Coastal Landscapes

How do waves shape and change our coastline? -
- When wind blows over the sea, it creates waves. The size and energy of the wave depends on: the fetch (how far it has travelled), the strength of the wind and how long the wind has been blowing for.
- There are two different types of waves – constructive and destructive. When a wave reaches the shore, the water that rushes up the beach is the swash. The water that flows back down towards the sea is known as backwash. The energy of these determine the type of wave.
- Destructive waves have a WEAK SWASH and STRONG BACKWASH. The strong backwash removes sediment from the beach. The waves are steep and close together.

- Constructive waves have a STRONG SWASH and WEAK BACKWASH. The strong swash brings sediment to build up the beach. The backwash is not strong enough to remove the sediment. The waves are low and far apart.

How does weathering and mass movement contribute to our changing coastlines?
- Weathering is the natural processes that cause breakdown of rocks and minerals by chemical, biological or physical agents. Exposed rocks on the coastline experience this.
- Freeze-thaw weathering occurs when rocks are porous (contains holes) or permeable (allows water to pass through). Water enters into cracks in rocks, when temp drops water freezes and expands causing the crack to widen. The ice melts and water makes its way deeper into cracks. This process repeats until the rock splits entirely in half.
- Biological weathering is when roots enter smell cracks, growing and weakening the structure of rocks until they break away.
- Chemical weathering – Rainwater and seawater can be a weak acid. If a coastline is made up of rocks such as limestone or chalk, over time they can be dissolved by the acid in the water.

What are the erosional processes? -
- Erosion is the wearing away of rocks along a coastline. Destructive waves are responsible for this. There are 4 types:
- Hydraulic action is the sheer power of water smashing against cliffs. Air becomes trapped in cracks of rocks and causes them to break apart.
- Abrasion is when pebbles grind along a rock platform like sandpaper. Over time the rock becomes smooth.
- Attrition is when rocks knock against each other and break apart becoming smaller and more rounded.
- Solution is when sea water dissolves certain types of rocks, especially chalk and limestone cliffs.

What are other marine processes?
- Mass movement is the downhill movement of sediment due to gravity.
- Rockfall is when bits of rock known as scree fall of the cliff face, usually due to freeze-thaw weathering.
- Mudflow is when saturated soil (soil filled with water) flows down a slope.
- Landslide is when large blocks of rock slide down a hill.
- Rotational slip is when saturated soil slumps down a curved surface.

- Transportation is the movement of material. Sediment is carried by waves along the coastline.

- Solution is when minerals in rocks like chalk and limestone are dissolved in sea water and then carried in solution. The load is not visible.
- Suspension is when small particles such as slits and clays are suspended in the flow of water.
- Saltation is when small pieces of shingle or large sand grains are bounced along the sea bed.
- Traction is when pebbles and larger material are rolled along the sea bed.
- The movement of material is known as longshore drift. Waves approach the coast at an angle because of the direction of prevailing wind. The swash will carry the material towards the beach at an angle. The backwash then flows back to the sea down the slope, repeating in a zigzag pattern.

- Deposition is when material is dropped due to the sea losing energy. It occurs on coastlines with constructive waves. Factors leading to this are: Waves slowing down and losing energy, shallow water, sheltered areas e.g. bays, little or no wind.

What landforms are found at the coast? -
- Coastlines where the geology alternates between strata (or bands) of hard rock and soft rock are called discordant coastlines. A concordant coastline has the same type of rock along its length, and tend to have fewer bays and headlands.
- Cliffs are shaped through a combination of erosion and weathering.
- Hard rocks such as chalk and limestone are more resistant than soft rocks, such as clay and sandstone, so they erode more slowly. Hard rock creates steeper cliffs, soft rock creates gently sloping cliffs.
- Wave cut platform – The sea attacks the base of a cliff between high and low tide marks, hydraulic action and abrasion create a wave-cut notch. Over time this notch increases in size and the upper cliff is unsupported while weathering weakens the upper cliff. They cause it to collapse, and a wave-cut platform is the bedrock left behind as the cliff moves backwards. The backwash carries the rubble towards the sea smoothening it. The process repeats and the cliff continues to retreat.
- Headlands are a stretch of coast made of rock that juts out into the sea made of harder rock and is left because the surrounding softer rock has been eroded away. Bands of soft rock erode more quickly. The areas next to headlands are called bays.

- Erosion creates caves, arches, stacks and stumps along a headland.
1. Cracks in the rock erode through abrasion.
2. Caves occur when waves force their way into cracks in a cliff face. The water contains sand and other materials that grind away at the rock until the cracks become a cave. Hydraulic action and abrasion are the predominant erosion processes.
3. If the cave is formed in a headland, it may eventually break through to the other side to form an arch.
4. The arch will continue to be eroded (attrition) and will gradually become bigger until it can no longer support the top of the arch. When the arch collapses, it leaves the headland on one side and a stack (a tall column of rock) on the other.
5. The stack will be attacked at the base in the same way that a wave-cut notch is formed. This weakens the structure and it will eventually collapse to form a stump.
- Beaches are made up of eroded material transported from elsewhere and deposited. Constructive waves help to build beaches. Material (e.g. sand, shingle) depends on geology of area and wave energy. A cross-section is called a beach profile. The smallest material is deposited near the water and larger material is found nearer to cliffs at the back. Larger material is deposited in times of high energy such as a storm. Most waves break near the shoreline so sediment near the water is more effectively broken down by attrition. Waves need limited energy so beaches often form in sheltered areas like bays where the water is shallow.

- Shingle beaches are where strong swash waves are assisted by windy and stormy conditions to throw large pieces of shingle further up. Smallest material at beach face and larger thrown to the back. Steeper profiles than usually as wave percolates through shingle, making backwash too weak to remove sediment.
- Sandy beaches have strong swash waves moving sandy material up. Backwash is weaker. Coarsest/biggest sand found at wave limit further up the beach. Gently sloping profile as less percolation of water and sand is lighter so can be removed more easily.
- Spits are created by deposition. They are an extended stretch of beach material that projects out to sea and joined to the mainland at one end. Spits are formed where prevailing wind blows at an angle to the coastline resulting in longshore drift. Longshore drift moves material in the direction of prevailing wind, the angled swash brings material onshore whilst the backwash removes the material in a straight line, perpendicular to the coastline. Spits occur when there is a change in the shape of the landscape or there is a river mouth (longshore drift continues). Waves cannot get past a spit creating a sheltered area where slit is deposited and mud flats or salt marshes are formed.

- A spit can grow across a bay and joins two headlands together, known as a bar. They can trap shallow lakes known as lagoons. These don't last forever and can fill with sediment.
- Sand dunes are accumulations of sand on a beach. Obstacles such as drift wood are dropped and wind blows sand up the beach, which gets trapped on the obstacle. Colonising pioneer plants like marram grass grow on the dune and stabilise it with their roots and trap more sand, creating an 'embryo dune'. As plants die they add organic matter to the soil improving it for other plants to live in.

How are coasts managed through hard engineering? -
- Erosion can cause cliff collapse due to erosion therefore coasts need to be managed. Hard engineering involves building artificial structures which try to control natural processes.
- Sea walls are concrete walls placed at the foot of cliffs to prevent erosion. They are curved to reflect the energy back into the sea. They are effective at protecting the base of a cliff and usually have promenades for people to walk along, however waves can break down and erode it due to their power and they are expensive (approx. £2000 per metre).
- Rock armour is large boulders placed at the foot of a cliff that break the waves and absorb their energy. It's cheaper than a sea wall and easy to maintain, and can also be used for fishing. However they look out of place to the local geology and are expensive to transport.
- Gabions are rocks held in mesh cages placed in areas affected by erosion. They are cheap (approx. £100 per metre) and absorb wave energy, however not very strong and look unnatural.
- Groynes are wooden or rock structures built out at right angles into the sea. They build a beach encouraging tourism and trap sediment being carried by longshore drift. However, by doing this it starves the beach further down the coastline increasing rates of erosion. They also look unnatural.

How are coasts managed through soft engineering? -
- Soft engineering does not involve artificial structures and takes a more sustainable and natural approach to managing the coast.
- Beach nourishment involves pumping sand onto an existing beach to build it up. It blends in with the existing beach and larger beaches appeal to tourists, however it needs to be constantly replaced and the sand has to be brought in from elsewhere.
- Reprofiling is redistributing sediment from the lower part of the beach to the upper part. It is cheap and simple and reduces the energy of waves, however only works for low wave energy and needs to be constantly repeated.
- Dune nourishment is when marram grass is planted on sand dunes to stabilise them and help to trap sand to build them up. It is relatively cheap and maintains a natural looking coastline, however can be damaged by storm waves and areas have to be zones off from the public which is unpopular.

