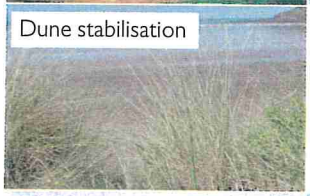
Soft engineering

A range of soft-engineering techniques attempt to work with natural processes to protect coasts (see Figure **4**). They can also be used to manage changes in sea level, for example, by allowing low-lying coastal areas to flood (creating marshes).

Figure 4 *Soft engineering – advantages, disadvantages and costs*

Method	Description	Advantages	Disadvantages	Cost
Beach nourishment 	The addition of sand or pebbles to an existing beach to make it higher or wider. The sediment is usually dredged from the nearby seabed.	Relatively cheap and easy to maintain. It looks natural and blends in with the existing beach. It increases tourist potential by creating a bigger beach.	Needs constant maintenance because of the natural processes of erosion and longshore drift.	£300 000/100 m
Cliff regrading and drainage 	Cliff regrading reduces the angle of the cliff to help stabilise it. Drainage removes water to prevent landslides and slumping.	Can be effective on clay or loose rock where other methods will not work. Drainage is cost-effective.	Regrading effectively causes the cliff to retreat. Drained cliffs can dry out and lead to collapse (rock falls).	Cost is variable
Dune stabilisation 	Marram grass can be planted to stabilise dunes. Areas can be fenced in to keep people off newly planted dunes.	Maintains a natural coastal environment. Provides important wildlife habitats. Relatively cheap and sustainable.	Time consuming to plant marram grass. People may respond negatively to being kept off certain areas.	£200 to £2000/100 m
Marsh creation 	A form of managed retreat, by allowing low-lying coastal areas to be flooded by the sea. The land then becomes a salt marsh.	Relatively cheap (land reverts to its original state before management). Creates a natural buffer to powerful waves. Creates an important wildlife habitat.	Agricultural land is lost. Farmers or landowners need to be compensated.	The cost is variable – depending on the size of the area left to the sea.

Sustainable integrated approaches

Soft-engineering schemes adopt sustainable principles (they are intended to work with nature over a long period of time) but they tend to be very focused on a particular stretch of coastline to solve an issue at a specific locality. Increasingly, management authorities – both political and non-political – are looking at holistic management plans for significant stretches of coastline.

Figure 5 *Managed retreat at Alkborough Flats, Lincolnshire*

ACTIVITIES

S

1 Using diagrams, explain how hard-engineering methods alter physical systems and processes.

2 To what extent do soft-engineering techniques represent sustainable approaches to coastal management?

3 Describe the coastal management measures shown in Figure **2** and suggest the advantages of combining hard and soft engineering.

4 Assess the advantages of integrated management plans such as Shoreline Management Plans (SMP) and Integrated Coastal Zone Management (ICMZ).

5 Is there ever a case for deliberately *not* protecting a stretch of coastline from erosion?

Traditional approaches

Coastal erosion can be prevented – up to a point – but it is an expensive business. The cost of protecting the coast is often controversial. Until the 1990s, it was usual for local councils to tackle coastal erosion by designing *hard-engineering* structures. However, most of those structures are very expensive to build (see Figure **3**), so now the use of *soft-engineering* techniques is more popular. Each method has advantages and disadvantages.

Hard engineering

Many stretches of coast in the UK exhibit a mixture of nineteenth-century hard-engineering structures, which have been since upgraded, extended and altered. Some of the most common types of hard-engineering structures are described in Figure **3**.

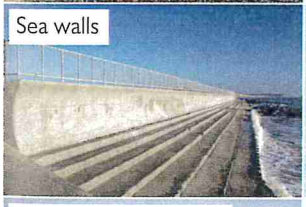
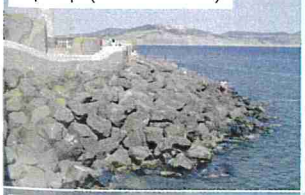
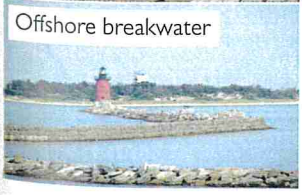
Cost-benefit analysis (CBA)

A cost-benefit analysis is carried out before a coastal-management project is given the go-ahead. Costs are forecast (e.g. a sea wall – its design, building costs, maintenance, etc.) and then compared with the expected benefits (e.g. value of land saved, housing protected, savings in relocating people, etc.). Costs and benefits are of two types:

- tangible – where costs and benefits are known and can be given a monetary value (e.g. building costs)
- intangible – where costs may be difficult to assess but are important (e.g. the visual impact of a revetment).

A project where costs exceed benefits is unlikely to be given permission to go ahead.

