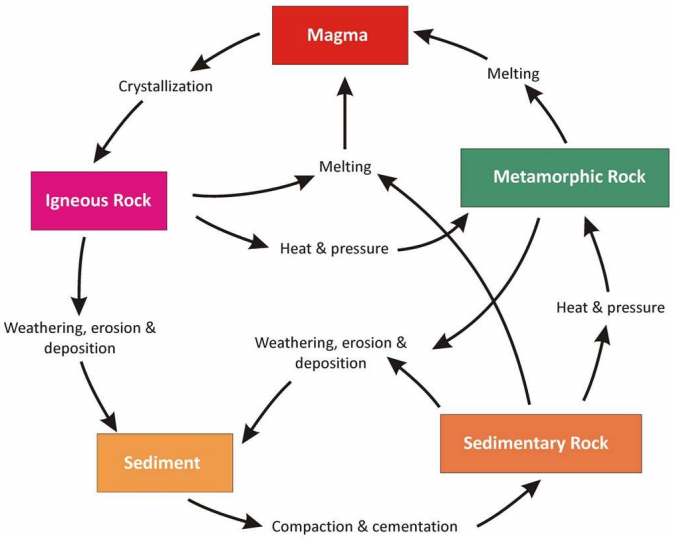
ENVIRONMENTAL MANAGEMENT

CHAPTER 1: rocks and minerals and their exploitation

FORMATION OF ROCKS: 1.1

- **The rock cycle:** a representation of the changes between the three rock types and the processes causing them.



Types of Rocks

- Igneous rocks:
  - Made when liquid magma cools to form solid rock.
  - Molten rock below the surface is called magma, and lava when it reaches the surface.
    - **Extrusive igneous rock:** if the rock cools quickly, small crystals are formed e.g. basalt.
    - **Intrusive igneous rock:** if the rock cools slowly, large crystals are formed e.g. granite.
    - **Examples:** Granite and Basalt
- Sedimentary rocks:
  - Formed by the weathering of existing rocks at the Earth's surface.
  - Fossils may be present.
  - Sediments (small particles of rocks) accumulate into layers and get pressurized due to the newer deposits above them.
  - The sediments are transported by water and wind (erosion).
  - Particles like clays, silts, sands, gravels, and small boulders are found in sediments.
    - **Examples:** limestone, sandstone, and shale.
- Metamorphic rocks:
  - Formed from the existing rock when heat and/or pressure causes changes in the rock crystals without melting it.
  - The changes can be physical, chemical, or both.
    - **Examples:** marble and slate.

EXTRACTION OF ROCKS AND MINERALS FROM THE EARTH: 1.2

Exploring for minerals:

- **Prospecting:** a process of searching for minerals by examining the surface of the rocks
- **Ore:** A rock with enough important mineral to make it worth mining

Methods of exploration

- **Remote sensing:** a process in which information is gathered about the Earth's surface from above.
    - Photographs of the area are taken from air.
    - The images are carefully analysed for mineral presence.
    - Aerial photography can cover more ground than a person on the surface.
- **Satellite signals:**
    - Some satellites send signals to the Earth's surface and collect the reflected signals, indicating the presence of minerals.
    - The unique radiation pattern is processed and analysed by computers
    - The system works in all weather conditions.
    - The GPS gives the exact location
    - Large area covered in low cost
    - Most efficient method
- **Geochemical analysis and field surveys**
    - Geochemical analysis: analysing the chemical properties of rocks (by taking samples).
    - The samples can be taken from stream sediments, soil or rocks (using shallow drilling).
    - The location of the sample points can be accurately found using the Global Positioning System (GPS).
- **Geophysics:** method to identify mineral ores present in rocks using their physical properties.
    - A series of vibrations (seismic waves) are sent through the Earth's surface.
    - Several sensors are placed at different distances from the source of vibrations on the surface.
    - The vibrations create shock waves that travel down into the rock layers.
    - They are reflected back to the sensors on the surface.
    - The shock waves record different patterns depending on the mineral present in the rock layers.

Methods of extraction:

- There are two methods of extraction
    - **Surface mining:** includes open-cast (open-pit, open-cut) and strip mining.
        - Open-pit mining is used when a valuable deposit is located near the surface.

        - The vegetation is cleared and topsoil removed.

        - The rocks are broken up and loosened with explosives.
        - The loose rock is removed using diggers.
        - The rock or mineral is tipped into trucks or railway wagons.
            - Building materials such as sand, gravel, and stone are removed from open pits called quarries.
        - Strip mining is used to mine a seam of mineral.
        - The overburden (the unwanted overlying rock and soil) is removed as a thin strip. \n
        - It is mainly used to mine coal and lignite
    - **Sub-surface mining:** includes deep and shaft mining.
        - A vertical shaft is sunk to the rock layer containing minerals.
        - A horizontal tunnel is made, following the mineral layer.
        - The minerals are extracted by digging (by machines and miners).
        - The loose rock is brought from the mine and piled up on waste heaps on the surface.
        - The minerals are brought to the surface and transported in trucks or trains
        - **Resources:** Gold and Diamonds

Factors that affect the decision to extract rocks and minerals:

- **Geology:**
    - High-grade ores yield more of the required chemical elements than low-grade ores.
    - Small deposits of high-grade ore are worth mining.
    - Small deposits of low-grade ore that cannot be mined at a profit is left as reserves.
- **Accessibility:**
    - Transporting the ore from the mine to processing plants can be difficult and expensive.
    - The cost of building road or rail links to the processing plant or to the nearest port for export has to be considered.
    - Carrying out some processing at the mine reduces transport costs.
    - The mining company must be given a licence before extracting a deposit.
    - A long-term agreement between the government and mining companies must be reached to avoid rapid rises in the tax, which makes mining unprofitable.

- **Environmental impact assessment:**
    - For the license application to be approved, the company must have a plan to keep the loss of habitat minimal, followed by the restoration of land proceeding with the completion of mining.
    - The choice of site for mine waste should also be considered.
- **Supply and demand:** the relation between how much of a commodity is available and how much is needed or wanted by the consumers.
    - An increase in world demand for any mineral ore will elevate the prices.
    - The profit from a working mine depends on changes in supply and demand.
    - If the demand is too high, mines that were not profitable before becoming worth mining.
    - If the demand falls, working mines may get into a loss due to the transport and extraction expenses.

IMPACT OF ROCKS AND MINERAL EXTRACTIONS: 1.3

Environmental impacts

- **Ecological impacts:**
    - Loss of habitat as the vegetation is cleared
    - plants do not have a place to grow,so the animals depending on them for food and shelter are affected.
- **Pollution:**
    - **Noise pollution:** due to machinery and explosives
        - disturbs the behaviour of animal species and causes hearing problems for people.
    - **Water pollution:** water supplies may also be polluted, making it unsafe for people to drink.
        - The water may become acidic and dissolve toxic metal ions-this combination kills many aquatic organisms.
    - **Bioaccumulation:**organisms absorb the ions and retain them in their body, reaching a concentration higher than that in water.
    - **Biomagnification:** the concentrations increase higher up in the food chain and cause the death of top consumers.
    - **Land pollution:** toxic nature of the waste doesn't allow plant growth even years after the mining is stopped.
    - **Air pollution:** dust particles settle on the vegetation, not allowing sunlight to reach the leaves and thus, reducing the rate of photosynthesis.
        - Breathing in dust that remains in the lungs can cause serious lung diseases.
    - **Visual pollution:** the landscape is damaged.

Economic impacts:

- Jobs are created in the extraction and transporting of minerals
- Increase in the Country's economy
- Earn foreign exchange.
- The income earned can be used for buying goods and services and investing in infrastructure projects.
- Improvements to transport

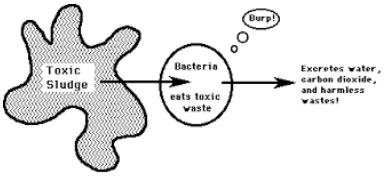
Social impacts:

Positive	Negative
○ Better standard of life due to economic gain ○ Improvements to services, like healthcare and education ○ Investing in infrastructure projects can help the country in building more well-designed communities.	○ Affects health of the labour workers ○ Affects health of civillans due to pollution ○ Lack of safety

MANAGING THE IMPACTS OF ROCKS AND MINERAL EXTRACTIONS: 1.4

Safe disposal of mining waste

- Mine waste must be stored to prevent collapse.
- The site of the mine must prevent the chances of water pollution.
- The waste must be monitored to detect any movement or further pollution.
- **Land restoration:**
    - **Soil improvement:**
        - After (sanitary) landfilling, mine waste can be covered by a layer of soil, that can be enriched with fertilizers.
        - **Landfilling:** the waste is tipped into a hole; from time to time it is leveled off and compacted.
        - **Sanitary landfilling:** As in landfilling, the waste is used to fill the hole, but alternating layers of waste and sand are used.
    - **Tree planting:**
        - After improving soil fertility, plants and trees can be grown in that area, helping an ecosystem to be reborn.
    - **Bioremediation:**
        - It is a process of removing pollutants from waste using living organisms.
        - **In situ treatment:** treatment of contaminated waste where it's left.
        - **Ex-situ treatment:** removal of contaminated waste from a site to a treatment plant.
            - Often happens slowly (can be sped up by providing oxygen and nitrogen).



        - Microorganisms, like bacteria, can absorb pollutants and metabolize them into less harmful substances.
        - Some plants have the ability to bioaccumulate toxic metals.
        - After these plants grow for a while, the parts of the plants aboveground are removed so the waste in the ground becomes less toxic.

- **Making lakes and natural reserves:**
  - Several tree and herb species are introduced. This will help maintain the biodiversity
  - As their populations grow, they create habitats for many species.
  - These nature reserves become valuable green spaces for human recreation and help in maintaining biodiversity.
  - If the rock lining the hole (created by the extraction) is non-toxic and impervious to water, it can be filled with water to form a reservoir or lake.
    - It is used for irrigating farmland or processing to provide clean, safe drinking water for humans.

SUSTAINABLE USE OF ROCKS AND MINERALS: 1.5

- **Sustainable resource:** a resource that can be continuously replenished e.g. agriculture, forestry, etc.
- **Sustainable development:**development that meets the needs of the present, without compromising the ability of future generations to meet their own needs.

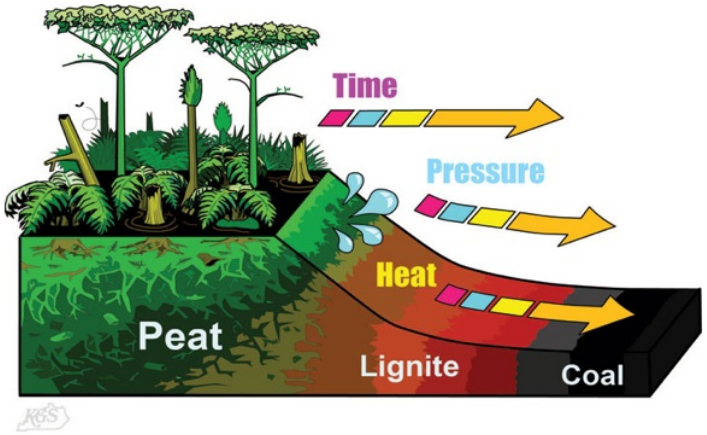
  Strategies for the sustainable use of rocks and minerals:

  Increasing the efficiency of the extraction of rocks and minerals:
  - Mine wastes must be processed for the second time.
    - This allows the valuable minerals to be recovered and reduces the risk of pollution due to mine waste.
  - Chemical treatment of the waste and biological treatment (using microorganisms) extracts much of the valuable mineral still within it.
  - Improvements in the performance of the machines used in mining and processing.
  - Greater use of data analysis by computers (to predict geological conditions).
- Increasing the efficiency of the use of rocks and minerals:
  - Engineering solutions e.g. design of steel beams with the same strength but using less steel.
- The need to recycle rocks and minerals:
  - Recycling uses less energy than processing the ores.
  - Recycling also produces less waste and thus, reduces the risk of pollution.
- Legislation:
  - The governments pass laws that require manufacturers to become responsible for recycling and reuse.

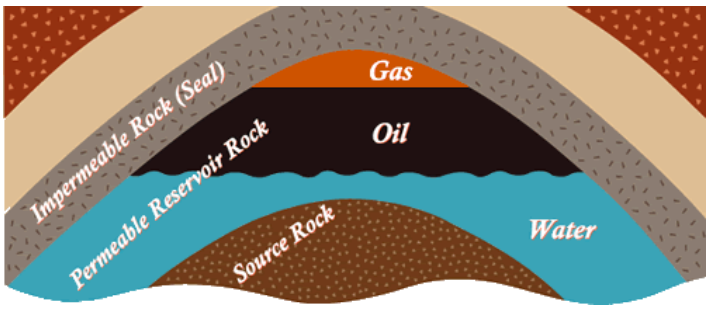
CHAPTER 2: Energy and the environment

FOSSIL FUELS: 2.1

- **Fossil fuels:** carbon-based fuels, formed over millions of years ago from the decay of living matter.
- **Coal:** formed from plants.
- **Oil and natural gas:** formed from sea creatures.
    - ***Formation of coal:***
    - Huge forests grew millions of years ago covering most of the Earth.



    - The vegetation died and formed peat.
    - The peat was compressed between layers of sediments to form lignite (low-grade coal).
    - Further compression formed coal.
    - ***Formation of oil and natural gas:***
    - Small animals and plants die and fall to the bottom of the sea.
    - Their remains are covered by sediments.
    - As the sediments start forming layers, they start to change into sandstone as the temperature and pressure increase.



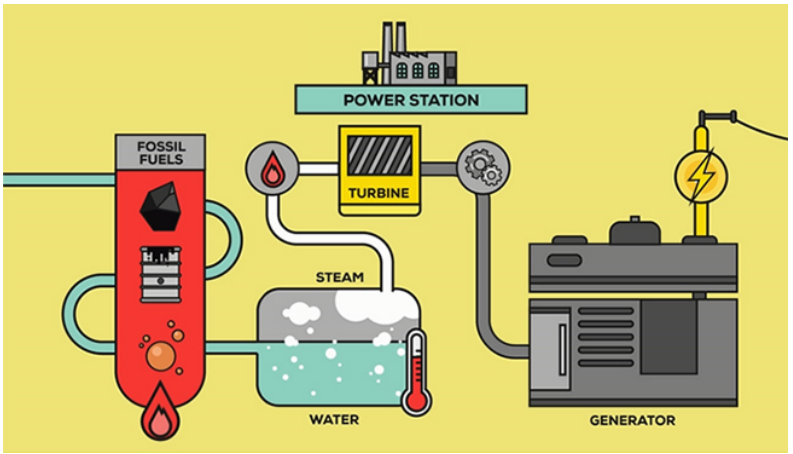
    - The heat and pressure turn the remains into crude oil and natural gas.
    - They separate and rise through the sandstone, filling in the pores.
    - The rock above the oil and gas is **impervious** (non-porous).
    - So, they get trapped underneath it.

ENERGY RESOURCES: 2.2

- **The demand for energy is increasing worldwide due to:**
- Increasing population size.
- Increasing industrialisation and urbanisation.
- Improvements in standards of living and expectations.
- **Types of energy sources:**

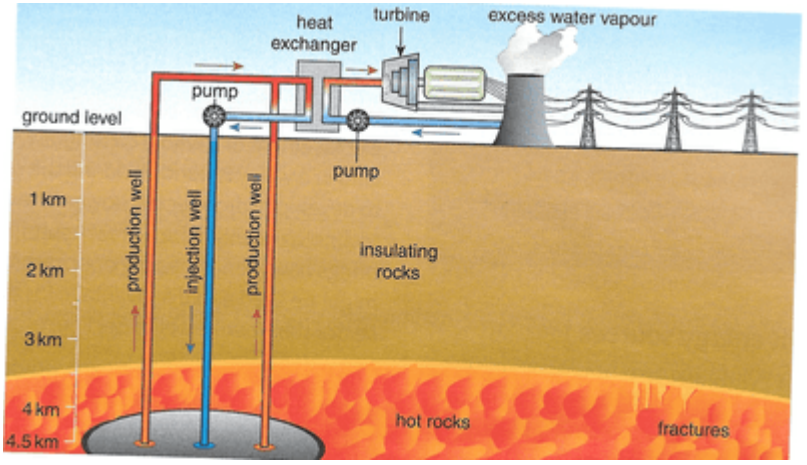
Non-renewable	renewable
• Limited • Take millions of years to get replenished • Fossil fuels (coal, oil and natural gas) • Nuclear power (using uranium)	• Can be used over and over again • Can be replenished in a short period of time • Geothermal power • Hydro-electric power • Tidal power • Wave power • Wind power • Solar p my ower • Biofuels e.g. bioethanol, biogas and wood

- Nuclear fuels last for centuries and are a good replacement for fossil fuels, but the source material (uranium) is limited.
- Biofuels may become limited, but it can be renewed by replacing the cut-down trees with new ones to obtain bioethanol and wood.
    - Biogas can be obtained by recycling waste products.
- **How energy sources are used to generate electricity:**
- **Turbine:** a machine, often containing fins, that is made to revolve by gas, steam or air (it is connected to a generator).

