GEOGRAPHY

A LEVEL Abridged Textbook to be used for Bridging Work 2025

Physical Geography

Weathering, mass movement and runoff

In this section you will learn about geomorphological processes in coastal environments

Weathering

Weathering is the breakdown or disintegration of rock in situ (its original place) at or close to the ground surface. Energy flows can be clearly demonstrated as most processes involve (directly or indirectly) energy transfer from the Sun, in the form of radiation, or rain. As a process, weathering leads to the transfer (flow) of material. There are also important links with other natural systems, such as the water cycle (e.g. freeze-thaw) and the carbon cycle (e.g. carbonation).

Weathering is active at the coast where rock faces are exposed to the elements and cliff faces kept fresh by the constant removal of debris by the sea.

- If the rate of debris removal exceeds the rate of weathering and *mass movement* then a positive feedback may operate, as the rate of weathering and mass movement could increase.
- If debris removal is slow and ineffective, this will lead to a build-up of an apron of debris (*scree*) that reduces the exposure of the cliff face as it extends up the cliff face. Weathering and mass movement rates will decrease – a negative feedback.

Weathering can be divided into three different types: mechanical, biological and chemical. By breaking rock down, weathering creates sediment that the sea can then use to help erode the coast.

Mechanical (physical) weathering

Mechanical (or physical) weathering involves the break-up of rocks without any chemical changes taking place. There are several types of mechanical weathering processes that are active at the coast.

- *Frost shattering* (also known as *freeze-thaw*) occurs when water enters a crack or joint in the rock when it rains and then freezes in cold weather. When water freezes, it expands in volume by about 10 per cent. This expansion exerts pressure on the rock, which forces the crack to widen (see 2.6 and 4.6). With repeated freezing and thawing, fragments of rock break away and collect at the base of the cliff as scree. These angular rock fragments are then used by the sea as tools in marine erosion. Although the coast tends to be milder than inland, frost shattering is still important. For example, in 2001 (following a very wet autumn and a cold February) frost shattering triggered several major rockfalls along the south coast of England (see Figure 1). Chalk (a permeable and porous rock) was the main rock affected.
- *Salt crystallisation.* When salt water evaporates, it leaves salt crystals behind. These can grow over time and exert stresses in the rock, just as ice does, causing it to break up (see 2.6). Salt can also corrode rock, particularly if it contains traces of iron.
- *Wetting and drying.* Frequent cycles of wetting and drying are common on the coast. Rocks rich in clay (such as shale) expand when they get wet and contract as they dry. This can cause them to crack and break up.

Figure 1 *A major rockfall at the White Cliffs of Dover in 2012, caused by frost shattering*

Biological weathering

The breakdown of rocks by organic activity is *biological weathering*. There are several ways in which this can operate at the coast.

- Thin plant roots grow into small cracks in a cliff face. These cracks widen as the roots grow, which breaks up the rock (Figure **2**).
- Water running through decaying vegetation becomes acidic, which leads to increased chemical weathering (see below).
- Birds (e.g. puffins and sand martins) and animals (e.g. rabbits) dig burrows into cliffs.
- Marine organisms are also capable of burrowing into rocks (e.g. piddocks, which are similar to clams), or of secreting acids (e.g. limpets).

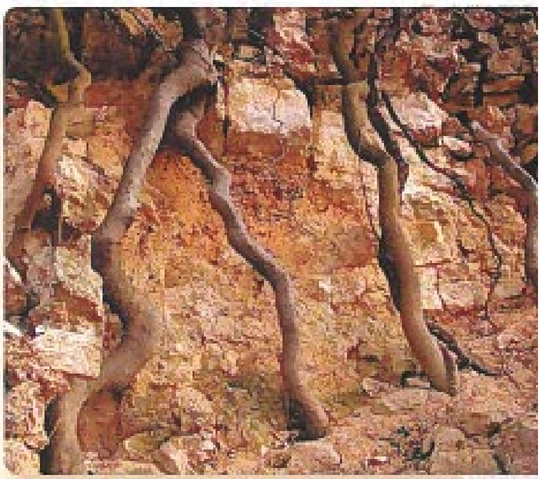


Figure 2 *Biological weathering*

Chemical weathering

Chemical weathering involves a chemical reaction where salts may be dissolved or a clay-like deposit may result which is then easily eroded.

- *Carbonation* – rainwater absorbs carbon dioxide from the air to form a weak carbonic acid. This reacts with calcium carbonate in rocks, such as limestone and chalk, to form calcium bicarbonate, which is easily dissolved. The cooler the temperature of the rainwater, the more carbon dioxide is absorbed (so carbonation is more effective in winter). Carbonation is an important part of the carbon cycle (see 1.13).
- *Oxidation* – the reaction of rock minerals with oxygen, for example iron, to form a rusty red powder leaving rocks more vulnerable to weathering.
- *Solution* – the dissolving of rock minerals, such as halite (rock salt).

Figure 3 *One of seven holiday chalets that had to be demolished and removed from this location at Lyme Regis in 2014 following a series of landslips*

Mass movement

The downhill movement of material under the influence of gravity is known as **mass movement**. It can range from being extremely slow – less than 1 cm a year (e.g. soil creep) – to horrifyingly fast (e.g. rockfalls and landslides). Mass movement at the coast is common – the sheer weight of rainwater, combined with weak geology, is the major cause of cliff collapse.

In February 2014, following the wettest winter on record, the Jurassic Coast near Lyme Regis in Dorset was affected by a number of dramatic landslips, damaging holiday chalets (Figure **3**). This exposed stretch of coastline and is constantly being shaped and reshaped by processes of mass movement invigorated by undercutting by the sea.

Mass movement forms an important group of processes and flows within the coastal system, transferring both energy (in response to gravity) and sediment. The sediment forms an important input to shoreline processes, forming the 'tools' for erosion and providing material to be transported and deposited elsewhere along the coastline. Mass movement, along with cliff erosion, provides an important input to sediment cells (see 3.3).

Types of mass movement

lass movement can be classified into four main ypes – creep, flow, slide and fall (Figure **4**). Each rocess represents a flow or transfer of material nd can be considered to be an output from one tore (land) and an input to another store beach/sea). The type of movement at any one lace depends upon a range of factors – angle f the slope or cliff; rock type and structure; egetation cover; how wet the ground is.

Type of mass movement	Nature of movement	Rate of movement	Wet/dry
Soil creep Solifluction	Creep/flow	Imperceptible	Wet
Mudflow	Flow	Often quite rapid	Wet
Runoff	Flow	Rapid	Wet
Landslide/debris slide Slump/slip	Slide	Usually rapid	Dry Wet
Rockfall	Fall	Rapid	Dry

Figure 4 *Classifying different types of mass movement*

Soil creep

As the name implies, *soil creep* is an extremely slow form of movement of individual soil particles downhill. The precise mechanism of movement often involves particles rising towards the ground surface due to wetting or freezing and then returning vertically to the surface in response to gravity as the soil dries out or thaws (see 4.7). This zigzag movement is similar to that of longshore drift. Soil creep cannot be seen operation but its action can be implied by the formation of shallow terracettes, the build-up of soil on the upslope side of walls and the bending of tree trunks (Figure **5**).

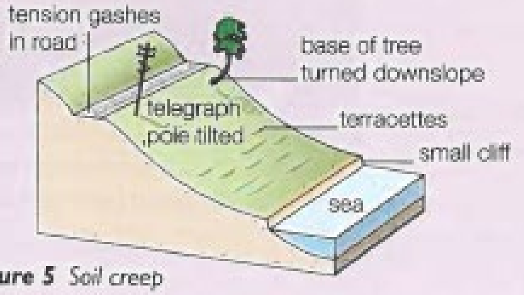


Figure 5 *Soil creep*

Mudflows

A *mudflow* involves earth and mud flowing downhill, usually over unconsolidated or weak bedrock such as clay, often after heavy rainfall. Water gets trapped within the rock, increasing pore water pressure, which forces rock particles apart and leads to slope failure. Pore water pressure is a form of energy within the slope system and it is an extremely important factor in determining slope instability. Mudflows are often sudden and fast-flowing so can represent a significant natural hazard.

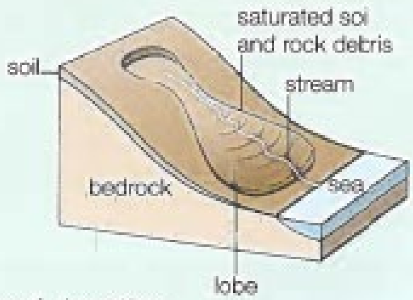


Figure 6 *A mudflow*

Landslide

A *landslide* involves a block of rock moving very rapidly downhill along a planar surface (a slide plane), often a bedding plane that is roughly parallel to the ground surface (Figure **7**). Unlike a mudflow, where the moving material becomes mixed, the moving block of material in a landslide remains largely intact.

Landslides are frequently triggered by earthquakes or very heavy rainfall, when the slip surface becomes lubricated and friction is reduced. Landslides tend to be very rapid and pose a considerable threat to people and property. In 1993, 60 m of cliff slid onto the beach near Scarborough in North Yorkshire, taking with it part of the Holbeck Hall Hotel (Figure **8**).

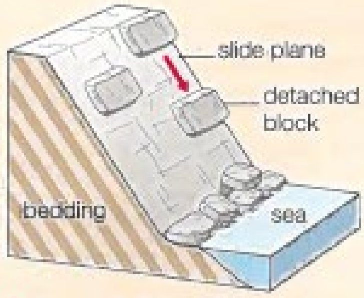
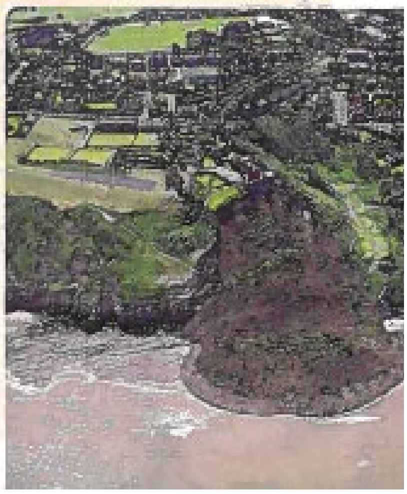


Figure 7 *A landslide*

Figure 8 *Landslide in 1993 at Holbeck Hall, Scarborough*



Rockfall

A *rockfall* involves the sudden collapse or breaking away of individual rock fragments (or a block of rock) at a cliff face. They are most commonly associated with steep or vertical cliffs in heavily jointed and often quite resistant rock. A rockfall is often triggered by mechanical weathering (particularly freeze-thaw) or an earthquake. Once broken away from the source, rocks fall or bounce down the slope to form scree (also known as talus) at the foot of the slope (Figure **9**). Scree often forms a temporary store within the coastal system, with material gradually being removed and transported elsewhere by the sea. When this occurs the scree forms an input into the sediment cell.

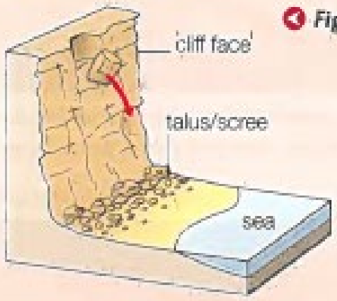


Figure 9 *A rockfall*

Runoff

Runoff is a good illustration of the link between the water cycle and the coastal system. When overland flow occurs down a slope or cliff face, small particles are moved downslope to enter the littoral zone, potentially forming an input into the sediment cell. Runoff can be considered a type of flow that transfers both water and sediment from one store (the rock face) to another (a beach/the sea).

Toxic chemicals can contaminate stormwater and cause threats to coastal ecosystems, illustrating yet another link between natural systems (see 6.10).

Solifluction

Essentially, *solifluction* is similar to soil creep but specific to cold periglacial environments (see 4.7 and 4.11). In the summer, the surface layer of soil thaws out and becomes extremely saturated because it lies on top of impermeable frozen ground (permafrost). Known as the active layer, this sodden soil with its blanket of vegetation slowly moves downhill by a combination of heave and flow. Solifluction characteristically forms features called *solifluction lobes* (see 4.11).

Landslip or slump

A *landslip* or *slump* differs from a landslide in that its slide surface is curved rather than flat. Landslips commonly occur in weak and unconsolidated clays and sands, often when permeable rock overlies impermeable rock, which causes a build-up of pore water pressure. Landslips or slumps are characterised by a sharp break of slope and the formation of a scar (Figures **10** and **11**). Multiple landslips can result in a terraced appearance on the cliff face.

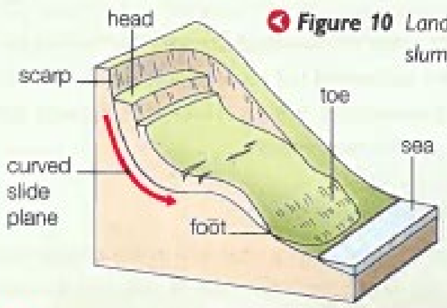


Figure 10 *Landslip or slump*

Figure 11 *A rotational scar at Christchurch Bay, Barton-on-Sea, Dorset*

ACTIVITIES

1. In pairs, discuss and decide (**a**) the part played by weathering and its influence on the rate of coastal retreat, (**b**) which forms of weathering are likely to have the greatest impact in different parts of the UK.
2. Explain why evidence of past solifluction can be seen in some parts of the UK.
3. Explain the significance of weathering and mass movement in relation to the coastal system. Use the correct systems terminology in your answer and consider drawing a simple diagram to support your answer.
4. Explain how the methods by which sediment is supplied to the coastal system are likely to vary between areas of resistant and weak geology.
5. Distinguish between the following pairs of terms: (**a**) weathering and mass movement; (**b**) flows and slides; (**c**) landslides and landslips; (**d**) soil creep and solifluction; (**e**) rockfalls and slumping.