Figure 3 *Hard engineering – advantages, disadvantages and costs*

Type of structure	Description	Advantages	Disadvantages	Cost
Groynes 	Timber or rock structures built at right angles to the coast. They trap sediment being moved along the coast by longshore drift – building up the beach.	Work with natural processes to build up the beach, which increases tourist potential and protects the land behind it. Not too expensive.	Starve beaches further along the coast of fresh sediment (because they interrupt longshore drift), often leading to increased erosion elsewhere. Unnatural and can be unattractive.	£5000 to £10000 each (at 200-metre intervals).
Sea walls 	Stone or concrete walls at the foot of a cliff, or at the top of a beach. They usually have a curved face to reflect waves back into the sea.	Effective prevention of erosion. They often have a promenade for people to walk along.	They reflect wave energy, rather than absorbing it. They can be intrusive and unnatural looking. They are very expensive to build and maintain.	£6000/m
Rip rap (rock armour) 	Large rocks placed at the foot of a cliff, or at the top of a beach. It forms a permeable barrier to the sea – breaking up the waves, but allowing some water to pass through.	Relatively cheap and easy to construct and maintain. Often used for recreation – fishing, sunbathing.	Can be very intrusive. The rocks used are usually not local and can look out of place with local geology. Can be dangerous for people clambering over them.	£100000 to £300000/100m
Revetments 	Sloping wooden, concrete or rock structures placed at the foot of a cliff or the top of a beach. They break up the waves' energy.	They are relatively inexpensive to build.	Intrusive and very unnatural looking. They can need high levels of maintenance.	Up to £4500/m
Offshore breakwater 	A partly submerged rock barrier, designed to break up the waves before they reach the coast.	An effective permeable barrier.	Visually unappealing and a potential navigation hazard.	Similar to rock armour – depending on the materials used.

This classification helps avoid making the situation worse elsewhere when protecting one section of coast by unintentionally depriving a neighbouring section of essential coastal material.

Thinking like a geographer

Geographers need to consider events from different viewpoints. How would you explain the benefits of coastal erosion to a disgruntled farmer whose land is being lost?

Investigate

On the Environment Agency website, find shoreline management plans for different sediment cells around the coast of England and Wales. What factors encourage the decision to 'Hold the Line'?

3.6 Reducing the rate of coastal erosion

A variety of engineering methods are available to protect the coast from erosion.

Hard engineering

Some strategies are intended to intercept and impede natural marine and coastal processes so that they are less likely to produce undesirable consequences. They are referred to as **hard engineering** methods (Table 3.3).

Key term

hard engineering: strategies that are designed to intercept and impede natural marine and coastal processes so that they are less likely to produce undesirable consequences

Hard engineering techniques	Operation	Advantages	Disadvantages
Revetments	A form of wooden or rock beach fence that allows waves through but reduces their power.	Can be implemented swiftly. Relatively cheap in the short term.	Unattractive and might reduce beach access. Require regular maintenance and repair.
Gabions	Open wire cages filled with rocks placed at the foot of soft cliffs to absorb wave force.	Can be implemented swiftly. Relatively cheap.	Looks unnatural. Can house rodents in gaps between rocks. Deteriorate over time.
Groynes	Wooden or boulder structures extending at right angles from a beach. Accumulate material from longshore drift to build up beach width and height.	Traditional technique used at resorts since Victorian times. Increased beach area benefits tourism.	Traditionally built from unsustainable hardwood sources. Down-coast beaches robbed of sediment, increasing their rate of erosion.
Concrete tetrapods	Moulded concrete multi-pronged forms placed in interlocking concentrations along a shoreline.	Can be created onsite using standard moulds, which reduces transport costs. Long-lasting, requiring little maintenance.	Can restrict shoreline access. Can be hazardous to coastal vessels. Unattractive.
Rock armour (rip-rap)	Large boulders of highly resistant rock (often granite, gneiss or schists) placed at the foot of cliffs.	Effective at absorbing wave energy. Long-lasting, requiring little maintenance. More natural looking than tetrapods.	Can restrict shoreline access. May be hazardous to people climbing on them. High transport costs.

Hard engineering techniques	Operation	Advantages	Disadvantages
Offshore reefs / breakwaters	Man-made islands, bars or reefs just offshore to cause waves to break and provide calmer water between them and shore.	Arguably the least 'hard' technique in that it is relocating a natural process to offshore. Islands may form additional habitats.	May need regular replenishment if material is eroded swiftly. Construction material may contaminate local waters.
Sea wall	Thick concrete or rock encasement of shore front. May have recurved top to assist deflection of waves back to sea.	Standard frontage of seaside resorts for many decades. Effective and long-lasting.	Expensive construction costs. Maintenance required to prevent fracturing and undercutting beneath foundation.