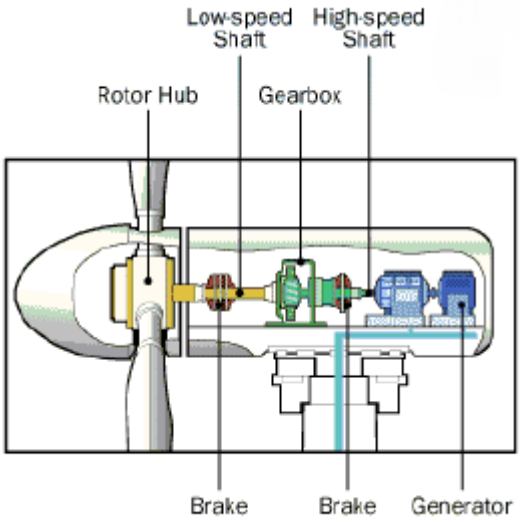


- **Generator:** a machine that converts mechanical energy into electrical energy.
- Fossil fuels and biofuels:
    - These produce a massive amount of energy during combustion that is used to heat water and convert it into steam, which thereby drives the turbines.

- *Nuclear power:*
  - *Uranium, a radioactive element, releases huge amounts of energy when nuclear fission (splitting of the atom) occurs.*
  - *This energy is used to heat the water, produce steam, and rotate the turbines.*
- *Geothermal power:*



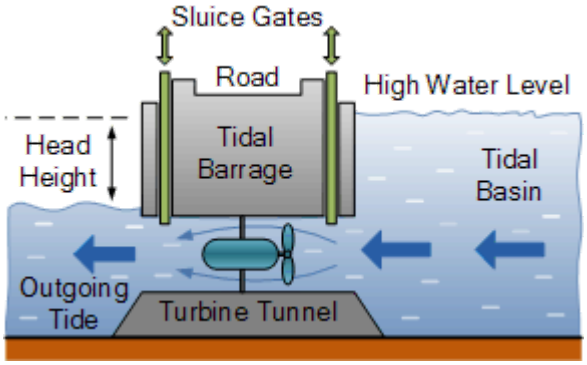
  - *Cold water is pumped under pressure into a layer of hot rocks.*
  - *The rocks heat the water.*
  - *The hot water returns to the surface under pressure and heats the second supply of water using a heat exchanger.*
  - *The steam produced in the second supply moves the turbine, generating electricity.*



- *Wind power:*
  - *Wind turbines have shafts (blades) that rotate due to wind.*
  - *Gearbox maximises the rotation of the shaft.*
  - *Brakes slow down or stop the rotor in very windy conditions, preventing damage to the blade.*
  - *As the turbine rotates, the generator produces electricity.*

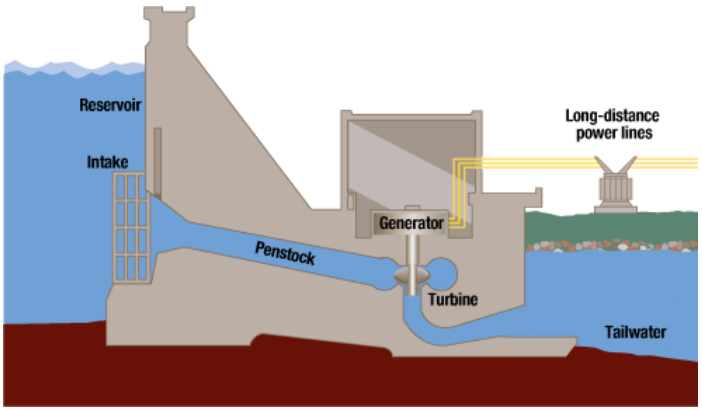
- Solar power:

  - Uses photovoltaic cells that produce a small electric charge when exposed to light.
  - A bank of cells organised into solar panels produce a significant amount of electricity.



- Tidal power:
  - Uses the natural rise and fall in the level of water in an area.
  - When the levels drop, water is held back by a tidal barrage (a small dam that releases water back through a turbine).

- Wave power:
  - Also uses turbine and generator.
  - Uses the smaller differences in water levels that are caused by wind.



- Hydro-electric power:
  - Uses a dam on a river to store water in a reservoir.
  - Water is released from the reservoir that flows through the turbine, rotating it.
  - The turbine then activates a generator that generates electricity.

Advantages and disadvantages of:

Fossil fuels:

advantages	disadvantages
• Plentiful supply • Provides job opportunities (mining and processing) • The technology used is well-known and the methods of extraction are well-practised.	• Carbon dioxide and toxic gases are released when burnt contributes to global warming • Damages local area • Limited supply (non-renewable).

Biofuels:

advantages	disadvantages

• Renewable source
• Growing more plants uses carbon dioxide
• Plentiful supply.
• The fuel tends to be cheap.
• The methane gas from the waste would otherwise end up in the atmosphere - and methane is a worse "greenhouse gas" than carbon dioxide.
• Biofuel production is closer to being carbon-neutral than using fossil fuels
	• Carbon dioxide and toxic gases are released when burnt
	• Lot of land needed.
	  ◦ Shortage of land for agriculture
	  ◦ making biofuels from algae does not need so much land
	• Removal of natural ecosystems
	• Some of the materials are not available all year round.

DEMAND OF ENERGY: 2.3

Domestic demand:

- Created by affordability, availability and social status.
- Most of the purchases that are considered as necessities now increase the demand for energy supplies, notably electricity.
- Example:
  - Fruits and vegetables, that aren't naturally available in the season locally, are produced in glasshouse or in areas with a favourable climate and are then transported.
  - In both the scenarios (glasshouse operation and transport), the energy cost is significant.

Industrial demand:

- Manufacturing requires the use of large amounts of energy throughout the production e.g. iron and steel production.
- Advanced manufacturing techniques made the products, that were once luxury items, cheaper.
  - So, more people want to buy them.
  - The demand for the product increases.
  - The demand for energy (needed for production) also increases.

Transport:

- Manufacturers supply customers across the globe.
- This decreases production costs in countries that import, but increases the transport costs as they require large amounts of fossil fuels to operate.

Personal and national wealth:

- If economic conditions are good:
  - Higher employment;
  - More money to spend on luxury items;
  - Increase in demand for the product;
  - Increase in demand for energy (for production).
- If economic conditions are poor:
  - Families have less money to spend on luxury items;
  - Need to make savings;
  - Reduce the use of fuel;
  - Reduce the purchase and use of electrical items;
  - Decrease in the demand for energy.
- Decline in the economy of one country can have a global impact.
- Reduction in the economy of China meant a worldwide:
  - Reduction in production of steel.
  - Decrease in the amount of manufactured goods (transported by ships).
  - Decrease in the price of oil (energy source).

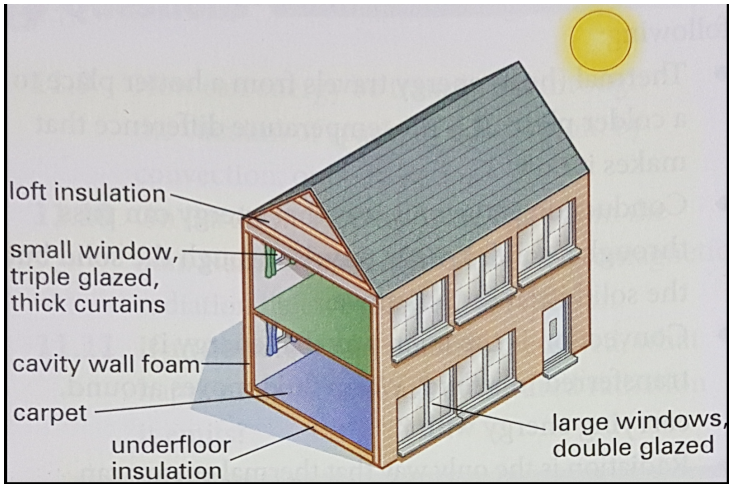
Climate:

- The demand for energy with regard to climate depends on the country.
- People living in a temperate climate are likely to experience colder winters, so the energy demand for heating would be far higher.
  - They also experience fewer hours of daylight.
  - This increases the usage of electrical lighting.
- Climate change (excessive heat or cold) increased the energy consumption (particularly in urban areas).
  - Need for additional heating.
  - Installation and operation of air-conditioning units.

CONSERVATION AND MANAGEMENT OF ENERGY RESOURCES: 2.4

Strategies for the efficient management of energy resources:

- Reducing consumption:
  - Reducing the amount of energy used to heat a building.



    - **Insulation:** constructing using material with good insulation properties prevents loss of heat.
    - **Loft insulation:** adding an insulation layer into the roof space.
    - **Underfloor insulation:** adding an insulation layer on the floor e.g. carpet.
    - **Cavity wall insulation:** a gap between inside and outside walls is filled with an insulating material, causing the heat to pass through more slowly.
    - **Double glazing:** two panes of glass with a gap in the middle to act as an insulator.
        - This sealed gap is usually filled with air or an inert gas e.g. argon.
        - Triple glazing can also be used, but it is too expensive.
    - **Electrical devices must be turned off when not in use.**
        - Devices can be left in 'standby' mode and can be accessed rapidly.
        - More energy-efficient devices must be bought.
    - Developing alternative fuels for vehicles and further development in engine technology.
    - **'Scrappage' schemes:** remove inefficient machines from use (electrical appliances or vehicles).
- **Energy from waste:**
    - Reusing existing materials to extract energy from them before they are disposed.
    - **Anaerobic digestion:** breaking down of organic matter (waste food and vegetation) using bacteria.
        - This process takes place in a sealed container and releases methane (a flammable gas) that can be used for heating purposes.
        - The composted waste can be used as organic matter to improve soil structure.
    - Household rubbish can be incinerated (burnt) to produce heat, that can be used to generate electricity;

Advantages	disadvantages
Waste from burning (ash) is small in volume. Thus, it doesn't take up much space.	Produces poisonous gases during combustion.

- Vegetable oils, once used, should be disposed;
    - These oils can be collected and recycled into biofuels suitable for running vehicles;
    - It can be used exclusively or as an additive.
- **Education:**
    - Benefits of the technology must be communicated to others;
    - Promote new ways of thinking;
    - The message must be that significant savings in energy bills can be made over the longer term, reducing energy use;
    - Energy-efficiency ratings must be provided for new products to compare with the old ones.
    - **Laws passed by the government to make changes rapidly:**
        - Stricter building regulations: new constructions must be more energy efficient.
        - Preventing the sales of inefficient types of electrical devices.
        - **Incentives to encourage the purchase of more efficient technologies:**
        - Insulating older houses that are energy efficient;
        - Replacing older, inefficient electrical devices;
        - Scrapping older, inefficient cars, that emit more pollutants.

- *Exploiting existing energy resources:*
    - *The type of energy source used depends on social, environmental and economic factors.*
    - *The current solution is to use a renewable resource as a primary energy source when possible and have a fossil-fuel (or biofuel) powered station available as a backup when weather conditions are not suitable.*
    - *This is a reliable source for industry and households and reduces the amount of fossil fuels used.*
- *Transport policies:*
    - *Regulations regarding the quality of exhaust gases from vehicles;*
    - *Check on the fuel efficiency;*
    - *Restrictions on where vehicles may go;*
    - *Taxation on fuels;*
    - *Surcharges for travelling to certain places at peak times;*
    - *Improving public transport so it is easier and cheaper than using cars;*
    - *Improving routes for cyclists and pedestrians;*
    - *Encouraging car-sharing;*
    - *Restricting when cars can be used e.g. odd even rule in Delhi;*
    - *Providing incentives to buy more fuel-efficient vehicles and for vehicles using cleaner technology.*
- *Development of new resources:*
    - **Fracking:** *obtaining oil or gas from shale rock by splitting them open using water, sand and chemicals.*
    - *A vertical hole (2-3 km deep) is drilled to reach the fuel-rich rocks (shale rocks).*
    - *Water, sand and chemicals are pumped down into the shale rock layer.*
    - *This causes the rock to fracture, releasing oil and natural gas, which are forced back to the surface and collected.*
    - *Purpose of the three components:*
        - **Water:** *easy to handle (in high pressure).*
        - **Chemicals:** *stop the blockage of pipes.*
        - **Sand:** *keeps the cracks in the rock open.*

Advantages	Disadvantages
• Access to more oil and gas; • Less pollution than burning coal; • The need to import reduces; • Provide many jobs locally.	• Risk of toxins entering the water table; • Chemicals are toxic and may affect local residents; • Uses a lot of water; may cause water scarcity; • Noise pollution; • Natural areas damaged; • May cause additional Earth tremors.

IMPACT OF OIL POLLUTION: 2.5

- *Main causes of marine oil spills:*
    - *Offshore oil extraction: leakage from the rigs.*
- **Oil pipelines:** *leaks in the oil pipework.*
- **Shipping:** *risk of collision or damage to oil tankers.*

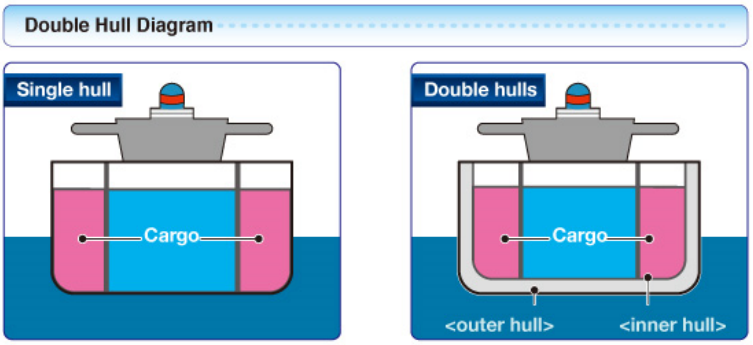
- *Effects of an oil spill:*

Organism or habitat	Impact of oil
Phytoplankton	• Oil floats on the surface of the water and blocks the sunlight from entering. The phytoplankton can't photosynthesise, so they die.
Fish	• Shortage of food; reduction in phytoplankton. • Oil floating on the surface prevents gas exchange. Fish become short of oxygen and die; Direct contact of the fish with oil affects their gills.
Birds	• Shortage of food as fish and other creatures die; • May consume oil when eating fish (toxic); • When hunting for food, feathers get covered with oil, affecting their ability to fly.
Mammals	• Food sources are depleted; • Mammals may also swallow oil while feeding (toxic); • Coating of oil will affect their skin.
Reefs	• Complete devastation of the reef due to lack of oxygen (species die); • Areas may be covered in oil.
Beaches	• Oil (washed by tides) coats rocks; • Organisms in shallow water and rock pools may die due to toxic effects of the oil; • Animal food sources and tourism are affected.

MANAGEMENT OF OIL POLLUTION: 2.6

- **Reducing oil spills in marine environments:**
- **MARPOL (Marine Pollution):** International Convention for the Prevention of Pollution from Ships.
- **Regulations of the MARPOL:**
  - Supervise the transport of oil at sea;
  - All tankers must be certificated to show they have appropriate systems in use;
  - Else, it can result in a heavy fine or the ship may not be permitted to leave port.
- **Tanker design:**
  - Oil spill can be caused by damage to the hull (a hole in the hull of the boat causes its contents to leak).
  - **Increase in the number of compartments within the hull of the ship:** if one of the compartment's damaged, the contents of the whole ship aren't lost.

- **Double-hulled tankers:** if the outer layer's damaged, the contents are still secure by the inner plate.