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6. In pairs, discuss and devise two flow diagrams to outline the sequence of processes that probably led to the rockfall at Dover (Figure **1**) and the landslip at Lyme Regis (Figure **3**).

Marine processes – erosion, transportation and deposition

In this section you will learn about coastal processes

An unbelievable storm

The residents of Riviera Terrace in Dawlish are used to their homes shaking when a storm hits the South Devon coast. 'But this was different,' said one resident. 'It was like being in a car wash. The storm was unbelievable and waves were pounding against the terrace.'

The winter storm that hit Dawlish in February 2014 was so powerful that the waves destroyed part of the sea wall – leaving a section of rail track dangling in mid-air and cutting the rail connection between Devon, Cornwall and the rest of the UK for two months.

Figure 1 *The powerful storm of February 2014 – waves crash against the sea front and railway line in Dawlish*

Coastal erosion

Coastal erosion plays a vital role in the coastal system, removing debris from the foot of cliffs and providing an input into coastal sediment cells. The storm of February 2014 transformed the shape of parts of the Devon coast as huge quantities of sediment were swept away from beaches; a few miles from Dawlish, sand dunes at Dawlish Warren (spit) were severely eroded by the powerful waves and several groynes were damaged.

Coastal erosion is a manifestation of the energy of the Sun, converted by the power of the wind into waves capable of sculpting landforms and eroding sediment. While it is possible to identify several distinctive processes of marine erosion, in reality they will often work collaboratively to erode a stretch of coastline. Figure **2** shows undercutting of a cliff resulting from the processes of erosion.

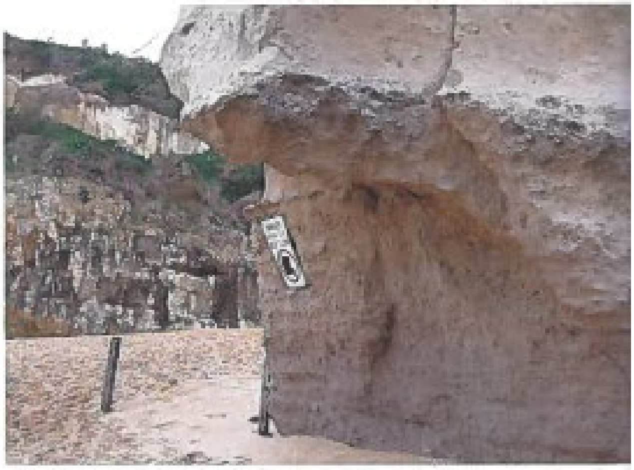


Figure 2 *Cliff undercutting and weakening*

Coastal erosion processes

Hydraulic action

Look at Figure **3**. The sheer force of the water as it crashes against a coastline is called *hydraulic action*. When a wave advances, air can be trapped and compressed, either in joints in the rock or between the breaking wave and the cliff. When the wave retreats, the compressed air expands. This continuous process can weaken joints and cracks in the cliff, causing pieces of rock to break off. Simultaneously, bubbles formed in the water may implode under the high pressure. This generates tiny jets of water which will, over time, erode the rock. This process is specifically termed cavitation.

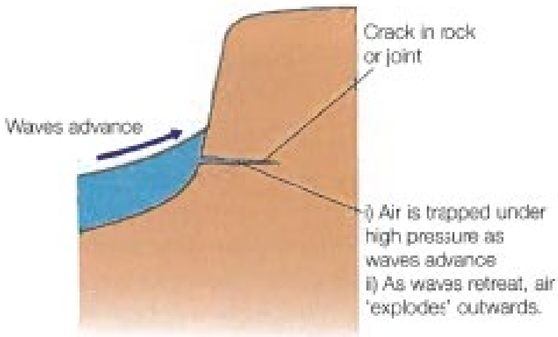


Figure 3 *Cliff-foot erosion – hydraulic action*

Wave quarrying

Wave quarrying is the action of waves breaking against unconsolidated material such as sands and gravels. Waves scoop out the loose material in a similar way to the action of a giant digger in a quarry on land.

Corrasion

When waves advance, they pick up sand and pebbles from the seabed, a temporary store or sediment sink. When they break at the base of the cliff, the transported material is hurled at the cliff foot – chipping away at the rock. This is *corrasion* (Figure **4**). This is a good example of an energy flow in action within the coastal system. The size, shape and amount of sediment picked up by the waves, along with the type of wave, determines the relative importance of this erosive process.

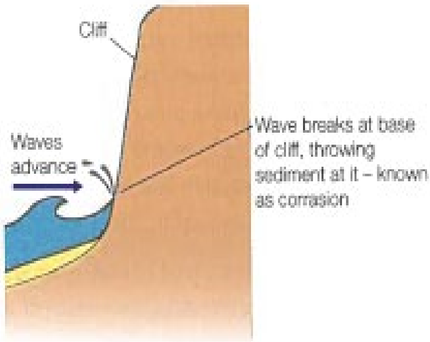


Figure 4 *Cliff-foot erosion – corrasion*

Abrasion

Corrasion hurls sediment at a cliff face. Abrasion involves more of a 'sandpapering effect' as sediment is dragged up and down or across the shoreline, eroding and smoothing rocky surfaces. Abrasion is particularly important in the formation of a *wave-cut platform* (see 3.6).

Solution (corrosion)

Weak acids in seawater can dissolve alkaline rock (such as chalk or limestone), or the alkaline cement that bonds rock particles together. This is *solution*. The action of this type of erosion may be indistinguishable from the action of carbonation, a type of weathering (and an important link to the carbon cycle). This is a good example of processes (in this case erosion and weathering) working collaboratively and being hard to separate. Does it really matter?

In addition, the process of *attrition* also takes place at the coast but it is not directly responsible for the erosion of a coastline. Attrition refers to the gradual wearing down of rock particles by impact and abrasion, as the pieces of rock are moved by waves, tides and currents. This process gradually makes stones rounder and smoother.

Figure 5 *Boulder clay cliffs on the Holderness coast*

Factors affecting coastal erosion

There are several factors that affect the nature and rate of coastal erosion, including waves, rock type and geological structures, the presence or absence of a beach, subaerial processes and management.

- Waves – the rate and type of erosion experienced on a particular stretch of coast is primarily influenced by the size and type of waves that reach that coast. Most erosion happens during winter storms (such as the one that hit Dawlish in 2014), when destructive waves are at their largest and most powerful.
- Rock type (lithology) – rock lithology (its physical strength and chemistry) is important in determining the rate of erosion. Tough and resistant rocks such as granite erode at very slow rates compared to weaker clays and shales. In the UK, some of the fastest rates of erosion occur on the Holderness coast in Lincolnshire where unconsolidated glacial till deposits have been eroded by 120 m in the past century (Figure **5**). During the same time period, the granite at Land's End has been eroded by just 10 cm!

Marine processes – erosion, transportation and deposition

- Geological structure – cracks, joints, bedding planes and faults create weaknesses in a cliff that can be exploited by erosive processes. On a large scale, variations in rock type and geological structure can lead to the formation of headlands and bays, as a result of the subsequent differential erosion.
- Presence or absence of a beach – beaches absorb wave energy and reduce the impact of waves on a cliff. If a beach is absent, following excessive erosion or as a result of management techniques elsewhere on the coast, a cliff may experience increased erosion as it is more vulnerable to wave attack.
- Subaerial processes – weathering and mass movement will weaken cliffs and create piles of debris that are easily eroded by the sea, potentially increasing the rate of erosion.
- Coastal management – the presence of structures such as groynes and sea walls will have an impact on sediment transfer (and the build-up of beaches) and patterns of wave energy along a coastline. In trapping sediment moved by longshore drift, groynes may deprive beaches further down-drift of sediment input and may decrease in extent. Sea walls may deflect wave energy elsewhere along the coast exacerbating erosion in those localities.

Coastal transportation processes

Coastal transportation plays a major role in the coastal system, transferring sediment from one store to another, for example, from the foot of a cliff to a spit or an offshore bar. As with coastal erosion, it is a manifestation of an energy flow, governed, controlled and determined by the power of waves, tides and currents. It is possible to identify four methods of transportation:

- *Traction* – the rolling of coarse sediment along the sea bed that is too heavy to be picked up and carried by the sea
- *Saltation* – sediment 'bounced' along the seabed, light enough to be picked up or dislodged but too heavy to remain within the flow of the water
- *Suspension* – smaller (lighter) sediment picked up and carried within the flow of the water
- *Solution* (dissolved load) – chemicals dissolved in the water, transported and precipitated elsewhere. This form of transportation plays an important role in the carbon cycle, transferring and redepositing carbon in the oceans.

The key factors affecting the type of transportation are velocity (energy) and particle size (mass). In high-energy environments, larger particles will be able to be transported, whereas in low-energy environments only the finest particles (clays) will be transported.

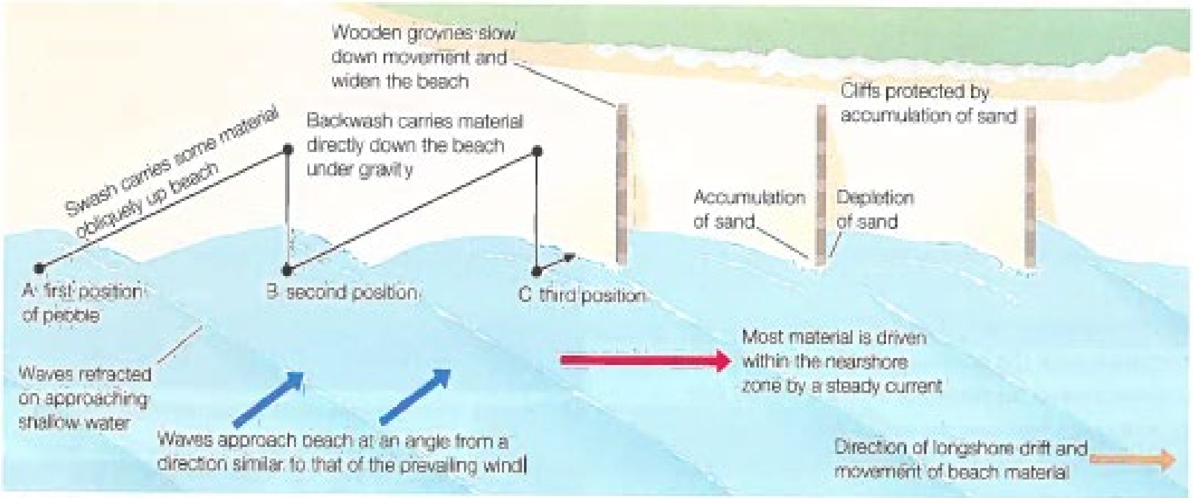
Longshore (littoral) drift

Most waves approach a beach at an angle – generally from the same direction as the prevailing wind. Along the coast of southern England, for example, winds blow onshore from the south-west throughout the year. As the waves advance, material is carried up the beach at an angle. The backwash then pulls material down the beach at right angles to the shore (due to the force of gravity, in effect a source of energy). The net effect of the zigzag movement of sediment up and down the beach is a process is known as *longshore (littoral) drift* (see Figure **6**).

Longshore drift is an important transfer (flow) mechanism as it is responsible for moving vast amounts of sediment along the coastline and eventually out to sea, for example, at the tip of a spit. It is a very important component in a sediment cell and, if interrupted by management strategies, can lead to distortions of natural patterns, depriving beaches of material and exacerbating erosion.

Stores, flows and sinks will all be affected if longshore drift is interrupted. For example, in West Africa, the prevailing south-west winds transport sediment from west to east, from Ghana eastwards to Togo and Benin. However, due to coastal management, not enough sand is reaching the eastern countries to replace that transported away by longshore drift. As a result of this, parts of Benin's coastline is being eroded at an astonishing 10 m per year due to the lack of a protective beach in front of the cliffs.

Figure 6 *The process of longshore drift*



Coastal deposition

Deposition takes place when the velocity of the water (or wind) falls below a critical value for a particular size of particle and can no longer be transported. In high-energy environments, such as exposed parts of the south coast of England, clay and sand will be easily transported away leaving behind the larger, coarser pebbles to form the characteristic shingle beaches. In low-energy environments, such as river estuaries in the lee of spits, the very smallest clay particles will eventually drop to the seabed to form mudflats. Some sediment may be carried offshore to form underwater sandbanks.

Sediment deposition is an extremely important part of the overall coastal system and, more specifically, the sediment cell. Areas of deposition – beaches, spits, mudflats, sand dunes and offshore bar – are all sediment stores or 'sinks' (Figure **7**). While some sediment sinks may be considered to be outputs they can also act as important inputs to the coastal system. For example, offshore sediment deposits have been driven onto the south coast of England by rising sea levels following the end of the last glacial period.

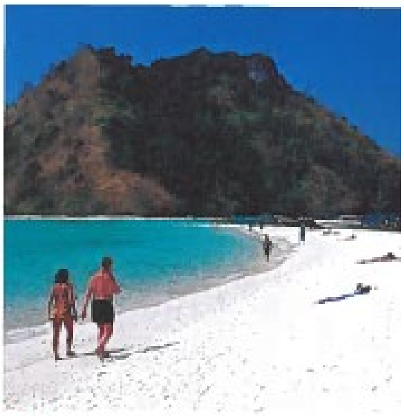


Figure 7 *A sandbank at Ko Poda Island, Thailand – an example of a sediment sink*

ACTIVITIES

1 **a** Study Figure **2**. What types of erosion are likely to have been dominant? Give reasons for your answer.

b Suggest the factors responsible for the nature and extent of coastal erosion of this cliff.

