and pesticides?

It is usually thought that it is best to source food locally, because the amount of greenhouse gas (GHG) used to transport it is reduced. But the food may have other hidden sources of GHG, for instance if fertilizers and chemicals (pesticides, herbicides) have been used in its production. It might have one "good" environmental impact and one "bad" one. Weighing up their overall relative impacts might not be easy.

Activity 11

1. Explain the meaning of the term "agro-industrialization".
2. Outline the effects of agro-industrialization on the physical environment.
3. Describe the movement of food for the Christmas dinner as shown in Figure 6.15.
4. What is meant by the term "food miles"?
5. How does agro-industrialization affect food miles?

Concepts in context

Global interactions create environmental risks for particular **places** and people. Transboundary pollution (TBP) affects large areas/more than one country. In addition, global flows have many environmental impacts at a number of scales, including localized pollution, for example, along shipping lanes, and global pollution linked to the flows of food, goods and people. Moreover, there are environmental issues linked with the global shift of industry, such as the relocation of polluting manufacturing industries.

ATL Research skills

Visit http://www.fallsbrookcentre.ca/cgi-bin/calculate.pl for a food miles calculator. You could work out the cost of getting food to you from (a) the USA, (b) India and (c) New Zealand.

Visit www.agriculturalproductsindia.com and click on the "Agro Scenario" tab for information on the agro-industry in India, and www.fao.org/DOCREP/005/Y4383E/y4383e0d.htm for a detailed account of the effects of agro-industrialization on the valleys of Chincha and Mantaro, Peru.

Check your understanding

1. Outline the differences between wet and dry deposition.
2. Briefly explain why the decline of the *Daphnia* species is a problem in north-eastern Canada.
3. Describe the location of the main areas affected by pollution from shipping.
4. Comment on the carbon footprints for trade in food.
5. Outline the main differences in the carbon footprint for goods with that of the carbon footprint for food.
6. Explain how population flows contribute to carbon footprints.
7. Briefly explain why some manufacturing industries outsource their polluting industries to LICs.
8. Describe the main characteristics of agribusiness.
9. Outline the impacts of globalized farming on Happy Valley in Kenya.
10. Comment on the usefulness of the concept of food miles in the understanding of the environmental impact of agriculture.

Synthesis and evaluation

- Global interactions have many impacts on the natural environment, from climate change and ocean acidification on the global scale, to the localized pollution of groundwater supplies for farming, or the relocation of manufacturing industries creating localized waste. The severity of the impacts also varies: some may harm human health.
- Some impacts have slowed down in some places, such as acidification in north-eastern North America, but emerged in others, such as acidification in eastern Asia. Some impacts are immediate, such as the effect of oil pollution on marine ecosystems, whereas others are much more long term, such as global warming.
- Geographers use a number of skills to show these impacts and changes, such as flow lines, circular graphs and desire lines. Each type of graph has its own advantages and disadvantages.

3 Local and global resilience

Conceptual understanding

Key question

What are the new and emerging **possibilities** for managing global risks?

Key content

- The success of international civil society organizations in attempting to raise awareness of, and find solutions for, environmental and social risks associated with global interactions.
- Strategies to build resilience: reshoring of economic activity by TNCs; use of crowdsourcing technologies by government and civil society.
- New technologies for the management of global flows of data and people, including cyber security and e-passports.

▲ **Figure 6.16:** The WWF logo

International civil society organizations and risks related to global interactions

An environmental civil society: the World Wide Fund for Nature

The World Wide Fund for Nature (WWF) is an international environmental non-governmental organization (NGO), or civil society. It was founded in 1961 with the aim of preserving wilderness areas and the species that inhabited them, and of reducing human impact on the environment. Its original name was the World Wildlife Fund, which it is still called in the USA and Canada.

The WWF is the world's largest conservation civil society, working in over 1,300 projects in more than 100 countries, and with over 5 million supporters worldwide. In 2014 it derived 55 per cent of its funding from individuals, 19 per cent from multi-government organizations (MGOs), including the World Bank and USAID, and 8 per cent from TNCs. WWF's mission statement is "to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature".

The WWF's first manifesto stated that it needed "money, to carry out missions and to meet conservation emergencies by buying land where wildlife treasures are threatened, money … to pay guardians of wildlife refuges … for education … for sending experts to danger spots and training".