- Managed retreat (also known as coastal realignment) is the controlled flooding of low-lying coastal areas that are at high risk for erosion. It is usually done on low-value land such as farmland. It is cheap compared to sea defences and creates a salt marsh which can provide habitats for wildlife and a natural defence against erosion and flooding. Salt marshes are diverse ecosystems supporting many species. However, land is lost when reclaimed by the sea and landowners need to be compensated (£5k-£10k per hectare).
- Medmerry in West Sussex is Europe's largest coastal realignment scheme. The area often faced problems with flooding and damage as a result (£5M+). It now has a 7km embankment creating a new intertidal zone (exposed at low tide) protecting properties. A channel was built to collect draining water. 60,000 tons+ of rock from Norway was used to build up rock armour. A 110-metre breach was made in the shingle.
Social benefits: Selsey now has the best protection with a 1/1000 change of flooding. Avoided breach during severe winter storms. 10km+ footpaths, 7km+ bike paths, 5km+ bridleways. Now has a standard of 1 in 100 years (was 1 in 1).
Social issues: Some residents believe they shouldn't have given up on the land so easily, exploring offshore reefs or continued beach realignment. Some opponents outside the area resented such a large sum being spent on a sparsely populated area.
Economic benefits: Caravan parks and Selsey's main route protected to 1 in 100 years. Local economy has received a boost in green tourism and caravan parks can extend their season (generating income and jobs). Two new car parks and four viewing points. Vegetation on the salt marsh supports extensive cattle farming, producing expensive salt-marsh beef.
Economic issues: Project was expensive (£28 million) compared to 200k a year to maintain the shingle wall. Good agricultural land was abandoned leading to the loss of three farms.
Environmental benefits: 300 hectares of habitat of principal importance under UK biodiversity action plan. Mudflats, reed beds, saline lagoons, grassland. Now a huge nature reserve managed by the RSPB.
Environmental issues: Despite extensive planning the habitats of existing species were disturbed.

- The Holderness coastline on the East Coast is the fastest eroding coastline in Europe. 1.8 metres per year because: Made from less-resistant boulder clay which slumps when wet, naturally narrow beaches giving less protection as doesn't reduce wave power, groynes narrowing unprotected beaches elsewhere and powerful waves (have a long fetch over North Sea).
- It is managed through hard engineering such as sea walls (4.7km in Bridlington), groynes and rock armour. Farms and holiday homes were destroyed due to groynes. Sea defences negatively impact tourism and profits in an area.

River Landscapes

How do rivers change from source to mouth? -
- The long profile shows the gradient of a river as it journeys from source to mouth. It shows how it loses height with increasing distance. It falls steeply to begin with and then becomes concave, then almost flat.
- The source is usually in an upland area. The upper course of the river includes areas which are steep with uneven surfaces. In the middle course the gradient decreases, then in the lower section it almost becomes flat.

- The cross profiles of a river are from one bank to another, showing the changes in river channel.
- The upper course is shallow, has steep valley sides (V shaped), is narrow, low velocity, large bedload, rough channel bed, high levels of friction and vertical (downward) erosion. It creates a steep valley in a V shape that takes the easiest route through soft rock, forming interlocking spurs. This is where you would find gorges (steep-sided river channel from waterfalls) and waterfalls.
- The middle course is deeper, wider, great velocity, smaller material, smoother channel bed, lower levels of friction and lateral (sideways) erosion. This is where you would find meanders, and oxbow lakes.
- The lower course is deep, has flat floodplains, greater velocity, carries sediment and alluvium, smooth channel bed, lowest friction and deposition is dominant. This is where you would find floodplains and levees.

- Discharge (the volume of water passing through) and velocity increase downstream. Discharge increases along its course as tributaries join it adding more water. Velocity increases as there's less water in contact with the bed and banks (less friction).
- Interlocking spurs are ridges that extend alternately from opposite sides of a V-shaped valley. It winds and bends to avoid areas of hard rock.

- Rapids are stretches of fast-flowing water over a rocky-shallow riverbed. They're formed by alternate bands of hard and soft rock. Soft rock will be more eroded making the river bed uneven and the flow turbulent leading to white water sections.

Waterfalls and Gorges -
- A waterfall is a sudden drop along the upper course of a river formed when hard rock is positioned over soft rock.
1. The soft rock is eroded faster creating a step. As this continues, the hard rock is undercut making an overhang.
2. Abrasion and hydraulic action erode to create a plunge pool. Over time this gets bigger, increasing the size of the overhang until it is no longer supported and collapses.
3. This process continues and the waterfall retreats upstream.
4. A steep sided valley is left where the waterfall once was called a gorge.

Meanders and Oxbow Lakes -
- As the river makes its way to the middle course, it gains more water and more energy. Lateral erosion widens a river, and develops large bends called meanders over flatter lands.
- As a river goes around a bed most water is pushed to outside causing increased erosion (HA and Abr). Lateral erosion on outside causes undercutting of the bank to form a river cliff.
- Water on the inner bend is slower causing the water to slow down and deposit eroded material, causing a gentle slope of sand and shingle. This build-up is known as a slip-off slope.

- Due to this erosion and deposition the shape of a meander changes over time. Erosion narrows the neck of the land within it and meanders move closer. When there is very high discharge (usually in a flood) the river cuts across the neck taking a new, shorter route. Deposition will cut off the original meander leaving a horseshoe-shaped oxbow lake.

Levees and Floodplains -

- A floodplain is the area around a river that is covered in times of flood. A large, flat area formed by erosion and deposition. Erosion on the outer bends of a meander will gradually wear down and flatten the land on either side of the channel. When the river overflows it leaves the channel and flows across neighbouring land. Due to increased friction between water and floodplain, the river will lose energy and deposit sediment (alluvium). The area is very fertile due to the rich alluvium deposits, making it a good area for agriculture. Over time, floodplains become wider and deeper due to erosion and deposition.
- A levee is a raised bank formed on the banks of a river in the lower course. They are formed by the repeated flooding of a river during periods of high energy where the load leaves the channel. Due to friction the biggest material is dumped close to the river banks, building it up over time. The river also deposits slit in the riverbed making the river level higher.

Estuaries and Mudflats -

- An estuary is where the river meets the sea. The river here is tidal and when the sea retreats the volume of water in the estuary is less reduced. When there is less water the river deposits slit to form mudflats (sheltered coastal areas where mud is deposited), which are an important habitat for wildlife.

How do rivers flood? -

- An increase in discharge causes river levels to increase, and flooding occurs when the bank's full capacity is exceeded.

- Prolonged rainfall results in saturated land (holding too much water), so when it next rains no more can be soaked up and it runs across the surface (surface run-off).
- Heavy rainfall means there is less change of infiltration (being soaked up) so it runs off and reaches the river faster.
- A high relief such as a steep valley means rainfall will run off into the river more quickly.
- Impermeable rocks don't allow water to pass through pores and cracks, so if a valley is made of this there is higher chance of flooding as more surface run-off.
- Trees and plants absorb water and slow/stop it from reaching the surface (interception layer), reducing flood risk. If trees are cut down (deforestation) more water reaches the channel as infiltration and interception increase.
- Urban land use around the area of a river with a lot of impermeable surfaces such as tarmac and concrete means surface run-off occur more. Drains and sewers take water directly to the river which increases flood risk.

Flood Hydrographs –

- A hydrograph shows how a river responds to a period of rainfall.

- Peak discharge is the maximum amount of water held in the channel.
- Lag time is the time taken between peak rainfall and peak discharge.
- Base flow shows the normal discharge of the river.
- Lag time can vary based off of the size of the drainage basin, vegetation (interception), valley side steepness and soil type. A short lag time means water is reaching a river quickly so there's a higher chance of flooding.