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2 With the aid of a simple diagram describe the process of longshore (littoral) drift.

3 Under what circumstances and for what reasons does coastal deposition occur?

4 Discuss the factors affecting the rate and nature of coastal transportation.

5 How can coastal management schemes such as constructing sea walls and groynes result in a positive feedback loop by increasing the rate of erosion elsewhere at the coast?

STRETCH YOURSELF

Find out more about the effect of the storm at Dawlish in 2014 and the subsequent rebuilding that was required. Consider the reasons for the severe erosion and summarise the impacts the storm had on this stretch of coastline. Explain how the magnitude of the different components of the coastal system changed during the storm.

Landforms and landscapes of coastal erosion

In this section you will learn about landforms and landscapes of coastal erosion and factors and processes in their development

Coastal landforms and landscapes

Figure **1** was taken from Beachy Head, to the west of Eastbourne, on the Sussex Heritage Coast, one of the UK's most iconic stretches of coastline. Towards the bottom right is Birling Gap, a collection of buildings that has for some time been threatened by coastal erosion.

It is important to appreciate the difference between *landscape* and *landform*. The landscape in Figure **1** is the big picture – the entirety of the sea, coast and rolling countryside. Landforms are individual components of the landscape – cliffs, beach and the emerging wave-cut platform. You need to be able to distinguish between the two; always consider individual landforms in the context of the broader landscape.

Landforms of coastal erosion

Cliffs and wave-cut platforms

When waves break against the foot of a *cliff*, erosion (hydraulic action and corrosion in particular) tends to be concentrated close to the high-tide line. This creates a *wave-cut notch* (Figure **2**). As the notch gets bigger, the cliff is undercut and the rock above it becomes unstable, eventually collapsing.

As these erosional processes are repeated, the notch migrates inland and the cliff retreats (Figure **3**), leaving behind a gently sloping *wave-cut platform* (Figure **4**), which is usually only completely exposed at low tide. Wave-cut platforms rarely extend for more than a few hundred metres, because a wave will break earlier and its energy will be dissipated before it reaches the cliff, thus reducing the rate of erosion, limiting the further growth of the platform. This is another excellent example of a negative feedback.

Figure 1 *The landscape of the Sussex Heritage Coast*

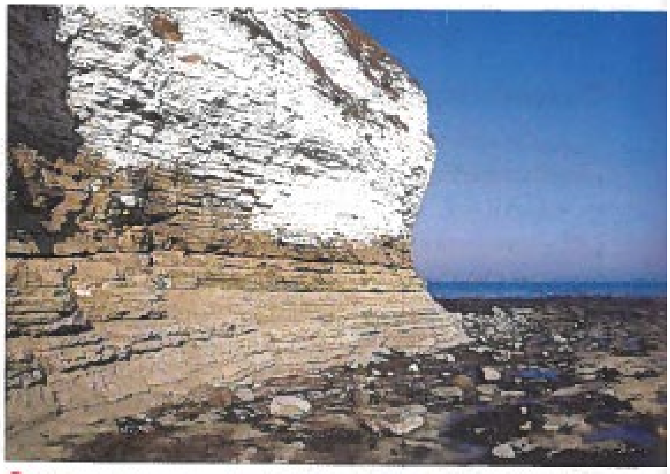

Figure 2 *A wave-cut notch at Flamborough Head in Yorkshire*

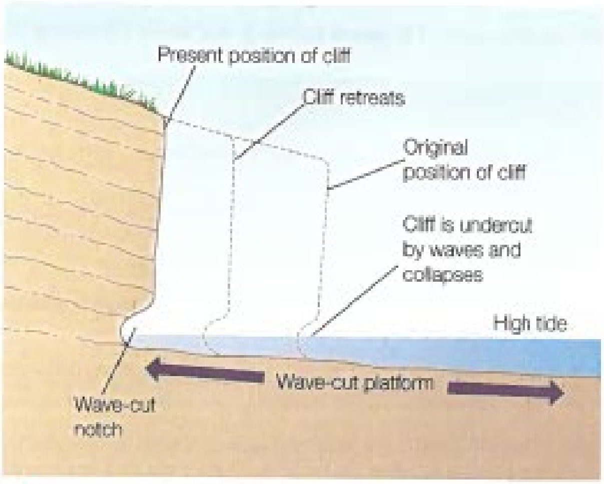

Figure 3 *Cliff retreat*

Cliff profile and rate of retreat

There are several factors that affect the cliff profile and its rate of retreat.

- Steep cliffs tend to occur where the rock is strong and resistant to erosion, such as most igneous and metamorphic rocks. Sedimentary rocks that are dipping steeply or even vertically tend to produce steep and dramatic cliffs (Figure **5**), as will the absence of a beach and an exposed orientation with a long fetch and high-energy waves that encourage erosion and undercutting by the sea.
- Gentle cliffs usually reflect weak or unconsolidated rocks that are prone to slumping. Rocks that are dipping towards the sea also tend to have low-angle cliffs. A sheltered location with low-energy waves and a short fetch will result in subaerial debris building up at the foot of the cliff, reducing its overall angle. A wide beach will absorb wave energy, preventing significant undercutting and steepening.
- The rate of retreat of a cliff very much depends on the balance between marine factors – such as wave energy, fetch, presence of a beach – and terrestrial factors – such as subaerial processes, rock strength, geology (Figure **6**). The most rapidly retreating cliffs tend to be composed of very weak rock, such as the glacial till cliffs of the Holderness coast.

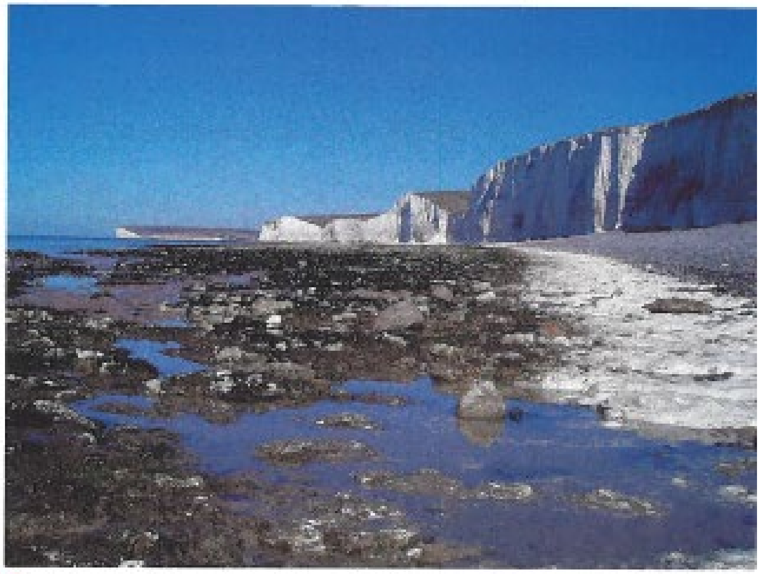

Figure 4 *Cliffs and a wave-cut platform near Eastbourne, West Sussex*

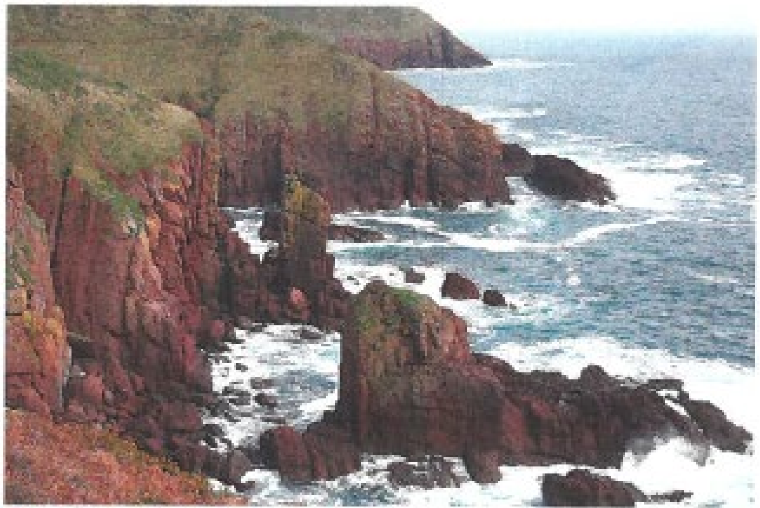

Figure 5 *Vertical rock structure in cliffs near Tenby, South Wales*

Other factors leading to rapid rates of cliff retreat include rising sea levels, and human activities such as coastal defences elsewhere leading to increased erosion.

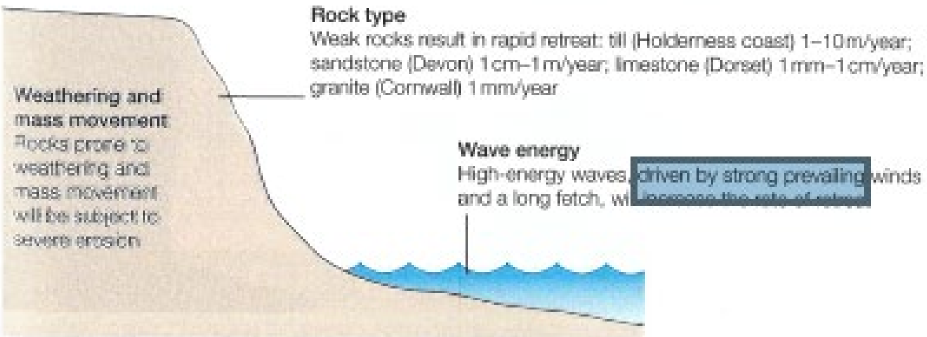

Figure 6 *Factors affecting the rate of retreat*

Landforms and landscapes of coastal erosion

Coastal morphology is related not only to the underlying geology, or rock type, but also to its *lithology* – its geological structure. Lithology means any of the following characteristics:

- Strata – layers of rock
- Bedding planes – horizontal, natural breaks in the strata, caused by gaps in time during periods of rock formation
- Joints – vertical fractures caused either by contraction as sediments dry out, or by earth movements during uplift
- Folds – formed by pressure during tectonic activity, which makes rocks buckle and crumple (e.g. the Lulworth Crumple)
- Faults – formed when the stress or pressure to which a rock is subjected, exceeds its internal strength (causing it to fracture). The faults then slip or move along fault planes
- Dip – refers to the angle at which rock strata lie (horizontally, vertically, dipping towards the sea, or dipping inland).

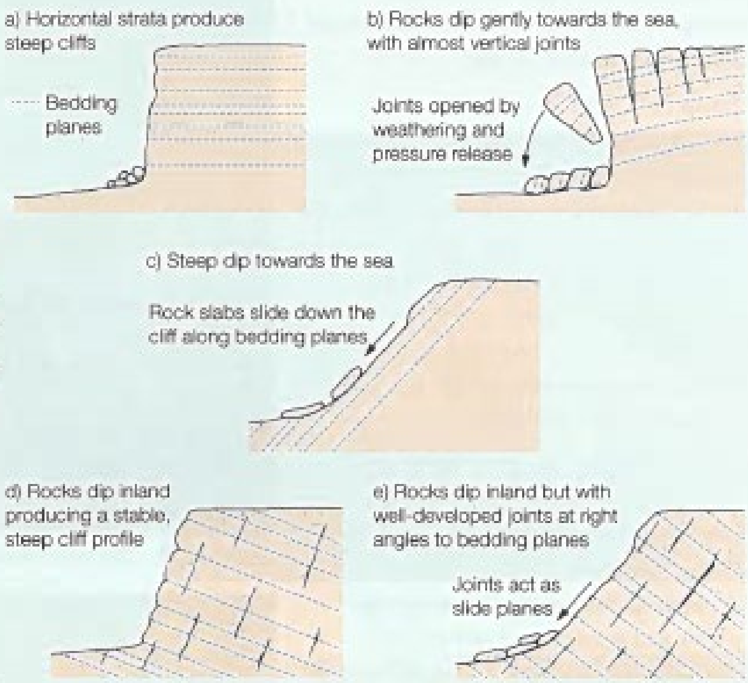

Figure 7 *Cliff profiles and geological structure*

The relief – or height and slope of land – is also affected by geology and geological structure. There is a direct relationship between rock type, lithology and cliff profiles. The five diagrams that make up Figure **7** help to illustrate this.

Cliffs profile features – caves, arches and stacks

One of the world's most iconic road trips is the Great Ocean Road coastal route in Southern Australia between Melbourne and Adelaide. With its towering sandstone cliffs, isolated stacks, and spectacular arches, this stretch of coastline is one of the most dramatic landscapes in Australia (Figure **8**). It demonstrates clearly how erosion on a high-energy coast will create several landforms as the cliffs – notice their steep profile – are steadily eroded.

