Edexcel IAL Geography

Water Conflict

Detailed Notes

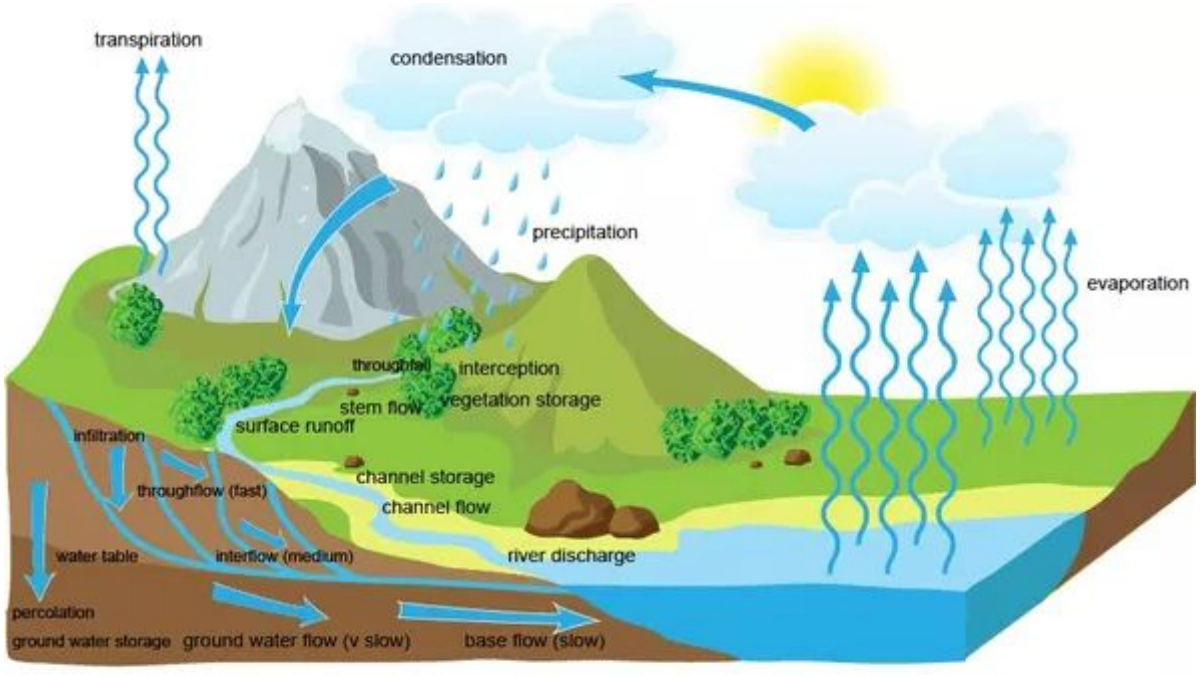
The Hydrological Cycle

The **hydrological cycle** is a **closed system** of the Earth's water in all forms (water, ice and vapour). It is driven by **solar radiation** and **gravitational potential**:

- The Sun's radiation provides **energy** that allows water to **change state** through melting and evaporation. As air heats up, it rises within the atmosphere.

- Gravity acts on water as it cools, since the molecules become closer together and the fluid becomes denser and **heavier** and sinks. Gravity acts on **glaciers**, causing ice to break off and so increasing the glaciers' surface area. Water will **flow downstream** due to the pull of Gravity to lower levels which drives the flow of water around the system.

The global hydrological cycle is made up of smaller, more localised drainage basins. Drainage basins are **open subsystems** and are defined as an area of **land drained by a river and its tributaries** with a boundary (known as the **watershed**), usually composing of hills and mountains. The basic flows, inputs and outputs are shown below:



On a **local scale,** the water cycle is an **open system** (a system of processes of water inputs, outputs and throughputs); on a **global scale**, the water cycle a **closed systems** (a system that has no inputs or outputs, only throughputs). The water cycle contains **flows/transfers, inputs, outputs and stores/components.**