Its initial focus on protecting endangered species broadened into other areas, including preserving biodiversity, the sustainable use of resources, reducing pollution, and climate change.

In the 1990s the WWF revised its mission statement to "stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature", by:

- conserving the world's biological diversity
- ensuring that the use of renewable natural resources is sustainable
- promoting the reduction of pollution and wasteful consumption.

The WWF symbol (Figure 6.16) is based on the giant panda named Chi Chi that was living in London Zoo in 1961, and was the only panda at the time in the western world.

The WWF's current strategy is to:

- restore populations of keystone species, species that are important for their ecosystem or people, including elephants, whales and tuna
- reduce ecological footprints in terms of carbon emissions, cropland, grazing, forestry and water.

The WWF gets involved in a number of projects but also voices opinions on developments. For example, it has been a critic of the Canadian tar sands programme. From 2008–10 the WWF and the Cooperative Group published reports that concluded that the tar sands programme could contribute significantly to climate change, that carbon capture and storage (CCS) technology was not as effective for tar sands as for other forms of oil, that the money spent on extracting oil from tar sands would be better spent on R&D into renewable energy technology, and that the development of the tar sands represented a major risk to caribou herds in Alberta.

Nevertheless, critics argue that the WWF is too close to some large companies, such as Coca-Cola and IKEA. It receives large donations from corporations ($80 million in 2010). Wilfried Huismann's documentary *Silence of the Pandas* (2011) criticized WWF's involvement with TNCs responsible for destruction of the natural environment. His research was later published as a book, *PandaLeaks*. In 2016 Survival International complained that the WWF was using eco-guards who had abused the rights of indigenous people in the Cameroon rainforest. WWF denied the allegations.

ATL Research skills

Each year the WWF publishes the Living Planet Index, which reviews progress in reducing ecological footprints. Go to http://www.livingplanetindex.org/home/index and find out from the latest report the state of the world's biodiversity.

Activity 12

Visit http://www.panda.org/about_wwf/index.cfm to find out more about the work of WWF. Choose a project to research.

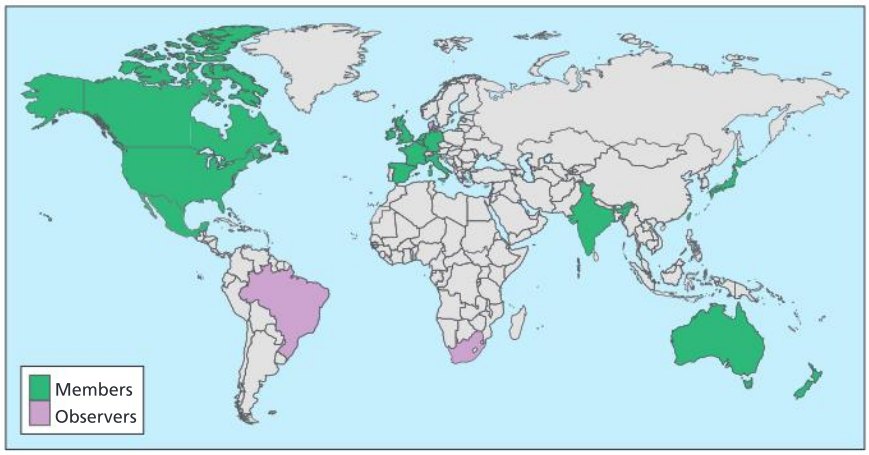
A social civil society: Oxfam

Oxfam is an international charity focused on the alleviation of global poverty. It was originally founded in Oxford, UK, in 1942, as the Oxford Committee for Famine Relief, with the aim of getting food to people in Greece during the Second World War. The first Oxfam office outside the UK was established in Canada in 1963.

Oxfam's aims have changed to address the causes of poverty and injustice, having human rights to the fore of its mission. The Oxfam International strategic plan states that everyone has the right to:

- a sustainable livelihood
- basic social services
- life and security
- be heard
- an identity.

Oxfam believes that poverty and powerlessness can be eliminated if there is political will and human action. Nevertheless, Oxfam continues to work in three main areas: development support, which aims to lift people out of poverty with sustainable projects, for example the Saving for Change initiative, a microfinance scheme in which local communities form small credit groups; humanitarian work following natural disasters and conflict; and lobbying and campaigning.