Figure 8 *Coastal landforms on the Great Ocean Road in southern Australia. The stacks in the foreground are called the Twelve Apostles and are a big tourist attraction.*

Caves, arches, stacks and stumps are all connected as part of a sequence of coastal landform development:

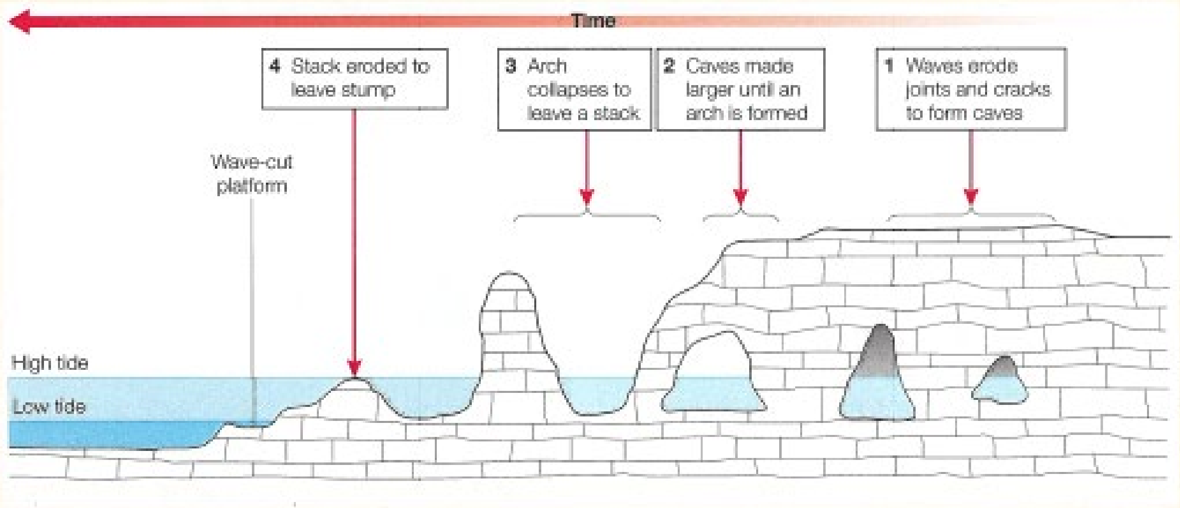

Figure 9 *The formation of caves, arches, stacks and stumps at a headland*

- The erosion of rocks like limestone and chalk tends to exploit any lines of weakness – joints, faults and cracks.
- When joints and faults are eroded by hydraulic action and abrasion, this can then create *caves*. If the overlying rock then collapses, a *blowhole* will develop. During storm high tides, seawater can be blown out of these blowholes with considerable and spectacular force.
- If two caves join up, or a single cave is eroded through a headland, an *arch* is formed. The base is widened and the gap is further enlarged by erosion and weathering.
- Eventually, the top of the arch collapses leaving an isolated pillar of rock called a *stack*. As it continues to be eroded by the sea, the stack collapses to leave a *stump*, which may only appear above the surface at low tide.

ACTIVITIES

S 1 Draw a sketch of Figure 1 and add labels to identify aspects of the coastal system, such as inputs, outputs, stores and transfers. Can you suggest the operation of any feedback loops?

2 Study Figure 5. To what extent do you think geological structure is responsible for the profile of these cliffs?

S 3 a Draw an annotated field sketch of the coastal landforms shown in Figure 8.

b What is the evidence that this stretch of coastline is being actively eroded?

c Suggest how this landscape might change over the next hundred years.

S 4 Produce a flow chart to show the development of wave-cut notches, wave-cut platforms and cliffs.

5 How might a negative feedback loop operate during the development of an extensive wave cut platform? Use simple diagrams to support your answer.

STRETCH YOURSELF S

Using Google Maps/Earth imagery, identify two stretches of coast in the UK, and two stretches in the rest of the world, where features in this section can be seen. Add labels to identify the landforms and write a few sentences describing the overall landscape.

Landforms and landscapes of coastal deposition

In this section you will learn about landforms and landscapes of coastal deposition and factors and processes in their development

Landscapes of coastal deposition

Figures **1** and **2** show two contrasting landscapes of coastal deposition. Figure **1** is Chesil Beach in Dorset, a huge shingle ridge several metres in height and stretching for some 29 km. It is a high-energy, south-facing coastline with a long fetch across the Atlantic Ocean and is an important store of sediment. The relatively coarse sediment is a reflection of the high-energy waves (energy flow) that batter this coastline for much of the year. Although it is currently being reshaped by longshore drift (a transfer in the coastal system), most of the sediment was driven onshore by rising sea levels after the last glacial period. The direct source of this sediment was the English Channel, where it was originally dumped by meltwater some 8000 years ago, as the ice on the land melted. This illustrates the 'temporary' nature of some sediment stores as well as the importance of time; is 'temporary' measured in years or thousands of years?

Figure 1 *High-energy, shingle coastline at Chesil Beach, Dorset, UK*

In contrast, Figure **2** shows a sheltered bay on the south coast of Finland. Here, the low-energy waves (resulting from wave refraction) in the bay have created a large sandy beach, which is popular with visitors in the summer (what do you think the white structures are?). Some of the sand is blown onshore by winds (energy flow) to form sand dunes (a store), which are colonised by vegetation, tolerant of the salty and exposed conditions.

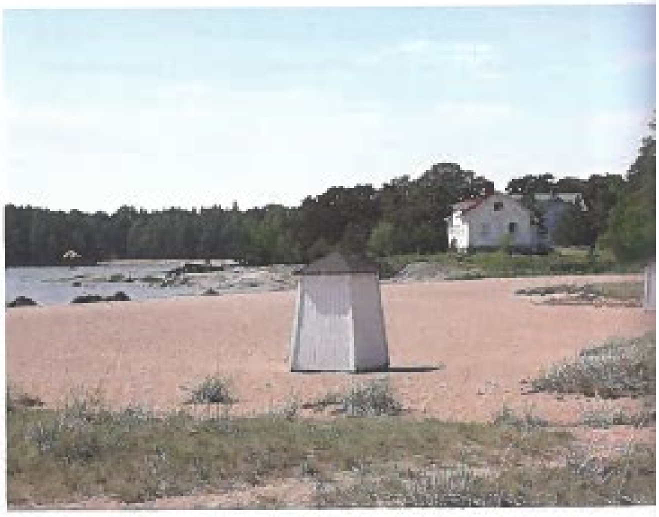

Figure 2 *Low-energy, sandy coastline at Hanko on the south coast of Finland*

Landforms of coastal deposition

Deposition occurs along the coast when waves no longer have enough energy to transport sediment. Depending on how and where the sediment is deposited, a variety of landforms can be produced.

Beaches

A beach can be described as a depositional landform extending from approximately the highest high tide to the lowest low tide. It is an extremely important temporary store in the coastal system. Beach **accretion** will take place during a prolonged period of constructive waves driven by storms many hundreds of miles away. Destructive waves, resulting from localised storms, may excavate the beach, removing vast quantities of sediment and even exposing previously covered wave-cut platforms.

Swash-aligned and drift-aligned beaches

Beaches can be described as being *swash aligned* or *drift aligned* depending on their orientation relative to the prevailing wind (and wave) direction (see Figure **3**).

- **Swash-aligned beaches** tend to form in low-energy environments such as bays that are affected by waves arriving roughly parallel to the shore. You can see the effect of wave refraction in Figure **3**. The bayhead beach may consist of either sand or shingle, depending on factors like the nature of the sediment and the power of the waves. High-energy waves will transport sand leaving behind coarser shingle (Figure **1**) whereas low-energy waves will deposit sand (Figure **2**) or mud.
- **Drift-aligned beaches** form where the waves approach the coast at an angle. Longshore drift (a transfer process) moves sediment along the beach, often culminating in the formation of a spit, essentially a sediment sink or store. Sediment may be graded along a drift-aligned beach. Finer shingle particles are likely to be carried further by longshore drift and also to become increasingly rounded as they move.

Beach forms

Beaches often form part of a much broader area of deposition extending into the offshore zone (Figure **5**). Several features characterise beaches, including **berms** (ridges), **cusps** (Figure **4**) and runnels. Notice in Figure **5** that there are often several berms on a beach representing different tidal levels – there may also be a storm berm at the highest point on a beach. Berms can be made of sand or pebbles.

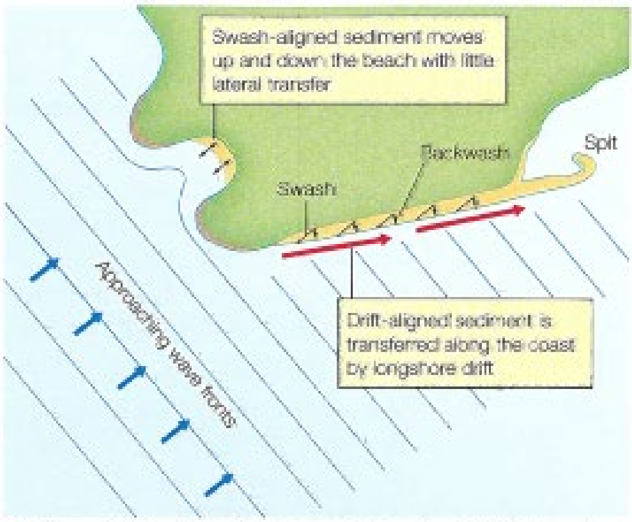

Figure 3 *The formation of swash-aligned and drift-aligned beaches*

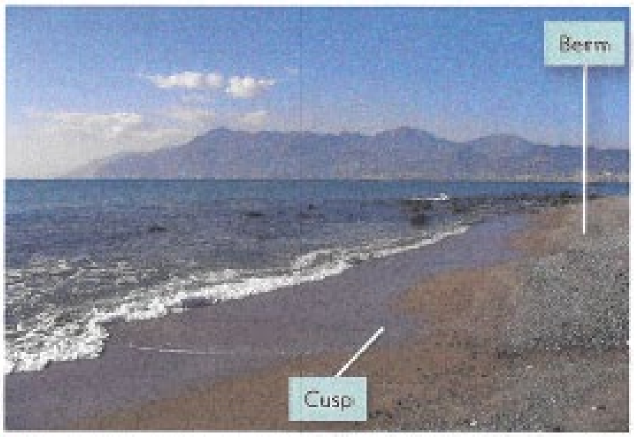

Figure 4 *Berms and cusps, Gulf of Salerno, Italy*

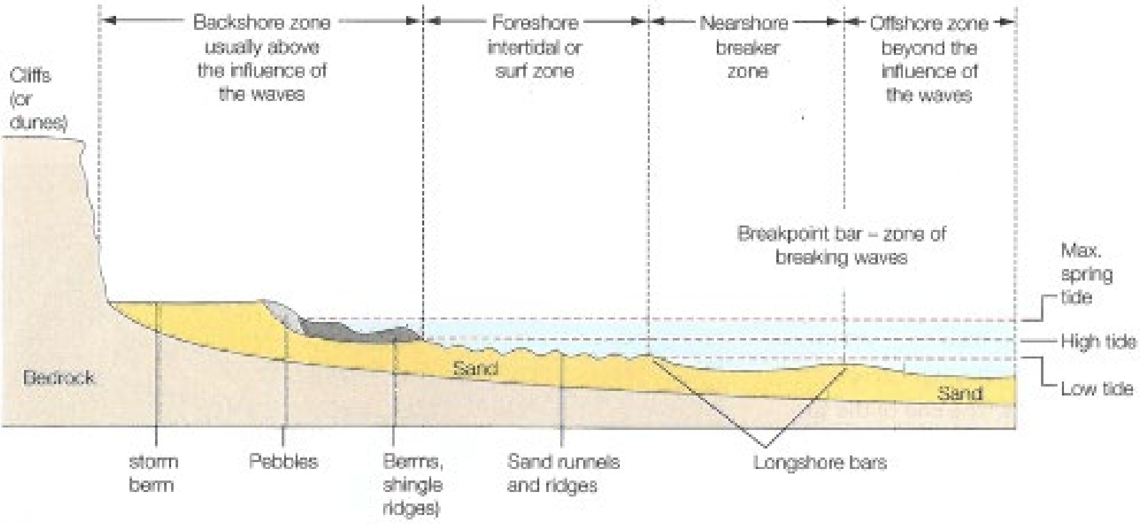

Figure 5 *Typical features of a beach*

Landforms and landscapes of coastal deposition

Beach profiles

The material along a beach profile also varies in size and angularity, depending on distance from the shoreline (as Figure **6** shows).

- Larger pebbles tend to be near the top of the beach. Constructive waves will carry a range of sediment sizes up a beach due to the strong swash but, due to water percolating into the beach, the weaker backwash will only be able to drag back the smaller pebbles. Over time, this leads to the pebbles being sorted with large at the top through to smaller at the bottom.
- Pebbles at the bottom of the beach tend to be more rounded due to the constant action of the waves causing abrasion and attrition. Scree falling off a cliff face can also explain the presence of mostly angular pebbles near the top of the beach.

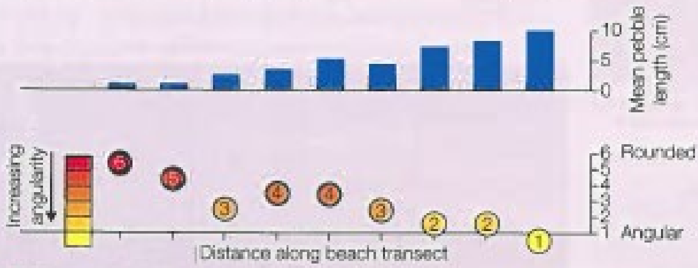

Figure 6 *Pebble size and shape along a beach transect*

Seasonal changes in wave type create summer and winter profiles – sediment is dragged offshore by destructive waves in winter and returned by constructive waves in summer (Figure **7**).

- Beach profiles are steeper in summer, when waves are more constructive than destructive. Constructive waves are less frequent and have a longer wavelength (6–9 per minute), so wave energy dissipates and deposits over a wide area (weakening the backwash).
- In winter, destructive waves occur at a higher frequency (11–16 per minute). Berms may be eroded by plunging waves and high-energy swash crashing down onto the beach. Strong backwash transports sediment offshore (depositing it as *offshore bars*). Sometimes, the backwash exerts a *rip current*, or undertow – dragging sediment back as the next wave arrives over the top (see 3.2).

