Look closely at Figure 2.16. What different land uses can you identify?

Figure 2.16: *Coastal development*

As a result of these and other human activities, the natural landscapes and features of the coast can be greatly changed. So too the actual shape of the coastline.

2.4 Coastal ecosystems and their distributions

Given the large amounts of development and settlement which have taken place in the coastal areas of the world, it is easy to forget that the coast is home to a variety of ecosystems. In their natural state, coasts can be very rich in **biodiversity**. In this section, we will look at four different ecosystems. Two of them, coral reefs and mangroves, have tropical distributions. The other two, salt marshes and sand dunes are common across the world.

Coral reefs

Coral reefs are a unique marine ecosystem. They are built up entirely of living organisms (Figure 2.17). Reefs are huge deposits of calcium carbonate made up mainly of corals. Their global distribution is shown in Figure 2.18. It is mainly controlled by four factors:

- **temperature** – coral growth needs a minimum water temperature of 18°C. They grow best between 23°C and 25°C
- **light** – is needed for the coral to grow; because of this need, corals grow only in shallow water
- **water depth** – because of the need for light, most reefs grow where the sea is less than 25 metres deep
- **salinity** – since corals are marine creatures, they can only survive in salt water.

Figure 2.17: *Section of a coral reef*

At a local level, there are other factors affecting where coral reefs develop:

- **wave action** – corals need well oxygenated salt water; this occurs in areas of strong wave action