▲ **Figure 6.17:** Countries in which Oxfam is present

In its 2015 Report, Oxfam claimed that the combined wealth of the world's richest 1 per cent will overtake that of everyone else by 2016, given the trend of rising inequality. In its activities, Oxfam focuses on economic justice, essential services, rights in crisis and gender justice.

- Economic justice focuses on improving farming for farmers and labourers, fairer trade, and reducing shocks from energy changes and climate change.
- Essential services refers to the provision of health education, water and sanitation.
- Rights in crisis refers to assistance given during conflicts and after disasters, as well as attempts to prevent conflict, improve peacekeeping and allow reconciliation.
- Gender justice seeks to support women's leadership and increase the number of women receiving an education.

Oxfam opened its first shop in 1948 and it now has about 1,200 shops worldwide, selling books, CDs, crafts, clothing, toys and ethnic products. In 2013 Oxfam established a "Behind the brands" project, in which they provided information on the policies of the biggest food brands against the following criteria:

- transparency at a corporate level
- women farm workers and small-scale producers in the supply chain
- workers on farms in the supply chain
- small-scale farmers growing the commodities

▼ **Table 6.4:** Progress of food companies in Oxfam's "Behind the brands" project (as companies improve, their scores go up)

Company	Score, February 2013	Score, October 2014
Nestlé	54%	70%
Unilever	49%	70%
Coca-Cola	41%	59%
PepsiCo	31%	44%
Mondelēz	29%	34%
Danone	29%	31%
Mars	30%	31%
Kellogg's	23%	31%
General Mills	23%	30%
Associated British Foods	19%	30%
Average score	**32.8%**	**43%**

- land rights and sustainable use of land
- water rights and the sustainable use of water
- methods of reducing climate change and adapting to climate change.

Oxfam's Make Trade Fair aims to eliminate a number of practices, including the dumping in LICs of highly subsidized foods produced in HICs; high import tariffs, which makes sales of goods from LICs expensive; unequal labour laws, in which women earn less than their male counterparts; and patent issues of seeds, medicines, software, and so on.

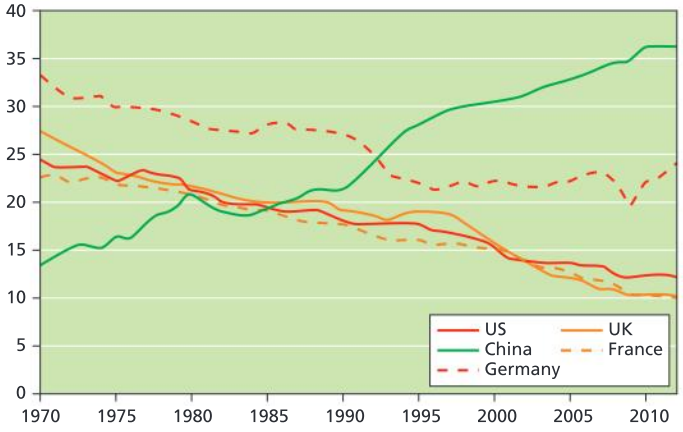
However, there have been some criticisms of Oxfam. They include allegations that Oxfam is politically motivated; that it has a corporate-style internal structure; that some of its trustees were tax avoiders, and that its stores have forced the closure of small specialist stores and other charity shops.

Strategies to build resilience

Reshoring of economic activity by TNCs

During the 1970s and 1980s, there was a massive reduction in manufacturing employment in HICs as a result of offshoring to LICs (Figure 6.18), which offered the advantage of low-cost labour. However, that advantage is being eroded as the cost of labour in LICs rises, and concerns now exist in HICs over the source of goods, working conditions in LICs, delivery times and rising unemployment.

▼ **Figure 6.18:** Changes in the manufacturing share of national output (% of national value added)



Reshoring offers many benefits, although they are not guaranteed. According to EY, it could generate £15.3 billion for the UK economy and provide 315,000 jobs – although this estimate did not take into account the possible impacts of the UK's decision to leave the EU with its implications for access to the EU market.