River Management Techniques -
- Hard engineering involves building artificial structures to control rivers, and tends to be more expensive.
- Dams and reservoirs – Dams trap water which builds up behind it, forming a reservoir. Water can be released in a controlled way. It can be used to produce electricity by passing it through a turbine and can attract tourists. However, it is very expensive, can trap sediment which means less water, it can causes habitats to be flooded leading to rotting vegetation and releasing methane (a greenhouse gas). Settlements are lost leading to the displacement of people, and locals often have little say in where they are relocated.
- River straightening and dredging – This involves straightening the river to speed up water so higher volumes can pass through it. Dredging makes a river deeper so it can hold more. More water can be held and it reduces flood risk in built-up areas, however dredging has to be done frequently and speeding up rivers increase flood risk downstream.
- Embankments – Raising the banks of a river so they can hold more water. It is cheap with a one-off cost and allows for flood water to be contained, but looks unnatural and it can increase flood risk downstream.
- Flood relief channels – Floodwater flows into a relief channel and flows into an area where it can be absorbed or re-enters a river further down its course. This removes excess water reducing flooding, however is expensive to build and the relief channel could eventually flood.

- Soft engineering takes a more sustainable and natural approach to managing the potential for river flooding.
- Flood warnings and preparation – The environmental agency monitors rivers and issues warnings via newspapers, TV, radio and the internet where they are likely to flood so people can prepare. People have time to protect their property and many possessions can be saved. However, some people cannot access these warnings, flash floods may be too fast for these to be effective, and they do not stop land from flooding, just warn people it is likely.
- Floodplain zoning – Allowing only certain land uses on the floodplain, such as restricting lower parts to agriculture and grazing protecting houses and important buildings. Less damage is caused, however it is not always possible to change existing land uses and planners have to decide what type of flood to plan for.
- River restoration – Returning a river to its natural state by removing man-made levees or removing river straightening. Discharge in the river reduces so less flood risk downstream, and little to no maintenance is required so low-cost. Biodiversity of maintained. However flood risk could increase.
- Planting trees – This increases interception and lag time. Discharge in the river is reduced, and trees can reduce the risk of soil erosion, which can reduce the capacity of the river. However it restricts what land can be used for.

- In August 2004 the village of Boscastle saw a month's worth of rain in 2 hours. The drainage basin of Boscastle is steep and impermeable rock, and it is at a confluence of three rivers. Over 1k homes, cars and businesses were swept away.
- To prevent this happening again over £10M was invested in widening and deepening the river channel (to carry more water), removing low bridges (large amounts of water could flow freely and they wouldn't act like a dam for debris), raising the car park and using a permeable surface (cars are much higher and less likely to be swept away) and tree management (dead trees removed and land owners encouraged to maintain vegetation and plant new trees.

Natural Hazards – Tectonic and Weather

What are natural hazards? -

- Natural hazards are extreme natural events that can cause loss of life, extreme damage to property and disrupt human activities.
- Some hazards need climatic or tectonic conditions to occur, such as tropical storms or volcanic eruptions. Some occur anywhere in the world such as floods, whereas some only occur in specific places such as tsunamis.
- They are classified in to tectonic and climatic. Tectonic hazards (such as earthquakes, tsunamis, volcanoes and mountain avalanches) occur when the Earth's crust moves. When plates move, friction causes them to become stuck and tension builds until they release leading to an Earthquake. Climatic hazards (such as flooding, tornadoes, tropical storms and droughts) occur when a region has certain weather conditions, for example heavy rainfall can lead to flooding.
- Hazards can have economic, social and environmental consequences. In developing countries the death toll tends to be high but the short-term costs are low, whereas in developed countries the death toll is low but the short-term costs are extremely high. The long-term situation is more complex: developing countries tend to repair damage slower leading to a reduction in tourists and a loss of valuable income. Hazard risks are increasing due to population growth, urbanisation, pressure on marginal land (difficult to develop, little profit) and changes to the natural environment.

What are tectonic hazards? -

- The Earth is made up of different layers. The inner core is the centre and hottest part (solid, made of iron + nickel, 5500C). The outer core surrounds inner, liquid layer. The mantle is the thickest section (2900km, semi-molten rock called magma).
- The crust is the outer layer of the Earth (thin, between 0-60km, solid rock, continental or oceanic). It is broken into tectonic plates. It was believed convection currents (movement within mantle from heat) caused them to move, however it is now recognised by other concepts.
- Slab pull and ridge push are believed to move them. Ridge push is when new crust formed at divergent plate margins (where plates meet, intense seismic activity) is less dense than surrounding crust so rises to form oceanic ridges. The older seafloor either side of the ridge slides away moving the seafloor apart, moving tectonic plates. Slab pull is when older, denser tectonic plates sink into mantle pulling newer and less dense sections of plate along. Sinking in one place leads to plates moving apart in other places. This is called the theory of plate mechanics.
- Oceanic crust is found under oceans and is denser than continental. Can be subducted (one pulled under another). Continental crust is found under land masses, is generally older than ocean and is less often destroyed.

- Earthquakes are found along all types of plate margins, however volcanoes only occur at constructive and destructive plate margins. A lot of volcanic activity occurs in the ‘ring of fire’ (group location along plate margin of Pacific plate). Hawaii is an arc of volcanic islands found above a hot spot.

Plate Margins -
- A destructive plate margin usually involves an oceanic and continental plate. They move towards each other and this can cause earthquakes. As the plates collide, the oceanic plate is forced beneath the continental (subduction) because the oceanic is denser (heavier). When the plate sinks into the mantle it melts to form magma. The pressure of the magma builds up until it escapes through weaknesses in rock and rises up through a composite volcano. The eruptions are violent, with lots of steam, gas and ash.

- If two continental plates collide, neither can sink so the land buckles upwards to form fold mountains. This is called a collision margin. Earthquakes can occur here.
- At a constructive plate margin the plates move apart from one another. When this happens magma from the mantle rises up to make new land in the form of a shield volcano. The movement of plates over the mantle can cause an earthquake.

- At a conservative plate margin, the plates move past each other or are side by side moving at different speeds. As they move, friction occurs and they get stuck. Pressure builds up and when released, it sends out huge amounts of energy causing an earthquake. It can be very destructive as it’s close to the Earth’s surface. There are no volcanoes at conservative plate margins.
- Japan is prone to eruptions because the Philippine plate and Pacific plate are moving towards the much bigger continental Eurasian and North American plates. It is a destructive margin where a subduction zone has formed (pacific under Eurasian). Friction builds up over time and releases.

Chile Earthquake -
- In Februrary 2010 an 8.8 magnitude earthquake occurred off the coast of central Chile, at the destructive plate margin (south American subducted by Nazca). Tsunami warnings were issues as waves crossed the pacific at speeds of over 800km/h.
- Primary effects: 500 people died, 12,000 people injured, 800,000 people affected. 220,000 homes, 4500 schools, 56 hospitals and 53 ports destroyed. Main airport and port severely damaged. Disrupted power, water supplies and communication across the country. Cost estimated to be US$30 billion.
- Secondary effects: Tsunami waves devastated several coastal towns. The tsunami struck several Pacific countries, however thanks to warnings prevented loss of life. A fire at Santiago chemical plant led to the local area being evacuated. Landslides destroyed up to 1500km of roads, cutting off key communications.
- Immediate responses: Emergency services. International support of field hospitals, satellite phones, floating bridges. Within 24 hours north-south highway temporarily repaired allowing aid to be transported. Within ten days 90% of homes had power and water restored. US$60 million raised after a national appeal funding 30,000 emergency shelters.

- Long term responses: Chile’s government launched a housing reconstruction plan to help nearly 200,000 families affected. Chile’s strong economy reduced the need for foreign aid for rebuilding. The recovery took over four years.

2015 Nepal Earthquake -
- Nepal is one of the poorest countries in the world, located between China and India along the Himalayan Mountains. In April 2015 a 7.9 magnitude earthquake struck the country. The focus was only 8km deep and the epicentre just 60km from the capital (Kathmandu). This capital had 800,000 inhabitants at the time, popular with tourists planning to trek the Himalayas.
- The Earthquake occurred on a collision plate boundary between the Indian and Eurasian plates.
- Primary effects: 9,000 died, 19,000 injured, 8M affected. 3M made homeless. Electricity, water and communications affected. 1.4M people needed support (food, water and shelter). 7,000 schools destroyed, hospitals overwhelmed. Airport became congested. 50% of shops destroyed affecting food supply and livelihood. Cost estimated to be US$5 billion.
- Secondary effects: Avalanches and landslides triggered blocking roads and hampering relief effort. 19,000 people lost their lives on Mount Everest due to avalanches. 250 people missing in Langtang region. Kali Gandaki River blocked by a landslide causing evacuations due to high flood risk. Tourism employment and income declined. Rice seed ruined causing food shortage and income loss.
- Immediate responses: India and China provided $1 billion+ of international aid. 100+ search and rescue responders provided by UK along with three Chinook helicopters. Aid workers from Red Cross came to help. Temporary housing set up (e.g. ‘Tent city’ in Kathmandu, 500k tents to homeless). Helicopters rescued people caught in avalanches and delivered aid to villages cut off by landslides. Field hospitals set up. 300k migrated from Kathmandu to seek shelter and support from family/friends. Facebook launched a safety feature to indicate if users were safe.
- Long term responses: $3M grant by ADB immediately and $200M for rehabilitation. £73M from UK (from government and public), alongside 30 tonnes of humanitarian aid and 8 tonnes of equipment. Landslides cleared. Roads repaired. Stricter building codes introduced. Thousands rehoused, damaged homes repaired. 7000 schools rebuilt. Repairs made to Everest base camp and trekking routes. Blockade at Indian border in 2015 cleared, allowing better movement of fuels, medicines, construction materials.