  - Though double-hulled tankers cost more than single-hulled, the risks of oil spill are far less.
- Minimising the impact of oil spills:
  - **Floating booms:** a floating barrier is used to surround the oil slick, preventing it from spreading.
  - This process works well when the spill covers a relatively small area and the sea is calm.
  - Detergent sprays: detergents help break down the oil slick into smaller droplets, that eventually degrade, and disperse it.
  - They are effective on smaller spills, but cause damage to the coral reefs themselves as they're not tolerant to detergents.
  - **Skimmers:** clean the water using a material that oil easily attaches to.

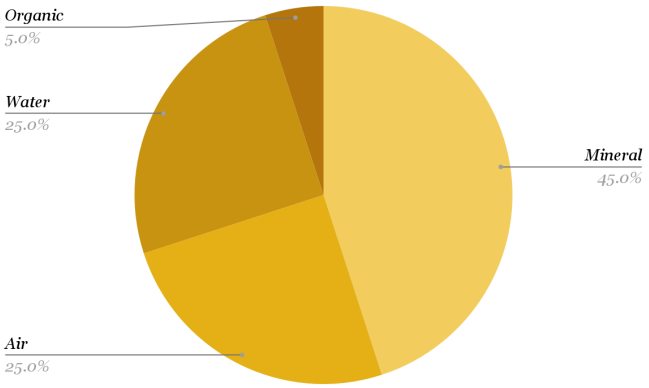
  - The skimmer drags oil off the seawater surface, that is then scrapped off into a container.
  - This system is used when oil slick is contained within a boom and the sea is calm.
  - When the oil reaches beaches, it can only be removed by hand (difficult and time-consuming).

CHAPTER 3: Agriculture and the environment

THE SOIL: 3.1

Soil composition:

- **Mineral particles:** combination of rock fragments and other inorganic substances.
    - They are formed due to physical, chemical and biological weathering of the parent rock.
- **Organic content:** mixture of living plants, animals, microorganisms and their dead remains.
- **Air:** held within the pore spaces (between the mineral particles and organic content).
    - Air enters the soil by diffusion.



- **Water:** held within the pore spaces (water that is available for plant growth).
    - Water enters the soil when there's precipitation or when the soil is irrigated.
- **The proportion of these components depends on:**
    - Type of soil;
    - Way it has been managed;
    - Local climatic conditions;
    - Size of the mineral particles.
- **Soil can be classified into three groups:**

Type	Size	Texture
Sand	2.0-0.02 mm	Gritty
Silt	0.02-0.002 mm	Silky or soapy
clay	<0.002 mm	Sticky when wet and Hard when dried

SOILS FOR PLANT GROWTH: 3.2

- Soil is the cheapest and most abundant medium in which water, mineral nutrients, anchorage and oxygen can be supplied to a plant.
- Plants require a supply of nitrogen, phosphorus, potassium and a range of other elements to construct proteins and carry out life processes.

Element	Supplied as
Nitrogen	Nitrate ions (NO_3^-)
Phosphorus	Phosphate ions (PO_4^{3-})
Potassium	Potassium ions (K^+)

- **Organic content**: decomposers that produce humus (rich in nutrients):
- **Earthworms**: break down vegetation; mix the soil; aerate the soil; spread organic matter through the soil.
- **Fungi**: feed directly on dead matter; digest hard woody items; aid plants to take up nutrients through their roots.
- **Bacteria**: work on organic matter; convert waste products to simple chemicals; some convert nitrogen to nitrates ∴ important in nitrogen cycle.
- **High levels of organic matter:**
  - Increase the water-holding capacity (like a sponge);
  - Increase air spaces in the soil;
  - Increase no. of decomposers, tunnels and burrows in the soil, providing additional drainage and less compaction;
  - Prevent the loss of mineral nutrients (humus holds on to mineral nutrients).
- **Soil pH:**
  - Depends on the type of parent rock and pH of water that flows into the area;
  - Affects the uptake of nutrients by plant roots;
  - Affects the availability of nutrients;
  - Farmers can try changing the pH of the soil either to acidify it
- (using fertilisers that have an acidic effect) or make it alkaline (adding ground limestone).

Sand	Clay
Larger air spaces	Poor air spaces
Drains well	Poor drainage
Poor retention of humus	Retains humus
Easier to cultivate	Hard to cultivate

- **Drainage**: capacity of the soil to drain water must be medium (no water loss; no surplus amount of water).
- **Ease of cultivation**: how easily the soil can be ploughed.

AGRICULTURE: 3.3

Subsistence	Commercial
Cultivation of food to meet the needs of the farmers and their families;	Cultivation of food with the main aim of selling them for cash;
Surplus is bartered for other goods (or cash).	Some food may be used by the farmers.
Examples: wheat and rice.	**Examples:** tea, coffee, cocoa, sugarcane, cotton, rice, wheat and corn.

Arable	Pastoral
Production of plants for consumption by humans.	Production of animals or animal-related products.
Examples: rice, wheat, maize and soybeans.	**Examples:** grass/grain (to feed the animals), milk, wool and eggs.

- Mixed:
  - Farms that grow crops for food and rear animals.

INCREASING AGRICULTURE YIELDS: 3.4

- **Crop rotation:** the principle of growing different types of plants in different plots each year.
- **Legumes:** have nitrogen-fixing bacteria in their root nodules.
- **Leafy crops:** vegetables that are required for their leaves (require a lot of nitrogen left by legumes).
- **Root crops:** have deep root systems.
- **Fallow:** the land is ploughed but left barren for a period to restore soil fertility and to avoid surplus production.
- **Advantages of crop rotation:**
  - Diseases in the soil affecting the plant are left behind;
  - Pests need to find a new site ∴ their population is reduced;
  - The soil in the new plot is likely to have the essential nutrients;
  - Crops ready to harvest at different times ∴ less potential waste, less labour and machinery needed.

- **Fertilisers**: contain minerals such as nitrogen, potassium and phosphorus. Add on to the nutrients available in the soils.

Type	Advantages	Disadvantages
Organic	• Uses natural resources • Supplies organic matter	• Unpleasant to handle • Harder to transport • Variable in composition
Inorganic	• Meet a particular need • Easier to store	• Cost of manufacture • Transportation costs
quick acting	• Deficiency problems are dealt with swiftly	• Easily leach out in heavy rain
slow acting	• No need to reapply	• Little immediate impact

- **Irrigation**: supplying water to the crops.
  - Large percentage of a plant is made up of water;
  - Essential for cell activity;
  - Used in photosynthesis;
  - Mineral nutrient uptake requires water in the soil;
  - The water must be free from pollution and low in salt.
- **Common water application methods:**

Overhead Sprinklers

Advantages	Disadvantages
• Easy to setup • Can cover a large area from one sprinkler • No need to attach pipes to each plant	• Large droplets may cap the soil • Small droplets may be blown away by wind • Water lands on leaves and soil, which evaporates quickly

Clay Pot Irrigation System

Advantages	Disadvantages
• Simple technology; • Easy to check the amount of water; • High efficiency.	• Only suitable for permanent plants; • Large labour cost.

Trickle Drip System

Advantages	Disadvantages
• Water placed directly at the base of the plant; • Automated and controlled via computer; • Water is used very efficiently.	• Expensive to install; complex to maintain. • Grit can block tubes; • Inflexible; cannot be moved easily.

Flood Irrigation

Advantages	Disadvantages
• Inexpensive; • Can cover large areas quickly.	• Inefficient use of water; • Damages soil structure.

- **Pest**: an animal that attacks or feeds upon a crop plant.
- **Pesticide**: used to control pests.
- **Weed control**: weed-killing chemicals are known as herbicides.
- **They must be controlled because they:**
    - Compete with crops for light, water and nutrients;
    - Reduce the quality of a seed or grain crop;
    - Might be poisonous;
    - Make cultivation difficult;
    - Can block drainage systems with excessive growth;
    - Can be a source of pests and diseases;
    - Can look untidy (impact on tourism areas).
- Advantages of herbicides:
    - Easier to manage;
- **Alternatives may be less effective;**
    - Cheaper;
    - Results are more predictable;
    - Less labour needed;
    - Effect is more rapid.
- **Alternatives to herbicides are cultural controls:**
    - Hand weeding and hoeing;
    - Weed barriers;
    - Flame guns.
- **A crop disease is caused by fungi, bacteria or viruses (pathogens).**
    - The most common are fungal diseases and are controlled by fungicides.
- **Insect control**: insect-controlling chemicals are called insecticides.
- **Alternative to insecticides:**

Biological control: find natural predators

Advantages	Disadvantages
• No chemical residues; • No impact of sprays; • No need of reapplication; • The predators will die naturally when the pests are controlled.	• Not as instant as chemical control; • Pests may breed faster than the predator; • Predator may feed on an unintended plant.

- **Mechanisation:**
  - Larger area can be cultivated;
  - Reduces labour cost;
  - Ploughing can be done even when soil is heavy
  - Additional attachments can be done to apply fertilisers and pesticides.
- **Selective breeding:**
  - Choose parents that exhibit the desired characteristics of the species;
  - Raise the offspring from these parents;
  - Select the best offspring that shows the desired characteristics;
  - Repeat the process.
  - **Examples:** beef cattle, dairy cattle, wheat and rice.
  - **Drawbacks:** slow process; less success rate.
- **Genetically Modified Organisms (GMO):** the DNA of one organism is inserted into another.

Advantages	Disadvantages
• Disease and pest-resistance may increase • Nutritional value may increase • Crops can be grown in inhospitable areas • Herbicide resistance may increase • Crops with longer storage lives	• Unknown impact of the new characteristics on human health • Products are not natural • Genes might get into wild plants if they interbreed with GMOs reducing biodiversity • Reduction in the gene pool

- **Controlled environments:**
- **Greenhouse: used to manage the environment for plant growth.**

Growth factor	How to increase	How to Decrease
temperature	Operate heating system (e.g. insulation).	Open roof ventilators.
light	Supplementary lighting.	Shading material in the roof.
humidity	Misting units.	Open roof ventilators.
day length	Supplementary lighting.	Shading material and curtains.
water	Sprinkler or irrigation.	Drainage material underneath.

IMPACT OF AGRICULTURE ON PEOPLE AND EARTH: 3.5

- **Overuse of herbicides and insecticides:**
  - Regular use of one insecticide can cause resistance within the pest population. **Solution:** use a range of different pesticides.
  - **Unintended environmental damage:** beneficial insects like bees are also affected and food web is disturbed.
  - **Spray drift:** herbicides stay longer in the soil and may affect the next crop.
- Heavy rainfall can cause leaching of the chemicals into nearby lakes.
- **Overuse of fertilisers:**

  Addition of extra mineral nutrients is waste of money and resources if the soil has reached its maximum level;

  Heavy rain can dissolve the nutrients and cause leaching;

  Excess water containing dissolved fertilisers drain into nearby lakes and rivers, leading to eutrophication;

  Nitrates from fertilisers if consumed can cause diseases such as blue-baby syndrome;

  Large quantities can affect the pH of the soil and in turn, the availability of minerals;

  Too much of trace elements can be toxic to the plant.

  Too much fertiliser dehydrates the plant (scorching);

  Imbalance of nutrient makes the plant produce lots of foliage, but no flower.

  Solution: strict limits on where, when and how the fertilisers must be applied; can replace with organic fertilisers.
- **Mismanagement of irrigation causing salinization and water logging:**

  Damage to soil structure ∴ soil is compacted;

  Death of plant roots as waterlogged soils prevent plant roots from getting enough oxygen;

  Loss of nutrients as they are dissolved and washed away with water;

  High levels of run off ∴ soil erosion.

  Soil capping: surface of the soil becomes hard.

  Salinization: salt content of the soil can increase.

  Irrigation water soaks into the soil to a great depth;
  - Salts dissolve in the water at a great depth;
  - Water evaporates from the field;
  - Water and salts are drawn up to the surface;
  - Salt remains at the surface and kills plant roots.
  - Prevents soil cultivation as it's difficult to cultivate soil with a high-water content.
- **Overproduction and waste:**
  - **Waste from overproduction:** the unsold proportion of the crop.
  - **Waste of storage space**: may take longer to sell a crop; some crops need special conditions.
  - **Waste of transportation**: to sell a crop, a farmer may need to travel longer distances.
  - **Waste of quality products:** low quality means less demand.
  - **Waste of labour**: not an efficient use of time and labour if too much is produced.
- **Exhaustion of mineral ion content:**
  - The farmers use the soil over and over again with little to no rest which leaves the soil depleted of nutrients and minerals.
  - **Solution:** crop rotation, mixed cropping and leaving the land fallow.

- **Soil erosion:**
    - **Overcultivation:** soils that are cultivated regularly lose soil structure and are more vulnerable to erosion as they break down to smaller particles.
- **Cash crops replacing food crops:**
    - Most commercial farmers prefer to grow crops that generate more cash. This causes a decline in the staple food available.

CAUSES AND IMPACTS OF SOIL EROSION: 3.6

Causes of soil erosion:

- **Removal of natural vegetation**: no more roots to bind the soil together or slow down the torrents of water, so flash flooding and rainwater run-off pick the soil and carry it away.
- **Overcultivation:** ploughing breaks the soil into smaller and lighter particles. These are more easily carried away by wind.
- **Overgrazing:** livestock reduces the vegetation to nearly ground level, sometimes leaving no roots to hold the soil.
- Animals trample down the plants and their hoofs compact the ground.

- **Wind erosion:** deforestation (due to need for space, excessive grazing, increase in development of arable crops) increases the chance of soil getting eroded by wind.
- **Water erosion:** heavy rainfall carries the particles away.
    - Excess run-off water that can't be absorbed by soil transports the soil from that area;
    - Soil compaction reduces infiltration;
    - Gully erosion (volume of water erodes local soil further) forms deeper and deeper crevices.

Impacts of soil erosion:

- **Topsoil is removed:** the most productive layer is absent (subsoil lacks in nutrients ad air spaces).
- **Organisms living in the topsoil lose their habitat:** impact on the entire ecosystem.
- **Silting up of water courses:** flooding occurs as water bodies can't hold excess water (space taken up by silt).
- **Silt deposits can form lagoons:** providing breeding grounds for mosquitoes.
- Silt affects the quality and availability of water for drinking.
- **Aquatic organisms are buried under the silty layer**: preventing light from reaching the underwater plants (low oxygen levels in ecosystem no photosynthesis).
- **Desertification:** the process by which fertile land becomes desert.
    - Severe droughts lead to migration of the whole community.
    - Risk of famine and malnutrition, leading to lesser food source.

MANAGING SOIL EROSION: 3.7

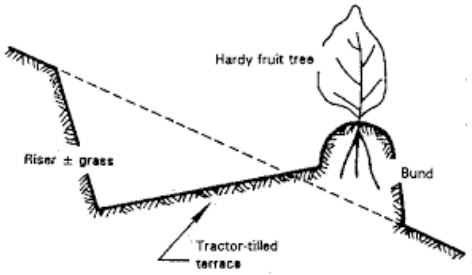
- **Terracing**: prevents the erosion of soil by rainwater on steep slopes.

- *In a natural slope: water runs down, increasing in speed and volume, carrying soil in the run-off.*
- *In a terraced slope: water is held in the flat terraced areas, causing less risk of run-off and more chance of infiltration.*
- *Often used for cultivation of rice.*

- ***Contour ploughing:** ploughing of land along the contour in a parallel way.*

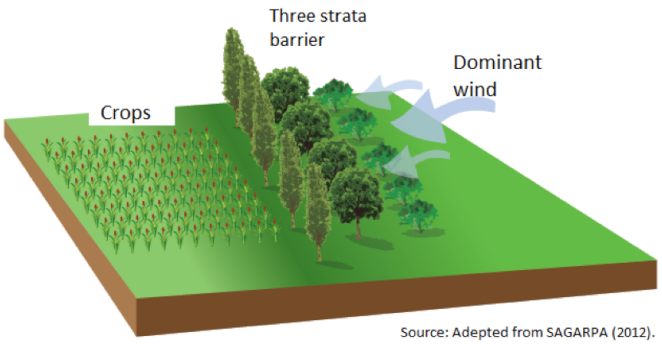
- *Ridges and troughs (furrows) run along the contour.*
- *Each furrow holds water and prevents large torrents of water running down the slope, preventing the formation of gullies and run-off of topsoil.*
- *Useful for all gradients of slopes.*

- *Bunds: artificial banks at the edges of growing spaces to hold back water.*



- *Useful for crops that require moist soils e.g. rice.*
- *The water is retained on the terrace.*
- *Increases the quantity and fertility of the soil.*

- *Windbreaks: a permeable barrier used to reduce the impact of wind on an area.*



Source: Adepted from SAGARPA (2012).