Inputs to the Drainage Basin – Precipitation

Precipitation is caused by the **cooling and condensation** of water moisture in the atmosphere, forming clouds that release moisture in the form of rain, snow, hail, sleet, etc. Primary factors affecting volume or the condition of precipitation include:

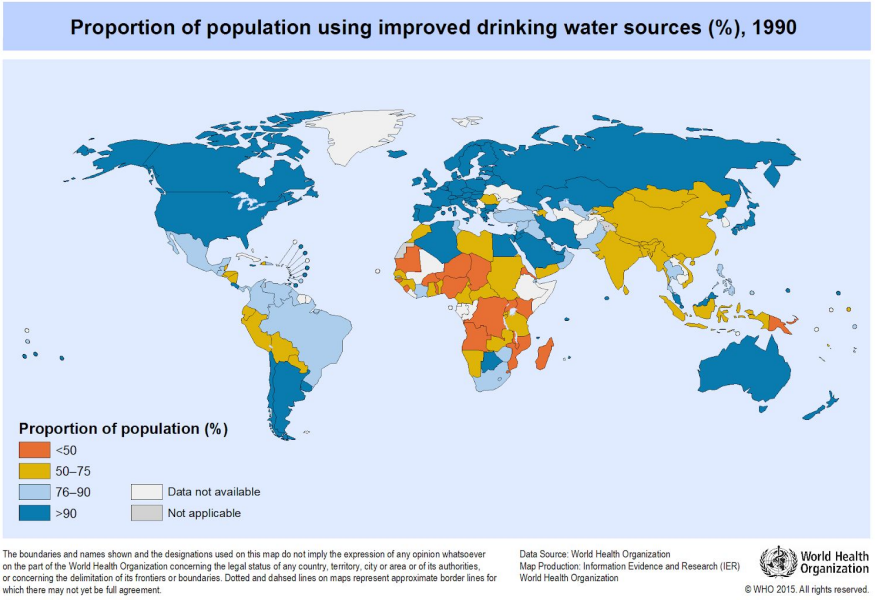
- **Seasonality** – In some climates (such as monsoon and Mediterranean) there are strong seasonal patterns of rainfall. Therefore the time of year determines the precipitation input within the drainage basin
- **Variability** - sudden or long term changes to the climate can happen, which would affect precipitation levels and so the drainage basin as a whole.
  → **Secular Variability** – long term (for example as a result of climate change trends)
  → **Periodic Variability** – annual, seasonal or monthly context
  → **Stochastic Variability** – random factors like localisation of thunderstorm
- **Latitude** - The location of the drainage basin has a major impact on climate, and so the volume and type of precipitation falling. In most cases, the higher the latitude from the Equator, the colder the climate, and so snowfall occurs more often than rainfall. Also, at latitudes where air cells converge (**ITCZ**), the climate will be categorised by the rise or fall of air.

Factors influencing the Drainage Basin

Physical Factors	Anthropogenic Factors (Human)
➢ **Climate** – influences amount of rainfall and vegetation growth. ➢ **Soil Composition** – influences rate of infiltration and throughflow. ➢ **Geology** – affects percolation and groundwater flow ➢ **Relief** – steeper gradients of land will encourage faster rates of surface runoff ➢ **Vegetation** – affects interception, overland flow ➢ **Size** – larger basins collect more precipitation generally	➢ **Cloud seeding** – substances dispersed into the air to provide something for condensation to occur on in. For example, China used cloud seeding before the 2008 Beijing Olympic Games to try and reduce pollution levels ➢ **Deforestation** – Less vegetation means less interception, less infiltration, more overland flow leading to more flooding, cycle speeds up ➢ **Afforestation** – More vegetation means interception, less overland flow, more evapotranspiration ➢ **Dam construction** – Dams reduce downstream river flow and discharge, increase surface stores so more evaporation Example: Lake Nasser behind Aswan dam in Egypt – 10-16 billion m^3 water loss from Nile ➢ **Change in land use** – Infiltration is 5 times faster under forests compared to grasslands. Converting land to farmland means less interception, increased soil compaction and more surface runoff ➢ **Ground water abstraction** – When water is taken out faster that the water is recharged, groundwater flow decreases and the water table drops Example: In China, groundwater irrigates 40% of farmland whilst 70% of drinking water comes from groundwater ➢ **Irrigation** – Drop in water tables due to high water usage. Example: Aral Sea in Kazakhstan shrank in 1960s due to farmers using the water to grow cotton ➢ **Urbanisation** – Impermeable surfaces reduce infiltration, increase surface runoff, river discharge increase. Cycle speeds up like