- Chile is a HIC whereas Nepal is an NIC so responses are very different. Chile had a lot less deaths (500 vs 9,000) due to stronger infrastructure and responses to the earthquakes. Despite Chile having a lot more damage in terms of cost ($30B vs $5B), the damage in Nepal was substantially higher than Chile and it was able to be repaired much quicker. Chile had a lot better preparation for an event like this in advance. Chile could recover much quicker and made a full recovery in only 4 years. Nepal required much more external help (such as UNICEF, red cross, international aid) to assist in their recovery, whereas Chile provided a lot of resources by themselves. Chile had a very quick response and had major roads repaired in as little as 24 hours. Power and water in Chile was restored to 90% of homes in only 10 days.

- Many people choose to live in tectonically active areas for a number of reasons.
- If the volcano is dormant and not erupted recently, people don’t think of it as a threat, especially if it is not likely to in their lifetime. Many people have family and friends in that areas and don’t want to abandon them.

- Ash on soil from previous eruptions makes land very fertile meaning the land produces excellent quality crops and can be used to make money from it.
- Volcano tourism is a big business. Millions travel to visit tourists and people can be tour guides, sell merchandise, staff hotels or provide transport.
- Geothermal energy uses steam heated from magma to drive turbines. This is especially effective in volcanically active areas due to the large amounts of hot magma underground and how cheap it is. Lava from deep within the Earth that cools can contain valuable minerals such as gold, diamonds, silver, copper and zinc.
- Technology can bring us “earthquake-proof” aseismic buildings and therefore people believe they are safe there (e.g. Japan).

How can we reduce risks of living near volcanoes or earthquakes? -
In earthquakes:
- Prediction involves using seismometers to monitor earth tremors. Experts know where earthquakes are likely to happen, but it is difficult to say when they will happen.
- Protection involves constructing buildings safe and that won’t collapse. Improvements include rubber shock absorbers in the foundations to absorb tremors, steel frames that can sway during movements and open areas outside the buildings where people assemble during evacuations.
- Preparation involves practising for this event, having drills in all public buildings so people know what to do. This helps reduce the impact and increase their chance of survival.

- In volcanoes:
- Prediction: Volcanoes tend to change shape before eruptions. Tiltmeters and satellites are used to detect changes in the surface shape of a volcano. Monitoring levels of gas (radon, sulphur) is used as these are often released before activity. Thermal heat sensors can detect changes in surface temperature. Seismometers and lasers can detect movements before an eruption. This allows for evacuation plans to be initiated.
- Protection: Lava flows, lahars and ash fallout cannot be protected against, so evacuation is the only real solution. In the past the US airforce dropped bombs on advancing lava flows. In Iceland in the 1970s Lava from Eldfell on the island of Haimey was blasted with seawater for over 4 months and the lava flow was redirected, though 1/5 of the town was lost.
- Planning/Preparation: Evacuation plans ensure evacuation strategies are in place along with emergency shelter and food supplies. Exclusion zones based on monitoring data can be set up to ensure the right people are evacuated. Local people can be educated abouts actions to take to reduce risk of loss of life or injury. For example, if unable to be evacuated go indoors to avoid falling ash and rock.

- Weather Hazards:

Global Atmospheric Circulation -
- Movement of air across the planet is in a specific pattern. It is driven by the equator. Air rises at the equator leading to low pressure and rainfall. When it reaches the edge of the atmosphere, it cannot go any further so it travels north and south. It becomes colder and denser and falls, creating high pressure and dry conditions around 30 degrees north and south of the equator. This is how large cells of air are formed.
- Air rises again at around 60 degrees north and south and descends again at around 90 degrees north and south.
- Global atmospheric circulation creates winds across the planet and leads to areas of high rainfall, like the tropical rainforests and areas of dry air, like deserts.

- The Hadley Cell is around the equator. The ground is intensely heated by the sun causing air to rise creating a low pressure zone on the Earth's surface. As air rises, it cools and forms thick cumulonimbus (storm) clouds. The air continues to rise and separates, moving north and south. When it reaches around 30 degrees it cools and sinks, becoming warmer and drier and creating high pressure forming deserts. The air completes the cycle and flows back towards the equator through trade winds. In north, they are northeast trade winds. In south, they are southeast trade winds. This is due to the Coriolis force (spinning of Earth deflects movement of particles and wind) and friction.
- The Ferrel Cell is next, at 30-60 degrees N/S. Air on the surface is pulled towards the poles, forming the warm winds that pick up moisture as they travel over the ocean. At around 60 degrees N/S they meet cold air drifted from the poles. The warmer air from the tropics is lighter than dense, cold polar air so it rises as they meet. This uplift of air causes low pressure and unstable weather conditions (mid-latitude depressions), which are what influence the UK's weather.
- The Polar Cell is next. Air is cooled and sinks towards the ground forming high pressure (polar high). It flows towards lower latitudes and mixes with warm air.

- Low pressure areas are created when air rises (it is called this because the weight of the air is lower than average). The equator is low pressure. High pressure areas are created when air sinks (it is called this because the weight of the air is heavier than average). Hot air rises and cooler air sinks through convection.
- Air moving from high to low pressure creates winds, differences in air pressure because the Sun heats the Earth's surface unevenly.

- The Earth has several climate zones based on maximum and minimum temperatures and distribution of precipitation: Polar (cold and dry), temperate (cold winters, mild summers), arid (dry hot), tropical (hot and wet), mediterranean (mild winters, dry hot summers) tundra (mountains, very cold).
- Jet streams are very strong and fast-moving meandering wind bands, found at high altitudes where circulation cells meet. They are caused by pressure differences in the upper atmosphere and move the weather systems around the planet.
- Coriolis effect is the appearance that global winds and ocean currents curve as they move. This is due to the Earth's rotation on its axis causing winds to blow diagonally.

Tropical Storms -
- Tropical storms are rotating intense low pressure systems. They are known as: Typhoons (in west Pacific), Hurricanes (in Gulf of Mexico, Caribbean) and Cyclones (in Indian Ocean).
- Between 482-644km wide and 6-8 km high. Move at up to 65km/h. Central part known as the eye and has light winds and no rain. Surrounded by large cumulonimbus clouds (warm air condensing) with heavy rainfall.
- Tropical storms are formed when rising air draws further moist, warm air up from the ocean's surface generating stronger winds. The air spirals upwards, cools, condenses and form large cumulonimbus clouds. These clouds form the eye wall. Cold air sinks at centre creating the eye of the storm. Tropical storms need heat energy and moisture to drive them.
- Sea temperatures must be 27C and above. They only form between 5 and 30 degrees N/S of the equator (warmest waters).

- Tropical Storms last 7-14 days, have heavy rainfall, high wind speeds and high waves and storm surges. Winds spiral rapidly around a calm centre called the eye (with no clouds or rain). They are rated in the Saffir-simpson scale based on wind speeds (considered major when category 3 – 111-129mph speeds).
- It can change speed when it reaches land as it loses its source of energy (warm waters, loss of moisture over land) and because winds begin passing over land and become slower).
- If global ocean temperatures continue to rise they may affect areas further from the equator (sub tropics, south Atlantic, NE USA) and have a broader distribution on larger parts of the world.
- Tropical storms spin due to the Coriolis effect (rotation of the Earth causes particles and wind to move).
- Initially move westward and slightly towards the poles, drift away from equator.