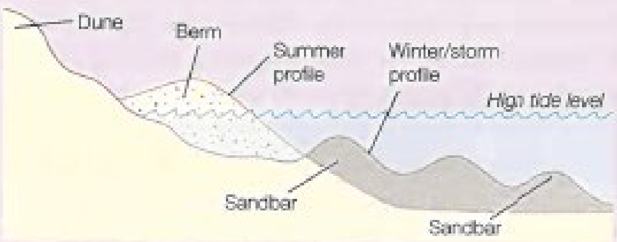

Figure 7 *Typical summer and winter beach and dune profiles*

Spits

A *spit* is a long, narrow feature, made of sand or shingle, that extends from the land into the sea (or part of the way across an estuary). Spits form on drift-aligned beaches (see Figure **3**). Sand or shingle is moved along the coast by longshore drift, but if the coastline suddenly changes direction (e.g. because of a river estuary), sediment begins to build up across the estuary mouth and a spit will form (see Figure **8**). The outward flow of the river will prevent the spit from extending right across the estuary mouth. The end of the spit will also begin to curve round, as wave refraction carries material round into the more sheltered water behind the spit. This is known as a *recurved tip*.

Figure 8 *The formation of a spit*

The entrance to Poole Harbour (Figure **9**) is unusual in that it has two spits extending from both the northern and southern sides of the bay – forming a *double spit*. A saltmarsh may develop behind a spit, where finer sediment settles and begins to be colonised by salt-tolerant plants (such as the one behind the left-hand spit in Figure **9**). A *compound spit* occurs where the transport processes are variable over time, which produces a series of 'barbs' along the spit (Figure **8**).

Tombolo

A **tombolo** is a beach (or ridge of sand and shingle) that has formed between a small island and the mainland. Deposition occurs where waves lose their energy and the tombolo begins to build up. Tombolos may be covered at high tide, for example, at St Ninian's in the Shetland Islands (Figure **10**) and at Lindisfarne in Northumberland. Chesil Beach (Figure **1**) is also an example of a tombolo, linking the Isle of Portland with Weymouth on the mainland.

Offshore bars

Also known as sandbars, **offshore bars** are submerged (or partly exposed) ridges of sand or coarse sediment created by waves offshore from the coast. Destructive waves erode sand from the beach with their strong backwash and deposit it offshore (Figure **11**). Offshore bars act as both sediment sinks and, potentially, sediment input stores. They can absorb wave energy thereby reducing the impacts of waves on the coastline.

Figure 9 *The double spit at the entrance to Poole Harbour, Dorset*

Figure 10 *The tombolo linking St Ninian's Isle to Mainland, Shetland is the largest active sand tombolo in the UK*

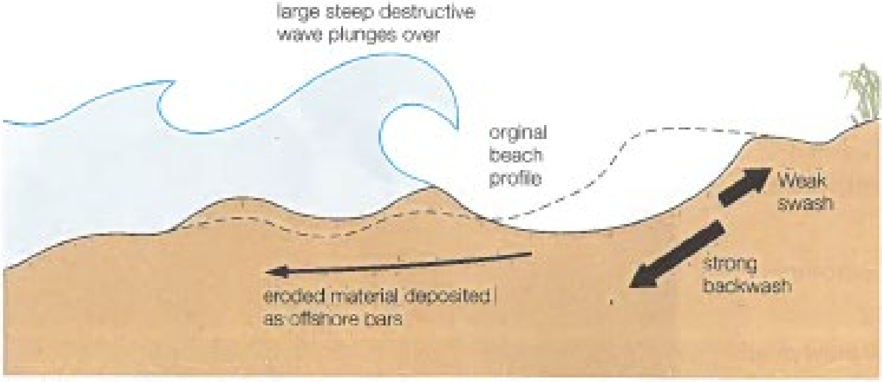

Figure 11 *Formation of offshore bars*

Landforms and landscapes of coastal deposition

What is the carbon cycle?

Barrier beaches (bars)

Where a beach or spit extends across a bay to join two headlands, it forms a *barrier beach* or *bar*. The barrier beach at Start Bay in Devon (Figure **12**) is 9 km long and is formed from rounded shingle deposits (consisting mostly of flint and quartz gravel). Barrier beaches and bars can also trap water behind them to form lagoons, such as Slapton Ley in Figure **12**.

Barrier beaches and bars on the south coast of England are believed to have been deposited following rising sea levels after the last glacial period. Sediment deposited by meltwater in what is now the English Channel was bulldozed onshore to form the present-day barrier beach or bar. Subsequently, longshore drift has added more material and has reworked the sediment. This is a good illustration of energy flows and it also demonstrates the importance of time in the formation of present-day landforms. We cannot always assume that landforms are the result solely of processes operating at the present time.

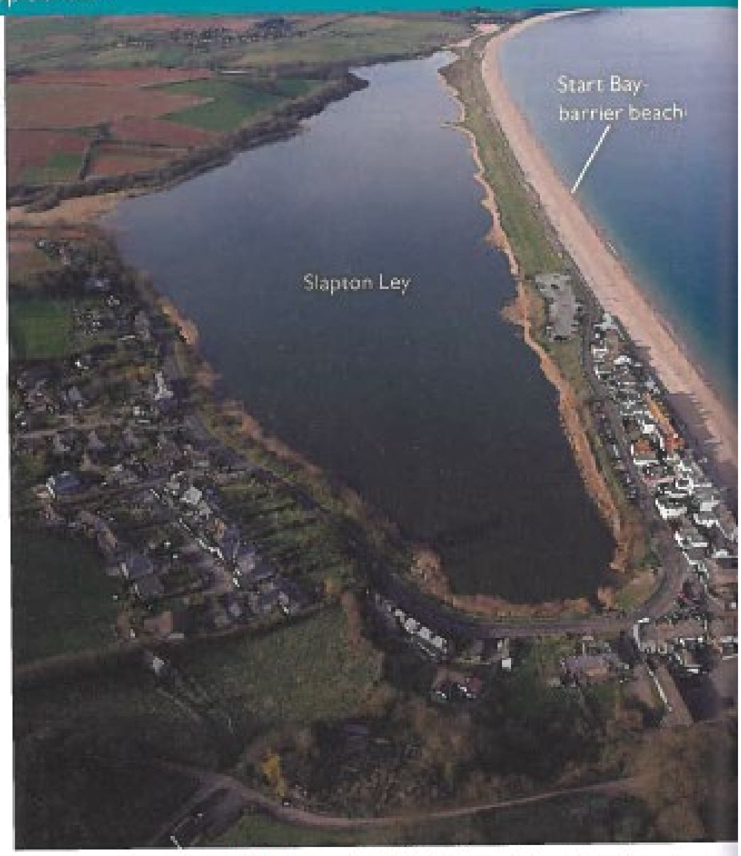

Figure 12 *Start Bay barrier beach and Slapton Ley lagoon*

Where a beach becomes separated from the mainland, it is referred to as a *barrier island*. Barrier islands vary in scale and form – are usually sand or shingle features – and are common in areas with low tidal ranges, where the offshore coastline is gently sloping. Large-scale barrier islands can be found along the coast of the Netherlands, and in North America along the South Texas coast.

Sand dunes

Many depositional landforms consist of sand and shingle – loose, unstable sediment that can be easily eroded and transported. Sandy beaches may be backed by *sand dunes*, like those at Studland in Dorset (see Figure **13**), which consist of sand that has been blown off the beach by the onshore winds. In order for sand dunes to form a number of prerequisites are required:

- large quantities of available sand, washed onshore by constructive waves (an offshore sand bar is an ideal source of sand)
- large tidal range, creating a large exposure of sand that can dry out at low tide
- dominant onshore winds, that will blow dried sand to the back of the beach.

Figure 13 *Sand dunes at Studland in Dorset*

Dunes develop where sand is initially trapped by debris towards the back of the beach. Vegetation helps to stabilise the sand and gradually dunes develop. Over a period of several hundred years a transformation takes place known as a *vegetation succession* (see 1.9 and 6.9).

- The first colonising plants are called **pioneer species**, which have special adaptations to help them survive in hostile conditions. Plants such as sea rocket and couch grass are able to cope with the very dry, salty and exposed conditions. When they die, the plants add important organic matter to the developing soil.
- As the pioneer plants take hold, they help to bind the sand and form low sand dunes called *fore dunes*. *Marram grass* is a typical species found in this zone. It is extremely well adapted with long tap roots to seek water. The growth of marram grass is stimulated by burial and its tangle of lateral roots is perfect for binding the sand.
- As the environment changes over time, different species colonise the sand dunes until they become stable. The final community will be adjusted to the climatic conditions of the area, and is known as the *climatic climax community*. In Figure **15**, this is represented by trees such as oaks and pines.

Figure 14 *European sea rocket has adapted to hostile conditions*

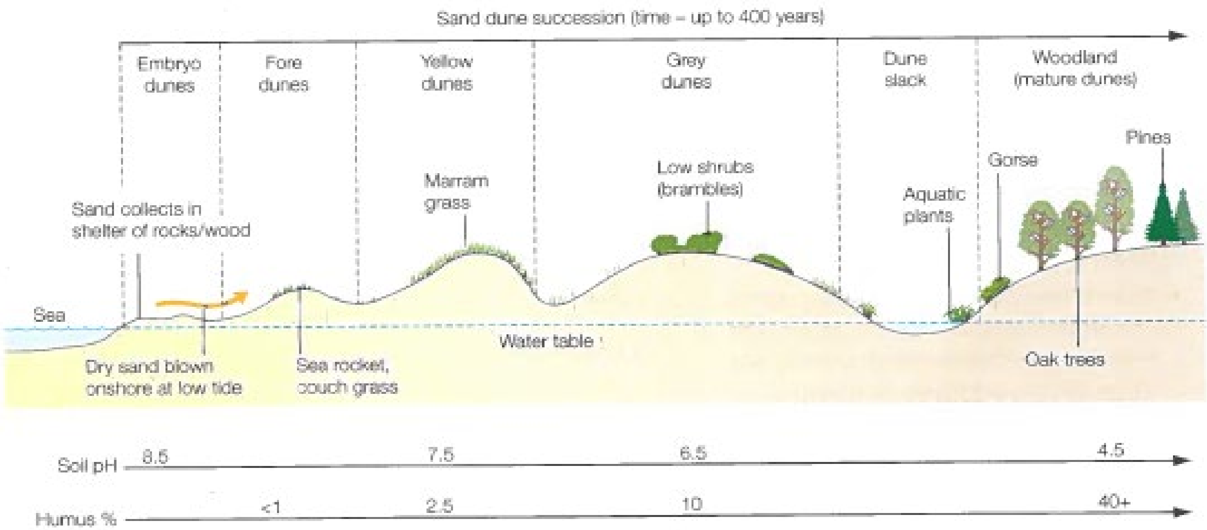

Figure 15 *Sand dunes and plant succession*

- Embryo dunes are the first dunes to develop.
- As embryo dunes develop, they grow into bigger fore dunes – which are initially yellow in colour, but darken to grey as decaying plants add humus.
- Depressions between dunes can develop into dune slacks – damper areas where the water table is closer to, or at, the surface.

Human

Geography

Global patterns of urbanisation

In this section you will learn about urbanisation, its importance in human affairs and global patterns of urbanisation since 1945

The rise of the city!

In 1945, less than one-third of the world's population lived in cities or urban areas. By 2008, more people lived in urban areas than in rural areas and this proportion is expected to rise to around two-thirds by 2030. In the UK, for example, urban life is now a reality for nearly 85 per cent of the population. This unprecedented move from a rural to an urban society has enormous potential to bring positive change but it also carries risk.

Urbanisation and urban growth

Do you live in an urban area? Looking out of your bedroom window you might think that this is a straightforward question. A town or city is an urban area – but today's city boundaries are far from clear. You might live in the extended suburbs far from the shopping or commercial centre (CBD) and still officially live within an urban or metropolitan area. The metropolitan county of Greater London constitutes nearly all of Middlesex, parts of Kent, Essex, Hertfordshire and Surrey.

Note the difference between the following terms:

- *Urban growth* – the increase in the total population of a town or city.
- *Urbanisation* – the increase in the proportion of the population living in urban centres.
- *Urban expansion* – the increase in size or geographical footprint of a city.

A city may experience urban growth and expansion, but if this growth is matched by population increases in rural areas, then urbanisation is not occurring.

The importance of urban centres in human affairs

Cities are not only important as centres of population but they also influence and shape our lives at every level. They are important for:

- the organisation of economic production, for example, concentration of financial services
- the exchange of ideas and creative thinking, for example, universities
- social and cultural centres, for example, theatres and national stadia
- centres of political power and decision-making, for example, seat of government.

Look at Figure **1**. This shows a number of important features of an economy and the percentage of each feature that is concentrated in some cities.

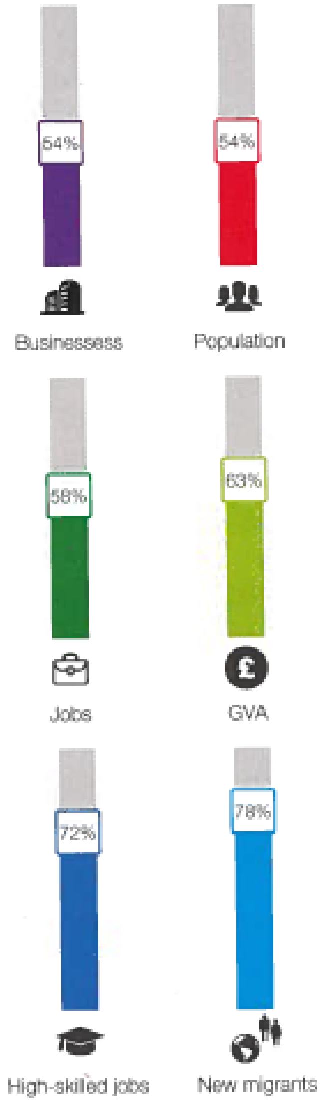

Figure 1 *Some economic features of the 64 largest cities in the UK*

Did you know?

