

Edexcel IAL Geography

Crowded Coasts

Essential Notes



Classifying Coasts

Sediment Cells

Coasts can be split into sections called **sediment cells**. These are typically considered a closed-system in terms of sediment. There are eleven sediment cells in England and Wales.

- **Sources** – Where the sediment originates from (e.g. cliffs, offshore bars).
- **Through flows** – The movement of sediment along the shore through longshore drift.
- **Sinks** – Locations where deposition of sediment dominates (e.g. spits, beaches).

Under normal conditions, the coastal system operates in a state of **dynamic equilibrium**. Dynamic equilibrium in a sediment cell is where input and outputs of sediment are in a constant state of change but **remain in balance**. Physical and human action can change this equilibrium.

Sediment cells are **not** fully closed systems, so it is important to remember that actions within one cell may affect another.

Different Types of Coasts

Coasts have different **characteristics**, which can be used to **classify** the type of coastline.

- Coastlines may be **concordant** - alternating bands of resistant rocks run parallel to the seafront - or **discordant** - alternating bands of resistant rocks run perpendicular to the seafront.
- Waves hitting the beach may be **constructive** (swash > backwash) or **destructive** (swash < backwash). Similarly, a coast could be **high energy** (rate of erosion > rate of deposition) or **low energy** (rate of erosion < rate of deposition).
- The coast may have a distinct **morphology**. Coasts tend to have cliffs or coastal plains, determining the **relief** of the coast.
- Coastlines may be:
 - **Advancing** - Gaining sediment and land
 - **Retreating** - Losing sediment and land
 - **Emerging** - The sea level is falling relative to the coastline
 - **Submerging** - The sea level is rising relative to the coastline

The Littoral Zone

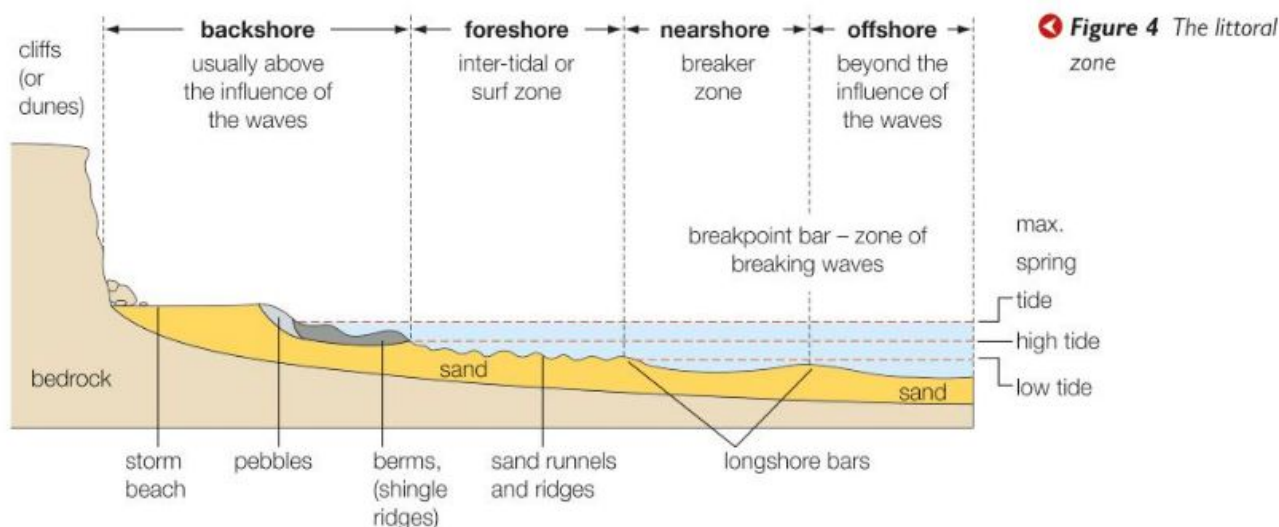
The **littoral zone** is the area of the coast where land is **subject to wave action**. It is constantly changing and varies due to:

- **Short-term** factors like **tides** and **storm surges**.
- **Long-term** factors like **changes in sea level** and **climate change**.