Uneven Distribution of Water Across The Globe

Water is **spatially distributed unevenly** across the globe. 66% of the world's population live in areas which only have access to 25% of the world's annual rainfall.



Countries don't have equal access to water, due to many factors:

- **Physical Resources Available** - Not every country has a river or lake (freshwater store). Some countries are **landlocked**, so doesn't receive saltwater for desalination. Some countries' supply of freshwater is **locked** into glaciers and frozen ice, and so must rely on meltwater to survive.
- Different **climates** affect the availability of water in the liquid state. Cold climates such as the **tundra** mean water is most likely to be **frozen**, whereas in hotter climates such as **arid climates**, **evaporation** is a prominent process and so most surface water stores will evaporate.
- The **level of development** of a country - More developed countries can afford **hard engineering schemes and water trade** to reduce their water security. However, emerging and developing countries may not have the **finances, technology or workforce** to construct dams, reservoirs, desalination plants, etc.

Inequality and Insecurity over Water

Demand has risen because of:

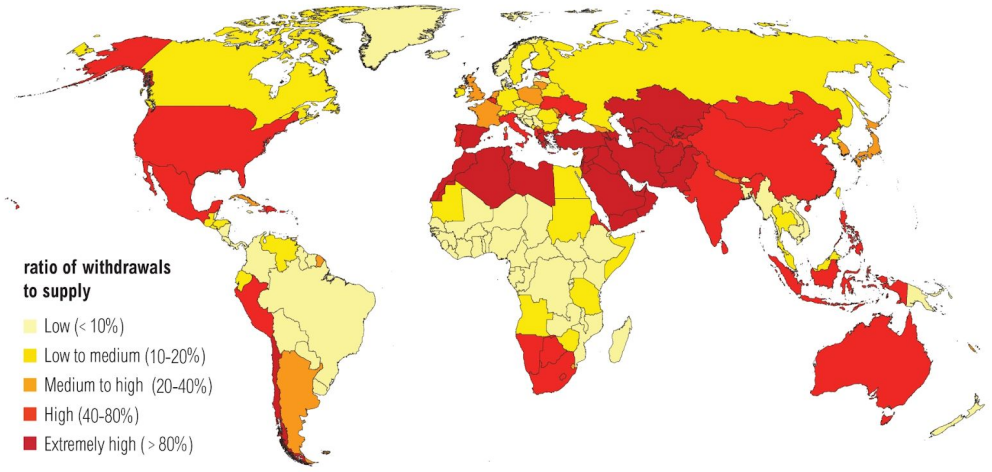
- Population growth - generally more people = more water needed.
- Growing middle class population as countries develop and industrialise, therefore increasing lifestyle and domestic demand.
- Economic growth means industrial demand may also increase.

However, **supply cannot meet demand** since:

- Aquifers and deep-water wells are being dug, especially for water-intensive agriculture.

- Water tables (groundwater storage) are dropping as a result.
- Water is being extracted at a faster rate than the soil is able to recharge.

Water Stress by Country: 2040



Source: www.visualcapitalist.com

Many countries experiencing the most water stress lie on or slightly above the **Tropic of Cancer**. There is less available water moisture here, so **little cloud cover** and so the temperatures remain high and water continues to **evaporate** rather than condense.

Countries with **large populations** also experience water stress and insecurity, such as the USA, China and South Africa.

Causes of Physical Water Insecurity

- **Precipitation** varies across different climates: mid-latitude areas generally receive the most rainfall.
- **Topography** is also significant because areas with high relief generally get more precipitation and surface runoff is greater for more inclined planes, so channel flow tends to be larger and so water can be easily stored by **dams and reservoirs**.
- **Geology** also determines water security or insecurity; permeable rocks can be infiltrated, and water can be easily stored underground.