The city status of Maza in North Dakota was removed by US authorities in 2002. It had a population of five!

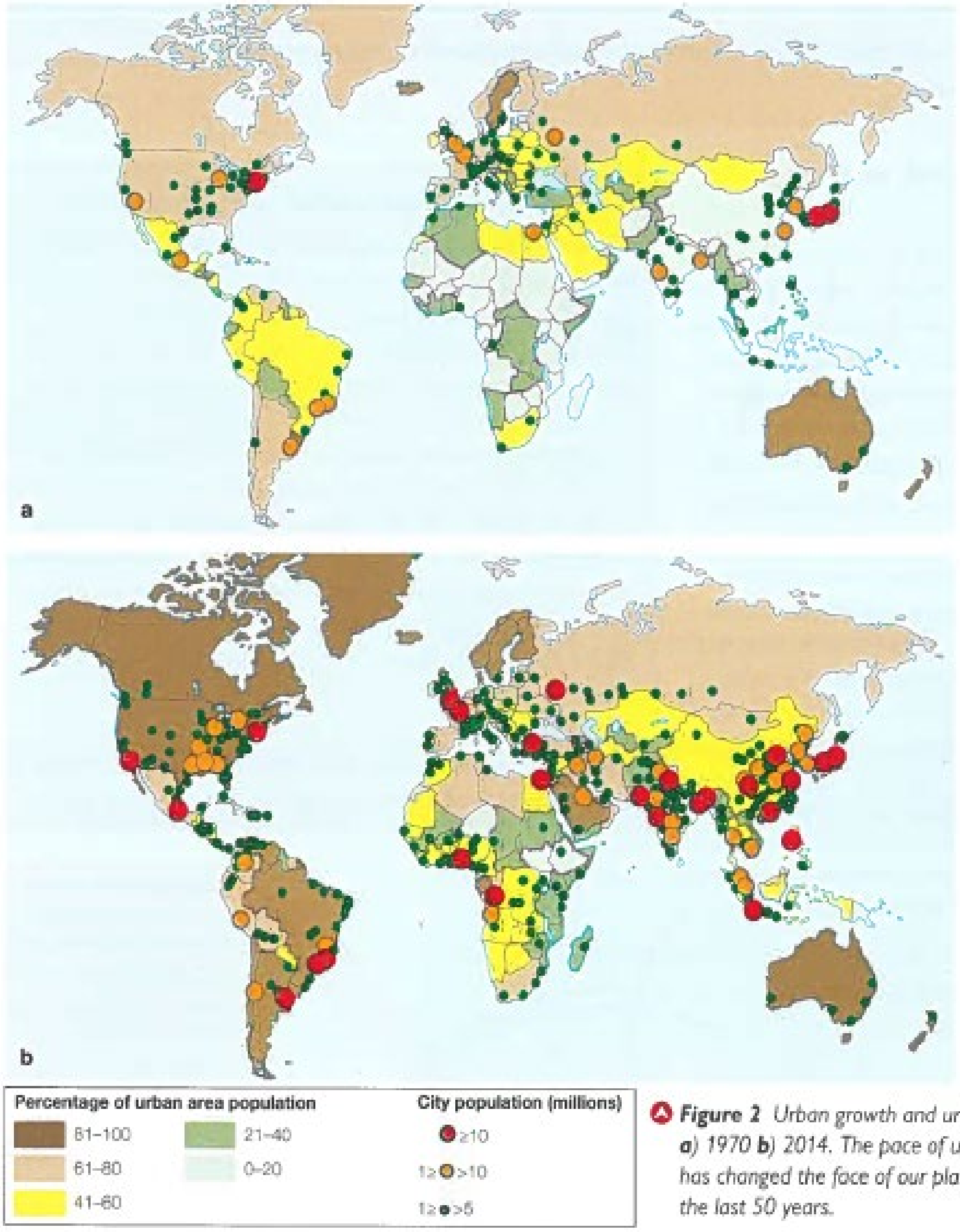

Figure 2 *Urban growth and urbanisation* ***a)*** *1970* ***b)*** *2014. The pace of urbanisation has changed the face of our planet over the last 50 years.*

ACTIVITIES

1 a With reference to named places, explain the difference between urbanisation and urban growth.
  b Why are HICs likely to continue to see urban growth but reducing rates of urbanisation?

2 Study Figure 1. Why do you think medium-sized cities are sometimes more attractive for migrants than either the largest cities or smaller towns?

S 3 Study Figure 2.
  a Compare and comment on the percentage urban population 1970–2014.
  b Describe the location of the world's largest cities in 1970. How has this pattern changed by 2014?

STRETCH YOURSELF

Look at the United Nations website (esa.un.org/unpd/wup/Maps) and look at the 'Percentage urban and urban agglomerations by size class' map. Describe and suggest reasons for how the pattern has changed on the 1990 and 2030 maps.

Forms of urbanisation

In this section you will learn about urbanisation, suburbanisation, counterurbanisation and urban resurgence

One step forward, one step back…

If you blink you might miss it. There are around 1.3 net additions to the worldwide urban population every second – but where do they all live? Like an ecosystem, urban metropolises have expanded and adapted to meet the changing needs of their populations. All cities are different but they do broadly follow four stages of growth and change.

Look at Figure **1**. It shows the four main forms of urbanisation (sometimes also referred to as the cycle of urbanisation). In most cities in HICs, all four processes are taking place at the same time, although it is likely that for a period of time one process will dominate (Figure **2**). In LICs, urbanisation continues to be the main urban process but many Asian cities are already beginning to show the effects of suburbanisation and even counterurbanisation.

The nature of urbanisation

Urbanisation is the process of change by which places become more urban. This simple definition hides a multi-strand process that is dynamic across space and time and is conditioned, in part, by the level of development of a country or region. For example, demographic changes (the increasing percentage of urban population) may be linked to structural changes (such as the development of industrial capitalism) and changes in social attitudes and behaviours (such as use of social media). Studies of the experiences of HIC urban areas would suggest that three processes are related to urbanisation – suburbanisation, counterurbanisation and urban resurgence. While it is helpful (and usual) to consider all four processes as a sequence (see Figure **1**), it is also important to appreciate that they may also occur concurrently, 'out of order' and are not necessarily a feature of all cities in all places. For further research on the generalised experiences of urbanisation in countries around the world, 'the urbanisation curve' is a useful starting point.

Figure 1 *The four processes or cycle of urbanisation for a typical western European city*

1 Urbanisation: an increase in the proportion of a country's population living in a town or city.

2 Suburbanisation: the **decentralisation** of people, employment and services towards the edges of an urban area. This outward growth of lower density urban development, or urban sprawl, is closely linked to the development of transport networks, particularly roads and in London the extension of the underground network.

3 Counterurbanisation: population movement from large urban areas to smaller urban settlements and rural areas. People move as a combined result of the *push* problems of the city (e.g. crime, congestion, land degradation) and the *pull* of rural life (e.g. bigger living space, 'safer' environment).

4 Urban resurgence: population movement from rural back to urban areas. Associated with upwardly mobile young people, including couples, and also university students who are pulled to the centre of the '24-hour' city. This influx of youth and new wealth encourages a revival of some inner-city and CBD areas. This is the fourth population movement and completes a cycle of rural–urban movements.

In the 1980s, and 90s the most dominant form of urbanisation in UK cities was counterurbanisation. This followed the suburbanisation of the 1960s and 70s when increasing car ownership allowed the population to be more mobile. More recently, many UK cities have experienced reurbanisation or an urban resurgence. Some, such as Sunderland, have struggled to do so, and there is very little evidence of resurgence.

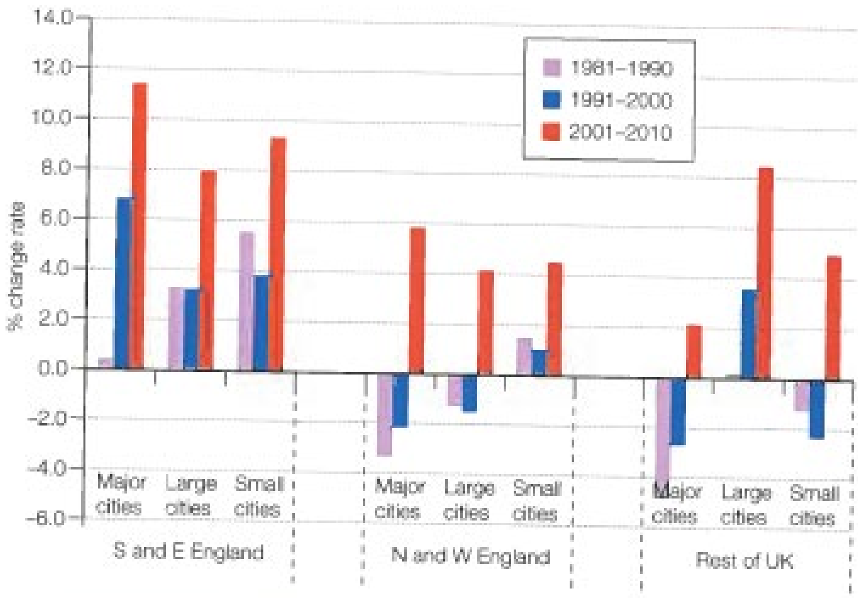

Figure 2 *Population change rate, by region, for the UK's three city sizes 1981–2010.*
Major cities: *London, Birmingham, Leeds, Liverpool, Manchester, Newcastle, Sheffield, Belfast, Glasgow*
Large city: *population 275 000+*
Small city: *population 75 000–125 000*

Urban resurgence: Ubisoft, Montreal

Ubisoft is a large computer-animation firm that decided to locate in the Mile-End neighbourhood centre of Montreal, Canada. As a high tech industry, it has all the characteristics of a footloose industry but chose to locate in an old textile factory in the downtown district of Canada's second largest city. Ubisoft argue that their employees work at all hours and it was important that they located in the centre of a 24-hour city where employees had good access to shops and services.

Many of their 2700 employees are recruited from the nearby McGill University and École de Technologie Supérieure. Ubisoft argue that they do not want a long commute – many walk or cycle to work from city centre neighbourhoods.

Ubisoft, unlike the manufacturing industries of the last century, needs relatively little floor space – the power engines of this industry are desk-sized laptops or PCs – and can therefore afford the higher downtown land prices.

ACTIVITIES

1 Around 13 per cent of the land area in England is designated as Green Belt. The purpose of Green Belt policy is to prevent urban sprawl by keeping land 'permanently open'.
- a Where on Figure 1 would Green Belt be marked? Explain your answer.
- b Which of the urban processes would Green Belt encourage? Conversely, which would it act as a barrier against? Justify your answer.

S

2 Study Figure 2.
- a Compare the urban population change rate for south and east England with north and west England.
- b Suggest reasons why large cities in the rest of the UK are tending to attract a far greater percentage of population than major cities.
- c Explain why the urban population growth rate for the south and east of England is significantly higher than the rest of the country.

STRETCH YOURSELF

Champion and Townsend (1990) discussed a so-called 'north–south drift' and 'urban–rural shift'. In other words, the rural south was the most dynamic quarter and the urban north the least. Discuss the validity of this viewpoint today. (The UK Government's Foresight Future of Cities Project is a good starting point for research.)

Megacities

One striking feature of the last 30 years has been the rapid development of **megacities** – urban areas with a population of more than 10 million people. In 1990, there were 10 megacities; in 2020 there were 30; and by 2030 the UN predicts there will be 43 megacities – housing over 13 per cent of the global population. As Figures 9.1–9.3 show, the development of megacities is largely concentrated in Asia. In 2015, Tokyo was the world's largest city with over 37.4 million inhabitants. There were another eight cities – Delhi, Shanghai, São Paulo, Mexico City, Dhaka, Cairo, Beijing and Mumbai – all with populations in excess of 20 million and rising rapidly. Between 2018 and 2030, the population of Delhi is projected to increase by more than 10 million, while Tokyo is projected to decline by almost 900,000. Such settlements can be defined as **metacities**, the term given to a conurbation (continuous built-up area) of more than 20 million people. The Chinese government has plans to merge nine cities in the Pearl River Delta creating an urban area 26 times larger than Greater London.

Key terms

Megacity – A city or urban agglomeration (urban area incorporating several large towns or cities) with a population of more than 10 million people. According to the UN, London achieved megacity status in 2013. This classification included residents in the Greater London area.

Metacity – A conurbation with more than 20 million people.

Urban growth – An increase in the number of urban dwellers. Classifications of urban dwellers depend on the census definitions of urban areas, which vary from country to country. They usually include one or more of the following criteria: population size, population density, average distance between buildings within a settlement and legal and/or administrative boundaries.

Urbanisation – An increase in the proportion of a country's population that lives in towns and cities. The two main causes of urbanisation are natural population growth and migration into urban areas from rural areas.