Climate Change and Tropical Storms -
- Climate change could lead to more locations being affected by tropical storms because seas get warmer so the source area (where they form) extended further N/S of the equator.
- It's unclear whether they increase the frequency of tropical storms but climate models predict their intensity may increase. Warmer ocean temperatures, higher sea levels, higher wind speeds, higher rainfall rates.
- Sea level rise can make tropical storms more damaging due to increases in coastal flooding and storm damage. Low-lying coastal communicates that are low income are at the highest risk. In future, more will live in coastal communities.

Effects of tropical storms -
- Primary effects: Buildings and bridges destroyed, roads, railways, ports, airports damaged, electricity lines damaged, gas lines broken, sewage overflows, river and coastal areas flooded, businesses destroyed.
- Secondary impacts: People are homeless (distress, poverty, illness, death. Cost of rebuild expensive, no insurance). Emergency vehicles and aid can't get there. Life support systems, hospitals, shops, homes without power. Risk of fires and explosions. Clean water supplies contaminated (waterborne diseases), people drown or injured. Crops, livestock, habitats destroyed (shortage of food and famine). Economic impact, unemployment.

Responses to tropical storms -
- Immediate responses are when it is forecasted, as it is happening and immediately after. Long term is restoring an area to past conditions and reducing impact of future storms.
- Immediate responses: Evacuation of people, rescue people, recover dead bodies (reduce disease), set up temporary shelters for homeless, provide temporary power, food and water, restore communications, overseas aid sent (workers, supplies, equipment, financial aid), disaster response tools to confirm people's safety and report risks.
- Long term responses: Improve forecasting techniques, provide air/grants/subsidies to residents to repair properties, repair/improve flood defences, repair homes or rehouse people, repair/replace/improve infrastructure, improve building regulations so more can withstand impacts, encourage economic recovery.

Typhoon Haiyan Case Study -

- One of strongest ever recorded tropical storms, hit Philippines. November 2013, category 5, winds over 195mph. Philippines a series of island in South China Sea. Regularly suffers from typhoons. Sit in an area of warm ocean water. Sea level rise contributes to greater storm surges (rise in sea levels). Abstracting too much groundwater has caused some parts of country to sink.

- Short term impacts:
Social: 6201 people died, 1.1 million homes lost, 4M+ people displaced, 28,000+ casualties, 16M+ affected, UN admits its responses was too slow (reports of hunger/thirst).
Economic: $13B of damage, sugar/rice production areas damaged (50-120K tonnes sugar lost, 130K+ tonnes rice lost). Government estimated 175,000 acres of farmland damaged.
Environmental: Loss of forests/trees, widespread flooding. Oil and sewage leaks into ecosystems. Lack of sanitation for days. Coconut plantations flattened (half of agricultural exports), fishing communities severely affected.
- Long term impacts:
Social: UN feared possibility of disease, lack of food, water, shelter medication. Influx of refugees in less affected areas. 21k families still in evacuation centres two months later.
Economic: ‘State of national calamity’, asked for international help, Tacloban city decimated, country locked in debt cycle (20% of revenue spent on debt repayments).
Environmental: 90% of rural population affected. 33M coconut trees felled, 15M tons of timber rotting attracting pest and threatening healthy trees. Families struggling without their crop.

- Short term response: Declared a ‘state of national calamity’, asked for international help. International aid responses with food, water and temporary shelter. Red Cross delivered food aid. UK sent shelter kits. 1200+ evacuation centres set up for homeless. Field hospitals set up. $475 million sent as aid, 13,000 soldiers from US.
- Long term response: UN donated financial aid, supplies, medical support. 5 days before any aid (only 20% of victims received). UN admitted response too slow. Rebuilding of airport, ports, roads, bridges. ‘Cash for work’ scheme gave locals money to help clear debris. More cyclone shelters built.

Reducing the effects of tropical storms -
Prediction – Satellite and radar technology is used to track the development and approach of tropical storms. These alongside weather charts and computer software can predict the path a storm can take. HICs such as the USA have effective hurricane monitoring and predicting systems. Resultingly hurricane watches are issues when detected giving people time to prepare. LICs are often less prepared for this as monitoring equipment is expensive and they cannot communicate with people likely to be affected.
Protection – Storm shelters are the most reliable way to reduce life loss during a tropical storm. They can withstand strong winds due to: Windows covered with metal shutters, built off the ground with deep-pile concrete pillars that dissipate energy and are made from reinforced concrete. High sea walls can also protect coastal communities from storm surges.
Planning – Preparation is essential in reducing impacts. People in prone areas are advised to stock up on food and water. Governments and NGOs advise people on preparing and responding to tropical storms. Early warning systems are installed to reduce the number of deaths (e.g. in Bangladesh).

- Extreme Weather in the UK:

- The UK experiences different weather hazards such as droughts, depressions and storms, flooding, extreme cold and heat waves.
- The UK is at the convergence zone of several air masses causing varied weather and extreme weather. It rains 1 in 3 days in the UK. Highland areas to the west receive the most annual rainfall, south to the east receive the least. Southwest prevailing winds bring moisture from the Atlantic. Average rainfall is around 1000mm annually.
- Climate change can increase the frequency and intensity of extreme weather events.
- Extreme rainfall results in saturated soil that cannot absorb any more water so surface run-off.

- Relief rainfall occur when warm, moist air rises over mountains, cooling and condensing to form clouds and then descending to form a rain shadow (reduced rainfall as behind higher land).
- Convectional rainfall is when sun heats land creating rising pockets of warm air (convection currents). Air cools and forms large cumulonimbus clouds.
- Frontal rainfall is when a warm front meets a cold front. Heavier cold air sinks and warm air rises above it. When it cools, it forms clouds with heavy rain.

- Cumbria experienced severe flooding in 2009. 31cm of rain fell in 24 hours, resulting in Cockermouth flooding. Relief rainfall from the Atlantic meant rivers couldn't retain the sheer volume of water. Cockermouth is at the confluence of two rivers. Cumbria was hit again by floods in 2015.
- Other human causes include urbanisation, blocked sewers, lack of dredging (removal of sediment) and inefficient flood defences. Many towns are made of impermeable surfaces. ~
- Responses: A flood risk management scheme was implemented installing flood defences such as embankments and flood gates (£45 million). They now encourage regular river dredging to increase its capacity. Early warning systems and education to prepare people have been put in place. People have been moved to safer areas reducing economic and personal loss.
- Impacts:

Social: 2200 properties flooded leaving people homeless, many evacuated, 50+ rescued by helicopter, 1500 homes without electricity, 3 bridges destroyed isolating people.

Economic: £275M damage, £100M in insurance claims, farmland destroyed and livestock died, 3000 businesses affected (especially tourist related), disruption to public transport.

Environmental: River systems and habitats severely disrupted, increased rates of erosion, water pollution from sewage and debris, damage to bridges so increased congestion.

- Responses to extreme weather:
- Flooding: The Thames Barriers was installed to prevent storm surges (cost £500M+). Constantly monitor ground moisture levels in river basins to predict floods. Higher insurance on floodplain properties to prevent new properties built on them.
- Strong winds and storms: Highly advanced technology to predict storms several days in advance. Easy to issue severe weather warnings through computers, tables, smartphones, radio. Travel companies use these to cancel services.
- Drought and heatwave – Hosepipe bans means people won't waste water on non-essential uses. In summer of 2022 we did this. Water meters so people are charged appropriately for water usage to conserve it. Upgrading pipe networks to stop water leakages (2.4B litres leaked per day in England).

- Extreme cold – Councils clear snow and ice with gritters all night to reduce risk of accidents and send out ploughs in heavy snowfall. Cold weather warnings and advice (extra care, minimise travel). Charities support vulnerable people (isolated elderly, homeless).

Is extreme weather on the rise in the UK? -
- All of the top 10 warmest years since 1884 have occurred this century. The UK is becoming warmer, wetter and sunnier since the 20th century.
- Since 1960-1990s: approx. 1C warmer, 8% sunnier, 10% wetter, 19.5% fewer air and ground frosts.
- Warm spells have seen their average length more than double, alongside more tropical nights (above 20C). In August 2020 temps of 34C were recorded for 6 consecutive days.
- Six of the 10 wettest years have occurred since 1998. There has been an increase in number of days where rainfall is above 50mm. The UK is expected to experience drier summers and wetter winters, with summer rainfall more intense + flooding.
- No evidence of stronger winds, however warming in North Atlantic could bring tail-end of more hurricanes. Rising sea levels mean more coastal flooding and storm surges.
- The average coldest day has become 1.7C milder since 1960s. Far fewer very cold days (3.2 below 0C now compared to 4.8 in 1960s).