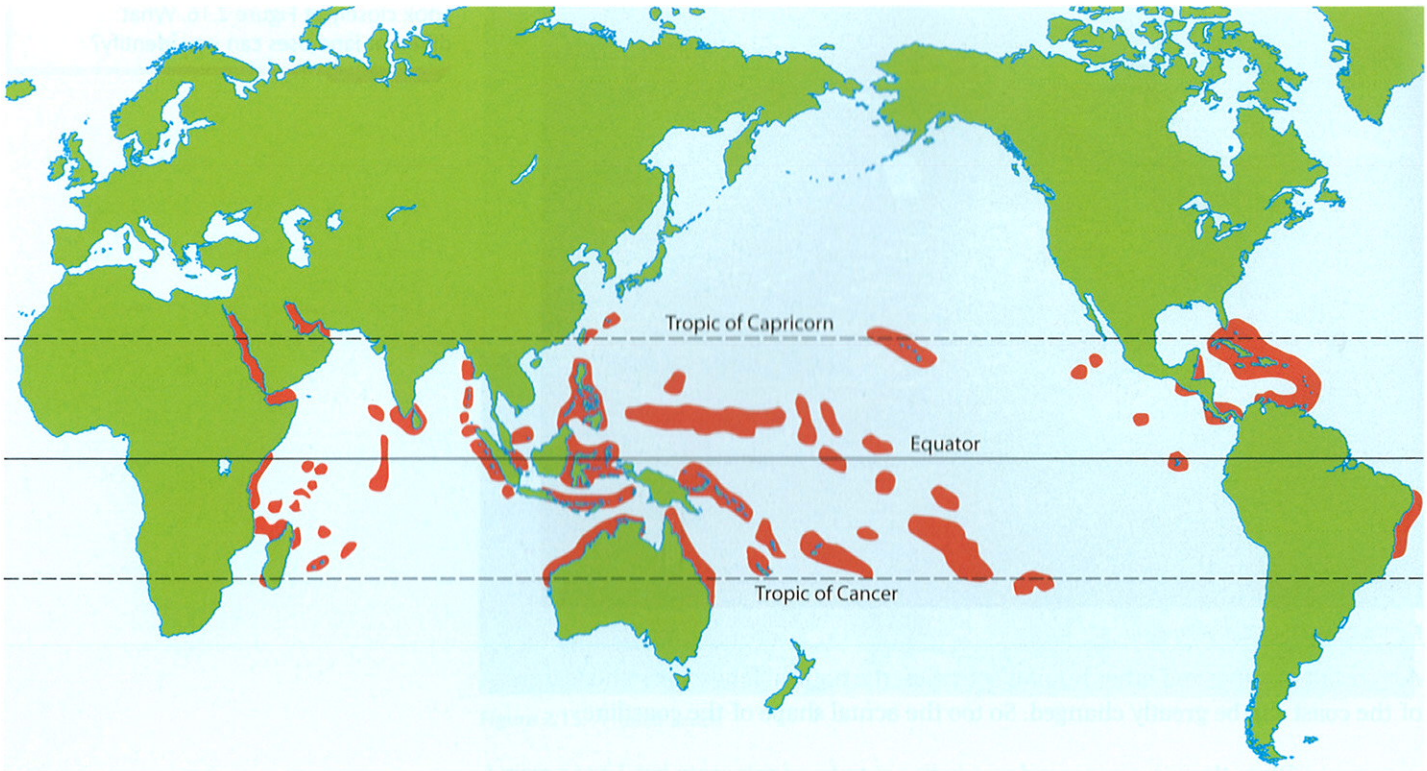

Figure 2.18: *The global distribution of coral reefs*

- **exposure to air** – whilst corals need oxygenated water, if they are exposed to the air for too long they die
- **sediment** – corals need clear, clean water. Any sediment in the water blocks their normal ways of feeding. Sediment also reduces the amount of light.

Many coral reefs take the form of horseshoe-shaped rings enclosing a lagoon. In this form, they are known as 'atolls'.

Coral reefs with the highest biodiversity occur in South-east Asia and northern Australia. The Great Barrier Reef is in Australia and is renowned not just for its great **biodiversity**, but also its extent and excellent condition.

Mangroves

Mangroves are most common in South-East Asia (Figure 2.19). It is thought that they originated here and subsequently spread around the globe. Today, most mangroves are found within 30 degrees latitude of the Equator, but a few hardy types have adapted to temperate climates. They reach as far as the North Island of New Zealand.

Mangroves literally live on the coastline – they have one 'foot' on the land and the other in the sea. Because they grow in the intertidal zone, they live in a constantly changing environment. They are regularly flooded by the sea. At low tide, especially during periods of high rainfall, there may be floods of fresh water. This quickly alters the salt levels, as well as temperatures. Mangroves are not only able to survive these changing water conditions, they can cope with great heat and choking mud.

Figure 2.19: *The global distribution of mangroves*

Despite these environmental difficulties, the mangrove ecosystem is among the most successful ecosystems on Earth. South-East Asia also boasts mangroves with the highest biodiversity in the world. There are many species of mangrove. They range in size from small shrubs to trees over 60 metres in height. They are all clever at adapting to their environment. Each mangrove has an filtration system to keep much of the salt out and a complex root system that is adapted for survival in the intertidal zone. Some have snorkel-like roots that stick out of the mud to help them take in air; others use prop roots or buttresses to keep their trunks upright in the soft sediments at tidal edge, as in Figure 2.20.

Identify the main features of the global distribution of mangroves shown in Figure 2.19. In what ways is the distribution similar or different to that of coral reefs (Figure 2.18)?

Figure 2.20: *A belt of mangrove*

It is these roots that trap mud and sand, and eventually build up the intertidal zone into land. At the same time, the mangrove is colonising new intertidal areas. The fruits and seedlings of all mangrove plants can float. As they drift in the tide away from the parent trees, they become lodged in mud where they begin to grow. So a new area of mangrove takes root.

Salt marshes

Salt marshes occupy a midway location between mudflats that are permanently submerged by water and terrestrial (land) vegetation lying above the high-tide mark. Like mangroves, they are an ecosystem of the intertidal zone.