While offshoring benefited consumers, it led to a decline in employment in HICs. In the UK, some £36 billion of output was offshored between 1995 and 2011, and over 560,000 jobs. Support services such as IT and call

▼ **Table 6.5:** Reasons for reshoring

Push factors from overseas	Pull factors to return home
• Rising global oil prices, increasing transport costs	• Increased demand for customization of products and smaller runs
• A relative lack of skilled labour in LICs compared with HICs	• A tradition of manufacturing and public demand to maintain employment in HICs
• Rising labour costs in LICs and NICs	• Consumers increasingly demanding quick delivery times
• Greater risks in the supply chain	• Higher levels of R&D

centres were also offshored, leading to a loss of about £6 billion and a further 144,000 jobs. However, the employment loss varied throughout the country. Losses were greater in the manufacturing heartlands of the Midlands and the north-east, whereas the jobs available in London grew by over 33 per cent between 1996 and 2014.

Examples of reshoring include Bathrooms.com, which is investing £2.5 million in the UK Midlands, where it will manufacture 25 per cent of its products in order to shorten delivery times for customers. Jaeger plans to return up to 10 per cent of its production to the UK from Asia, in order to reduce delivery times and improve quality.

Capital-intensive sectors with complex supply chains and rapidly changing markets (partly due to fashion) are most likely to reshore. These include petroleum, chemicals and aerospace (capital-intensive); pharmaceuticals and chemicals (R&D); and textiles, leather goods, tobacco and repair of transport equipment (complex supply chains).

▼ **Table 6.6:** Potential GDP and employment in the UK due to reshoring (top five sectors)

Sector	Total GDP (£ million)	Total employment	Reasons for reshoring
Electronic and optical products	1,350	18,100	Supply and demand of skilled labour
Motor vehicles	1,130	26,300	Supply and demand of skilled labour
Other manufactured goods (incl. musical, furniture, medical/ dental, sports goods)	1,100	25,200	Managing complex supply chains
Clothing	1,100	28,000	Reduce transport costs
Paper and paper products	870	18,700	Managing complex supply chains

Source: Adapted from "Reshoring manufacturing – time to seize the opportunity", http://www.ey.com/Publication/vwLUAssets/Reshoring_manufacturing_%E2%80%94_time_to_seize_the_opportunity/$FILE/3451_EY%20Reshoring%20Report_V8%200nline.pdf

There are a number of impacts of reshoring:

- direct impacts on output, GDP and employment
- indirect impacts in output, GDP and employment in the supply chain
- multiplier effects, when the employees of the reshored industries spend their earnings in the economy and increase demand for services.

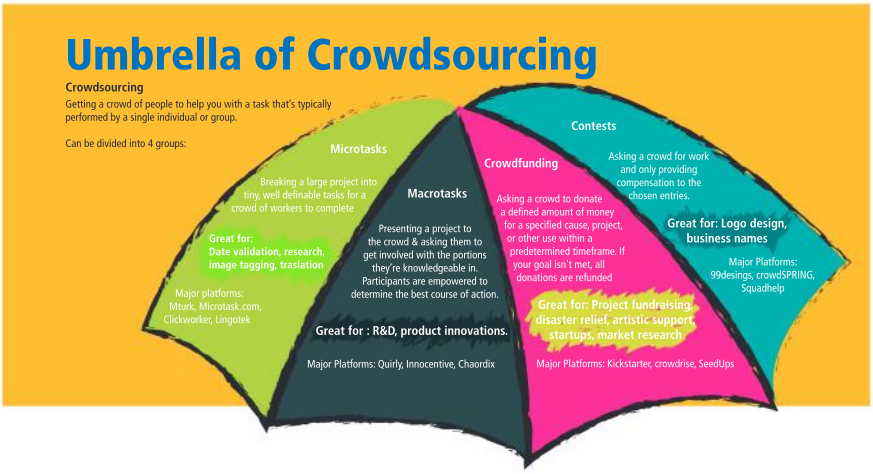
The benefits of reshoring are geographically diverse. In the UK, the south-east region and the north-west benefit most, partly because of the concentration of the defence, electronics and aerospace industries there. Although the UK's share of global car production and output of pharmaceuticals has decreased since 1980, reshoring has the potential to lift production, employment and sales of both.

Activity 13

1. Compare the share of manufacturing in national output between China and the USA/UK.
2. Explain why some companies in HICs are reshoring their production.
3. Identify the economic sectors and types of company that are most likely to reshore.