There are several subzones within the littoral zone:

- **Backshore** – area above high tide level and only affected by exceptionally high tides.
- **Foreshore** – this is land where most wave processes occur.
- **Offshore** – the open sea.





Coastal Processes and Land Formations

Erosional processes

Erosion is the **removal of sediment from a coastline**. There are five main processes of erosion:

- **Corrasion** - Sand and pebbles are picked up by the sea and **hurled against the cliffs** at high tide, causing the cliffs to be eroded.
- **Abrasion** - The **rubbing** of stones against a surface (often the sea bed or a rock face).
- **Attrition** - Wave action cause **rocks and pebbles to hit against each other**, wearing each other down and so becoming round and eventually smaller.
- **Hydraulic Action** - As a wave crashes onto a rock or cliff face, **air is forced into cracks, joints and faults** within the rock. The high pressure causes the **cracks to force apart and widen**.
- **Corrosion (Solution)** - The **mildly acidic seawater** can cause **alkaline rock** such as limestone to be eroded.

Factors affecting the Rate of Erosion

The conditions of the wave will affect the rate of erosion of a cliff face, including when:

- waves are high and have a **long fetch** (the distance the wind has travelled over the wave)
- waves approach the coast **perpendicular** to the cliff.
- **at high tide** - waves travel higher up the cliff so a bigger area of cliff face is able to be eroded.
- **heavy rainfall occurs** - water percolates through permeable rock, weakening cliff.
- in **winter** - destructive waves are the largest and most destructive during winter.

The **resistance of a rock** will determine its vulnerability to erosion, and is influenced by various factors:

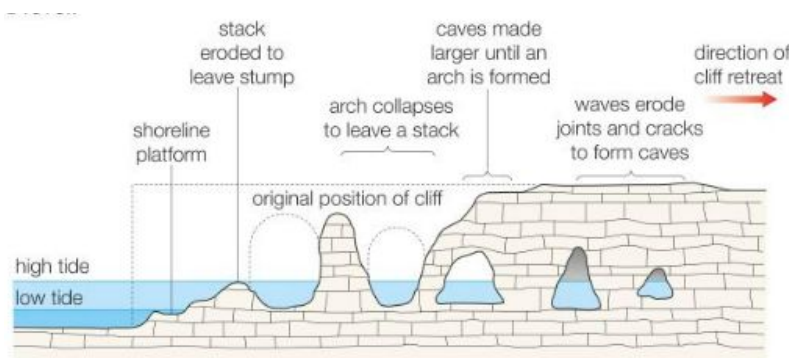


- The **amount of cracks, fractures and fissures** – the more weaknesses there are in the rock the more open it is to erosional processes, especially Hydraulic Action.
- The **lithology** of the rock - as shown in the table below, the type of rocks and the conditions of the rock's creation directly affects its vulnerability to erosion:

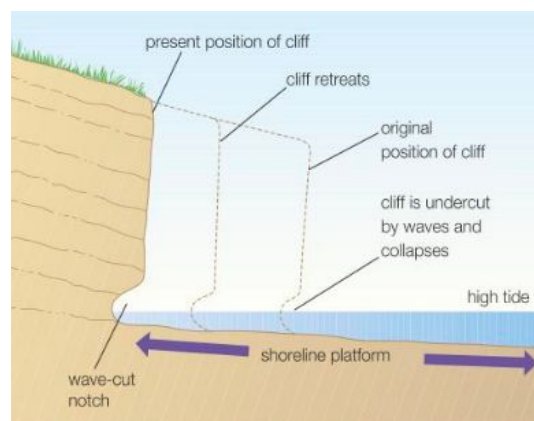
Type of Rock	Examples	Rate of Erosion	Structure of Rock
Igneous	Granite, Basalt	Very slow <0.1cm/year	Interlocking crystals which allow for high resistance to erosion
Metamorphic	Slate, Schist, Marble	Slow 0.1-0.3cm/year	Crystal all orientated in the same direction, resisting erosion
Sedimentary	Limestone	Very fast 0.5-10cm/year	Lots of faults making them weak and vulnerable to erosion

Erosional Landforms

- **Caves, Arches, Stacks and Stumps** - This sequence occurs on pinnacle headlands. Marine erosion widens faults in the base of the headland, widening over time to create a cave. The cave will widen due to both marine erosion and sub-aerial processes, eroding through to the other side of the headland, creating an arch. The arch continues to widen until it is unable to support itself, falling under its own weight through mass movement, leaving a stack as one side of the arch becomes detached from the mainland. With marine erosion attacking the base of the stack, eventually the stack will collapse into a stump.