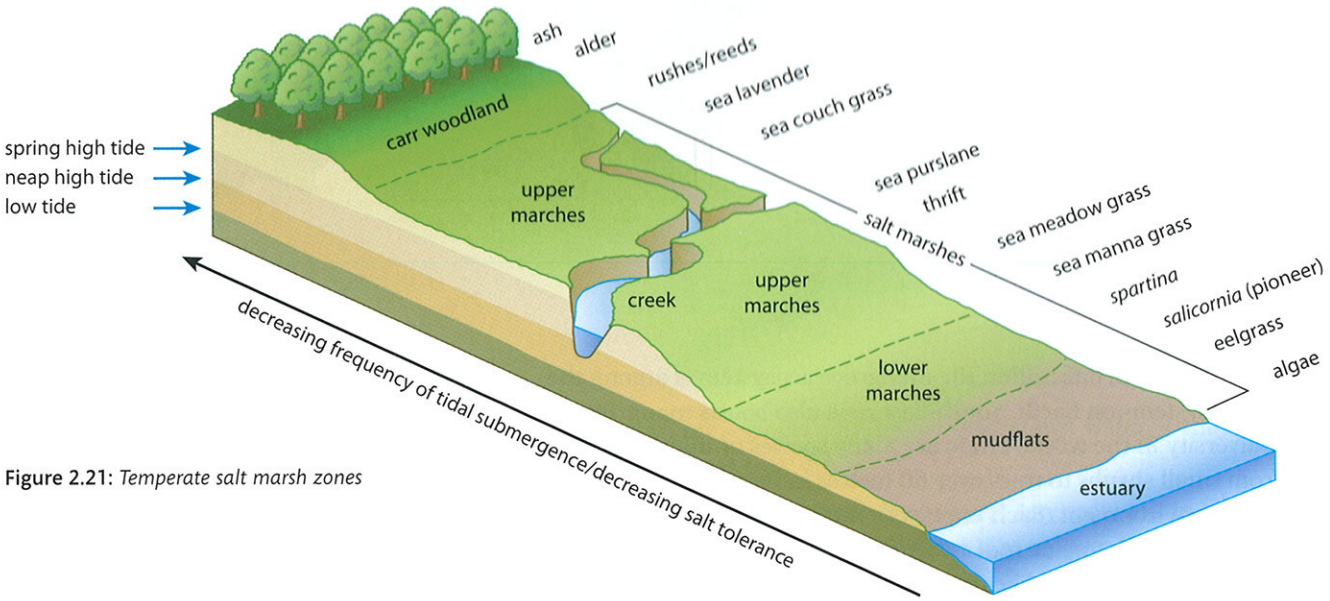

Figure 2.21: *Temperate salt marsh zones*

Coastal salt marshes develop in locations sheltered from the open sea, namely at the heads of bays and in estuaries. Since estuaries are where a river meets the sea, the water is brackish (partly salty and partly fresh). In bays, the water is salty.

Salinity (how salty the water is), and the frequency and extent of flooding of the marsh determine the types of plants and animals found there (Figure 2.21). In some cases, the low marsh zone floods twice daily while the high marsh floods only during storms and unusually high tides. These different environmental conditions result in differences in the types of plants and animals found in different parts of the same marsh area.

Research the difference between spring tides and neap tides. What is the significance of the difference in terms of salt marsh ecosystems?

Salt marshes are criss-crossed by meandering creeks, which allow tidal water to drain in and out (Figure 2.22). The creeks slow down tidal energy and the marsh plants slow down wave energy. As a result, there is an almost continuous deposition of silt and mud. Over time, this means that the salt marsh gradually extends seawards.

Figure 2.22: *A typical area of salt marsh*

Which of the salt marsh zones is shown in Figure 2.22? Refer to Figure 2.21 to see the possible choices. Give reasons for your choice of zone.

Coastal sand dunes

Coastal sand dunes are accumulations of sand shaped into mounds and ridges by the wind. They develop best where:

- there is a wide beach and large quantities of sand
- the prevailing wind is onshore (from the sea to the shore)
- there are suitable locations for the sand to accumulate.