- *Without windbreaks, the soil is eroded away.*
- *Solid structures, like walls, force the wind into smaller spaces, increasing wind speed and causing eddy currents.*
- *Permeable structures, like vegetation, allow some wind to pass through, decreasing its speed and thus, the amount of wind erosion.*
- *Advantages: additional habitats for beneficial insects; roots of the windbreak prevent erosion due to run-off.*

- Maintaining vegetation cover:
    - Sowing legumes immediately after a crop has been harvested prevents soil erosion.
    - It also provides more nitrogen to the soil, increasing its fertility, for the next major crop.
    - When cultivating, the legumes can be simply ploughed.
- 'No dig' method:
    - Existing vegetation is left until the new crop is grown.
    - Rather than cultivating the soil, herbicides are applied to kill the weeds.
    - Roots of the existing vegetation bind the soil until the major plant is established.
    - **Risks:** herbicide residues build up. If the control of the cover vegetation is ineffective, it may compete with the main crop as a weed.
- Addition of organic matter to improve soil structure:
    - Provides additional air gaps in the soil ∴ improves soil structure;
    - Increases decomposers in the soil as they feed on the matter;
    - Adds nutrients to the soil after decomposition.
    - Acts like a sponge, holding the extra water, preventing dehydration of the soil;
    - Reduces soil erosion as the organic matter acts like a base to smaller particles.
- Planting trees:
    - Row of trees acts as windbreak;
    - Tree canopy can provide shade for smaller plants that don't thrive for sunlight;
    - Provide a natural habitat for animals, that feed on pests;
    - Tree leaves fall to the ground and add on to the organic matter.
- Mixed cropping: growing more than one type plant in the same area.

    - Resources in the soil, like nutrients, are used more efficiently.
- Intercropping: rows of a different crop are grown between the rows of the main crop. This maximises the use of space and other resources.
- Crop rotation: (refer to section 3.4 Increasing agricultural yields; Crop Rotation).

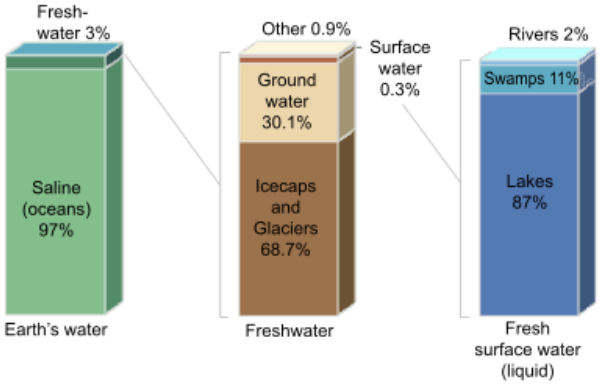
SUSTAINABLE AGRICULTURE: 3.7

- Aims of sustainable agriculture:
    - Meeting the needs of the population for agricultural products;
    - Making efficient use of non-renewable resources;
    - Supporting the natural ecosystem by following natural processes with farming techniques;
    - Sustaining the economic independence of farmers.

- **Organic fertilisers:**
  - Are slow acting reduces the risk of eutrophication;
  - Are a waste product using them saves on disposal costs
  - Are already present on many farms minimal transport costs
  - Do not require energy for their manufacture
  - Also improve soil structure.
- **Managed grazing:**
  - Prevention of overgrazing;
  - Ensure sufficient grazing;
  - Maintaining appropriate soil fertility by animal waste;
  - Maintaining good drainage prevents compaction of the soil.
- **Crop rotation:** (refer to section 3.4 Increasing agricultural yields; Crop rotation).
- **Use of pest-resistant varieties of crops:** reduces pesticide use.
- **Use of drought-resistant varieties of crops:** reduces water usage for irrigation.
- **Use of herbicide-resistant varieties of crops:** reduces herbicide use.
- **Trickle drip irrigation:** (Refer to section 3.4 Increasing agricultural yields; Irrigation).
- **Rainwater harvesting:** the collection of rainwater, for example from the roofs of buildings, and its storage in a tank or reservoir for later use.

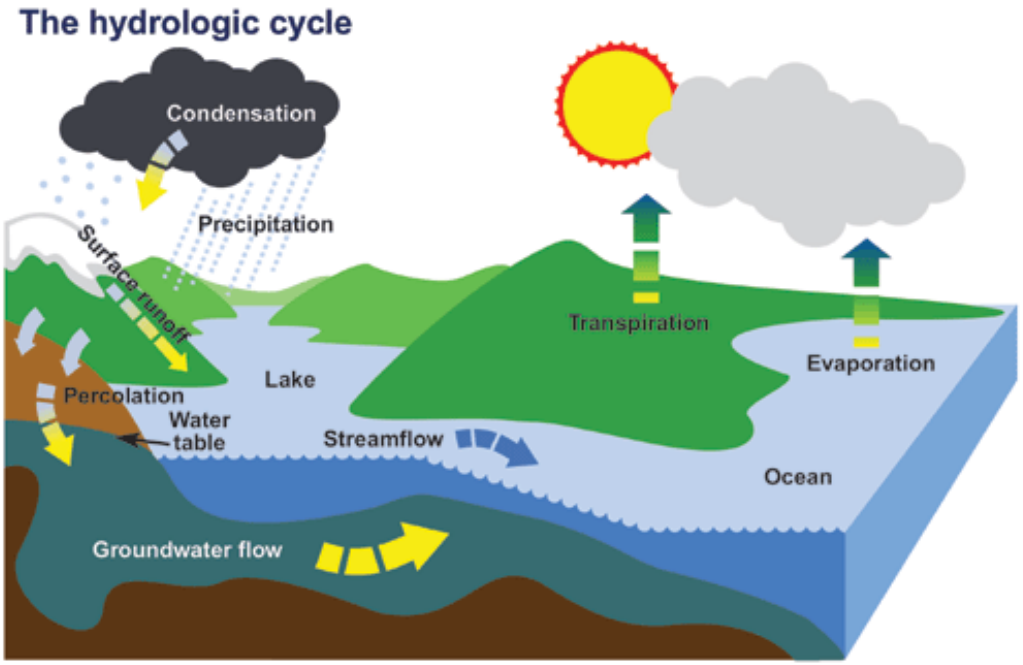
CHAPTER 4: Water and its management

DISTRIBUTION OF WATER ON EARTH: 4.1



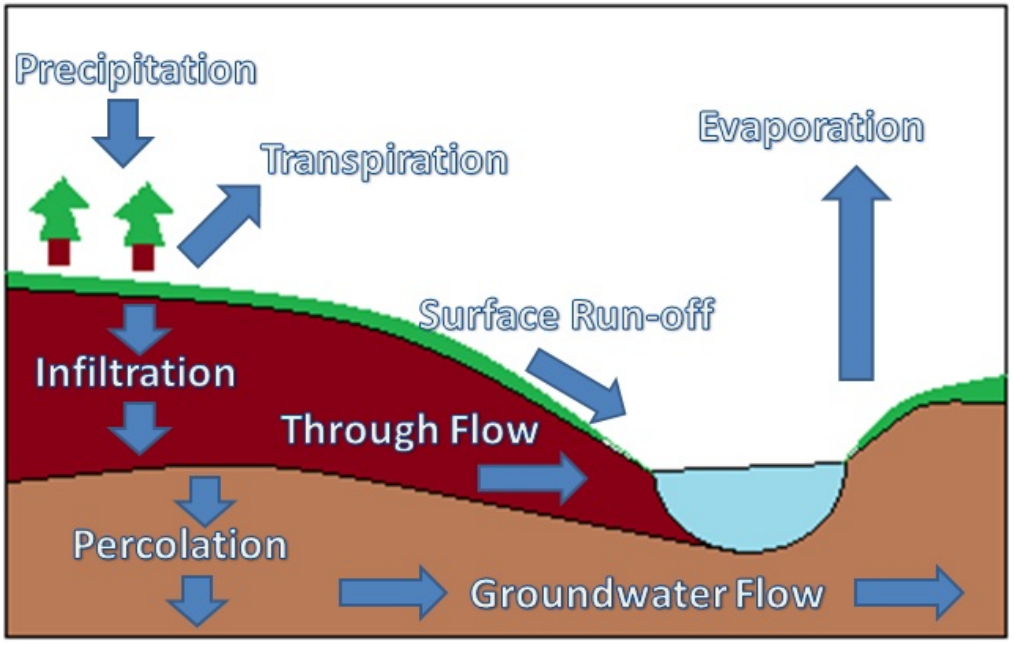
- Oceans cover 71% of the Earth's surface.
- Oceans and seas contain 97% of all the Earth's water.
- Only 3% of water on Earth is fresh-water.
- Nearly two thirds (65%) of this 3% fresh-water is in the 'deep freeze' in the ice sheets.

WATER CYCLE: 4.2



- **Precipitation:** moisture that reaches the surface in the form of rain, sleet, snow, or hail.
- Rain is the most common type.
- **Surface run-off:** precipitation that flows over the ground surface, eventually finding its way into streams and rivers.
- **Interception:** precipitation that doesn't reach the Earth's surface due to being obstructed by trees and plants.

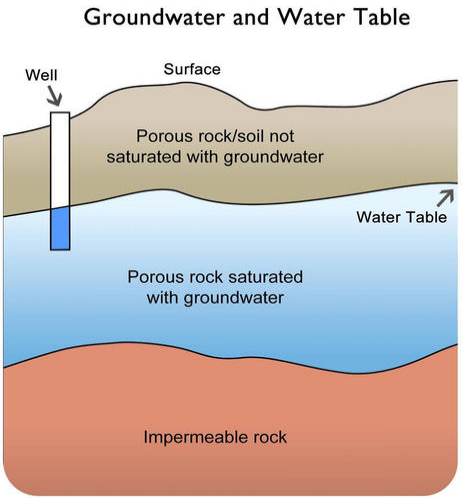
- **Infiltration:** *precipitation soaks into sub-surface soils and moves into rocks through cracks and pore spaces.*
- **Through-flow:** *downslope movement of water through the soil, roughly parallel to the ground surface.*



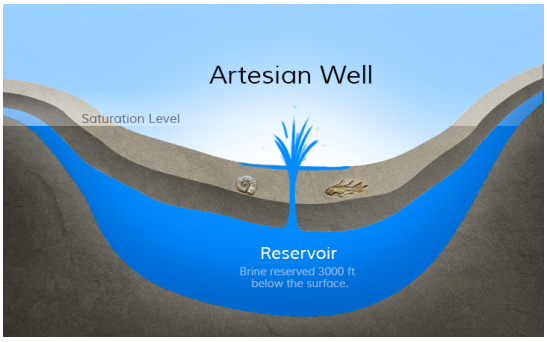
- **Ground water flow:** *slow horizontal movement of water through rock.*
- **Evaporation:** *water from oceans, seas and other water bodies is changed from water droplets to water vapour (invisible gas) in the atmosphere due to heat.*
- **Transpiration:** *evaporation or diffusion of water from plant leaves.*
- **Condensation:** *water vapour converted back into liquid (water droplets) or solid (particles of ice) due to a decrease in temperature with increasing height by air currents, e.g. clouds.*

Water supply:

- **Surface water:** *water in lakes, rivers and swamps.*
- **Ground water:** *water in the soil, and in rocks under the surface of the ground.*
- **Aquifers:** *water stored in porous rocks under the ground.*
  - *Alternating layers of permeable and impermeable rocks trap the water in permeable rock;*
  - *Folded layers of rock so water accumulates the most in the down fold;*
  - *Permeable rocks outcropping on the surface receive new supplies of rainwater;*
  - *Water is stored in the limestone and sandstone (porous) rocks below the water table;*
  - *Mechanical pumps, or human labour are used to raise water to the surface.*



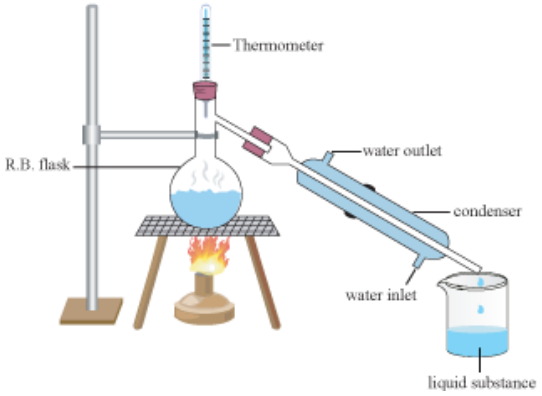
- **Artesian aquifer:** an aquifer in which the water is under pressure.



  - Water from a well sunk into an artesian aquifer will rise to the surface without the need for a pump.

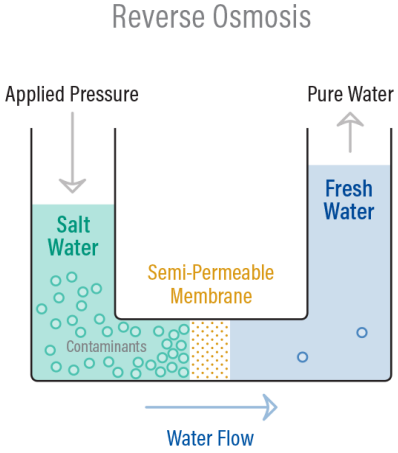
Concepts:

- **Potable:** safe to drink.
- **Reservoirs:** an artificial lake used as a source of water supply, usually created behind a dam or by the side of a river (bank-side reservoir).
- **Service reservoir:** a reservoir where potable water is stored e.g. Water tower and Cistern.
- **Wells:** a hole bored or dug into rock to reach the water stored in them.
- **Rivers:** a large, natural stream of water flowing in a channel to the sea, a lake, or another river.
- They provide surface transfers of water to low-land areas where farms, villages, towns and cities are concentrated.
- **Desalination:** removal of salt from seawater by:
- **Distillation:** water is boiled and released as vapour, leaving salt behind.



  - The vapour is then condensed as liquid water and can be used.
  - 10-30% efficient and uses a lot of energy.
  - Provision of energy and salt water (brine) is a source of pollution.

- **Reverse osmosis:** pumping water at high pressure through a fine membrane.



  - 30-50% efficient
  - requires less energy than distillation.

WHY HUMANS NEED WATER: 4.3

domestic

- At home for drinking and cooking (3% of domestic water)
- MEDCs
    - Washing and flushing the toilet (50%)
    - Washing clothes (20%)
    - Gardening
    - Washing cars
    - Lost in leaks.

industrial

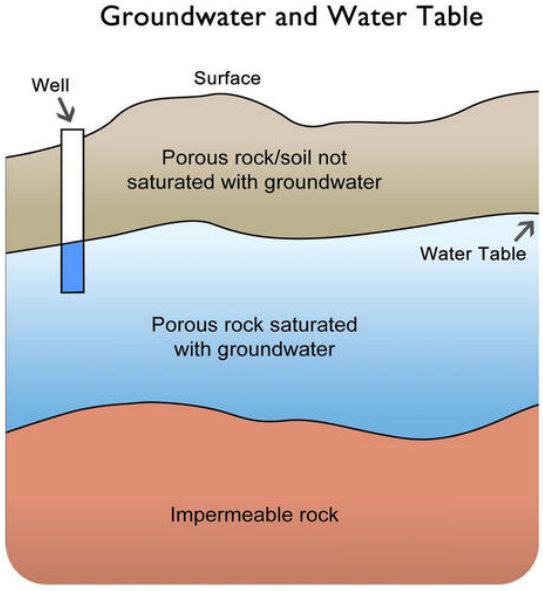
- In factories for:
- Cooling;
- Mixing and making products such as dyes and paints;
- Bottling and canning in food and drink industries;
- Power generation.

agricultural

- Mainly for irrigation (plants need water for transporting minerals, for photosynthesis, and for the prevention of wilting);
- For domestic animals.