Crowdsourcing

Crowdsourcing is the process of sourcing ideas, services, finances and information from the public via the Internet in order to benefit from the collective abilities of a large group of people. It has developed because top-down approaches, whereby the government provides the solutions to problems, have proved insufficient. Crowdsourcing empowers people and builds mutual support.



▲ **Figure 6.19:** A model of crowdsourcing

Crowdsourcing is seen as a way of improving a situation using a community's best assets, namely its population. Crowdsourcing has been used in times of natural disasters. Following the Haitian earthquake of 2010, 650 volunteers produced digital maps of the conditions of roads and levels of accessibility. Following the earthquake in Nepal, crowdfunding raised over $20 million in 60 days. It also provided images of buildings, schools and hospitals daily, to help search, rescue and relief workers.

Crowdsourcing allows organizations to tap into the creativity of large numbers of people. However, there are drawbacks: plans and expectations must be clearly stated because there is a danger that different people may interpret plans differently.

▼ **Table 6.7:** Crowdsourcing categories

Category	Description of technology-enabled crowdsourcing
Crowd wisdom	Initiatives to solve innovation challenges or complex problems
Crowd creation	Initiatives to produce marketable intellectual goods
Crowd review	Initiatives to promote knowledge sharing and combining for decision-making
Crowdfunding	Initiatives to support the raising of funds for projects, businesses or enterprises through the collective effort of many
Crowd democracy	Initiatives to promote open government
Citizen science	Initiatives to promote involvement of non-scientists in research projects
Citizen journalism	Initiatives to share and aggregate content of journalistic value
Crowdsourcing for crisis response	Initiatives to involve individuals in disaster and crisis response and recovery

Source: Smith, K. "Economic resilience and crowdsourcing platforms", *J. Inf. Syst. Technol. Manag.* Vol. 12, No. 3, Table 1, Ramos, I and Desouza, K. 2015

The concept of resilience refers to the ability of individuals, communities or environments to respond to shocks and changes while continuing to operate and/or improve under the new circumstances. Crowdsourcing allows for the creation of social networks of experience and knowledge. It allows for the rapid transmission of ideas and opportunities, which would have been more difficult in the era before the Internet. For example, Wikipedia is an example of a crowdsourced effort that enables people in most places to obtain information on most subjects very quickly, and at very limited cost.

Crowdsourcing can be used to find new ways of providing services. For example, in 2011 the Bill and Melinda Gates Foundation introduced the "Reinventing the Toilet Challenge", a US$100,000 challenge to design a toilet that could dispose of human waste without a septic tank or an outside water system. The winning design was a solar-powered system that could break down waste and water into fertilizer and hydrogen.

Crowdsourcing offers many opportunities for people to interact with one another and find solutions to old and new problems. High-speed global connections have facilitated these interactions. Indeed, the increased interdependence and complexity of global interactions necessitates the involvement of many different stakeholders in finding solutions for problems as they arise. Crowdsourcing is a high-technology, bottom-up approach to empowering communities around the world.

Activity 14

1. Briefly explain what is meant by crowdsourcing.
2. Comment on the range of crowdsourcing activities, as shown in Table 6.7.
3. Explain one advantage and one disadvantage of crowdsourcing.