- **Wave-cut notch and platform** - Marine erosion attacks the base of a cliff, creating a notch of eroded material between high tide height and low tide height. As the notch becomes deeper (and sub-aerial weathering weakens the cliff from the top) the cliff face becomes unstable and falls under its own weight through mass movement. This leaves behind a platform of the unaffected cliff base beneath the wave-cut notch.



- **Retreating Cliffs** - Through the process of repeat wave-cut notches and platforms, new cliff faces are created, whilst the land retreats.
- **Blowhole** - A Blowhole is a **combination of two features**: a **pot hole on top of a cliff**, created by chemical weathering, and a **cave**, formed by marine erosion. As the cave erodes deeper into the cliff face and the pothole deepens, they may meet. In this case, a channel is created for

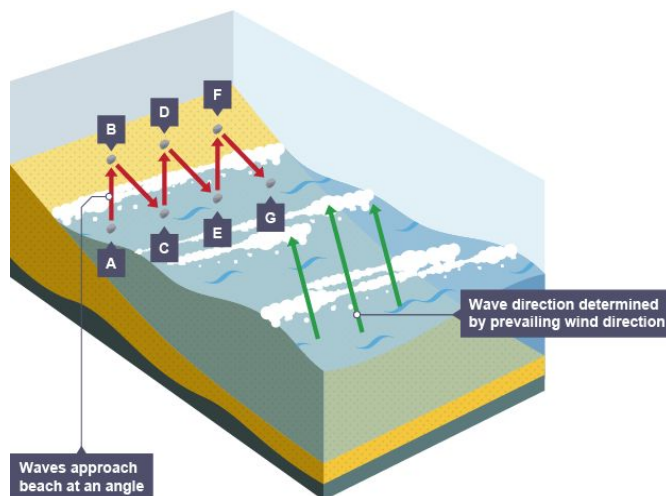


incoming waves to travel into and up the cliff face (occasionally water splashes out of the top of the blowhole when energetic waves hit the cliff face).

Transportation

Longshore Drift (LSD) - Sediment is predominantly transported along the coast through the process of **longshore drift**. It transports sediment along the beach and between sediment cells:

- Waves hit the beach at an angle determined by the direction of the **prevailing wind**.
- The waves push sediment in this direction and up the beach in the **swash**.
- Due to gravity, the wave then carries sediment back down the beach in the **backwash**.
- This moves sediment along the beach over time.



The rate of longshore drift depends on **several factors**:

- The angle of waves hitting the beach
- The size of sediment being transported
- Any obstructions along the beach front - resistant rocks, groynes, etc.

Other processes of transportation include:

- **Traction** – Large, heavy sediment rolls along the sea bed, being pushed by currents.
- **Saltation** – Smaller sediment bounces along the sea bed, being pushed by currents.
- **Suspension** – Small sediment is carried within the water column (a body of water)
- **Solution** – Dissolved material is carried within the water

Deposition

Deposition occurs when a wave **loses energy** meaning the **sediment becomes too heavy** to carry. Deposition tends to be a gradual and continuous process - a wave won't drop all of its sediment all at once.

- **Gravity settling** – the wave's energy becomes very low and so heavy rocks and boulders are deposited followed by the next heaviest sediment.
- **Flocculation** – clay particles clump together due to chemical attraction and then sink due to their high density.