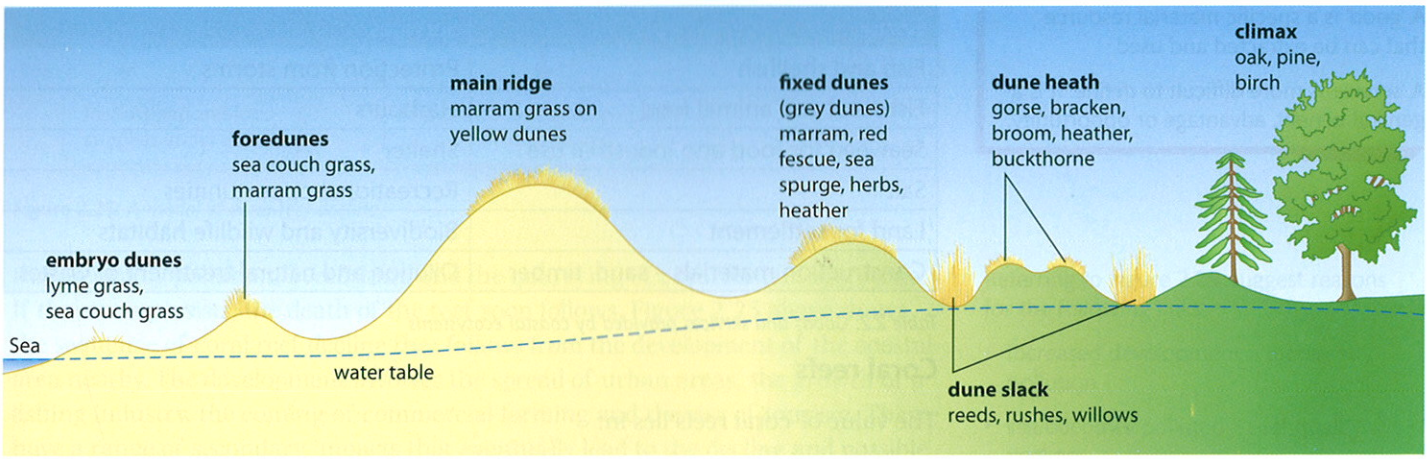

Figure 2.23: *A typical coastal sand dune cross-section*

When the beach dries out at low tide, some of the sand is blown to the back of the beach by the onshore wind. The sand accumulates there, often around a small obstacle such as a piece of driftwood or dry seaweed. As the accumulation grows, an **embryo dune** is formed. It continues to grow and becomes more stable. Another dune may eventually develop on the seaward side of the original dune. The original dune is now further inland and relatively sheltered from the prevailing onshore wind. If this sequence continues, a series of dunes will develop in the form of ridges running parallel to the shore (Figure 2.23).