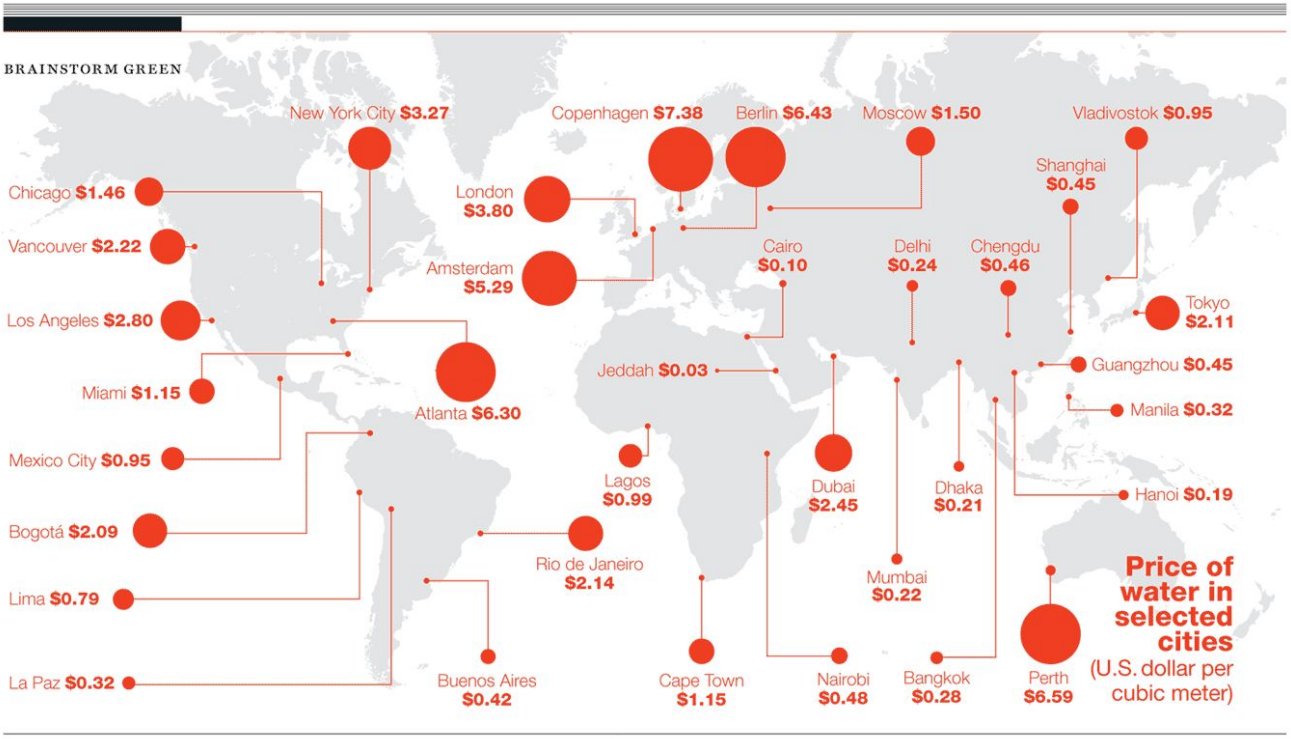
However, humans are also reducing supply through **pollution**. **Industrial activity** (especially in developing countries with slack environmental laws) and **population pressure** (lack of treatment of sewage, the “plastic tide”) are reducing accessibility to clean freshwater.

In addition, **saltwater encroachment** due to **over extraction and rising sea levels** (Climate Change) is further reducing freshwater stores, hence increasing water insecurity. For instance, as locals extract more and more freshwater from **aquifers** close to the coast, saltwater must flow in to replace. Saltwater encroachment can have a **negative effect on biodiversity** as few vegetation

can survive in **saline** (salty) conditions. This may make crop growing difficult, leading to **food insecurity**, and destroy habitats such as marshes.