Climate Change

- The Quaternary period stretches from 2.6 million years ago to the present day – a time that has been a global drop is temperature and the beginning of the most recent ice age. Global temperatures have fluctuated. Cooler periods known as glacial periods (ice covered much of UK, approx. 100,000 years), warmer periods known as interglacials (10,000 years). Changes can be evidenced by extracting ice cores.
- Temperature today higher than almost all of last 400,000 years.

Evidence for Climate Change -
- More recently we have used thermometers to monitor changes in temperature. For example, the temperature of our planet has increased by around 1C since 1990. Between 2013 and 2022 was the warmest 10 year period on record. If greenhouse gas emissions continue global temperatures will continue to rise.
- We can see how much glaciers are shrinking through photographic evidence, for example the Muir glacier in Alaska.
- Ice cores can be used to detect changes in temperature. When snow falls it traps air in ice. When scientists take a core of ice it reveals atmospheric gas concentrations at the time snow fell, used to calculate temperature at that time. This can be done for up to 400,000 years ago and has given clear evidence there has been a rapid increase in temperature in the past decades.
- Between 1900 and 2019 average global sea level rose by 0.21m.

Causes of Climate Change -
- A natural function of the Earth's atmosphere is to retain some of the heat lost by the build-up of greenhouse gases (the greenhouse effect). The heat is radiated back to the Earth. Greenhouse gases include methane, carbon dioxide and nitrous oxide.
- Human factors: Burning fossils fuels (e.g. coal, gas, oil) release carbon dioxide into the atmosphere. Trees absorb carbon dioxide during photosynthesis so when they're cut down

(deforestation), there will be higher amounts in the atmosphere. This is often done to make room for agriculture/farming. When waste in dumped in landfill it decomposes and produces methane. Livestock (particularly cattle) give off methane.
- Natural factors: Orbital changes of the Earth – natural warming and cooling periods caused by Milankovitch cycles or variations in the tilt/orbit of the Earth around the sun. During volcanic activity carbon dioxide is released into the atmosphere. There can be fluctuations in the amount of radiation from the sun (if high amount emitted, increase in temperature).

Impacts of climate change -
- Sea level rise could affect 80M people. Tropical storms will occur in more areas. Species in affected areas (e.g. Arctic) may come extinct. Diseases such as malaria could increase (addition 280M affected).
- In the UK: Droughts and floods become more likely. Increased demand for water in hotter summers (pressure on water supplies). Industry may be impacted (e.g. Scottish ski resorts may have to close due to lack of snow).
- Potential benefits: Winter heating costs reduced. More people in holiday in UK (economic growth), new crops such as oranges, grapes and peaches can be grown in UK. Globally: Decrease in energy consumption, growing season will increase in some areas (more crop yield), more areas can grow crops (e.g. Alaska).

Managing Impacts of Climate Change -
- Mitigation means to reduce or prevent the effects of something from happening (make less severe). Adaptation do not aim to reduce or stop global warming, just limit its negative effects.
- Mitigation strategies:
• Alternate energy such as solar, wind or tidal can reduce the use of fossil fuels, therefore less CO_2 released into atmosphere.
• Carbon capture is the removal of CO_2 from power station waste gases and storing it in old coal mines underground, reducing the amount in the atmosphere.
• Planting trees (afforestation, new habitats, stabilise soils, prevents surface run-off) means more trees to absorb the carbon dioxide during the process of photosynthesis.
• International agreements such as the Kyoto Protocol (2005) and Paris agreement (2016) take a stand to tackle climate change. Each year the United Nations have a meeting (COP) which was hosted in Glasgow in 2021.

- Adaptation strategies:
• Farmers will have to adapt as some crops cannot be grown in a warmer climate, however it opens doors for new crops (e.g. oranges and grapes) to be planted.
• Water transfer schemes can be where water is transferred from areas of water surplus to areas of water shortage.
• Areas at risk from sea level rise may use sea defences to protect the land from being eroded away.

Physical Diversity of the UK

- The UK has a varied landscape as the relief of the land changes throughout the country. Relief refers to the way the landscape changes in height.

- Upland areas are high above sea level, and often mountainous. Lowland areas are not very high above sea level, and are often flat.
- The shape of a landscape is largely determined by glaciation (build up of ice in past colder periods) and rivers.
- Upland areas are mostly found in Scotland (NW highlands, Cairngorm Mountains, Grampian Mountains, Ben Nevis is highest peak) and Wales (Snowdonia, Brecon Beacons) but also in England (Pennies, Lake District, Dartmoor). They usually consist of igneous rocks and experience lower temperatures, high rainfall and are often windy.
- Lowland areas can be found in Lincolnshire, the Midlands, York, East Anglia and the London Basin. They tend to be formed of sedimentary rocks like sandstones and clays, and experience milder temperatures and less rainfall.
- During the last ice age, ice covered a large part of the UK and eroded the land producing some of today's mountainous landscapes.
- The erosive powers have shaped the relief of the land.
- The major river systems in the UK are: Severn, Thames, Tyne, Trent, Great Ouse, Wye, Tay, Spey, Tweed, Avon.

Ecosystems Biodiversity and Management

- How do ecosystems operate?
- An ecosystem is a natural environment that includes the flora (plants) and fauna (animals) that live and interact with it. Flora, fauna and bacteria are the biotic (living) components.
- Ecosystems are dependent on abiotic (non-living) components too:

Climate: The temperature and amount of rainfall are important in determining which species can survive.
Soil – The soil type is important as provides nutrients that will support different plants.
Water – The amount of water available in an ecosystem determine what plants and animals can be supported.

- Biotic and abiotic components have a complex relationship and changing one will lead to a change in the other. For example, waste from dead plants and animals in the soil provides nutrients for plants to flourish.

- An example of an ecosystem in the UK is the freshwater pond ecosystem.
- Pond bottom – There is very little oxygen or light so decomposers (eats dead material) and scavengers (feeds on decaying flesh or plants) live here and feed on dead material such as water worms and rat-tailed maggots.
- Mid water – Fish are the main predators here. Food is found on the bottom or surface. Animals breathe through their skin or gills, for example stickleback fish, water fleas and dragonfly nymphs.
- Pond surface – Animals breathe here through gills, skin or lungs. There is plenty of oxygen and light. Animal here include ducks, water boatmen, midge larvae and tadpoles.
- Pond margin – Plants provide a sheltered habitat for insects and small animals such as frogs. There is lots of light and oxygen so plants such as marsh marigold thrive.
- Above the pond surface – Birds such as kingfishers and insects like dragonflies are common here.

- A food chain shows how each living thing gets food. In a food chain energy and nutrients are passed from one organism to the next. The producer (plants) provides the basic source of food (e.g. leaves, algae) which other organisms, the consumers (eat other organisms) then feed on.
- A food web includes all the connections between producers and consumers in an ecosystem and how interconnected all of the different organisms are.

- Ecosystems are very sensitive to change. Biotic and abiotic components can be altered by natural factors or human management.
- Changes naturally: Drought, flood, fire, disease. For example in 1987 a great storm resulted in the felling of 15M trees, leading to significant decline in consumers of the food chain.
- Deforestation and human-induced climate change can threaten the balance of ecosystems.
- Changes by human management: Introducing more fish (fish stocking), altering the drainage of the land (influence amount of water), changing the pH level of the water or altering the nutrient levels if fertilisers are leached (nutrients washed out) into water resulting in eutrophication (hyper-nutrition).

- A loss of gain of a species can affect the food web. For example, a decline in insects due to disease could lead to the reduction in the number of rabbits, mice and small birds and also more primary consumers such as caterpillars. However, deciduous trees may thrive due to the low number of insects feeding on them. There could also be indirect impacts such as fewer secondary consumers (foxes, owls, sparrow hawks) as there are few primary consumers.

- Ecosystem balance can be restored through management. In the past bears and wolves were removed from ecosystems in North America as they were a hazard to people and their cattle. However this has led to a population explosion of rabbits and deer who removed vegetation, stripping soil bare leading to soil erosion and disrupting the balance.
- ‘Rewilding’ is re-introducing animals back into an ecosystem. For example, in 1995 grey wolves were re-introduced to Yellowstone National Park in the USA. They were originally removed but elk population boomed alongside other prey animals causing overgrazing and deciduous woody plant species became diminished. There was also significant growth in the number of coyotes who replaced the niche left by wolves and they were unable to control the population of primary consumers.