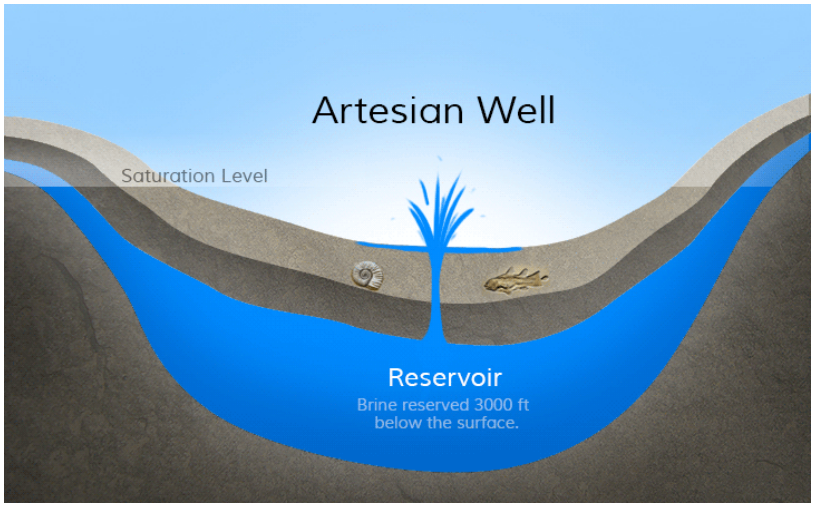
MAIN SOURCES OF WATER FOR HUMAN USE: 4.4.

- **Surface water:** water in lakes, rivers and swamps.
- **Ground water:** water in the soil, and in rocks under the surface of the ground.
- **Aquifers:** water stored in porous rocks under the ground.

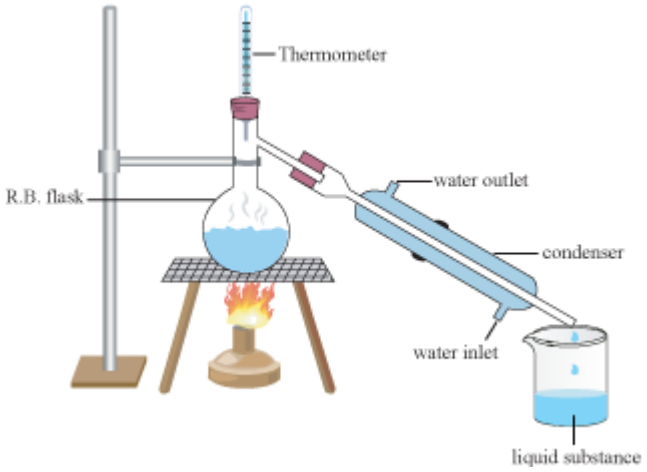


- Alternating layers of permeable and impermeable rocks trap the water in permeable rock;
- Folded layers of rock so water accumulates the most in the down fold;
- Permeable rocks outcropping on the surface receive new supplies of rainwater;
- Water is stored in the limestone and sandstone (porous) rocks below the water table;
- Mechanical pumps, or human labour are used to raise water to the surface.

- **Artesian aquifer:** an aquifer in which the water is under pressure.

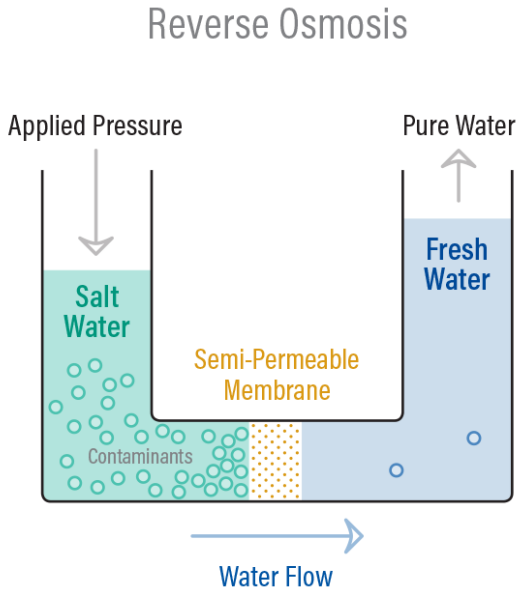


  - Water from a well sunk into an artesian aquifer will rise to the surface without the need for a pump.
- **Potable:** safe to drink.
- **Reservoirs:** an artificial lake used as a source of water supply, usually created behind a dam or by the side of a river (bank-side reservoir).
- **Service reservoir:** a reservoir where potable water is stored e.g. Water tower and Cistern.
- **Wells:** a hole bored or dug into rock to reach the water stored in them.
- **Rivers:** a large, natural stream of water flowing in a channel to the sea, a lake, or another river.
- They provide surface transfers of water to low-land areas where farms, villages, towns and cities are concentrated.
- **Desalination:** removal of salt from seawater by:
- **Distillation:** water is boiled and released as vapour, leaving salt behind.



  - The vapour is then condensed as liquid water and can be used.
  - 10-30% efficient and uses a lot of energy.
  - Provision of energy and salt water (brine) is a source of pollution.

- ***Reverse osmosis:*** *pumping water at high pressure through a fine membrane.*



- *30-50% efficient and requires lesser energy than distillation.*

AVAILABILITY OF SEA DRINKING WATER AROUND THE WORLD: 4.5

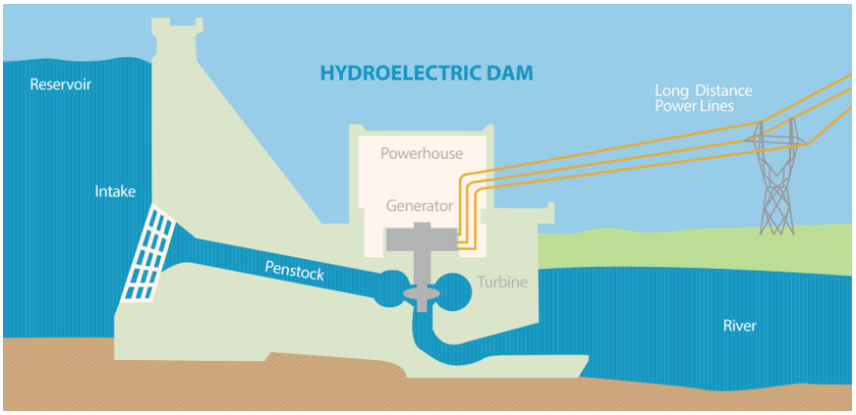
- ***Water-rich countries:*** *countries with plentiful fresh water supplies:*
- *Some are large countries with plenty of land for rain to fall on e.g. Russia, Canada, China, and some with the world's greatest rivers flowing through them e.g. Amazon, Yangtze, Mississippi.*
- *However, big areas do not ensure water availability e.g. Australia, Argentina, Sudan, due to containing substantial areas of desert within its borders.*
- ***Water-poor countries:*** *countries with scarce fresh water supplies:*
- *Dominated by desert countries.*
- *Except Singapore and Mauritius since they receive high precipitation totals, but are tiny island states that have only small areas for rain to fall on.*
- ***Water conflict:*** *conflict between countries, states, or groups over an access to water resources.*
- ***Physical water scarcity:*** *not enough water to meet both human demands and those of ecosystems to function effectively.*
- *Arid regions frequently suffer from physical water scarcity.*
- *It also occurs where water seems abundant, but resources are over-committed.*
- ***Economic water scarcity:*** *caused by a lack of investment in water infrastructure or insufficient human capacity to satisfy the demand of water in areas where the population cannot afford to use an adequate source of water.*
- ***Unlike Rural areas, Urban areas have higher access to safe drinking water because:***
- *Cities are more wealthy places with factories and offices;*
- *On average, people's incomes are higher;*
- *Easier to put pressure on the politicians or leaders to make improvements;*
- *Wealthy people are more likely to live in cities;*
- *Water pipes are easier and cheaper to build when a lot of people live close together.*

MULTIPURPOSE OF DAM PROJECTS: 4.6

- **Example:** the Ramganga Dam, Uttarakhand, India.
- **Choice of site:**
- High precipitation to provide sufficient water;
- Low temperature to prevent evaporation;
- Built on strong impermeable rock so water doesn't drain and has a good foundation;
- Built high up in order to have good potential for hydro-electric power;
- Narrow, steep sided valley for economic reasons;
- Rivers and lakes nearby to provide water;
- Away from developed areas to reduce the risk of pollution in reservoirs;
- Easily accessible;

Advantages	Disadvantages
• Generation of electricity in hydro-electric power plants; • Flood control; • Irrigation • Creates recreational land for tourism and leisure • Provision of water • Creation of habitat for wetland species • Access by boat to otherwise inaccessible areas • Renewable source of energy • Doesn't produce greenh • ouse gases • Reduces fossil fuel consumption • Creates more jobs	• Relocating people; • Flooding land; • Disrupting the life cycles of fish and other aquatic organisms • Dam may become redundant due to sediment build up • Very expensive to build • Requires maintenance • Reduces jobs for farmers if natural fisheries are affected • Altering water supply for people downstream the dam • Reducing soil enrichment downstream of the dam

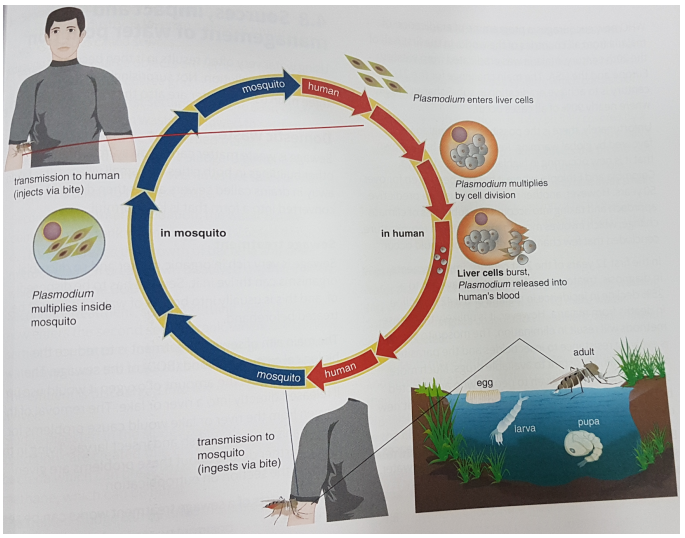
- Maximises water storage capacity.



- **Sustainability of dams:**
  - Alternative for burning of fossil fuels as no greenhouse gases are produced.
- **Unsustainability of dams:**
  - Reservoir can become silted due to material carried into it by rivers;
  - Dam structure under a lot of pressure can deteriorate and eventually fail;
  - Have negative effects on the environment and fish population.

WATER-RELATED DISEASES: 4.7

- **Water-borne disease:** spread by consuming contaminated water due to poor sanitation and untreated sewage, or by washing food, pots and pans, or hands and face in dirty water.
    - **Examples:** cholera and typhoid.
    - **Cholera:** intestinal infection that causes severe diarrhoea that may lead to dehydration and eventually death.
    - **Typhoid:** disease that cause fever, abdominal pain and skin rash
    - **Causes:** poor sanitation, contamination of water and food, disruption of piped water supplies after a natural disaster occurrence.
- **Water-bred disease:** the carrier breeds in water and spreads the disease by biting its victims.
    - **Example:** malaria.
    - **Malaria:** a life-threatening disease which is transmitted through the bite of an infected Anopheles mosquito (vector) that carries the Plasmodium parasite. Once bitten, the parasite reaches your bloodstream.
    - **Symptoms:** high temperature and fever, diarrhoea, dehydration and feeling weak.
    - Life cycle of the malaria parasite:



- **Strategies to control malaria:**
    - Sleeping under mosquito nets and using antimalarial drugs in and around homes;
    - Draining marshes and stagnant pools to eliminate breeding grounds;
    - Put kerosene over the tops of pools to choke the larvae;
    - Spray antimalarial drugs on stagnant areas of water to kill the larvae;
    - Use vaccinations;
    - Educate people on the risks of malaria by setting up campaigns and programmes.
- **Strategies to control cholera and typhoid:**
    - Ensure that sewage and drinking water are kept separate;
    - Sewage removed directly into a treatment works;
    - Water being treated before it's delivered into homes;
    - Do not use contaminated water to wash food;
    - Hands should be washed after contact with any faecal material;
    - Boiling water and chlorination

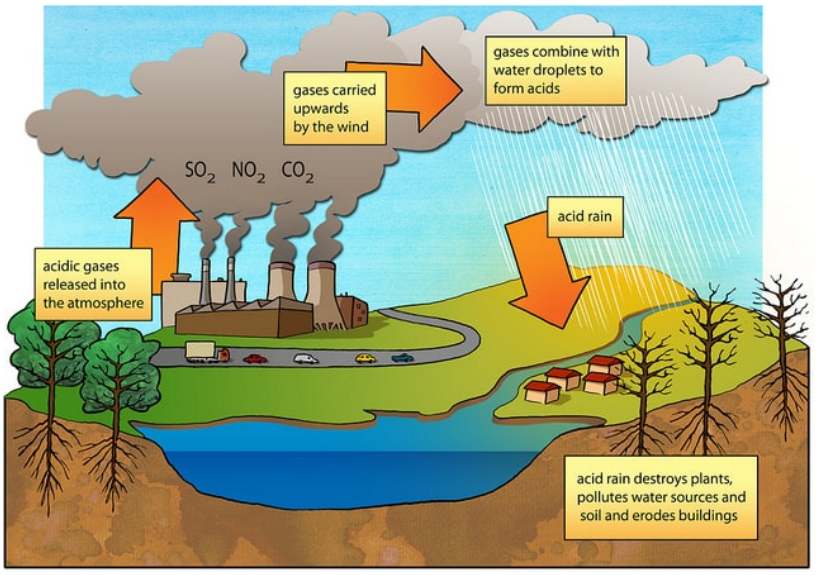
SOURCES, IMPACT AND MANAGEMENT OF WATER POLLUTION: 4.8

Water pollution and its sources

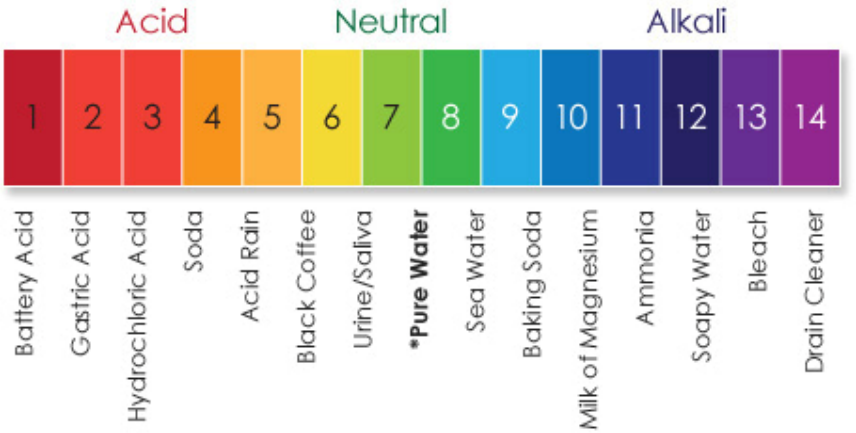
- **Sewage:** waste matter that is rich in organic matter, thus microbial organisms can thrive in it.
- It is usually disposed in water bodies, and thus has to be treated.
- **Domestic waste:** sewage from rural and urban settlements carry many pathogenic micro-organisms, increasing the content of nitrates and phosphates in rivers.
- Detergents, metals and other manufactured products contain traces of toxic chemicals.
- **Industrial processes:** use of chemicals, the processing of metal ores, and the leaching of metals from waste heaps and dumps cause the presence of metals in rivers (e.g. manganese, mercury, copper).
- Gases from industrial chimneys enter the atmosphere, where they dissolve in water and form acid rain.
- **Agricultural practices:** surpluses of phosphorous and nitrogen not absorbed by the plants are washed from the land or percolate into the ground water.
- On farms, animal manure, synthetic fertiliser, and chemical pesticides are main sources.
- **Agrochemicals:** pesticides, herbicides and fertiliser.