Causes of Economic Water Insecurity

Economic water insecurity is the unaffordable supply of water in a country, so locals cannot afford to access water supplies. Below is a map of the price of water across the world:



The price tends to increase with the **level of development** of a country, as **treatment of the water** tends to increase and so the **amount of energy consumed** to purify freshwater increases. Therefore water drawn from a local well will be cheaper than water purified in a treatment plant.

Also, some countries must **trade** with others and buy their water supply to meet demand. This is the case for Cape Town and Johannesburg in South Africa, who buy freshwater of neighbouring country Lesotho.

Finally, as **supply of water** decreases, the price of water will increase to discourage consumption. This means that prices may vary **seasonally** for some countries, such as European Nations. However, for countries with **long-term drought**, prices will remain high (e.g. USA, Australia).

Deficits in the Hydrological Cycle

An **imbalance** in inputs and outputs of water can have serious implications for the hydrological cycle. A **deficit** (more commonly known as a **drought**) refers to when input is less than output. This deficit can be caused by natural and/or human factors.

Types of droughts and their characteristics		
Features		Impacts
Meteorological Drought	**Rainfall deficit** Low precipitation High temperatures Strong winds Increased solar radiation Reduced snow cover	Loss of soil moisture Irrigation supply drops Reduction in water available for consumption.
Hydrological Drought	**Stream flow deficit** Reduced infiltration Low soil moisture Little percolation and groundwater recharge	Reduced storage in lakes and reservoirs Less water for urban supply Poorer water quality Threats to wetlands and habitats
Agricultural Drought	**Soil moisture deficit** Low evapotranspiration Reduced biomass Fall in groundwater level	Poor yields from rainfed crops Failing irrigation systems Livestock productivity falls Rural industries affected Government aid may be required
Socio-Economic Drought	**Food deficit** Loss of vegetation Increased risk of wildfires Soil erosion Desertification	Widespread failure of agricultural systems Food shortages Rural economy collapses Rural to urban migration International aid required Humanitarian crisis

Impacts of Water Insecurity

Water is essential for the development of a country, and impacts many aspects of the running of a country:

- **Health and sanitation** depends on the availability of water. Drinking **unclean water** can lead to many **water-borne diseases** such as cholera, diarrhea and liver disease. Many **infant mortalities** depend on the quality of water, since young children are more vulnerable to water-borne disease.

- Water scarcity will affect **agriculture** and could impact **food security** and crop growth. If water supplies are limited for farmers, crops won't grow to their fullest and could be more **vulnerable to disease** and **crop failure**.
- Water may be needed for **energy production** - steam engines, hydroelectric dams, etc - and so limited water will reduce the amount of energy produced. **Manufacturing** also demands water for the construction of many products. Water insecurity could **limit industrial productivity** and so economic growth can be stunted.

Solutions to Water Insecurity

The most common solutions include **hard-engineering schemes** that involve construction of a store or transfer of supplies to increase the availability of water:

	Advantages	**Disadvantages**
Mega Dams	👍Can provide a large volume of water 👍Can generate HEP, helping the development of a country 👍Reduces demand for groundwater	👎Floods land 👎Expensive due to the vast size of the construction 👎Countries/areas downstream suffer from lack of water 👎Water is stored on surface so prone to evaporation
Desalination Plants Video - How Desalination Plants Work	👍Can provide a large volume of clean water 👍Reduces demand for groundwater 👍Available for countries with access to the sea, and limited freshwater sources	👎Energy intensive process, which can release large amounts of CO_2 (depending on the source of energy used) 👎Produces concentrated salt waste, which must be disposed of correctly to avoid saltwater contamination 👎Expensive to build and maintain
Water Transfer Schemes	👍Can provide water for areas that lack water and arid areas 👍Water can become a valuable resource for countries otherwise poor and undeveloped	👎Can increase water stress for the source 👎If water trade is between countries, water insecurity may depend on international relations 👎People relocated to construct pipeline

Management of Drainage Basins

Attempting to manage a drainage basin **sustainably** can be challenging. Some river management schemes try to reduce runoff from precipitation, therefore reducing the risk of flash flooding or storm flow discharge, by:

- Growing **vegetation on roofs**, to increase interception and temporarily stores some water within plants.
- Create **permeable pavements** (gaps within paving blocks) to increase infiltration and reduce surface runoff .
- **Rainwater Harvesting** – collecting rainwater to use as domestic greywater
- Creating **wetlands** (areas with marsh and wetland vegetation) that will act as natural sponges and increase temporary water storage.