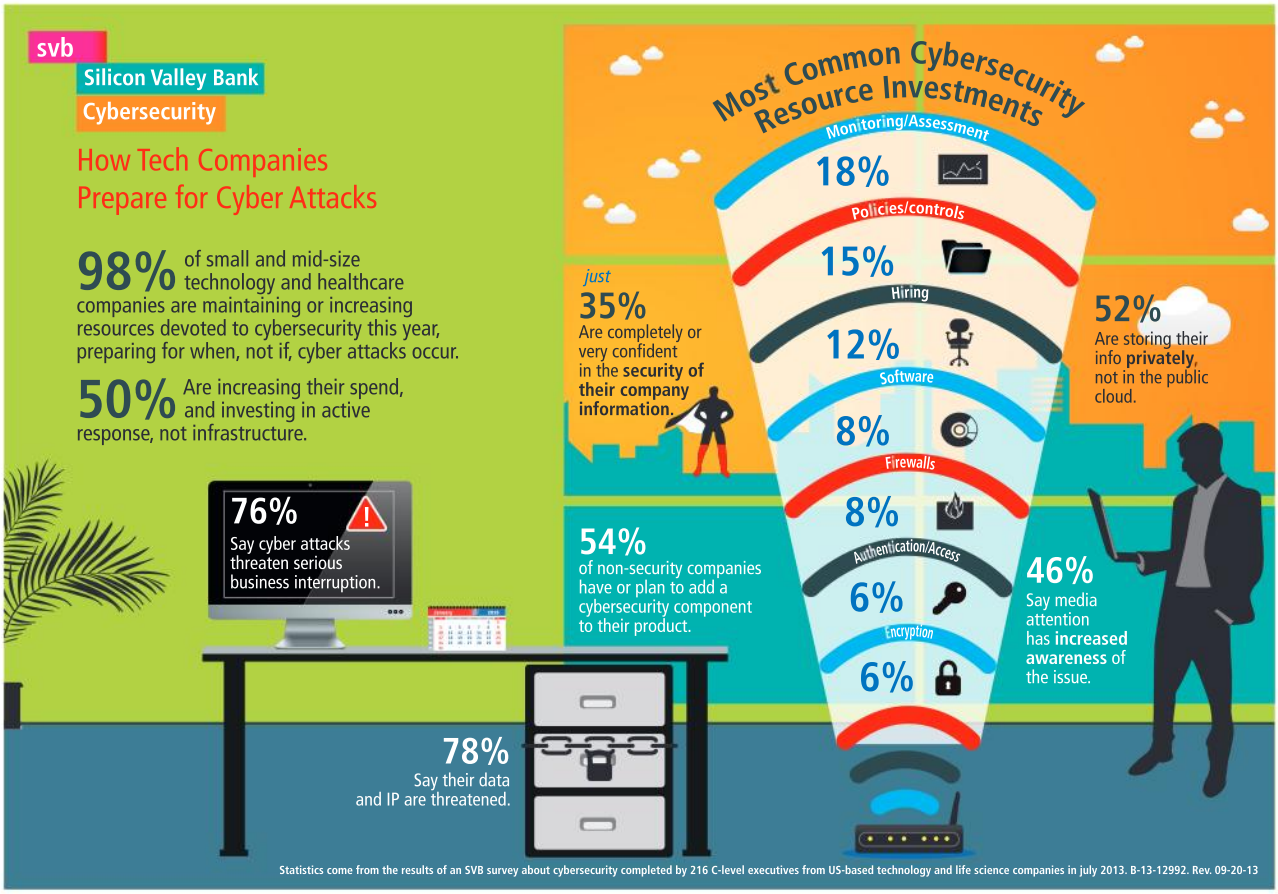
New technologies for the management of global flows of data and people

A number of new technologies have been developed to manage flows of global data and people. These include cybersecurity and e-passports.

Cybersecurity

Cybersecurity, or computer security, is the protection of information systems, hardware and software from theft or damage, as well as the protection of information on computers and related technology. The need for cybersecurity is increasing as more and more people and organizations rely on computers and the Internet.

There are many threats to computer security. One of the most common is "phishing" – the attempt to obtain personal or sensitive information such as user names, passwords, bank account details and credit card details. Most computers have some level of protection, but threats are becoming more sophisticated and protection systems need to keep ahead of the threats. Common targets are large organizations, government departments, military computer systems and airline carriers. The most common prevention systems are firewalls, which stop access to internal network systems and filter out different kinds of attack.



▲ **Figure 6.20:** Cyber security statistics

Activity 15

Study the infographic on cybersecurity, Figure 6.20.

1. Comment on the issues relating to cybersecurity provided in Figure 6.20.
2. Outline the ways in which companies and individuals are responding to cybercrime.

One of the main issues regarding cybersecurity is that there are no international regulations or common rules to abide by. Moreover, national security may be vulnerable to attacks from another country, making any international treaty difficult to regulate and enforce.

In December 2016, former US president Barack Obama expelled 35 Russian diplomats over the alleged cyber-attacks on the Democratic National Committee, Hilary Clinton and other political organizations, in the attempt to influence the US election in favour of the Republican candidate, Donald Trump.

E-passports

An e-passport has a computer chip in it, which contains data about the owner. The advantages of the e-passport include faster checking in and border clearance. E-passports may also help in crime detection as some contain biometrics such as fingerprints, which may be left at the site of a crime. In addition, if someone loses their passport, the documents should be retrievable from a database and allow travel. E-passports are difficult to reproduce or forge, so security is improved. They also make it more difficult for one person to have several passports (unless they have dual citizenship).