Impact of water pollution

- **Global inequalities in sewage and water treatment:** developing countries have difficulty treating water and sewage compared to developed countries as people aren't educated and can't put pressure on the government.
- **Risk of infectious bacterial diseases, typhoid and cholera:** water-borne diseases are caused by drinking contaminated water.
- **Accumulation of toxic substances from industrial processes in lakes and rivers:** reduces oxygen in lakes and rivers, causing reduction in photosynthesis and death of fish and insect larvae.
- **Biomagnification of toxic substances in food chains:** increases concentration of a toxic substance (e.g. mercury and pesticides) in the tissues of organisms at successively higher levels in a food chain, causing illness.
- **Bioaccumulation:** accumulation of a toxic chemical in the tissue of a particular organism.
- **Formation of acid rain:** burning fossil fuels such as coal and oil produce sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) that are blown long distances and react with water in the atmosphere.



- SO_2 dissolves in water to form sulfuric acid, and NO_x dissolves to form nitric acid that fall in the form of rain.
- **pH:** measured by acidity or alkalinity.



  - Ranges from very acidic, 1, to very alkaline, 14.
  - 7 is neutral.
- **The effect of acid rain on organisms in rivers and lakes:**
  - Lower pH makes the environment intolerable for aquatic life;
  - Fish egg-laying is reduced, and young fish are malformed;
  - Leaching of heavy metals such as aluminum, lead and mercury from the soil into the water;
  - Aluminium clogs fish gills and causes suffocation;
  - Minerals essential for life, notably calcium and potassium, are washed out of the lake or river, reducing algae growth and leaving less food for fish and other animals.
- **Nutrient enrichment leading to eutrophication:**
  - Increase in nutrients, such as nitrates and phosphates, in a water body causes algae bloom (rapid growth of algae).
  - Death of algae causes an increase in organic matter that acts as food for bacteria as they decompose the dead algae.
  - Bacteria use up oxygen, reducing oxygen content in the water and causing the death of organisms.

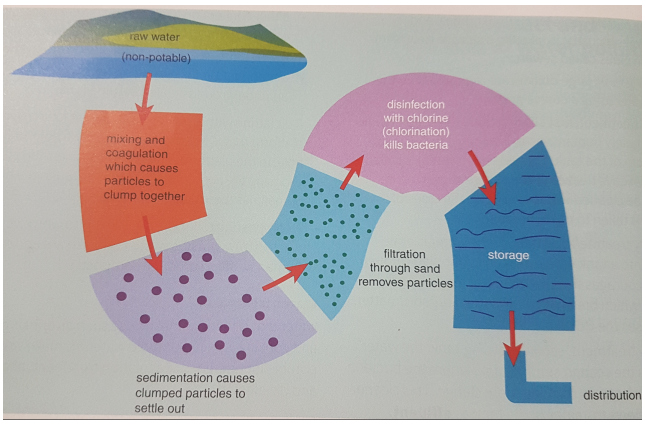
Managing pollution of fresh water

- **Improve sanitation:** separates human excreta from contact with humans, achieved by toilets and latrines. **Waste can be removed by:**
  - Connection to a system of sewer pipes or sewerage, that collects human faeces, urine and waste water.
  - Connection to a septic system, which consists of an underground, sealed settling tank.
- **Flush toilet:** uses a holding tank for flushing water, and a water seal that prevents smells.
- **Pour toilet:** has a water seal but uses water poured by hand for flushing.
- **Pit latrine:** type of toilet that collects human faeces in a hole in the ground that is sometimes ventilated to take away smells.
- **Composting toilet:** dry toilet in which vegetable waste, straw, grass, sawdust, and ash are added to the human waste to produce compost.

Treatment of sewage: aims to reduce the Biological Oxygen Demand (BOD) of the sewage.

- Sewage outfall: waste water from homes and industries is taken to a sewage treatment plant in sewers.
- Screening tank: large objects are removed from the waste using a coarse grid.
- Primary treatment, first settling tank: solid organic matter, mainly human waste, settles at the bottom of the tank (sludge), which is treated in a sludge-digester.
    - Clean water then overflows the sides of the tank and is taken to the next stage.
- Secondary treatment, oxidation: water is pumped into a tank where oxygen is bubbled through it.
    - This encourages the growth of bacteria and other microbes that break down organic matter, which cause BOD.
- Secondary treatment, second settling tank: water enters, where bacteria settle to the bottom, forming more sludge.
    - This cleaner water overflows the sides of the tank as effluent, usually discharged into a river.
- Sludge digester: oxygen-free conditions are created that encourage the growth of bacteria which can break down the sludge, releasing methane, that can be burnt.
    - Treated sludge can be dried in sludge lagoons and used as organic fertiliser on farmland.
- Tertiary treatment: further filtering out of its effluent or its chlorination which produces even cleaner effluent that protects the habitat in which it is released.

- **Water treatment:** Water is made potable by undergoing coagulation treatment, being filtered and disinfected.



- Coagulation: Particles in the water are stuck together and settle to the bottom of the container.
- Water is then filtered through sand.
- Chlorination: to kill remaining pathogens, chlorine is added as a disinfectant.
- Pollution control and legislation: puts pressure on polluters to find ways to reduce pollutants.
- Industries are required to monitor the pollution they cause and keep it within set level.
- Bi-national Great lakes water quality agreement (GLWQA): a loading limit of phosphorus was set at 11000 metric tonnes $year^{-1}$ (per year) in response to eutrophication issues in the Great Lakes of USA and Canada.
- Fines for exceeding set limits.
- Companies may be prosecuted and in extreme cases, forced to shut down.
- Companies may need government agreement on strategic plans to reduce pollution levels.
- Incentives may be used to encourage companies to take part, such as grants or tax relief, for those that do achieve a reduction in pollution.

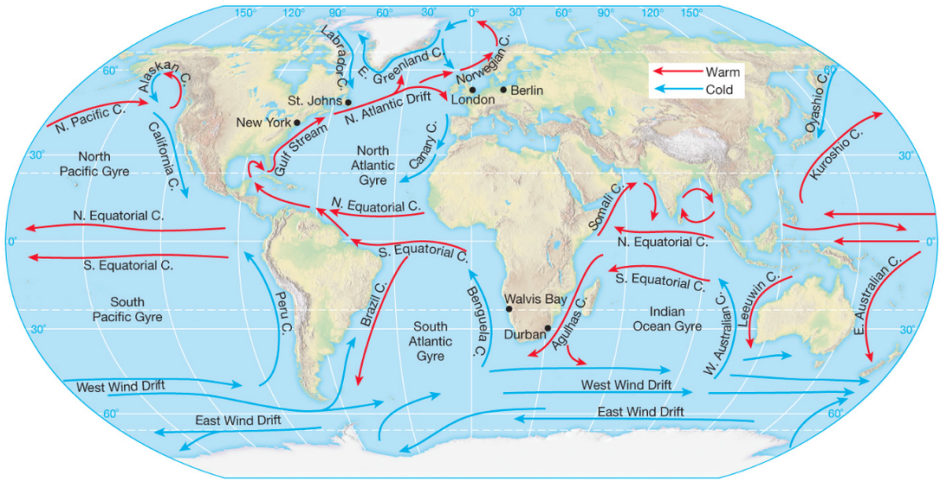
CHAPTER 5: Oceans and fisheries

THE RESOURCE POTENTIAL OF THE OCEANS: 5.1

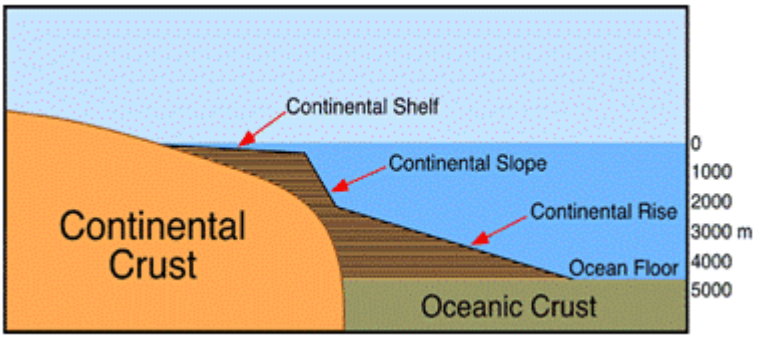
- **Food:** fish that includes true fish, finfish, shellfish and other sea animals that can be eaten.
    - Fishes are the main resources of the ocean
    - They are located on the continental shelves where the water is shallow, this means that light is able to penetrate, leading to a more oxygen rich habitat
    - It's a good area for plants to grow as well
- **Chemicals and building materials:** many materials in the oceans have been eroded from the land, where rain and wind break down rocks, and are carried into the oceans via rivers.
    - Salt from seawater
    - Diamonds are mined from the bottom of the ocean, this can be a difficult process though as the ocean floor needs to be dredged
    - Sand and gravel are also mined for construction, though it should be done carefully as there might be some physical damage to the seabed
    - Oil is a chemical that is extracted by offshore drilling rigs.
    - Fine particle clouds that are produced resettle and interfere with photosynthesis; they also act as a source of heavy metals that can enter food chains.
- **Wave energy**: an enormous amount of energy in the waves is estimated to produce twice the present world energy production if harnessed.
    - Due to the gravitational pull of the moon and the sun, the tides moves up and down twice a day
- **Tidal energy:** due to the varying gravitational pull of the sun and moon, water in the sea moves up and down on a twice-daily basis.
    - This causes it to come onto land and later recede, which can be harnessed to generate electricity.
- **Tourism:** seaside is a major tourist attraction. People of MEDCs are attracted to marine sites of great natural beauty, especially coral reefs.
    - Diving, snorkeling, windsurfing, jet skiing, deep-sea fishing or simply sunbathing on the beach are some adventurous activities.
    - There's a business in boat trips to view sea creatures, especially whales and dolphins.
- **Transport**: ships are important to transport people and goods; however, shipping is less common to transport people now due to the advent of aviation.
    - Pleasure cruises are still an important economic sector and bulk freight is best transported from country to country on ships.

WORLD FISHERIES: 5.2

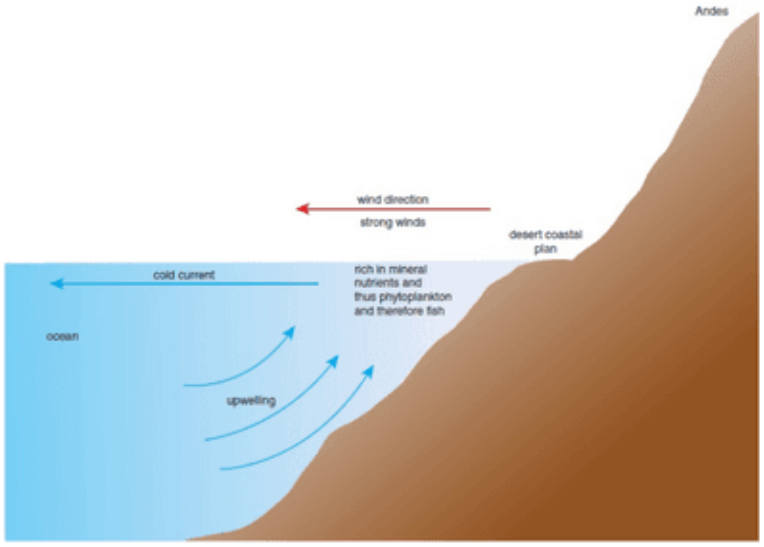
- **Surface currents:** movement of the surface water of the sea in a constant direction.
- **Prevailing wind:** the direction from which the wind nearly always blows in a particular area.
- **Currents**
    - Currents in the Southern Hemisphere are usually anti-clockwise
    - Cold currents are near the north and south poles
    - Warm currents are near the equator and the tropics



- They are found in shallow continental shelves due to the large abundance of oxygen and phytoplankton
- They're part of the food web, starting with the phytoplankton. Thus, fish are found where there are plentiful phytoplankton.
- Phytoplankton produce their own food by photosynthesis which requires light, water, and carbon dioxide (CO2).
- Water is abundant in the oceans and CO2 dissolves in the water from the atmosphere, therefore light is likely to be the limiting factor for photosynthesis.

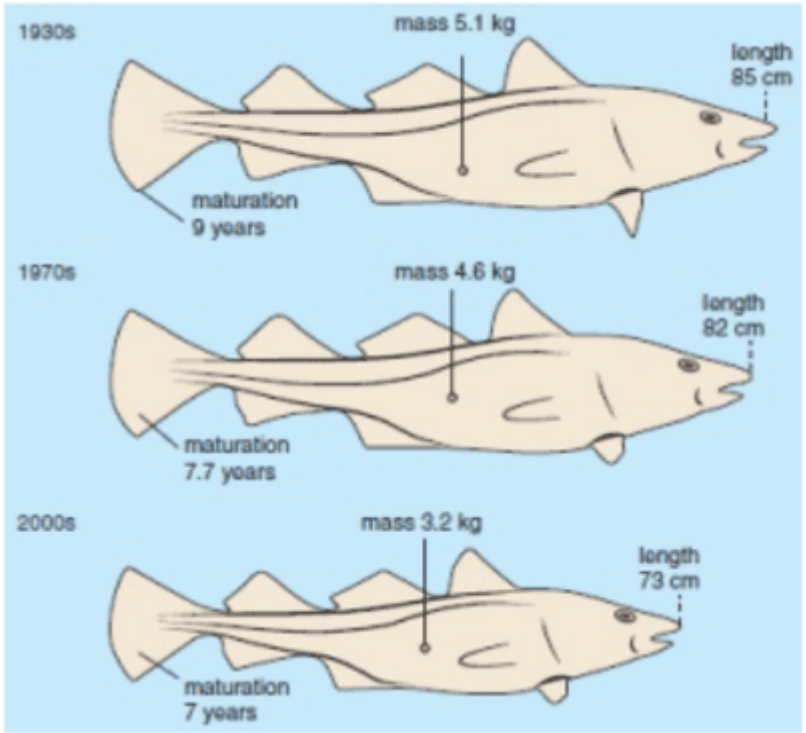


- **Limiting factor:** of all the factors that might affect a process, that one is in the shortest supply.
- **Not all areas with continental shelves have significant fisheries because:**
  - Phytoplankton need not just light, CO_2, and water, which allow it to make carbohydrates such as sugars, but they also require mineral nutrients to make proteins.
- **El Nino Southern Oscillation ENSO**
  - **Upwelling:** areas where minerals on the ocean floor are brought up to the surface by currents.
  - An example is the Peruvian anchovy off the **west coast of South America.**
  - **Overfishing:** when the number of fish that is caught is greater than the rate at which the fish reproduce, leading to a fall in fish numbers in an area.
- **El Niño Southern Oscillation (ENSO):** the change in the prevailing winds that lead to a change in the pattern of currents in the oceans of the South Pacific.
  - The upwelling of cold, nutrient-rich water is disturbed due to the change of prevailing winds
  - Leading to the upwelling of warm, nutrient-poor water
  - No nutrients mean the phytoplankton does not grow well, so there is less food for the fish.
  - This affects the fishing industry (namely anchovy fishes) negatively



EXPLOITATION OF THE OCEANS: IMPACT ON FISHERIES: 5.3

- *Causes of overfishing:*
  - *Demand for fish as food due to increasing world population*
  - *Economic gain*
  - *Creation of huge nets that scoop up everything in an area, often half of which is discarded as bycatch*
- **Bycatch**- *animals caught by fishers that are not the intended target of their fishing effort*



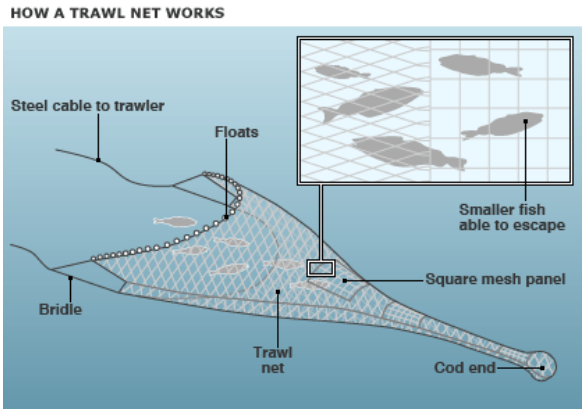
- *Impact of overfishing on marine fish species:*
  - *Reduced catch leading to loss of jobs and reduction in food supply*
  - *The size of fish gets progressively smaller, increasing the demand for food*
  - *Increase in fishing efforts*
  - *Harvest of untargeted/protected/endangered marine species that are discarded at the sea or shore (bycatch)*
  - *Reduction in marine biodiversity, causing a disruption in the food chain.*

- **Farming marine species :**
  - Due to the increasing human population, the increased demand for fish as food is above the production capacity of oceans and seas;
  - Overexploitation of the fisheries leads to a decline in wild fish populations;
- So, fish are farmed in **controlled environments.**
- **Aquaculture:** farming freshwater fish.
- **Mariculture:** aquaculture practiced in marine environments e.g. closed sections of an ocean, tanks, ponds, and raceways filled with seawater.
- Advantages and disadvantages

Advantages	disadvantages
• It reduces the pressure on the wild population, allowing their population to increase; • Production is constant; • No bycatch, as non-interest species are unlikely to be present on the farm; • No erosion of seabed, which is usually caused by trawl nets.	• More prone to diseases • Less likely to be successful due to pollution from waste

STRATEGIES FOR MANAGING THE HARVESTING OF MARINE SPECIES: 5.4

Nets



- If the mesh size is too small, juvenile fish will be caught which reduces the number of fish that grow to maturity and reproduce.
- A diamond-shaped mesh catches fish more easily, thus a square mesh the panel is often included in an otherwise diamond net.