Alternatively, trying to manage the anthropogenic impacts on a drainage basin can also be challenging. Allowing human development on a basin can outweigh the need for sustainable management, due to population or housing pressures. Impacts can include:

- **Deforestation, tree felling and slash-and-burn** - Soil becomes exposed and roots are lost (which bind the soil together), which leads to more soil erosion and so more surface runoff.
- **Impermeable surfaces** – As more tarmac and concrete is laid, less infiltration into the topsoil can occur, and so more surface runoff occurs.
- Bridges can act as dams for rivers, restricting channel flow (especially storm flow) and increasing the pressure the river's water is under, therefore worsening flood impacts.

Drainage and sewage systems will reduce lag time, and so a quick flow of water back to rivers, increasing the risk of flash flooding.

Sustainable Water Management

- Sprinklers are by **automated spray technology** or **advanced irrigation systems** which are more efficient.
- **Recycling city wastewater** is a relatively cheap method of conserving freshwater supplies, especially in areas of extremely high demand. 'Grey water' doesn't need to be cleaned as much to meet drinking standards, therefore is less energy intensive.
- **GM crops** are being developed, many are tolerant of dry and saline conditions
- Domestic conservation includes:
  - installing **smart metres**
  - **charging** more for water during times where there is a lack of water supply
  - using **eco-kettles**
  - taking a **shower** instead of a bath
- Restoration of damaged **lakes, rivers and wetlands** to increase natural water storage
- **Restoring meanders & replanting vegetation**

Water Sharing Treaties

Under the **Helsinki rules**, international treaties must contain concepts like equitable use and shares. The criteria could be based on:

- **Natural factors** → rainfall amounts, discharge, share of drainage basin
- **Social and economic needs** → population size, welfare of people, development plans
- **Downstream impacts** → restructuring flow, water tables, pollution
- **Dependency** → availability of alternative sources
- **Prior use** → the tricky question of existing historic rights and potential future use
- **Efficiency** → avoiding waste and mismanagement

Different organisations are involved in promoting effective water management schemes:

- The **UNECE Water Convention** promotes joint management and conservation of shared freshwater ecosystems in Europe and neighbouring areas.
- The **UN Water Courses Convention** offers guidelines on the protection and use of transboundary rivers.
- However, the **WWF** says that most agreements lack appropriate enforcement and monitoring.

Key players involved in water management include:

UN – UNECE (UN Economic Commission for Europe Water Convention) aims to protect and ensure the quality and sustainable use of transboundary water resources.
EU – Water Framework Directive agreed in Berlin 2000 – Targets to restore river, lakes, canals, coastal waters to suitable condition.
National Governments – e.g. the UK's environment agency which checks compliance with EU frameworks.

Water Conflict

Across the globe, there is **competition** for **transboundary water sources**. River that cross into multiple countries are the source of many **political conflicts**, as management is difficult to cooperate and rising pressure as country's populations increase.

There are many examples of conflict over water sources, such as:

- **The Nile** - Construction of **dams in Ethiopia** threatens the supply of water to Egypt, which has sparked **Egyptian protests**. South Sudan (following independence in 2011) plans to construct more dams too. With a **vastly growing population** in Egypt, pressure to secure its water sources will increase. More info here

- **The River Jordan** - **Overextraction** in the north of the river in Israel is causing **sinkholes** along the Dead Sea and dropping river levels. The river crosses Israel, Palestine and Syria - a **highly conflicted area** of the world with civil war continuing in Syria and tensions escalating between Palestinians and Israel. Political tensions make collaboration over the management of the river extremely difficult. More info here