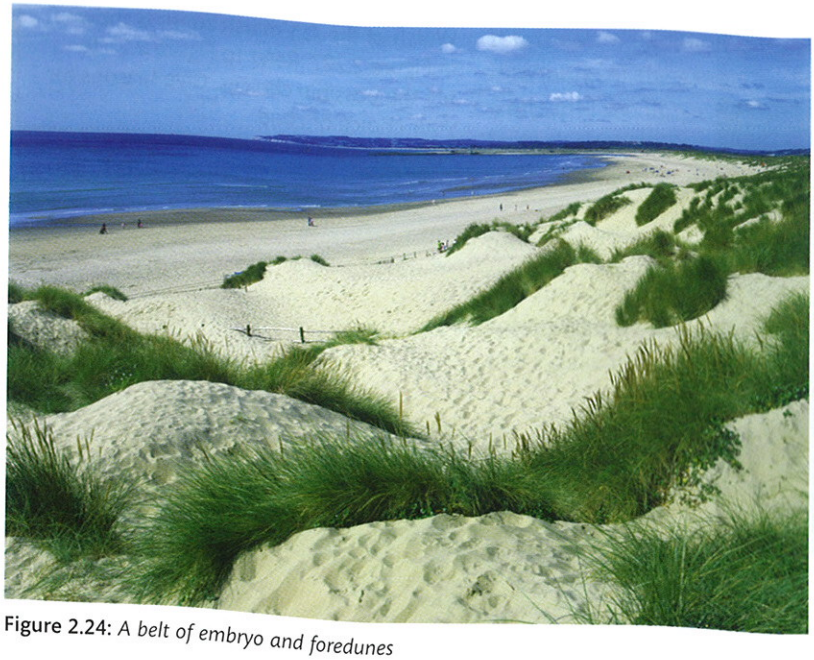

Figure 2.24: *A belt of embryo and foredunes*

Over time, the ridges of the dunes will be colonised and 'fixed' by vegetation. The older the ridge and the further inland, the greater the vegetation cover. The first plants, such as sea twitch and sea couch grass, have to be able to cope with the following conditions:

- salinity
- a lack of moisture as sand drains quickly
- wind
- temporary submergence by wind-blown sand.

Once some plants become well established, environmental conditions improve and other plants begin to appear. Eventually, in temperate areas, dune heath will become established (Figures 2.23 and 2.24).

2.5 Coastal ecosystems under threat

In this section, we return to the same four ecosystems examined in Part **2.4**. We will look at them at in terms of their value to people and how this, in turn, threatens their existence. All ecosystems offer people a range of opportunities. These opportunities are referred to as **goods and services**. Table 2.2 shows the main goods and services provided by coastal ecosystems.

A 'good' is a specific material resource that can be extracted and used.

A 'service' is more difficult to define. It is a general benefit, advantage or opportunity.

Goods	Services
Fish and shellfish	Protection from storms
Fishmeal and animal feed	Harbours
Seaweed for food and industrial use	Shelter
Salt	Recreational opportunities
Land for settlement	Biodiversity and wildlife habitats
Construction materials – sand, timber	Dilution and natural treatment of wastes

Table 2.2: Goods and services provided by coastal ecosystems

Coral reefs

The value of coral reefs lies in:

- their biodiversity – within the Great Barrier Reef there are 700 species of coral; 1500 species of fish and 4000 species of mollusc
- the protection they give to low-lying coasts from the impact of tropical storms
- their rich fish stocks – they supply the basic food requirements of many LICs
- their appeal to tourists and the recreational opportunities they offer such as snorkelling and scuba diving. Over 150 million people each year take holidays in areas with coral reefs.

Coral reefs are easily stressed by human actions. Any contact with the human body is likely to kill the coral immediately around the point of contact. Reefs are also