Depositional Landforms

- **Spits** - A spit is a long narrow strip of land which is formed due to **deposition**. **Longshore drift** occurs along the coast line but as the waves lose energy (normally due to going into a sheltered area such as behind a headland) they deposit their sediment. Over time this



creates a spit. Periodically, the prevailing wind will change direction causing a **hook** to appear. Over time, the sheltered area behind a spit can turn into a **salt marsh**. The length of a spit is influenced by surrounding currents or rivers. For example, in the diagram the spit is forming in an estuary and the current from the river is preventing deposition to occur across the bay and is instead causing a **recurved spit end**.



- **Bars** - A spit which, over time, crosses a bay and links up two sections of coast (the water within the bay is called a **lagoon**).
- **Tombolo** - A tombolo is a bar or beach that **connects the mainland to an offshore island** and is formed due to **wave refraction off the coastal island reducing wave velocity**, leading to deposition of sediments. They may be covered at high tide if they are low lying.
- **Cusate forelands** - Only occurs with triangular shaped **headlands**. Longshore drift along each side of the headland will create beaches, which where they meet, will form a cusate foreland.
- **Offshore bars** - A region offshore where sand is deposited, as the waves don't have enough energy to carry the sediment to shore. They can be formed as the wave breaks early, **scouring** the seabed and instantly depositing its sediment as a loose-sediment offshore bar.
- **Sand Dunes** - Sand dunes occur when **prevailing winds blow sediment to the back of the beach** and therefore the formation of dunes requires large quantities of sand and a large tidal range. This allows the sand to dry, so that it is light enough to be picked up and carried by the wind to the back of the beach. Frequent and strong onshore winds are also necessary. The dunes develop as a process of a vegetation succession:
 - **Embryo dunes** – Upper beach area where sand starts to accumulate around a small obstacle (driftwood, wooden peg, ridge of shingle)
 - **Yellow dunes** – As more sand accumulates and the dune grows, vegetation may develop on the upper and back dune surfaces, which stabilises the dune. The tallest of the dune succession.
 - **Grey dunes** – Sand develops into soil with lots of moisture and nutrients, as vegetation dies, enabling more varied plant growth.
 - **Dune slack** – The water table rises closer to the surface, or water is trapped between hollows between dunes during storms, allowing the development of moisture-loving plants (e.g. willow grass)
 - **Heath and woodland** – Sandy soils develop as there is a greater nutrients content, allowing for less brackish plants to thrive. Trees will also grow (willow, birch, oak trees) with the coastal woodland becoming a natural windbreak to the mainland behind.

Depositional landforms consist of **unconsolidated sediment** and are therefore vulnerable to change. During major **storms**, large amounts of sediment can be eroded or transported elsewhere removing a landform from one region of the sediment cell.



Sub-Aerial Processes - Weathering and Mass Movement

Weathering is the **breakdown of rocks** (mechanical, biological or chemical) over time, leading to the **transfer of material into the littoral zone**, where it becomes an **input to sediment cells**.

Mechanical (Physical) Weathering: the breakdown of rocks due to exertion of physical forces without any chemical changes taking place

- **Freeze-thaw (Frost-Shattering):** Water enters cracks in rocks and then the water **freezes** overnight during the winter. As it freezes, **water expands** which increases the pressure acting on a rock, causing cracks to develop. Over time these cracks grow.
- **Salt Crystallisation:** As seawater **evaporates**, salt is left behind. Salt crystals will grow over time, exerting pressure on the rock, which forces the cracks to widen.

Chemical weathering - the breakdown of rocks through chemical reactions. There are different types of chemical weathering:

- **Carbonation:** **Rainwater absorbs CO₂** from the air to create a **weak carbonic acid** which then reacts with **calcium carbonate** in rocks to form **calcium bicarbonate** which can then be easily dissolved. **Acid rain** reacts with **limestone** to form **calcium bicarbonate**, which is then easily dissolved allowing erosion.
- **Oxidation:** When **minerals** (often Iron Minerals) become exposed to the air through **cracks and fissures**, the mineral will become oxidised which will **increase its volume** (contributing to mechanical weathering), causing the rock to crumble.