Table 3.3 Hard engineering coastal protection methods.

Soft engineering

Soft engineering techniques work with natural processes, altering and redirecting them to bring about a desired influence. These often require continuous intervention, distributing the costs over time into the future.

3.7 Managing increasing coastal flood risk

The likelihood of more frequent and severe flooding at the coast is increasing around the world due to one or more of these factors:

- higher storm surges as a result of more intense low-pressure systems. The flooding of New York by Hurricane Sandy in 2012 is thought to have led to 48 fatalities and cost over $18 billion in damage.
- rising sea levels as a result of climate change
- estuarine flooding due to high river discharge, high tides and storm surges coinciding
- tsunami risk as densities of populations living on coasts increase globally.

Precautions that can offer protection against current and future coastal flooding impacts are costly. The implications are serious for many developing countries that have major coastal cities that are growing as urbanisation rates continue to climb, but lack access to funds to implement major coastal engineering. In a recent study of cities vulnerable to the effects of climate change, nine of the top ten identified as 'at extreme risk' are in Asia, topped by Dhaka, Manila and Bangkok. While Manila, in the Philippines, is preparing a largescale 50-year plan for coastal barriers and reclaimed land, other cities such as Mumbai face claims of increasing flood risk by permitting removal of energy-absorbing mangrove wetlands in order to build the new Navi Mumbai airport.

Hard engineering

Hard engineering strategies to reduce flood risk include:

- flood barrage: sophisticated engineering constructions across estuaries that contain sluices to permit passage of tidal water but close when unusually high tides, storm surges or flood tides are forecast.

Look on **Cambridge Elevate** to find out about the cost of coastal defences in 'Cost estimation for coastal protection' from the Flood and Coastal Erosion Risk Management and Research Development Programme (www.cambridge.org/links/gase6017).

Key term

soft engineering: low-incursion, sustainable coastal protection strategies that work with nature to manage the coast

Research point

Find out the responses to the Indian Ocean tsunami of Boxing Day 2004 that resulted in the deaths of over 220000 people. What has been put in place to reduce the impact of future tsunami events?

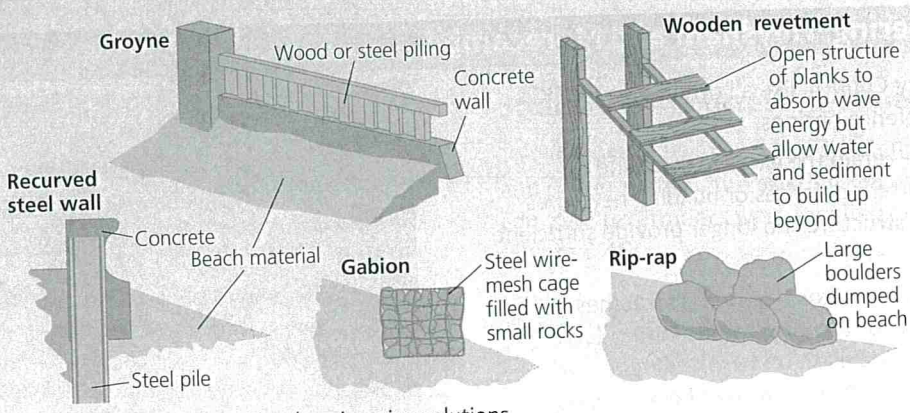


Figure 3.40 Examples of hard engineering solutions

Traditional approaches to coastal erosion and flood risk

Hard engineering

Hard engineering generally involves making a physical change to the coastal landscape using resistant materials, like concrete, boulders, wood and metal. Often each strategy is large scale and costs a significant amount of money. Each type of hard sea defence is built with a specific purpose (Figure 3.40):