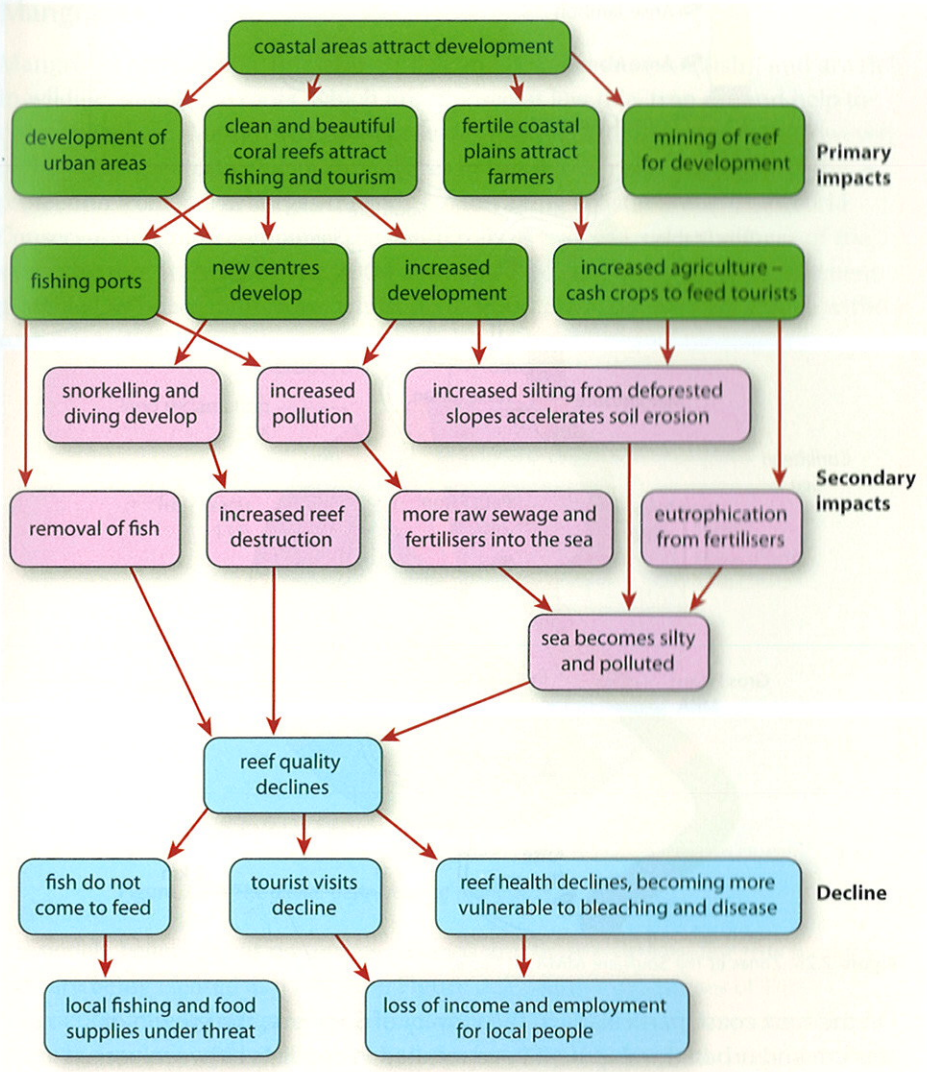

Figure 2.25: *A model of coral reef decline*

threatened by pollution, overfishing and the quarrying of coral for building stone. If the stress persists, the death of the reef soon follows. Figure 2.25 above shows the sequence of coral reef decline that follows from the development of the coastal area nearby. The development involves the spread of urban areas, the growth of a fishing industry, the coming of commercial farming and the rise of tourism. These have a range of secondary impacts that eventually lead to the decline and possible death of the coral reef.

A recent survey of the world's coral reefs showed that 27% of them were highly threatened by human activities. Another 31% were classified as being under 'medium threat'.

Referring to Figure 2.25, suggest reasons for the following links:

- increased development > increased pollution
- sea becomes polluted > reef quality declines
- reef health declines > loss of income and employment.

Case study: Coral reef management in St Lucia

The Caribbean island of St Lucia is fringed with coral reefs. A survey has identified 90 km² of those reefs as seriously threatened by human activities, particularly by overfishing, tourism and coastal development, marine pollution and sedimentation from the land.

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

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

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

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

Recreational areas
Areas for public recreation, sunbathing, swimming.

Figure 2.26: *Zones of the Soufriere MMA, St Lucia*

Both fishermen and divers damage the reef areas in a variety of ways, such as lowering metal anchors and chains and climbing over and touching the coral.

Moored yachts pollute the sea and this has an adverse impact on fish stocks.

On the west coast, particularly in the vicinity of Soufriere, the growth of tourism and urban development have resulted in conflicts between user groups – for example between fishermen and divers over reef areas, and between fishermen and yachts anchoring in fishing zones. In response to these conflicts, the Soufriere Marine Management Area (SMMA) was set up to try to resolve the conflicts and to reduce the threats to the coral reef.

The solution the SMMA came up with was an apparently simple one – divide the 11 km length of coast into five different zones (Figure 2.26):

- **marine reserves** – all uses forbidden, so future of coral reefs protected
- **fishing priority areas** – no diving or yachting
- **recreational areas** – mainly for diving and various water sports
- **yacht mooring areas** – mooring of yachts allowed
- **multiple-use areas** – open to all users.