Global Distribution of Ecosystems -
- The distribution of large-scale ecosystems (biomes) is determined by climate (latitude, air pressure, winds), altitude, ocean currents and mountain ranges are important in determining a location’s climate.

((((- In the lower latitudes around the equator temperatures are highest. Sunlight has a smaller area of atmosphere to pass through and the sun’s rays are concentrated. In areas of higher latitude such as polar regions temperatures are lowest. They drop due to the curvature of the Earth. Sunlight has a larger area of atmosphere to pass through and the sun is at a lower angle in the sky.
- Low pressure areas are associated with cloud and precipitation as when air rises it cools, condenses and forms clouds. Water droplets in clouds increase in size and eventually become too heavy to be held. High pressure areas are associated with dry, warm and settled weather conditions as sinking air does not result in precipitation.

- Air travels in the upper atmosphere and sinks approx. 30 degrees N/S of equator creating high pressure. These areas are very dry and warm resulting in hot desert climate (e.g. the Sahara). Winds blows from areas of high to low pressure transferring air from where it is sinking to where it is rising. This continuous transfer of wind maintains the pressure belts creating different global climatic zones.)))))

- Temperatures fall with height above sea level as air is thinner so can't retain much heat. On steep mountains trees are replaced by tough grasses.
- Cold ocean currents create dry conditions because of a lack of evaporation, whereas warm currents make countries warmer than they should be in relation to their latitude.
- Mountain ranges force air to rise upwards leading to relief rainfall, but this means moisture is quickly lost so the land the other side of the mountain range is dry (rain shadow).

8 main global ecosystems -
- Ecosystems change gradually between the Equator and the poles.
- Tundra - Found near the North and South Poles. Very few plants and animals can survive here.
- Coniferous forest – Found in Scandinavia, Russia and Canada. Evergreen trees thrive in this cool temperate climate.
- Temperature deciduous forest – Found across Europe and in the USA. Trees lose their leaves every year and thrive in mild and wet conditions.
- Temperate grassland – Found in Hungary, South Africa, Argentina and USA. Consists of grass and trees that thrive in this climate of moderate rainfall and mild conditions.
- Mediterranean – Found in Mediterranean Sea, around Perth in Australia and California in the USA.
- Desert – Found near Tropics of Cancer and Capricorn. Conditions are very hot and dry. Plants and animals are specially adapted to live in the hot conditions.
- Tropical rainforest – Found near the equator. Climate hot and humid and many species can be found here.
- Savanna grassland – Found mainly in central Africa, southern India, central South American. Long grasses and a few scattered trees are found in these hot and dry conditions.

Tropical Rainforest

- Tropical rainforests have distinct characteristics that support a wide variety of different species, resulting in high biodiversity. The biotic and abiotic components depend on each other.
- The climate is very wet with over 2,000mm of rainfall per year. It is very warm with an average daily temperature of 28C (range of 20C-35C). The atmosphere is hot and humid, and this climate is constant all year round with no seasons.
- Most of the soil is not very fertile (rich in nutrients). Only a thin layer of fertile soil is found at the surface where dead leaves decompose. It is red in colour as it is rich in iron. Due to heavy rainfall the nutrients are quickly washed out of the soil.
- The warm and wet climate provides perfect conditions for plant growth. The wide range of plant species support many different animals, birds and insects. Species have adapted to the conditions of the rainforest (e.g. trees and plants have shallow-reaching roots to absorb nutrients from the thin fertile soil layer).

- A tropical rainforest is made up of the layers:

• Emergents - Tallest trees over 50m tall such as the Kapok so they can get take in as much sunlight as possible.
•Canopy – Sea of leaves cover it and contains over 50% of wildlife including birds, monkeys, snakes.
• Under canopy – Mainly contains bare trees trunks and lianas (vines that climb vegetation for sunlight).
• Shrub layer – Has the densest plant growth including shrubs and ferns needing less light. Saplings of emergents are found here.
• Ground level/forest floor – Usually dark and damp. Contains a layer of rotting leaves and dead animals called litter. Decomposes rapidly (under 6 weeks) to form a thin humus rich in nutrients. Nutrients are rapidly absorbed by vegetation so there's little nutrients below the rich top soil.

Plant adaptations:
• Lianas – Woody vines that have roots in the ground but climb up the trees to reach sunlight (leaves and flowers grow in canopy).
• Tree trunks – Trunks are tall and thin to allow trees to reach the sunlight. Bark is smooth to allow water to flow down to root easily.
• Drip tips – Plants have leaves with pointy tips allowing water to run off the leaves quickly without damaging or breaking them.
• Buttress roots – Large roots have ridges which create a large surface area to support large trees (the soil isn't stable enough, and soil is only fertile in the top layer).
• Epiphytes – Plants which live on the branches of trees high up in the canopy that get their nutrients from the air and water, not soil.

Animal adaptations:
• Sloths – The sloth uses camouflage and move very slowly making it difficult for predators to spot.
• Spider Monkey – This monkey has long, strong limbs to help it climb through rainforest trees and can use its tail for support.
• Flying frog – Fully webbed hands and feet and a flap of loose skin that stretches between its limbs, allowing it to glide from plant to plant.
• Toucan – Has a long, large bill to allow it to reach and cut fruit from branches that are too weak to support its weight.

- The UN estimates that about half of all the world's rainforest have now been cleared, and since 2000 the rate of deforestation has increased in South American, Asia and Africa. 20% of the Amazon has already been lost. 1 hectare per second of rainforest is lost. 31 million hectares per year (an area larger than Poland).
- Slash and burn is a common method of cultivation involving removing and drying out vegetation followed by burning to create a nutrient rich ash layer in which crops can be grown. It risks fires spreading.
- Tropical rainforests face the threat of deforestation (particularly the Amazon Basin) due to:
• Farming – Large areas cleared for pastoral farming (animals reared for meat) as global demand for meat has increased. Arable farming is also responsible as many farmers clear land to grow cash crops such as soya beans.
• Logging – Tropical rainforests are cut down so that valuable trees like mahogany can be accessed and sold for timber to make furniture, or for paper products.

• Mining – The Amazon Basin is rich in natural resources such as iron ore, copper, tin, aluminium, manganese and gold, leading to the development of mines. The Carajas mine in Brazil is the world's largest iron ore mine.
• Roads – The construction of access roads for farmers, loggers and miners destroys parts of rainforests.
• Hydroelectric power – HEP stations has resulted in large areas of forest being flooded to create reservoirs and dams. The flooding of the Balbina dam in Brazil resulted in the loss is 920 square miles of tropical rainforest.
• Population growth has resulted in the loss of tropical rainforest as land is cleared to build houses and infrastructure.

- Impacts of deforestation:
• Soil erosion – Once land is cleared of rainforest vegetation the soil is left bare. When it rains nutrients are washed away and the nutrient cycle stops because there are no plants or trees shedding leaves to replace these nutrients. The soil can no longer support plant life and roots no longer hold soil together so it is easily eroded.
• Loss of biodiversity – Many different species of plants and animals die due to deforestation, especially since many are closely connected through the food web.
• Climate change – Trees and plants absorb carbon dioxide through photosynthesis. If there are fewer trees and plants less CO_2 is removed from the atmosphere resulting in global warming.
• Economic development – The creation of mines, farms and roads has led to economic development allowing a country to generate a foreign income used to pay off debts or be invested into further development projects.

- Tropical rainforest provide many good and services including food (nuts, diet of local people), cash crops (e.g. wild coffee that resists disease), medicines (e.g. rosy periwinkle from Madagascar can help treat childhood leukaemia) and raw materials (timber such as hardwoods for garden furniture, palm oil plantations in Indonesia used in cosmetics, confectionary, detergents, etc).
- Tropical rainforest act as life support systems for the planet. They regulate the composition of the atmosphere and offset climate change by taking in CO_2 and releasing oxygen. They maintain soil health with a rich fertile top soil due to rapid leaf fall and decomposition recycling nutrients, which can be used to grow cassava and maize (staple diet for locals). They provide a constant water supply for the population there through intercepting rainfall and release water into the atmosphere.