Biological Weathering - the breakdown of rocks due to the actions of plants, bacteria and animals

- **Plant Roots** - Roots of plants growing into the cracks of rocks, which exerts pressure, eventually splitting the rocks.
- **Rock Boring** - Many species of **clams** secrete chemicals that dissolve rocks and **piddocks** may burrow into the rock face
- **Seaweed Acids** - Some seaweeds contain pockets of **sulphuric acid**, which if hit against a rock or cliff face, the acid will dissolve some of the rock's minerals. (e.g. Kelp)

Mass Movement

There are several types of **mass movement**, which tend to be determined by the **weight** of the sediment and its **ability to flow downhill**.

The type of mass movement that occurs depends on:

- the **angle** of the slope/cliff
- the rock's **lithology and geology**
- the **vegetation** cover on the cliff face
- the **saturation** of the ground/ previous weather patterns



Mass movement processes include:

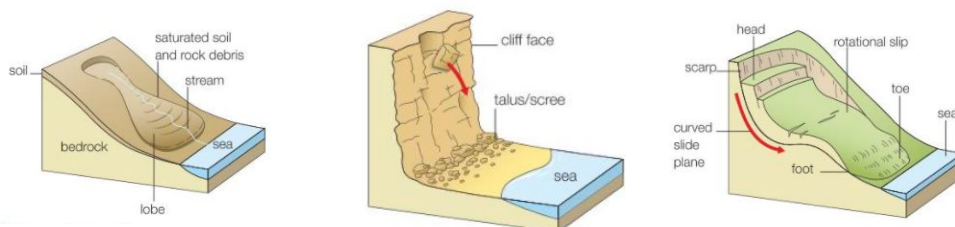
- **Solifluction** - Occurs mainly in tundra areas where the land is frozen. As the top layers thaws during summer (but the lower layers still stay frozen due to permafrost) the surface layers flows over the frozen layers.
- **Rock falls** - Occur on sloped cliffs (over 40°) when exposed to mechanical weathering.
- **Slumps** - Occur when the soil is saturated with water, causing a rotation movement of soft materials (such as clay and sand) forming rotational scars and terraced cliff profiles.

Cliff Profiles

Cliff profiles are influenced by many factors but the two main characteristics that dominate are:

- The resistance of the rock to erosion
- The dip in rock strata in relation to the sea

Many cliffed coastlines are **composite** (they have different rock layers) which makes explaining cliff profiles very complex.



Cliff profiles due to solifluction, rock falls and slumping.

Coastal Vegetation

Rocks and sediment play a very important role in influencing the shape of the coastal landscape. However, vegetation is essential in **stabilising** sand dunes and salt marshes from further change.

Vegetation helps to stabilise coastal sediment in many ways:

- **Roots** of plants bind soil together which helps to reduce erosion.
- When completely submerged, plants provide a **protective layer** for the ground and so the ground is less easily eroded.
- Plants reduce the **wind speed** at the surface and so less wind erosion occurs.

Plants grow in different coastal environments and are either halophytes or xerophytes

- **Xerophytes** – plants that are tolerant of **dry** conditions.
- **Halophytes (or brackish)** – plants that are tolerant of **salty** conditions.

Mangroves and Coral Reefs

Mangroves are the shrubbery and trees living at the edge of salty (**saline**) water. Coral reefs are underwater environments home to large populations of marine life. Both mangroves and coral reefs are highly valuable to the local coastline:



- **Natural Defences** - Mangroves and reefs dissipate wave energy, which reduces the risk of flooding due to storm surges and tsunamis for the coastline behind. The roots of the mangroves also bind coastal soils together, reducing coastal erosion.
- **Tourism** - Due to the vast biodiversity, many reefs and mangroves are popular tourist locations, especially for diving, snorkelling and kayaking.
- **Primary Industry** - Local settlements may rely on coral reefs for fishing or mangroves for timber (the wood is resistant to rot, making it extremely valuable).

However, mangroves are being cleared for **beach tourist resorts** and coral reefs are declining due to **coral bleaching**.

Sea Level Change

Sea levels change can be on a short-term or long-term basis. Short term sea level change can be because of:

- **High tide and low tide** - a daily phenomena due to the gravitational pull of the Moon.
- **Wind strength and direction** - these can change causing a change in sea level for a couple of minutes or longer
- **Atmospheric pressure** - the lower the pressure, the higher the sea levels.