The causes of urban growth

The process of urbanisation plays an important role in human affairs. It has historically been linked to other important economic and social transformations

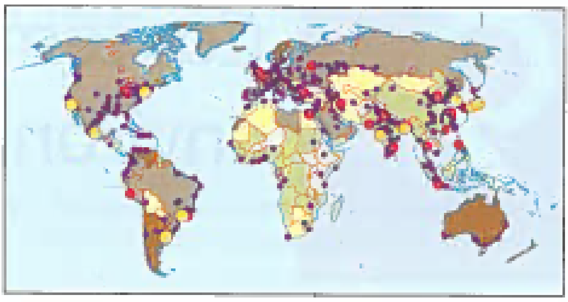

Figure 9.1 Percentage of urban population and city size, 1990

Source: UN Population Division

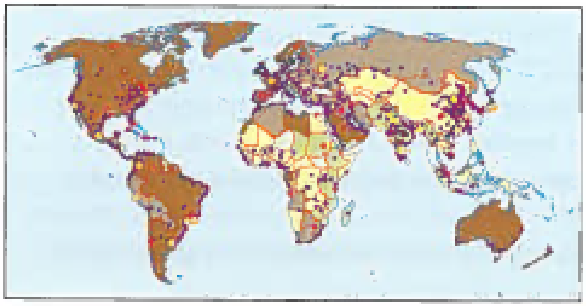

Figure 9.2 Percentage of urban population and city size, 2018

Source: UN Population Division

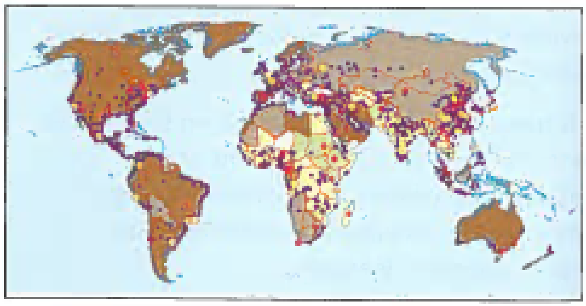

Figure 9.3 Percentage of urban population and city size projected to 2030

Source: UN Population Division

which have brought about greater geographic mobility, lower fertility and longer life expectancy. Cities also play an important role in reducing poverty. They hold much of the national economic activity, government institutions, business and transportation, and have higher levels of education, better health, easier access to social services, and greater opportunities for cultural and political participation. In 2020, São Paulo, Brazil's financial capital, represented 10.7 per cent of all Brazilian Gross Domestic Product (GDP) and was home to 63 per cent of the transnational corporations in Brazil. Likewise, in Kenya, Nairobi, with 8.4 per cent of the country's population, accounted for almost 20 per cent of the country's GDP.

Natural population growth

Urban areas have relatively young age profiles. Across the world, it has traditionally been young adults (15–40 years) migrating for higher paid jobs, better educational opportunities and greater social and cultural diversity. Between 2001 and 2011 the population of large city centres in England and Wales more than doubled, with residents aged 22–29 nearly tripling to make up almost half of their total population. These migrants are in their fertile years – the years during which people have children – and so the rates of natural increase are higher in cities than in the surrounding rural areas. In London, an area stretching from Clapham, south of the River Thames, westwards to Fulham, north of the river has been termed 'Nappy Valley' due to the high proportion of young families living here. In the past, professional couples with young children would have moved out to the suburbs when they could afford it but the rising costs and time involved in commuting has encouraged more young families to remain in the city.

Rural–urban migration

The reasons for rural–urban migration are often divided into 'push' and 'pull' factors. **Push factors** cause people to move away from rural areas, whereas **pull factors** attract them to urban areas. In low-income countries, push factors tend to be more important than pull factors.

Push factors are largely due to poverty caused by:

- population growth, which means the same area of land has to support increasing numbers of people, causing over-farming, soil erosion and low yields
- agricultural problems, including desertification because of low rainfall, systems of inheritance that cause land to be subdivided into small plots, systems of tenure and debt on loans taken out to support agricultural change
- high levels of local diseases and inadequate medical provision
- agriculture is increasingly being organised globally. Land previously used to grow food for local people is now used to produce cash crops for sale to higher income countries. Many traditional rural communities have been driven off their land and into cities
- natural disasters such as floods, tropical storms and earthquakes – people flee rural areas and do not return
- wars and civil strife cause people to flee their land.

Pull factors include the prospect of:

- employment in factories and service industries (for example, hotels) which is better paid than work in rural areas. There is an increasingly high demand for unskilled labour in cities
- earning money from the informal sector, for example, selling goods on the street or providing transport (taxi/rickshaw driver)
- better quality social provisions, from basic needs such as education and healthcare to entertainment and tourism
- a perceived better quality of life in the city, fed in part by images in the media.

Skills focus

Analyse the changes in:

- the percentage of urban population
- city size

between 1990 and 2030 as shown/projected in Figures 9.1 and 9.3.

Consequences of urbanisation and urban growth

Problems with housing, traffic, waste disposal, crime and pollution can be found in cities all over the world irrespective of their economic status. Instead, these issues tend to be linked to the unique geographical circumstances of the city, such as topography, climate and function. The following section details the key consequences of urbanisation and characteristics of cities in the twenty-first century.

A. Urban sprawl

Urban sprawl is defined as the spread of an urban area into the surrounding countryside. It has been linked to the processes of urbanisation and **suburbanisation** and has traditionally occurred in an uncontrolled and unplanned fashion.

Urban sprawl has many negative impacts:

- Urban sprawl requires more roads and infrastructure such as pipes, cables and wires. It is less economically efficient to service low-density rural areas compared to compact urban developments with the same number of households.
- The reach of urban sprawl into rural areas ranks as one of the main causes of wildlife habitat loss.
- Urban sprawl causes more commuting from the suburbs to the city and thus more fuel consumption and traffic congestion.
- Urban sprawl can increase air pollution since a more car-dependent lifestyle leads to increases in fossil fuel consumption and emissions of greenhouse gases. The areas may also experience higher temperatures in line with the urban heat island effect.
- Sprawl has contributed to the loss of farmland and open spaces, which in turn has led to the loss of fresh local food sources with greater food miles as a result.
- Urban sprawl can have a serious impact on water quality and quantity. Covering the countryside with impermeable surfaces means that rainwater is unable to soak into the ground and replenish the groundwater aquifers. In addition, it can lead to greater water run-off and increased flood risk.
- In addition to the movement of people to the suburbs, one other important component has been the accompanying movement of industry and businesses, including retail companies. This is referred to as **decentralisation** and this outward movement has been blamed for the decline of retail in some city centres and an increasing **homogenisation** of the landscape, where cities become indistinct from one another. American cities in particular have witnessed the huge growth of large edge-of-city complexes including shopping malls and leisure areas. In some cases, new self-contained settlements have developed beyond the original city boundary. These are known as **edge cities**.

B. Shortage of housing in lower-income countries

Population density tends to be high in urban areas and one of the consequences of this is a shortage of accommodation, leading to the presence of large areas of informal and often inadequate housing. These normally develop on the edge of the city or in areas of low land value prone to environmental hazards such as flooding or landslides. They may also be found adjacent to transport networks or in areas with high levels of air, noise or water pollution. These settlements tend to have limited access to basic infrastructure such as water, electricity and waste disposal and a lack of services such as health centres and schools.

In 2017, it was estimated that about 900 million people lived in informal settlements. That number rises to 1.6 billion if you include all the different types of informal settlements. This is approximately 25 per cent of the world's urban population. By 2030, it is estimated that one in four people globally will live in some sort of informal settlement. Mumbai alone had more than nine million people living in these conditions in 2020. The number of people residing in informal urban settlements throughout India is estimated to be 104 million, or nine per cent of the total population.

Informal settlements take on different names and different forms depending on their location. The settlements lining the hills of Rio de Janeiro in Brazil are called favelas; in parts of India they are known as bustees and in West Africa, bidonvilles. The use of the term 'slum housing' has been criticised by those who see it as a political label. In Mumbai, for example, settlements such as Shivaji Nagar and Dharavi are referred to by some as 'homegrown neighbourhoods'. The argument is that they were developed gradually, by the people who live there, with the help of local artisans of construction, and usually with little or no support from the authorities.

To describe the residents of informal urban settlements as 'slum-dwellers' is derogatory, as is the term 'slum'. What are the arguments for and against the use of such term?

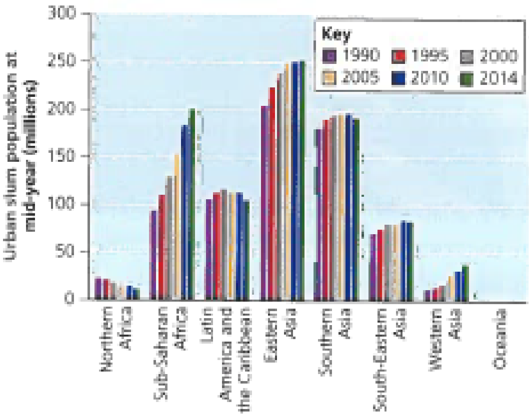

Figure 9.4 The proportion of urban population living in informal settlements, 1990–2014

Source: The New Climate Economy

Figure 9.4 shows that the changes in the proportion of people living in informal urban settlements varied globally. For example, in Sub-Saharan Africa it continued to grow at an ever-increasing rate while in other regions it slowed down or even fell (for example, Northern Africa). This should be viewed in a positive light alongside the relative success of Millennium Development Goal 7 (Ensure environmental sustainability) to improve the lives of people living in informal settlements. Between 2000 and 2014, for example, the UN reports that more than 320 million people living in informal settlements gained access to improved water sources, improved sanitation facilities or durable or less crowded housing. However, the total number of people living in informal settlements has continued to increase and one of the targets in the post-2015 sustainable development goals is to 'ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums by 2030.'

In the past, the most extreme strategy adopted by authorities was to eradicate informal settlements. However, this simply moved the problem elsewhere and a more common approach became to acknowledge the presence of these places and provide help in the form of materials or services. These self-help or 'site and service' schemes have proved remarkably successful in some cities but the quantity and/or quality of housing remains inadequate in most urban areas around the world. More recent initiatives have been informal settlement **upgrading programmes.** These seek to improve the informal settlements in partnership with local NGOs and development organisations. They focus on securing rights for dwellers, formalising land tenure rights and providing basic amenities such as electricity, water and waste disposal. **Shack/Slum Dwellers International (SDI)** is an organisation which gives a voice to those living in informal settlements and links up communities in areas of deprivation across Africa, Asia and Latin America. The idea is for people living in informal settlements to share their knowledge and expertise so that they are not excluded from the economic and political processes happening in their cities.

Dharavi, Mumbai, India: the setting for Slumdog Millionaire

Dharavi, home to more than one million people, is Asia's largest informal settlement. It is located on prime real estate in the centre of Mumbai. Many of the residents are second-generation residents, whose parents moved there many years ago.

The maze of narrow dirty lanes, open sewers and tightly packed huts is a far cry from its roots as a fishing village. Most of the huts have a constant supply of electricity, a gas stove for cooking and many even have a small colour television with a cable connection.

Dharavi is a thriving hub of small-scale manufacturing industries. Small manufacturing units produce leather goods, aluminium bricks and pottery and also recycle plastics for both the domestic and international markets.

The state government has a £1.1 billion plan to redevelop the area and transform it into a modern township, complete with proper housing and shopping complexes, hospitals and schools.

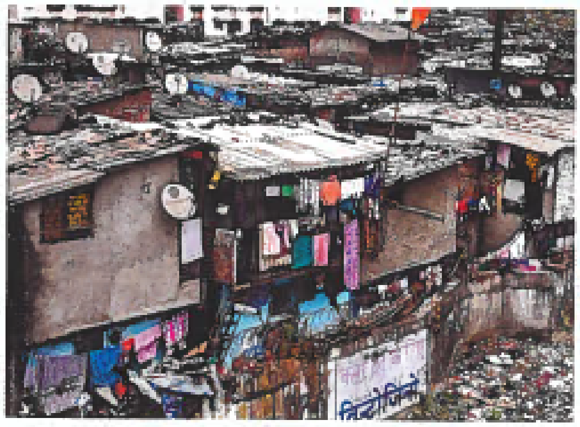

Figure 9.5 Dharavi – Mumbai, India

C. Shortage of affordable housing in higher-income cities

Shortage of affordable housing is a key problem in many wealthy cities. In the UK, the rising demand for accommodation in cities has led to a dramatic increase in both house prices and rental costs. In London, average house prices rose by almost 70 per cent between 2010 and 2019, fuelled partly by in-migration, **gentrification** and by the purchasing of properties by wealthy investors, often from other countries. The city is a major global hub and overseas investors buy properties in London to diversify their international portfolio.

D. Lack of urban services and waste disposal

Financial restraints in lower-income countries can result in a lack of basic services such as water and electricity. Maintenance of infrastructure such as roads, sewers and drainage is also limited and this can result in traffic congestion, polluted watercourses, flooding and the rapid spread of disease. In India, old pipeline infrastructure has not kept pace with urbanisation, resulting in large urban areas devoid of planned water supply and sewage treatment. In 2015, only five per cent of piped water reached the informal settlement areas in 42 Indian cities and towns, including New Delhi.

Waste disposal poses a further problem. The amount of waste increases year-on-year, but there are economic, physical and environmental restraints on its disposal. In Addis Ababa, Ethiopia, the city authority is only able to deal with two-thirds of the rubbish created by the rapidly growing urban population. The rest is left to private contractors to collect or is simply dumped on streets and in rivers, creating a huge health hazard. At Koshe, a huge landfill site on the edge of the city, families live in makeshift housing and search for anything they can use for themselves, or resell. In 2017, a part of the largest rubbish pile collapsed (Figure 9.6), injuring dozens and destroying many homes.

In other cities too, refuse is seen as an opportunity to make money. In Nairobi, recycling is an important part of the everyday economy:

- old car tyres are cut up and used to make cheap sandals
- washing machine doors are used as kitchen bowls, and the drums as storage units
- glass bottles are collected and returned to stores for refilling
- food waste is collected and fed to animals or composted for use on vegetable plots
- tin cans and old oil drums are used to make charcoal stoves, lamps, buckets and metal tips for ploughs.

E. Unemployment and under employment

Since a high proportion of the people who move to cities are relatively young, there is considerable pressure to create sufficient jobs. Unemployment rates are typically high although official data is hard to find and many migrants find employment in informal work such as street hawking. **Under-employment** refers to a situation in which a person is not doing work that makes full use of their skills and abilities. This may occur when a migrant moves to a new city.