Sustainable management of rainforests:
• Logging and replanting – Selective logging of mature trees ensures the rainforest canopy is preserved, allowing the forest to recover as younger trees gain more space and sunlight to grow. This planned ensures for every tree logged another is planted.
• Education – Promoting the values and benefits of biodiversity associated with tropical rainforests.
• Ecotourism – This encourages sustainable tourism, creating jobs for local people whilst ensuring money generated is used to protect and conserve the tropical rainforest for future generations.

• International agreements – Agreements to protect tropical rainforest have been made through debt-for-nature swaps (debt is cancelled if a country agrees to conserve its rainforests).

- Sustainable management has been implemented by the government in Malaysia to ensure the tropical rainforest can be conserved and enjoyed by future generations.
- They spread public awareness of the value of rainforests, include local communities in forest conservation projects, use alternate timber sources such as rubber trees, have a 40 year cycle of selective logging, promote ecotourism and set permanent forest estates and national parks to protect biodiversity and so no change of land use is allowed.

Hot Deserts

- Hot deserts are found near the Tropics of Cancer and Capricorn. The largest desert in the world is the Sahara. Hot deserts have an extreme climate and challenging environment. There is very little biodiversity, few species are specialised enough to survive. Biotic and abiotic components rely on each other.
- They are found between 15 and 30 degrees N/S of the equator. As air hits the stratosphere it is pushed outwards N/S (Hadley cell) and falls with little moisture.

- The climate is very hot. Temperatures can exceed 50C, however at night it is normally below freezing. They have less than 250mm of rainfall per year. Hot deserts have two distinct seasons: summer (35-40C) and winter (20-30C).
- Desert soils are thin, sandy, rocky and generally grey in colour. They are very dry. When it does rain they soak up water very quickly. The surface may appear crusty due to the lack of rainfall. Water is drawn up to the surface of the soil by evaporation and salts are left behind on the surface.

- Plants and animals have adapted to live in these hot and dry conditions. Plants that have done this are known as xerophytic. Adaptations that allow them to survive in the hot desert environment are:
• Small leaves that ensure less water is lost by transpiration (as it has a smaller surface area).
• Tap roots (long roots, 7-10m long) that reach deep underground to access water supplies. Much longer and bigger than the visible plant.
• Spines instead of leaves (e.g. on cactuses). Spines lose less water so are efficient in hot climates and prevent animals from eating it.
• Waxy skin to reduce water loss by transpiration.
• Some plants known as succulents store water in their stems, leaves, roots or even fruits. They have a thick waxy skin to keep this water in.
• Plants can be ephemeral which means they change their behaviour to suit environmental conditions. Some desert flowers lie dormant for years and germinate quickly after a period of rain, enabling them to complete their lifecycles in a few weeks.

- Camels have many adaptations to help them survive in the desert. They store fat in their humps meaning they can go without food for long periods of time. They have very concentration urine and faeces to reduce water loss. They have two pairs of eyelashes to protect their eyes from the bright sun. They have stretchy nostrils that they can close in a sand storm. They have long legs to keep their bodies away from the hot song, webbed feet to stop them sinking into the

sand, and a light woolly coat to reflect the sun but also keep them cool during the day and warm at night.
- Kangaroo rats get all the water they need from food. They don't lose water from perspiration (sweating) and lose minimal from urination as their kidneys are so efficient.
- Fennec foxes are protected from the scorching heat of the sand by having thick fur on their paws. They light fur offers camouflage and reflects the sunlight. Their massive ears allow heat loss by providing a large area of exposed skin full of blood vessels.

Opportunities in the Thar Desert -
- Despite its extreme climate the Thar Desert can provide development opportunities including…
• Mining – The desert has valuable reserves of minerals such as feldspar, phosphorite, gypsum and kaolin. They produce a range of things from cement to fertilisers. Limestone (for cement) and marble (used in construction) are also quarried.
• Energy generation – Solar panels are used for energy production here. It is used to clean water supplies contaminated with salt through desalination. Wind energy is also used – a wind farm of 75 turbines can produce 60 megawatts (MW) of electricity.
• Farming – Irrigation (channelling water from rivers to help crops grow has made commercial arable farming viable. Producing crops such as wheat and cotton has created many jobs and generated income for the local economy. Construction of the Indira Gandhi Canal has allowed areas to flourish that used to be scrub desert, and can also be used for drinking water, irrigation, and energy (solar panels cover it to stop evaporation).
• Tourism – The Thar Desert National Park attracts many visitors who want to see any of the 120 species found there. Tourists explore with local guides on camels. Tourism is an important source of income and creates many jobs for locals. The multiplier effect creates business opportunities.

Challenges of development -
• Extreme temperatures – Temperatures in the Thar Desert can exceed 50C in summer months. This makes it hard for people to farm, work in mines or as tourist guides potentially resulting in dehydration, sun stroke, decreased work yield, tiredness, etc.
• Water supply – The supply of water here is precious and limited. Water has to be used sensibly and sustainably due to the low rainfall (120-240mm), high temperatures and strong winds resulting on a lot of evaporation; it is required for mining, farming, tourism, etc. Some parts of the desert have experienced over-irrigation (watering land) which causes waterlogging of the ground. Here excess water evaporates and leaves a layer of salt on the surface making it difficult to grow crops. Water from underground (aquifers) using wells is often very salty.
• Inaccessibility – The desert covers a huge areas of 200,000 sq km. Most of the desert is inaccessible due to extreme environmental conditions and poor infrastructure. Tarmac can melt and sand is blown over roads, so many places can only be accessed by camel. Public transport often involves seriously overladen buses.

- Desert fringes are the border of hot deserts. We use the Sahel region as an example.
- Desertification is the process by which land becomes drier and degraded and turning into desert as quality of soil declines. The main causes are:
• Population growth – As population grows there is more pressure on food, water and wood resources. Armed conflict has driven many people to desert fringe areas, and natural increase

also increases populations. People are more attracted by areas with development in mining and tourism (more jobs).
• Removal of wood – In developing countries people use wood for cooking. In the Sahel region 80% of domestic energy is from burning firewood. As the population in desert areas increases there is a greater need for fuel wood. When a land is cleared of trees roots no longer hold it together so soil is more prone to erosion (earth washed or blown away). The loose top layer can blow away and there's no leaf litter to return nutrients back to it reducing fertility.
• Poor farming practices – An increasing population results in larger desert areas being farmed. Sheep, cattle and goats are overgrazing the vegetation and trample on it leaving it exposed to erosion. Overcultivation of water-hungry cash crops for exports results in aquifers and surface stores of water to be drained, as well as the nutrients in the soil. Planting just one crop leads to a lack of nutrients in the soil.
• Climate change – The climate of the Sahel has become much drier over the past 50 years. Less rainfall means poorer grazing and lower crop yields, and prevents underground water reserves from recharging. Lack of precipitation causes semi-arid desert fringe to slowly turn into desert.

Desertification has many impacts and has become a problem in the Sahel region. It results in soil erosion which removes the leaf canopy meaning no litter and means the top layer can be blown or washed away easily, leaving it vulnerable and exposed. This along with a lack of water means soil loses fertility resulting in crop failure of potentially whole harvests. This can impact food supply leading to malnutrition and even widespread famine. Farmers lose their income and could end up impoverished. On a global scale food prices could increases as crops become scarce. This could cause people to migrate as the land they live on can no longer support them, especially to urban areas causing overpopulation. Water sources will start to dry up, and stagnant water encourages mosquitos, increasing malaria rate. Loss of vegetation leads to reduced interception and infiltration so flooding is a possibility.

We can reduce the risk of desertification in many ways…
• Water and soil management – Crop rotation is when crop positions are switched around (e.g. barley, rye) so soil can stay nutritious. If one takes out a nutrient such as nitrates, another will replenish it. Educating people in the Sahel region could help to improve desertification, however farmers may not have the capabilities for crop rotation.
• Planting trees – The Great Green Wall is a large areas of trees being planted across 15 countries suffering from desertification. Trees roots hold water in soil and restore life to it. This strategy forces many from their homes but provides work for thousands and the space can eventually be used for crop growth. Leaves provide compost, trees provide shade coverage, their roots hold soil together and reduce soil erosion. However, some local people use newly planted trees for building materials or firewood.
• Appropriate technology – Appropriate means matching the level of development. Surface stones (0.5-1.5m high) can be lined along contour lines as a wall to control flow of water downhill. They can cause deposition of nutrient-rich soil. It makes use of locally available resources, is low cost and easy to learn to do. Barren land can be restored and vegetation can be reestablished. Water can be stored in earth dams in the wet season and used to irrigate crops during the dry season.