Other methods of fishing

- Fish aggression device (FAD)
  - These devices baits all the fish together and uses a net to collect it
  - Leading to a large bycatch and more younger fishes

- Pole and line
    - Very selective method leads to almost no bycatch
- Quotas
- Legislators e.g. government set limits on how many and what type of fish can be caught;
    - The limits are set according to the information gathered from networks across the world about fish populations
    - These limits ensure enough fish are left to reproduce and replenish the fishery for the following season.

Closed seasons:

- Governments close down fisheries for a part of the year, usually during the breeding season
- **Protected areas and reserves:** some fisheries are protected by preventing fishing in certain areas, often where the target species is known to breed.

  International agreements (implementing and monitoring):
- **Economic exclusion zone-** the zone around a country's coastline that is under the control of that country
- **International agreements**: needed to regulate fisheries in international waters, leading to the UN Convention on the Law of the Sea (UNCLOS).
- Countries can monitor varying levels of success
- **Conservation laws are used to aim to-**
    - Conserve fisheries and the territorial waters
    - Conserve fishing resources
    - Protecting fish habitats
    - Enforcing international fishing agreements
- **Effectiveness of these strategies:**
    - Because of the vastness of the oceans, it is difficult to monitor fishery laws and agreements;
    - Monitoring organizations based in ports have more success;
    - Fishing is important for both income and food for many people, and there is a huge incentive for illegal activities;
    - Quotas can easily be avoided by simply not declaring how many fish are being caught;
    - Overstretched authorities may not be able to check every boat, and fishers may be willing to risk under-declaring the size of their catch and not being checked;
    - Usage of the net with an illegally small mesh size, and in areas where patrols are inadequate;
    - Fishers frequently trespass in areas where they are not supposed to fish.

CHAPTER 6: Managing natural hazards

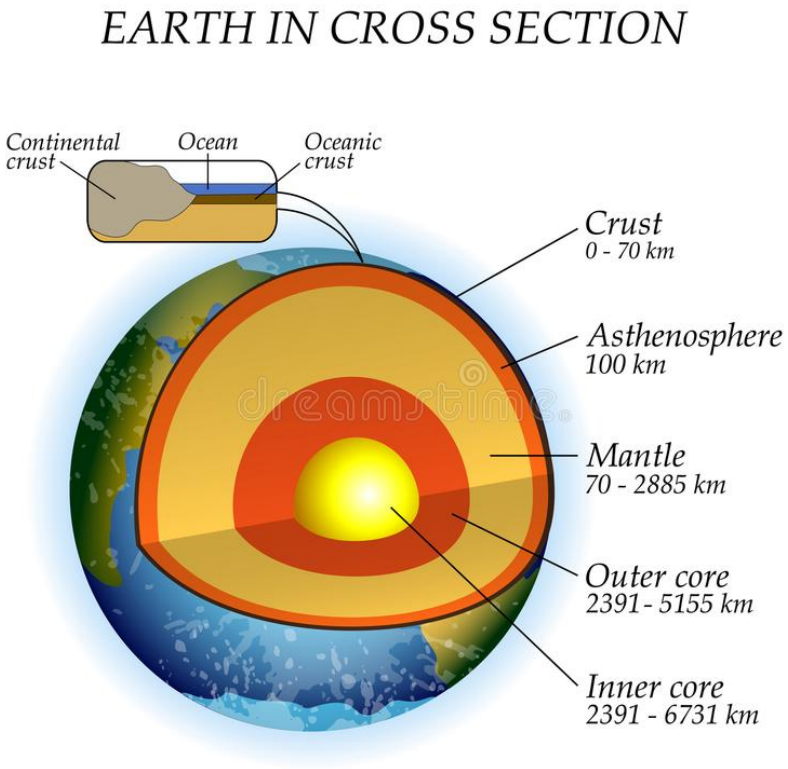
WHAT IS A NATURAL HAZARD: 6.1

- Physical event that has the potential to cause loss of life or injury and damage property and infrastructure. they can be:
    - Short term
    - Long term
- Classification:
    - Cause of the hazard
        - geological(earthquakes, volcanos)
        - climatic(droughts, tropical cyclones, floods)

- Based on the magnitude or intensity of the event
- Speed at which the event takes place
- Duration of the event
- Frequency of the event

WHAT CAUSES EARTHQUAKES AND VOLCANOES: 6.2

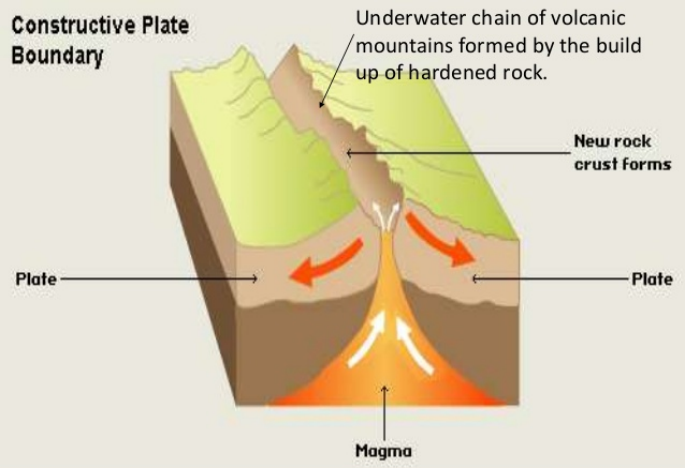
- The structure of the Earth:



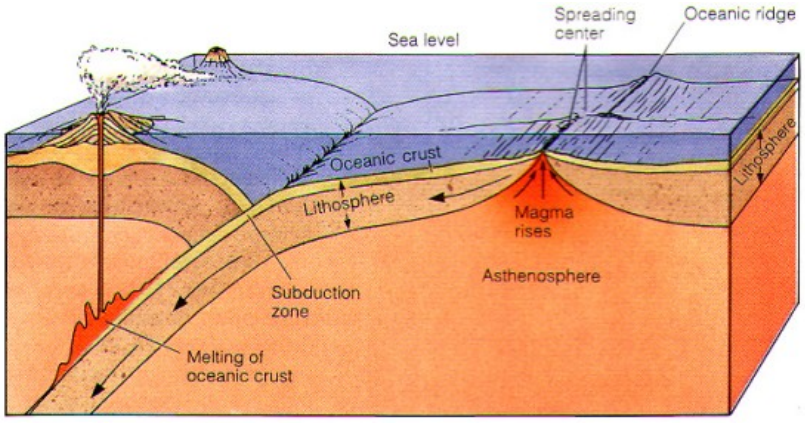
Layer	Temp (°C)	State	Material
INNER CORE	5000 – 6000	Solid (intense pressure from overlying rocks).	Iron and nickel.
OUTER CORE	4000 – 5000	Liquid.	Iron and nickel.
MANTLE	1000 – 1200	Liquid (flows slowly due to conventional currents from core).	Mainly silicate minerals.

- **Tectonic plate:** a piece of lithosphere that moves slowly. It is made of crust and upper mantle.
- Where the convention currents rise to the surface, the plates move away from each other (and vice-versa).
- **Plate boundaries:** where two or more plates meet.

- *Constructive (divergent) plate boundary:*

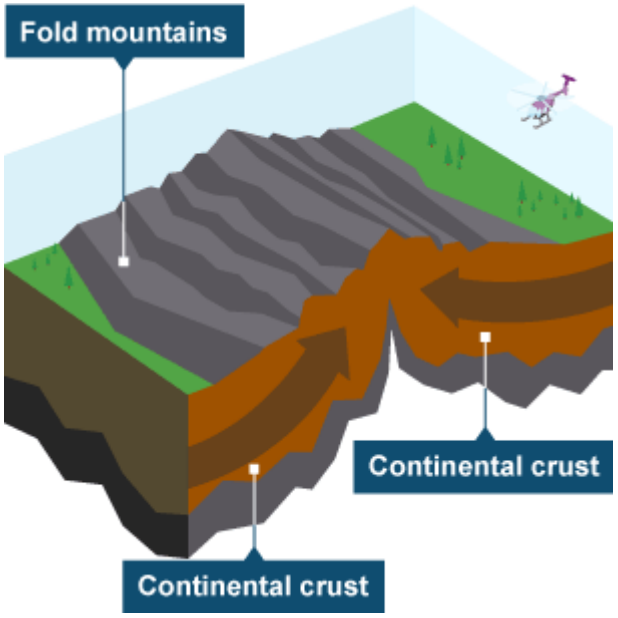


  - *Two plates move **away** from each other.*
  - *When **two oceanic plates** move away, magma rises to the surface (convention current) and solidifies when it comes in contact with cold ocean water.*
  - *The magma turns to lava and forms new basaltic ocean crust.*
  - *They can also form shield or basic volcanoes (submarine) and have non-explosive eruptions.*
  - *This is known as sea-floor spreading or ridge push.*
  - *Small Earthquakes are triggered.*
  - *If **two continental plates** move away from each other, a rift valley may form.*
- *Destructive (converging) plate boundary:*



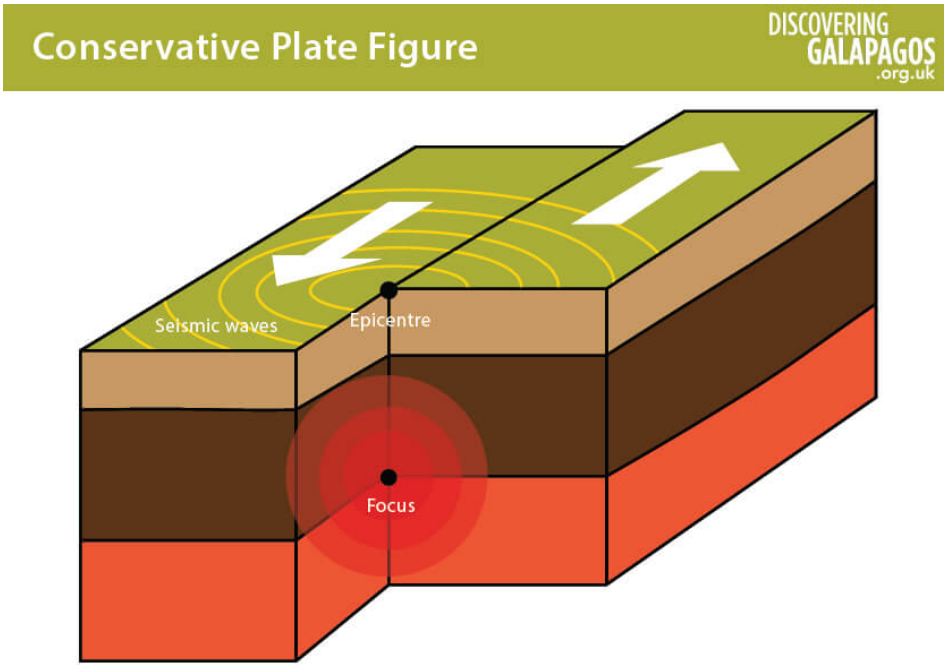
  - *Two plates move **towards** each other.*
  - *When **an oceanic plate and continental plate** move towards each other, the denser (oceanic) plate is forced down (subducted) under the lighter (continental) plate.*
  - *This happens in the subduction zone and an ocean trench is formed.*
  - *The friction between the plates triggers Earthquakes.*
  - *The heat produced due to friction turns the descending plate into magma.*
  - *The magma starts to rise and erupt (due to pressure) through a weakness in the crust as an explosive composite volcano.*
  - *Fold mountains are also formed.*
  - *The magma that erupts at the surface forms a chain of volcanic islands called an island arc.*

- If **two continental plates** move towards each other, the sediments between the two plates are compressed (collision zone) and pushed upwards to form fold mountains.



- Earthquakes occur, but no volcanic activity as there's no subduction of oceanic plate.

- Conservative plate boundary:

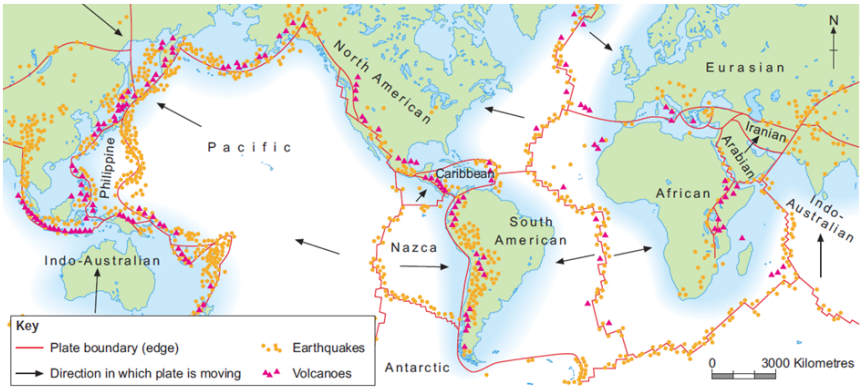


- Two plates **slide past** each other.
- They move in different speeds.
- The plates get locked together and pressure builds up until it is released as an Earthquake.