The segregation of different users of the coral reefs has resolved the conflicts. However, the plan does little to protect the coral reefs outside the marine reserves. The best hope is that each of the user groups will do their utmost to minimise their impact on the reefs.

Mangroves

Mangroves are valuable nurseries of fish and crustaceans (shellfish), and are rich in wildlife. Mangrove roots, which are exposed at low tide, trap silt and help to create new land. Mangrove timber provides fuel and building material. However, perhaps the greatest value of mangroves in this age of rising sea levels is the protection from storm surges they give to low-lying coastal areas. The World Conservation Union compared the death tolls in two Sri Lankan villages of the same size that were hit by the 2004 tsunami. Two people died in the settlement protected by dense mangrove, whilst up to 6000 people died in the village without such protection.

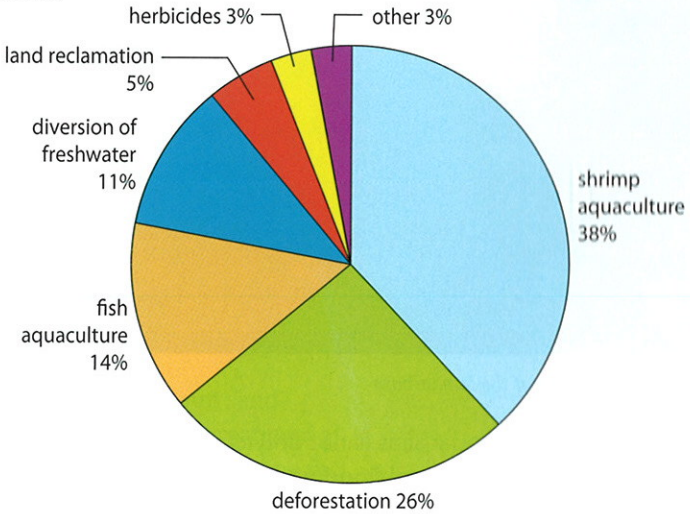

Figure 2.27: *The global destruction of mangroves*

It is widely believed that mangrove swamps are disease-ridden. For this reason, they are being cleared at a fast rate. Figure 2.27 shows the causes of this destruction at a global scale. Just over half of the mangrove swamps are being cleared to make way for aquaculture – the farming of fish and shrimps. A quarter is being cleared (deforestation) to provide timber for fuel and building purposes. The land reclamation is being undertaken to provide sites for the building of tourist hotels and other amenities. The diversion of freshwater is intended to meet the needs of tourists and expanding agriculture. The latter (farming) requires the application of herbicides to prepare cleared areas for cultivation.

What are the arguments for and against protecting mangroves from human use?

Case study: Management of the mangrove

Bangladesh is one country in the world that understands the value of the mangrove. It is a low-lying country. Its long coastline is vulnerable to tropical storms and storm surges. Bangladesh also has a huge population and a shortage of land. The mean population density is around 1000 persons per km^2. Up to 25 million people live less than 1 metre above sea level.

As part of its Coastal Zone Policy, the Bangladesh government is taking advantage of the fact that mangroves trap sediment and stabilise shores. By deliberately planting mangroves on delta sediments washed down from the Himalayas, it has gained over 120 000 hectares of new land in the Bay of Bengal. The plantings are relatively new, but there have been mangroves here for as long as the Ganges, Brahmaputra, and Meghna Rivers have been

draining into the Bay. The vast tidal woodland they form is known as the Sundarbans – it literally means 'beautiful forest'. Today, it is the largest surviving single tract of mangroves in the world (Figure 2.28).