Isostatic - localised sea level change

Isostatic sea level change could be due to

- **Post-glacial adjustment** (glaciers weigh down the land beneath, and so the land subsides until it melts).
- **Tectonic activity** (such as **earthquakes** and **volcanic eruptions**) may cause land subsidence, therefore causing isostatic sea level increase.

Eustatic rise - Global sea level change

Eustatic rise is due to **thermal expansion**. Water expands when it gets warmer, and so the volume of water increases which as a result, sea levels increase. This is due to **Global Warming**. However, predicting sea level change is very difficult because various factors could affect changes, and the cause isn't fully understood.

Risks to Coastal Environments

Coastlines and marine life are susceptible to local changes and risks both on and off shore:

- **Coastalisation** is the development of urban towns and cities along the coast. In MEDCs, coastalisation is rapidly increasing as coastal towns offer an **attractive lifestyle** - pretty surrounding/ views, local water sports, local source of food. However, increasing the built environment in sometimes **vulnerable locations** (bays at risk from storm surges) can add to pressure on natural coastal defenses ie. mangroves.
- **Unsustainable fishing or resource collection** will reduce the marine population and natural habitats, which can cause further decline along the **food chain**. Occasionally, local fishermen may try to introduce a productive species to a coast. This would increase their catch and so reduce food insecurity. However, **alien species** can threaten other wildlife and increase competition for food within the food chain.
- **Pollution** can greatly degrade the natural environment. **Water pollution** especially affects a coastline, since pollution and chemicals dumped from the coastline can flow outwards into



the ocean. **Plastic waste** is particularly threatening to coastlines, since plastic bags are mistakenly ingested by turtles and other marine animals. Also, **nuclear contamination** (by air or water) can spread quickly outwards from coastal stations, as evident in the 2011 Fukushima Disaster.

- **Storm surges** occur when there is a short-term change in sea level, which may be due to **low pressure** during a **depression or tropical cyclone**. This can cause regular damage to a coastal community and sometimes the loss of life (due to drowning or hyperthermia). Storm surges may also damage the natural environment and accelerate rates of erosion.

Coastal Management

Approaches to coastal management have changed greatly due to new knowledge and research about the positive and negative impacts that management can have on a coastline. New approaches have been created, though the specific strategies used can mostly be classified into two types - **hard and soft engineering**. Hard and soft engineering **both relate to traditional approaches to coastal management**. 'There is erosion occurring in this area, so let's build a beach or sea wall to reduce the erosion'. These approaches are a **direct solution** to the problem that is occurring.

There are different approaches to managing coastal areas.

- **Hold the line** – Defences are built to try and keep the shore where it is.
- **Managed realignment** – Coastline moves inland naturally but managed.
- **Advance the line** – Defences are built to try and move the shore seawards.
- **Do nothing** – No defences are put in place and the coast is allowed to erode.

Factors looked at when deciding on which policy to use:

- **Economic value of assets** that could be protected is looked at, for example the important natural gas terminal at Easington would be protected however farmland and caravan parks wouldn't
- The technical feasibility of **engineering solutions**, for example a sea wall may not be possible for a certain location.
- The **ecological and cultural value** of land. For example, it may be desirable to protect historic sites or SSSI.

Cost-benefit analysis (CBA)

This is an analysis that is carried out before any form of coastal management takes place. The cost involved include construction, demolition, maintenance etc. is then compared to the expected benefits like the value of land saved, homes and businesses protected. Costs and benefits include both tangible and intangible things. For a project to be given the go ahead, **the expected benefits have to outweigh the costs** (according to DEFRA's 1:1 analysis)

Types of Defences

Hard engineering

Hard engineering are often very effective at preventing erosion in the desired area, but are high cost and have a **significant environmental impact due to the use of concrete** and other man-made materials. By reducing erosion in one area of the coastline, they may act to increase rates of erosion elsewhere.