- **Sea walls** (sometimes **recurved**) aim to dissipate wave energy. The recurved structure throws waves back out to sea, into the path of the next incoming wave, thus also reducing its wave impact. Sea walls also provide a physical barrier to flooding by raising the height of the coastline. Sea walls must have a continuous facing because any slight gap will be exploited by hydraulic action. They also need drain outlets so that any water that does get over them does not accumulate inland.
- **Rock armour** (rip-rap) consists of large boulders dumped in front of a cliff or sea wall to take the full force of the waves. The boulders are deliberately left angular in appearance to present a large surface area to the waves, and create gaps for water to filter through, again mitigating their impact on the coast. Usually the boulders are not secured in place so energy is taken out of the most powerful waves by rocking or slightly moving the massive rocks.
- **Gabions** operate on the same principle as rip-raps, but smaller boulders are contained within steel wire-mesh cages, each of which can be joined together to form larger structures, or walls.
- **Revetments** are concrete or wooden structures placed across a beach or coastline to take the full force of the wave energy, preventing further erosion of the coast.
- **Groynes** are wooden, stone or steel breakwaters built nearly at right angles to waves (usually 5 to 10° from the perpendicular to prevent scouring on the down-drift side of the groyne). They are built to control longshore drift by trapping sediment to create higher and wider beaches which will then also dissipate wave energy. The groynes themselves will also break up the waves as they hit the coast. Halting the bulk of longshore drift in an area may have serious effects down the coast where it will cut off the supply of beach material and could leave the coast there exposed to erosion.
- **Cliff fixing** is often done by driving iron bars into the cliff face, both to stabilise it and to absorb some wave power.
- **Offshore reefs** force the waves to break offshore, which reduces their impact on the base of cliffs. In some places redundant ships have been deliberately sunk parallel to the shore to both slow down approaching waves, and to act as a substructure for reef material to begin to colonise.
- **Barrages** are large structures built to prevent flooding on major estuaries and other large sea inlets. A barrage acts as a dam across an estuary and prevents incursion of seawater. Good examples of barrages are those that are part of the Delta Plan in the Netherlands and the Cardiff Bay barrage in Wales which was completed in 1999.

Hard engineering strategies are generally long lasting and effective over their planned lifespan; however they do have several disadvantages, including:

- structures can be expensive to build and to maintain (to repair a sea wall can cost over £5,000/m)
- defence in one place can have serious consequences for another area of the coast
- structures are sometimes an eyesore, spoiling the landscape and physically disrupting natural habitats.

The coastal town of Morecambe in Lancashire is used as an illustrative example of the use of hard engineering strategies.

Soft engineering

Soft engineering uses natural systems for coastal defence, such as beaches, dunes and salt marshes, which can absorb and adjust to wave and tide energy. It involves manipulating and maintaining these systems, without changing their fundamental structures.

- **Beach nourishment:** This is the attempt to replace material that has been lost through longshore drift. It is not unknown for local councils to move material from one end of a beach to the other before the start of the tourist season.
- **Dune regeneration:** The fragile sand dune environment is easily disrupted by human activities. Most damage is caused by the removal of vegetation by either agriculture (overgrazing) or tourism (trampling the dunes). This can lead to blowouts during which large amounts of sand may be carried inland and deposited on valuable agricultural land. Management strategies to regenerate dunes include:
  - replanting vulnerable areas with plants such as marram grass and stabilising the surface with sacking or wire mesh
  - afforestation with quick-growing conifers
  - selective grazing
  - restricting access by fencing off areas
  - providing boardwalks for tourists
  - giving tourists information about potential damage.
- **Managed retreat:** This involves abandoning the current line of sea defences and then developing the exposed land in some way, perhaps with salt marshes, to reduce wave power. If old sea defences such as walls are abandoned, low-lying land will be flooded. This will be reclaimed naturally by marsh plants. The new area of marsh will act as a defence against rising sea levels. In this way the scale of hard sea defences can be reduced. There have been proposals in some areas to ban new developments on the coast. In California, for example, there are already requirements on some stretches of coastline that building must be a certain distance from the shore.
- **Land-use management:** Even if it is inevitable that a coastal area will be eroded or flood in the future, a local authority may be able to mitigate the impact. This strategy involves addressing people's behaviour and educating the local community. Officials can help people plan for the future, and encourage land owners to think about how they can continue to use land that is at risk. For example, caravan parks on cliff tops can provide an income from the land, but be moved and re-sited quickly when the time comes. Giving land at risk of flooding over to grazing rather than growing crops means the sheep or cattle can be moved if storms are forecast. This strategy only works if the local population agree to having their use of land limited, and it cannot remedy damage that has already been done.
- **Do nothing:** In the first decade of the twenty-first century a school of thought has grown up that asks whether the coast *should* be protected. Tens of millions of pounds are spent annually in the UK on coastal protection and it might be cheaper to let nature take its course and pay compensation to those affected. The storms of December 2013 and January 2014 illustrated how trying to control the power of nature is often futile, with the traditional hard sea defences of places like Dawlish in Devon and Aberystwyth in west Wales proving ineffective against the powerful wind and waves. Some argue that the limited funds available for coastal protection should be targeted to places like this that have significant infrastructural or economic value for large numbers of people. This debate is not new; the House of Commons Select Committee on Agriculture suggested in 1998 that large tracts of land should be 'surrendered to the sea' as trying to protect them is a waste of money. Obviously those living in places deemed not worthy of protection may view the debate quite differently.

The Sefton Coast is used to illustrate how some soft engineering strategies have been used in an attempt to protect another stretch of the Merseyside and Lancashire coast.

Key question

Why do you think the authorities have chosen to adopt soft engineering strategies to protect the Sefton Coast stretch of coastline?