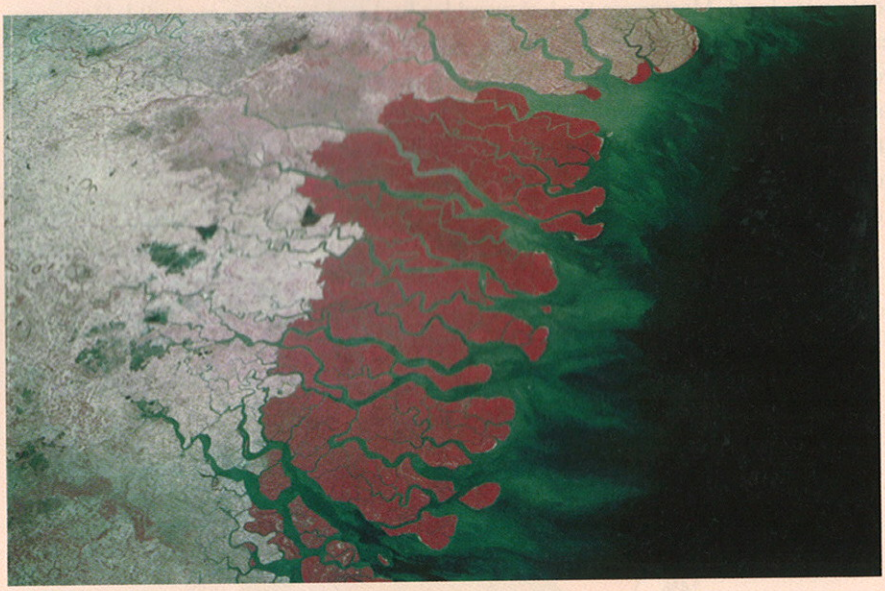

Figure 2.28: *Satellite image of the Sundarbans*

The management of the Sundarbans is not only creating new land and protecting Bangladesh from coastal flooding, it is also permitting local people to make use of its resources. The only real threat is the clearance of some mangroves to allow the aquaculture of shrimps and fish. The former is a valuable export; the latter an important food to help feed a large and hungry population.

There is more information about Bangladesh to be found in:

- Chapter 1.5 (page 14)
- Chapter 1.8 (page 30)
- Chapter 4.3 (page 99)
- Chapter 5.6 (page 128)
- Chapter 7.8 (page 205)

Salt marshes

On the face of it, areas of salt marshes appear to be of little obvious value. However, the reality is that many salt marshes are among the most used and therefore the most threatened ecosystems in today's world. Specific threats include:

- reclamation to create farmland and sites for industrial and port developments – this is based on the perception that marshes are wasted spaces that need to be put to some good use
- industrial pollution – particularly of water, as many marshes occur in estuaries which are favoured as sites for ports, power stations and oil refineries (Figure 2.29)
- agricultural pollution – heavy applications of fertilisers and pesticides on adjacent farmland lead to eutrophication (an increase in the concentration of chemical fertilizers in an ecosystem) of marshland waters
- pressure from developments such as marinas and other recreational facilities.

Salt marshes are also threatened by changes associated with global warming such as more storms and higher water levels.

Figure 2.29: *Industrial development on a salt marsh*

Why are salt marsh areas attractive to industry?

Coastal sand dunes

Of the four ecosystems, coastal sand dunes are probably the least threatened at a global level. This perhaps reflects the fact that they have little to offer people other than coastal protection. In the UK, however, they are put at risk by the density of people using them as recreational spaces. Various forms of recreation – such as trail biking and horse riding– are doing great damage. Sand dunes are delicate ecosystems and easily disturbed (Figure 2.30). Disturbance of dunes often leads to a loss of vegetation and to **blow-outs**. Because of their nearness to urban and industrial areas, whole tracts of coastal sand dune are at risk of being built over. Because of their nearness to the coastline, they are under pressure from tourism to provide amenities such as golf courses and caravan sites. In many parts of the world, areas have been planted with trees to help stabilise mobile dunes. The net effect of this has been to destroy the coastal sand dune ecosystem.

Figure 2.30: *An area of degraded sand dune*