▲ **Photo 6.8:** E-passports

E-passports have a number of disadvantages. If the passport is stolen, the data could be used illegally. It would be possible for someone to hack into the system and change the data. Moreover, the person who owns the passport does not have access to the data.

Activity 16

1. Identify the information contained in an e-passport.
2. Briefly explain how e-passports improve security.

Check your understanding

1. Outline the main focus of the WWF's environmental interests.
2. In what ways has the WWF been criticized for its actions?
3. Outline Oxfam's main interests in the development process.
4. How have Oxfam's interests changed over time?
5. Comment on the membership of Oxfam, as shown in Figure 6.17.
6. Explain why many TNCs are reshoring.
7. Outline the main advantages of crowdsourcing.
8. Briefly explain why cyber security has become a major global issue.
9. Explain why it is difficult to manage cyber security.
10. Outline the main advantages and disadvantages of e-passports.

Concepts in context

There are emerging **possibilities** for managing global risks. International civil society organizations have raised awareness about, and found some solutions for, environmental and social risks associated with global interactions. Strategies to build resilience include the reshoring of economic activity by TNCs, the use of crowdsourcing technologies to build resilience by government and civil society, and new technologies for the management of global flows of data and people, including cyber security and e-passports.

Synthesis and evaluation

- Many international civil society organizations aim to deal with environmental and social risks associated with global interactions. Some of these organizations are very large but some are quite small. They have to deal with many stakeholders, as well as those negatively affected by the impacts of global interactions. All organizations require funds in order to function, and many civil societies are criticized for the way they fundraise.
- Global interactions are also seen as having negative effects on HICs, in particular in terms of manufacturing industry and employment. Consequently, HICs are reshoring some industries to increase employment, reduce travel time and improve the quality of goods.
- New methods and new technologies are developing. Crowdsourcing is an umbrella term for many fundraising and information-sharing activities. High-speed global interactions have made this possible. However, the increase in global interactions has led to an increase in cybercrime, and there has been an increase in the need for cyber security. The development of e-passports has made people movement more secure, although not completely.
- Geographers need to be aware of new, evolving technologies and systems, and to see how they could benefit communities – and, equally, how they can be abused.

EXAM PRACTICE

(a) Examine the geopolitical and economic risks as a result of new technology. (12 marks)

(b) Examine the success of international civil society in raising awareness and finding solutions to the risks associated with global interactions. (16 marks)

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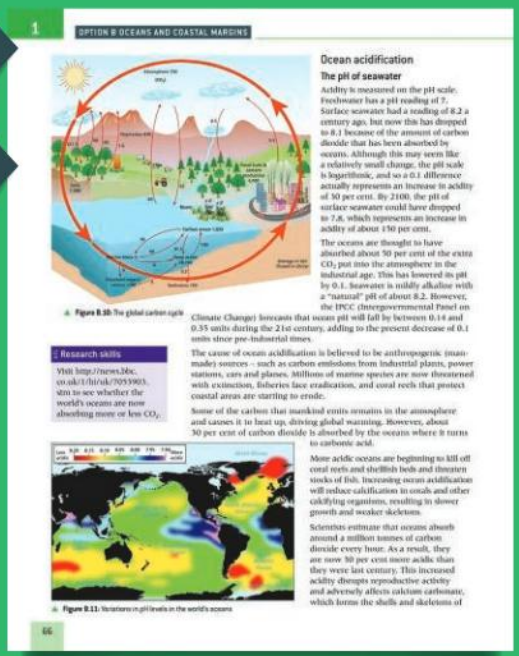

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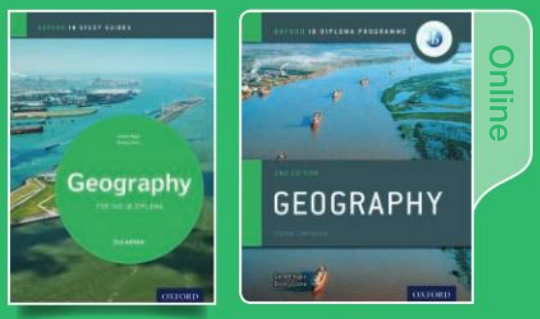

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