- *The magnitude (strength) of an Earthquake is measured using a seismometer on the Richter scale.*

Richter Magnitude	Earthquake effects
0-2	Not felt by people
2-3	Felt little by people
3-4	Ceiling lights swing
4-5	Walls crack
5-6	Furniture moves
6-7	Some buildings collapse
7-8	Many buildings destroyed
8-Up	Total destruction of buildings, bridges and roads

- ***Distribution and causes of volcanoes:***

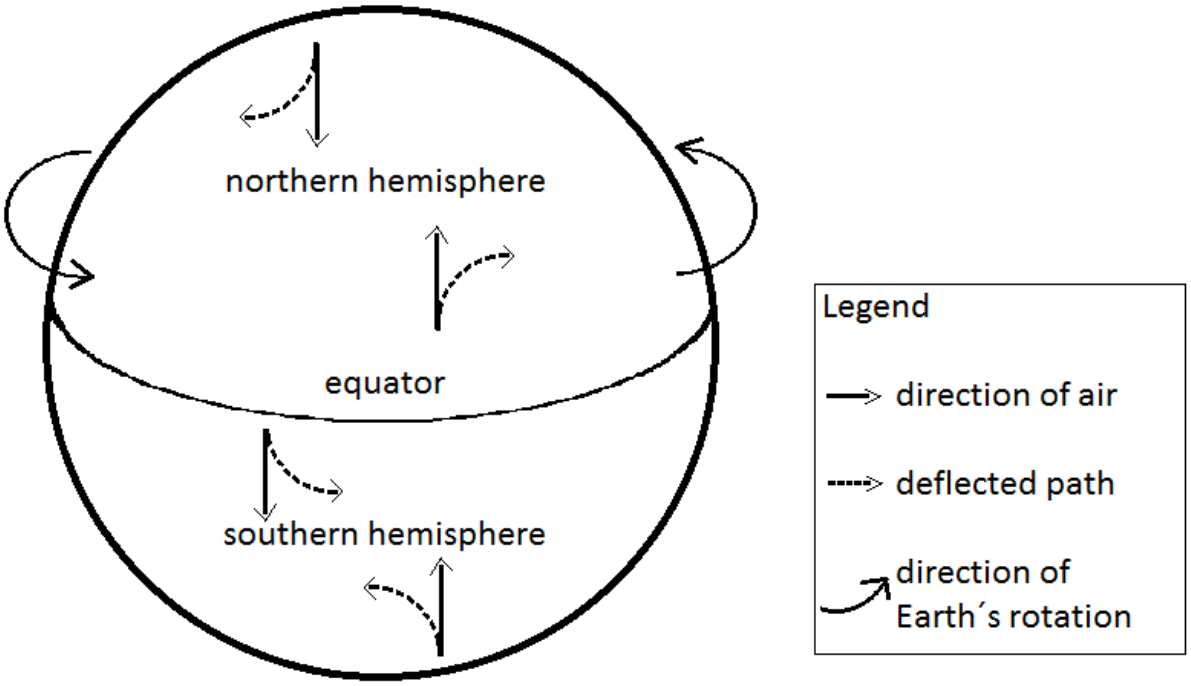


  - *Caused due to the tectonic activity (refer to 6.1; Plate boundaries).*
  - *Found on constructive and destructive plate boundaries and hotspots.*
  - ***Distribution and causes of Earthquakes:***
  - *Caused due to the tectonic activity (refer to 6.1; Plate boundaries).*
  - *Occur mostly on the destructive and conservative plate boundaries (and sometimes on the constructive plate boundaries).*
- ***Earthquakes**:*
- ***Focus**: where the Earthquake begins underground.*
- ***Epicentre**: point on the surface above the focus.*
- ***Seismometer**: an instrument used to measure the magnitude of an Earthquake (on the Richter scale).*
- ***Factors that affect the impact of an Earthquake:***
  - *Location of the epicentre;*
  - *Time of the Earthquake;*
  - *Geology of the area;*
  - *Relief of the area;*
  - *Severity of aftershocks;*
  - *Level of development of human settlement;*
  - *Population density;*
  - *Building density and strength.*

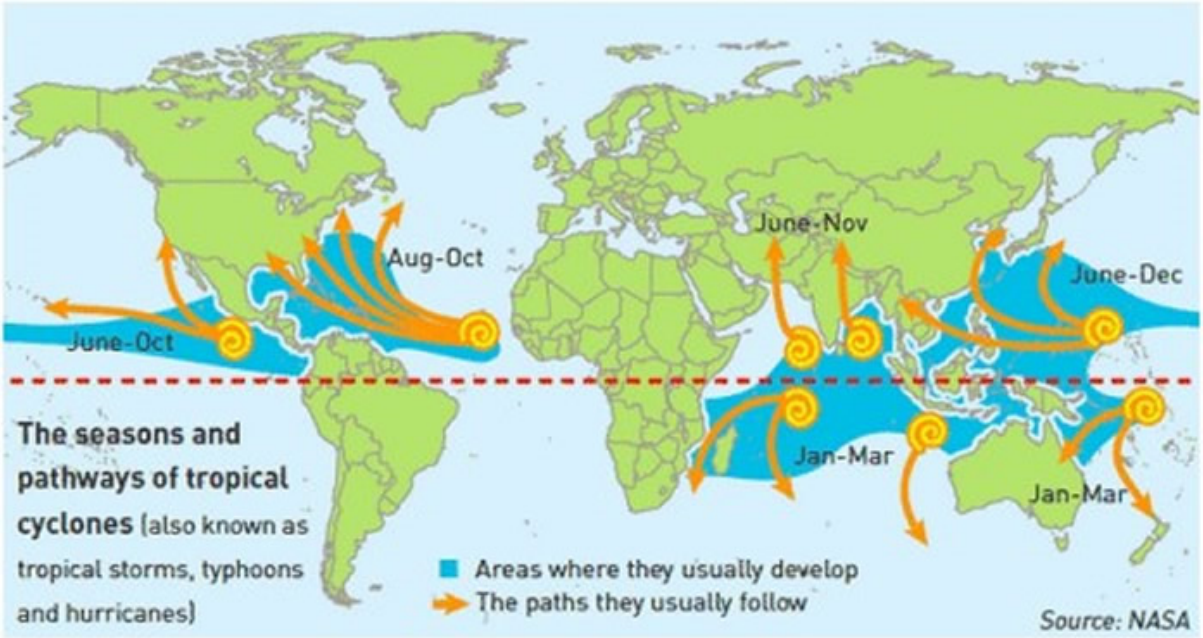
WHAT CAUSES TROPICAL CYCLONES: 6.3

Causes of tropical cyclones:

- Ocean surface temperature of at least 27°C.
    - Warm water provides the energy to evaporate more water, that rises, condenses, releasing huge amounts of energy.
- Ocean depth of at least 60m deep.



- These conditions occurring between 5° and 20° north and south to have sufficient Coriolis effect, making the air spin.
- Very little wind shear (change in wind speed or direction).
    - Allows the vertical development of the storm.
- Distribution of tropical cyclones:



- Between 5° and 20° north and south.
- They do not form on the equator because the Coriolis effect there is 0.

- The air at the equator tends to flow straight from high pressure to low pressure, without any rotation.

WHAT CAUSES FLOODING: 6.4

Physical cause	impact
heavy rainfall	• Reduces the infiltration capacity of the soil; • Increase in overland flow.
prolonged rainfall	• Saturates the soil; • Causes the water table to rise, reducing infiltration capacity.
snowmelt	• Overland flow occurs due to rapid snowmelt.
land relief	• Steeper gradients lead to faster overland flow ∴</spanwater has little time to infiltrate.
saturated soil	• The more saturated the soil is (before the rainfall), lesser infiltration and more overland flow.
storm surges, tsunamis	• Flooding of low-lying coastal areas.

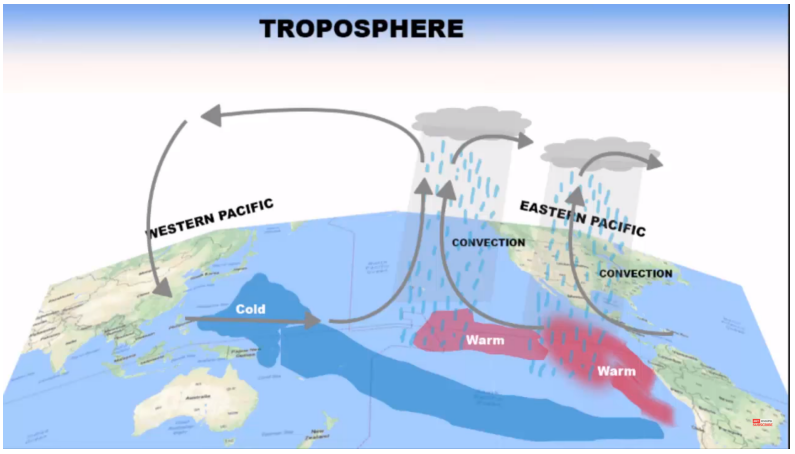
Human cause	Impact
Deforestation	Reduces interception and infiltration.
Cultivation	Ploughing down rather than across slopes increases the water flow.
Urbanisation	Concrete and tarmac are impermeable surfaces (no infiltration ∴</spanhigh overland flow).
Climate change	Global warming may lead to rise in sea levels and more rainfall in some areas.

WHAT CAUSES DROUGHTS: 6.5

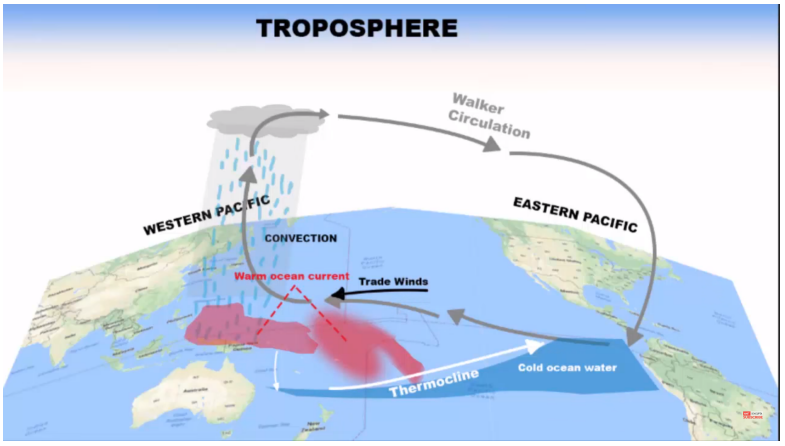
Causes of drought:

- Lack of rain caused by prolonged high pressure:
  - Air in a high-pressure system sinks and doesn't form rain clouds.
- Effect of El Niño Southern Oscillation and La Niña:

- El Niño causes the surface water in the Pacific Ocean along South America to be warmer.



- These warmer waters alter storm patterns and can cause droughts in Australia.
- Whereas, La Niña causes the temperature of the water along South America to
- decrease.



- The cooler conditions cause drought in parts of North and South America.
- (refer to Section 5.2 World Fisheries; **El Niño Southern Oscillation (ENSO)**)

- Effect of climate change:
  - Warmer worldwide temperatures cause the rainfall to decrease in some parts of the world, leading to drought.

IMPACTS OF NATURAL HAZARDS: 6.6

- Impacts of tectonic events:
  - Damage to buildings and infrastructure;
  - Fires from ruptures of gas pipes;
  - Tsunamis hit coastlines;
  - Landslides cover buildings and roads;
  - Destruction of farmland, leading to starvation;
  - Loss of wildlife habitats;
  - Water-related diseases because victims are in temporary accommodation with no sanitation or clean water;
    - Water is also contaminated by broken sewage pipes or untreated sewage.
  - Loss of life;
  - Trauma, poor mental health;
  - Financial losses when repairing the damage.

- *Impacts of tropical cyclones:*
    - *Flooding from storm surges and heavy rainfall;*
    - *Loss of life;*
    - *Damage to buildings and infrastructure;*
    - *Disruption of electricity, transport and water supply;*
    - *Water-borne diseases;*
    - *Economic loss as production is halted;*
    - *Damage to crops, food shortages and loss of export earnings;*
    - *Loss of wildlife habitats.*
- *Impacts of flooding:*
    - *Loss of life;*
    - *Damage to buildings and infrastructure;*
    - *Contamination of water supplies leading to disease;*
        - *Loss of crops and livestock leading to food shortages;*
    - *Deposition of silt from the flood waters;*
    - *Recharge of groundwater stores;*
    - *Rivers may change course;*
    - *Financial losses when repairing the damage.*
- *Impacts of droughts:*
    - *Water sources dry up, forcing people to travel long distances to fetch water;*
    - *Decline in crop yields;*
    - *Loss of crops, livestock, plants and wildlife;*
    - *Decrease in land prices as production declines and farmers lose money;*
    - *Migration from rural to urban areas;*
    - *Unemployment;*
    - *Increase in food prices;*
    - *Health problems due to malnutrition;*
    - *Soil erosion, leading to desertification;*
    - *Increased risk of wildfires and poor air quality;*
    - *Conflicts over water usage and food.*

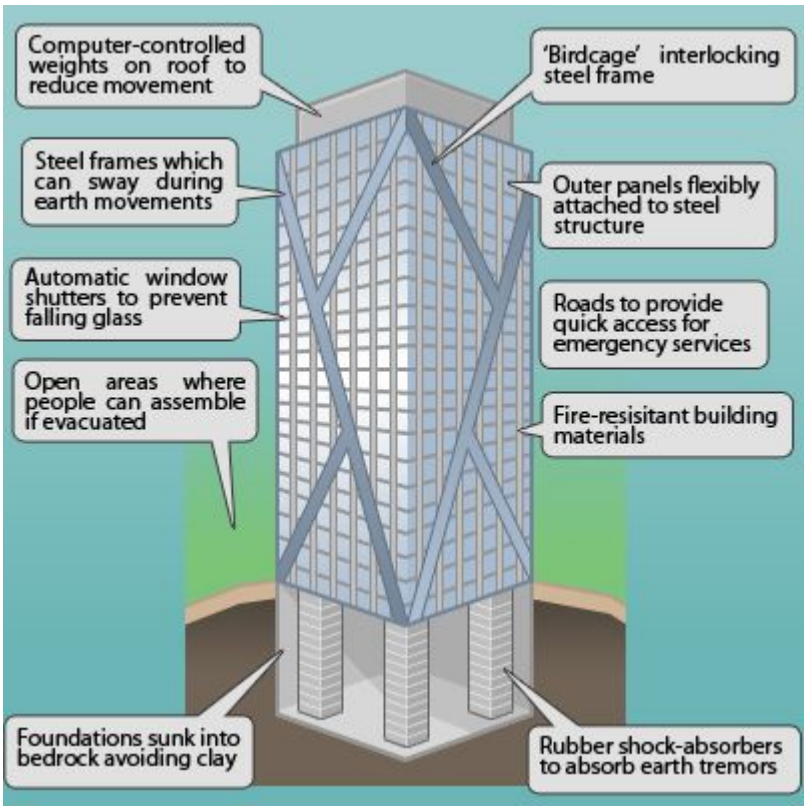
STRATEGIES TO MANAGE THE IMPACT OF NATURAL HAZARDS: 6.1

Volcanoes:

- *Prediction:*
    - *Seismometers can be used to monitor tremors caused by rising magma;*
    - *Satellites using heat-seeking cameras can be used to monitor increasing ground temperatures;*
    - *Tiltmeters (measure very subtle changes in the surface of the Earth as magma accumulates) and GPS can be used to monitor changes in volcano shape;*
    - *Emissions of steam and gas (sulfur dioxide) can be monitored.*
- *Preparation and protection:*
    - *Volcano hazard map (study past eruptions);*
    - *Lava diversion channels and lava barriers ;*
    - *Spraying lava with water;*
    - *Halting lava advance by dropping concrete slabs into the flow;*
    - *Building reinforcements (sloping roofs to protect against ashfall).*

Earthquakes:

- Prediction:
  - Monitor tremors (using seismometers), groundwater levels and radon gas;
  - Epicentres and frequencies of past events can be mapped to check if a pattern is developing;
  - Measurement of local magnetic fields;
  - Hazard zone map can be drawn (geological info and ground stability);
  - Unusual animal behaviour.
- Preparation and protection:
  - Earthquake-proof or aseismic buildings. Older buildings can be modernised;



  - Smart meters to switch off gas supplies, preventing fires;
  - Land-use planning: important services (schools, hospitals) must be built in low-risk areas.

Tropical cyclones:

- Prediction:
  - Tracked using satellites.
- Preparation and protection:
  - Cyclone shelters;
  - Embankments along the coast;
  - Preserve mangrove swamps to absorb the energy of storm surges.

Flooding:

- Prediction:
    - Monitoring the amount of rainfall and river discharge using an ADV;
    - Using the features of the drainage basin and type of storm to determine the severity of the flood.
- Preparation and protection:
    - Hard engineering projects (levees, flood barriers and dams);
    - Soft engineering projects (afforestation and storage basins);
    - Increasing the river channel (clearing vegetation);
    - Land-use planning to restrict development on floodplains;
    - Use of sandbags and pumps;
    - Adapt houses to position power sockets 1.5 m above ground level to prevent electrocution.

Droughts:

- Prediction:
    - Monitoring precipitation and temperature.
- Preparation and protection:
    - Increase water supplies (dams, reservoirs, wells, percolation ponds, aquifers, pumps, water transfer by pipeline and desalination);
    - Water conservation (storage tanks, spray irrigation, drought-tolerant crops, recycling water and reducing deforestation);
    - Agricultural improvements (shelterbelts to decrease wind and evaporation, bunds to increase infiltration and fencing to control overgrazing);
    - Government stockpiling supplies of water, food and medicine.

OPPORTUNITIES PRESENTED BY NATURAL HAZARDS: 6.8

- Individuals may want to be near family and friends.
- Confidence in prediction, preparation and protection.
- Employment opportunities e.g. tourism.
- No choice in moving if there is pressure on land or if it is too expensive to move.
- After a volcanic eruption, fertile soils are created that produce high crop yields.
- The scenery can be spectacular;
- Geothermal energy can be obtained easily;
- Possibility of mining minerals such as sulfur, diamonds and gold.
- Living near rivers may provide a source of food, water for drinking and irrigation.
- Communications may be easier;
- Flat land on either side is available for building on.