Offshore Breakwater



Source: Concrete Layer

Description: Rock barrier which forces waves to break before reaching the shore

- 👍 Effective at reducing waves' energy
- 👎 Visually unappealing
- 👎 Navigation hazard for boats
- 👎 Can interfere with LSD

Groynes



Source: Tripadvisor

Description: Timber or rock protrusions that trap sediment from LSD

- 👍 Builds up beach, protecting cliff and increasing tourist potential
- 👍 Cost effective
- 👎 Visually unappealing
- 👎 Deprives areas downwind of sediment increasing erosion elsewhere

Sea Walls



Source: Southampton University

Description: Concrete structures that absorb and reflect wave energy, with curved surface

- 👍 Effective erosion prevention
- 👍 Promenade has tourism benefits
- 👎 Visually unappealing
- 👎 Expensive to construct and maintain
- 👎 Wave energy reflected elsewhere, with impacts on erosion rates



Rip Rap (Rock Armour)

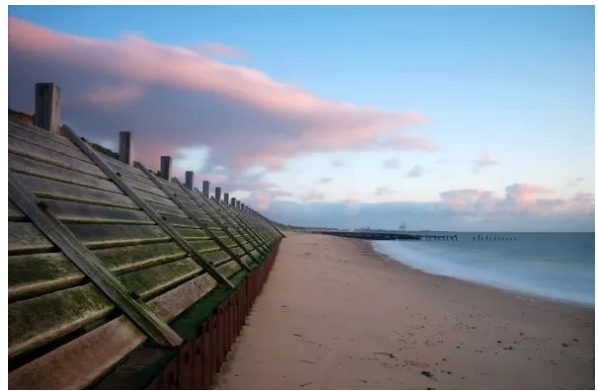


Source: Stacey.Peak-Media

Description: Large rocks that reduce wave energy, but allow water to flow through

- 👍 Cost effective
- 👎 Rocks are sourced from elsewhere, so do not fit with local geology
- 👎 Pose a hazard if climbed upon

Revetments



Source: Geographical.co.uk

Description: Wooden or concrete ramps that help absorb wave energy

- 👍 Cost effective
- 👎 Visually unappealing
- 👎 Can need constant maintenance, which creates an additional cost

Soft Engineering

Unlike hard engineering, soft engineering **aims to work with and complement the physical environment** by using natural methods of coastal defence. They are useful for protecting against sea-level change as well as coastal erosion.

Beach Nourishment



Source: Eastern Solent Coastal Partnerships

Description: Sediment is taken from offshore sources to build up the existing beach

- 👍 Builds up beach, protecting cliff and increasing tourist potential
- 👍 Cost effective and looks natural
- 👎 Needs constant maintenance
- 👎 Dredging may have consequences on local coastal habitats

Cliff Regrading and Drainage



Source: Stacey.Peak-Media

Description: Reduces the angle of the cliff to help stabilise it. A steeper cliff would be more likely to collapse

- 👍 Cost effective
- 👎 Cliff may collapse suddenly as the cliff is drier leading to rock falls which pose a hazard
- 👎 May look unnatural



Dune Stabilisation



Source: Wikipedia

Description: Marram grass planted. The roots help bind the dunes, protecting land behind

- 👍 Cost effective and creates an important wildlife habitat
- 👎 Planting is time consuming

Marsh Creation



Source: DurDoor

Description: Type of managed retreat allowing low-lying areas to flood

- 👍 Creates an important wildlife habitat
- 👎 Farmers lose land and may need compensation as a result

Sustainable Coastal Management

Aspects of managing coast in a sustainable way include:

- **Managing natural resources** like fish, water, farmland to ensure **long-term productivity**.
- Creating **alternative livelihoods** before people lose their existing jobs.
- **Educating** communities about the need and how to adapt.
- **Monitoring** coastal changes and then adapting or mitigating.
- Managing **flood risk** or relocating if needed.

Land Reclamation

Sometimes, in an effort to **increase the space available** in a coastal city, land is created by dumping vast volumes of sediment off the coastline. This may be successful in providing land for building, farming and industry. However, this reduces **fishing catchment areas**, buildings are prone to **liquefaction** if an earthquake occurs and any local coral reefs may be destroyed.