F. Transport issues

The processes of urbanisation and suburbanisation have led to increased traffic in cities across the world (Figure 9.7). This has created more congestion and pollution, damaging human health and wasting billions of pounds in lost productivity. The spread of houses into the suburbs and beyond has created surges of morning and evening commuters. Traffic flows for shopping, entertainment and other commercial services add to the problem.

Figure 9.6 The aftermath of the 2017 landslide at Koshe dump, leaving at least 30 people dead and levelling dozens of homes.


Figure 9.7 Kolkata experiences regular gridlock

During the car boom of the 1960s, city planners built more and wider roads as a solution. This didn't work. The more roads created, the more cars they attracted. A 1997 study in California found that new, additional traffic will fill up to 90 per cent of any increase in road capacity within just five years. No matter how much money is spent on traffic infrastructure, congestion and parking problems seem to get worse.

Contemporary urban processes

Higher-income countries have seen a much slower rate of urbanisation in the last few decades and some cities have even witnessed a decline in numbers. Rather than moving into urban areas, as seen in the industrial periods, a more significant trend has been the move outwards.

Key terms

Counter-urbanisation – The movement of people from large urban areas into smaller urban areas or into rural areas, thereby leapfrogging the rural–urban fringe. It can mean daily commuting, but can also require lifestyle changes and the increased use of ICT.

Decentralisation (1) – The movement of population and industry from the urban centre to outlying areas.

Decentralisation (2) – The movement of government institutions or headquarters of businesses away from the central/core areas of a country.

Deindustrialisation – This refers to the loss of jobs in the manufacturing sector, which occurred in the UK in the second half of the twentieth century.

Edge city – A self-contained settlement which has emerged beyond the original city boundary and developed as a city in its own right.

Gentrification – Gentrification is the buying and renovating of properties, often in more run-down areas, by wealthier individuals.

Suburbanisation – The movement of people from living in the inner parts of a city to living on the outer edges. It has been facilitated by the development of transport networks and the increase in ownership of private cars. These have allowed people to commute to work.

Urban resurgence – Urban resurgence refers to the regeneration, both economic and structural, of an urban area which has been through a period of decline. This is often initiated by redevelopment schemes but is also due to wider social, economic and demographic processes.

Urban sprawl – The spread of an urban area into the surrounding countryside.

Suburbanisation: characteristics, causes and effects

Suburbanisation has resulted in the outward growth of urban development that has engulfed surrounding villages and rural areas. During the mid to late twentieth century, this was facilitated by the growth of public transport systems and the increased use of the private car. The presence of railway lines and arterial roads also enabled wealthier commuters to live some distance away from their places of work.

The towns and cities of the UK demonstrate the effects of past suburbanisation. In the 1930s, there were few planning controls and urban growth took place alongside main roads – this was known as ribbon development. By the 1940s, this growth, and growth between the 'ribbons', became a cause for concern. This led to the creation of **green belts** – areas of open space and low-density land use around towns where further development was strictly controlled.

Since 1950, suburban expansion has increased and has been better planned. During the 1950s and 1960s, large-scale construction of council housing took place on the only land available, which was the suburban fringe. In the 1970s, there was a move towards home ownership, which led to private housing estates being built, also on the urban fringe. Building in these areas allowed people to have more land for gardens and more public open space.

As car ownership grew, the edge of town, where there was more land available for car parking and expansion, became the favoured location for new offices, factories and shopping outlets. In a number of cases, the 'strict control' of the green belt was ignored.

In recent years, new housing estates have been built in suburban areas, along with local shopping centres and schools (Figures 12.30 and 12.32, pages 667–668). People continue to move to the suburbs because of their desire for a quieter, less congested and less polluted environment. Suburbs are perceived as relatively crime-free environments and they also demonstrate other key benefits of the rural–urban fringe, such as woodlands and parks, golf courses and playing fields. Many are now well-established housing areas, highly sought after in the property market.

The negative effects of suburbanisation relate to urban sprawl and the environmental impacts of this process, discussed earlier. However, suburbanisation can also lead to:

- increasing social segregation within cities as the wealthy move out to the suburbs (for example, from inner London to Richmond) or gather in wealthy enclaves, such as Belgravia. Less affluent people remain in the inner city
- diversion of funding away from inner city areas to the suburbs to pay for new infrastructure and services.

Counter-urbanisation: characteristics, causes and effects

Counter-urbanisation is the migration of people from major urban areas to smaller urban settlements and rural areas. Counter-urbanisation does not lead to suburban growth, but to growth in rural areas beyond the main city. The difference between rural and urban areas is reduced as a consequence of this movement.

A number of factors have caused the growth of counter-urbanisation. One is that people want to escape from the air pollution, dirt and crime of the urban environment. They aspire to the 'rural idyll' – what they see as the pleasant, quiet and clean environment of the countryside, where land and house prices are cheaper. Car ownership and greater affluence allow people to commute to work from such areas. Indeed, many employers have also moved out of cities. Improvements in technology have allowed more freedom of location. The spread of broadband and high-speed internet access means that someone working from a home computer can now access the same global system as a person in an office block in the centre of a city.

At the same time there has been a rising demand for second homes and earlier retirement. The former is a direct consequence of rising levels of affluence. Alongside this is the need for rural areas to attract income. Agriculture has faced economic difficulties and one straightforward way for farmers to raise money is to sell unwanted land and buildings.

Counter-urbanisation affects the layout of rural settlements. Modern housing estates are built on the edges of small settlements, and small industrial units on the main roads leading into the settlement. Former open areas are built on, old properties and some agricultural buildings are converted and modernised.

As with gentrified areas in inner cities, there may be tension between the newcomers and the locals. One of the main areas of conflict is that, despite the influx of new people, local services often close down. Bus services to many rural communities have disappeared, schools and post offices have closed, and churches have closed as parishes are amalgamated into larger units. The main reason for these changes is that the newcomers have the wealth and the mobility to continue to use the urban services some distance away.

The evidence for counter-urbanisation in an area includes:

- an increase in the use of a commuter railway station in the area, including car parking for commuters
- increased value of houses in the area
- the construction of more executive housing in the area, often on newly designated building land, following the demolition of old properties
- conversions of former farm buildings to exclusive residences.

Counter-urbanisation is one of a number of processes contributing to social and demographic change in rural settlements, sometimes referred to as the rural turnaround. This may include:

- the out-migration of young village-born adults seeking education and employment opportunities elsewhere
- the decline of the older village-born population, through deaths
- the in-migration of young to middle-aged married couples or families with young children
- the in-migration of younger, more affluent people, which results in increased house prices.

These changes do not take place uniformly within all rural settlements. There are considerable variations between and within parishes. The ones with the most change are key settlements that have a range of basic services and good access to commuter routes. Such settlements are called **suburbanised villages**.

Urban resurgence: characteristics, causes and effects

Urban resurgence refers to the regeneration, both economic and structural, of an urban area which has been through a period of decline. An urban resurgence has been seen in many cities in recent years as redevelopment schemes have made city living more attractive. This is particularly the case for the former industrial cities of the UK which experienced manufacturing decline in the 1970s and 1980s but have reinvented themselves as cities of culture and commerce. London, Birmingham, Manchester and Leeds have all bounced back after severe **de-industrialisation** in the second half of the twentieth century. The cities have revived their fortunes by developing strong financial, business and consumer service industries and have also attracted more university students, young professionals and immigrant workers.

Urban resurgence is evident in the changing landscape of a city. Areas may still contain the industrial architecture of the past, including factories and warehouses, but increasingly these have been converted into housing or commercial use and modern infrastructure and services added. Many urban redevelopment schemes have successfully transformed run-down areas, rebranding them as fashionable districts or 'quarters', which then attract more newcomers, often young professionals, with a high disposable income.

Urban resurgence is often driven by government-led regeneration schemes but there are wider economic, social and demographic processes which are also important. Redevelopment by private companies has led to the wholesale transformation of parts of UK cities in recent years and this has served to attract further investment. City living has also become more attractive as urban areas are improved and people choose to live closer to work, entertainment and leisure facilities, rather than face long and costly commutes. Globalisation and technological change have facilitated the resurgence of some urban areas. Parts of inner East London have experienced a huge in-migration of people, attracted by its reputation for creative and digital start-up businesses. East London Tech City is home to a cluster of independent start-up companies as well as global organisations such as Facebook, Google, Amazon and EE. This area has also become fashionable for its independent shops, galleries, markets, bars and restaurants.

Major sporting events can act as a catalyst to changing the fortunes of an area. The London Olympics brought much needed investment to former industrial parts of East London, while the 2014 Commonwealth Games encouraged urban regeneration and business investment in parts of Glasgow depressed by the

The resurgence of central Birmingham

The Jewellery Quarter in Birmingham is one example of an area which has experienced bust and boom. In the early 1900s, it employed over 20,000 people in jewellery making, metalworking and hallmarking but a combination of international competition, reduced demand and the bombing of the area during the Blitz led to a sharp decline in the area's fortunes. Decline continued throughout the twentieth century and in spite of a small number of regeneration attempts, it was not until the early 2000s that large-scale improvements began to be seen. Former warehouses and factories have been converted into loft-style apartments and townhouses, and more than 30 restaurants, bars and cafés have helped create a vibrant hub for young businesses and professionals (Figure 9.8).

Further evidence of urban resurgence in Birmingham can be found in the Gas Street Basin canal area. Close to the city centre, this area was once the hub of a thriving canal transport network moving heavy goods such as coal and glass. Today, the canals have been cleaned up and are part of an attractive area where bars and restaurants line the waterways and traditional narrowboats navigate past large arts and entertainment complexes.

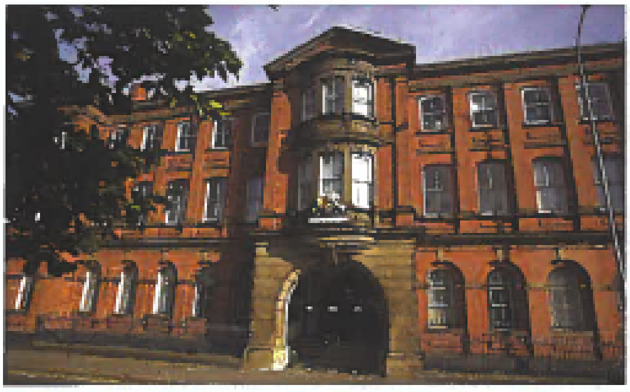

Figure 9.8 The Birmingham Mint redevelopment is found on the edge of the Jewellery Quarter in Birmingham. The Grade II listed former minting factory was converted into flats with many of its traditional features still intact.

decline of shipbuilding, steelmaking and heavy engineering. Resurgence has a positive multiplier effect, initiating further improvements and attracting greater investment into an area. However, as more people are attracted back into a city, greater pressure is put on the urban infrastructure and some people may find themselves displaced as house prices rise in line with demand. There are also concerns that not everyone benefits from resurgence and this has led to increasing inequality between people on high and low incomes.

Many American cities including New York, Boston and Los Angeles have experienced an urban resurgence in recent decades. The second half of the twentieth century saw a huge population decline in urban areas as families increasingly moved out to the suburbs. This was accompanied by the loss of manufacturing and retail businesses and soon the traditional 'downtown' areas – the major retail centre of the city – were in decline along with neighbouring residential areas. The term '**dead heart syndrome**' was used to describe this process.

The 1990s saw the beginning of a resurgence. A sustained period of national economic growth, successful regeneration schemes and more attractive urban design has helped revive the fortunes of many American cities. In addition, young people are remaining in cities even when they start a family, while many older people whose children have left home are moving back to the city to be closer to urban services. This population revival increases demand for services and has fuelled a prosperous urban economy in many cities.

Urban change

De-industrialisation, decentralisation and the rise of the service economy

De-industrialisation refers to the loss of jobs in the manufacturing sector, which occurred in the UK in the second half of the twentieth century. Prior to this, the Industrial Revolution and the rise of manufacturing industry had been a key development in the growth of many urban areas. Cities became synonymous with particular types of industry, such as textiles (Manchester), iron and steel (Sheffield) and shipbuilding (Glasgow). Thousands of jobs were created and people migrated into urban areas. By the 1980s, many of the older industrial cities were experiencing severe economic problems associated with the decline of manufacturing. This has been attributed to three main factors:

- mechanisation: most firms can produce their goods more cheaply by using machines rather than people
- competition from abroad, particularly the rapidly industrialising countries of the time such as Taiwan, South Korea, India and China
- reduced demand for traditional products as new materials and technologies have been developed.

Table 9.1 shows an overall downward trend in manufacturing employment in the UK. Urban areas bore the brunt of these job losses but unemployment figures varied significantly between cities and depended upon the size of the city, the composition of the urban economy and the actions of local government. Cities in the manufacturing heartlands of northern England

The New York City High Line

Urban resurgence is evidenced in New York with the changing nature of the New York City High Line – a 1.5 mile-long section of elevated rail track built originally to carry goods to and from Manhattan's largest industrial district. It was abandoned in the 1980s as the Lower West Side underwent a period of manufacturing decline but has been successfully redeveloped in the 2000s as an elevated park and walkway lined with trees, grasses and shrubs.

The walkway has become a site for artistic commissions and cultural events and the five million annual visitors have increased spending in local shops and cafes, as well as encouraging real estate development in the neighbourhoods that line its route.

The High Line has given new life to a piece of industrial infrastructure as a public green space and functions essentially like a green roof. Porous pathways contain open joints so water can drain between planks, cutting down on the amount of storm-water that runs off the site into the sewer system. The planting design is inspired by the self-seeded landscape that grew on the elevated rail tracks during the 25 years in which they were derelict.

Figure 9.9 New York City's High Line