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**Knowledge Rich Curriculum Plan**

Geography Y13



| **Unit: Physical Systems and Sustainability: Water Cycles and Insecurity**  |
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| **Learning Sequence/Key Idea**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* |
| EQ1: What are the processes operating within the hydrological cycle from global to local scale?The global hydrological cycle is of enormous importance to life on earth | * The GHC is the circulation of water around the Earth. It is a closed system of linked processes so there are no external inputs or outputs. The only thing that changes is the state in which the water exists.
* The power that drives the cycle comes from two sources: Solar Energy (in the form of heat). Gravitational Energy; causes rivers to flow downhill and precipitation to fall to the ground.
* The cycle involves stores, flows and fluxes. Stores are reservoirs where water is held.
* Stores: these are stocks of water, places where the water is held. For example, the oceans.
* Fluxes: this is the measurement of the rate of flow between the stores.
* Processes: the physical factors which drive the fluxes of water between stores.
* Stores include the atmosphere, cryosphere and oceans.
* The global water budget limits water available for human use and water stores have different residence times; some stores are non-renewable (fossil water or cryosphere losses).
* Residency Time: These are the average times a water molecule with spend in the reservoir or store. Residence times impact on turnover within the water cycle system.
* There is a strong link between residence times and levels of water pollution: stores with a slower turnover tend to be more easily polluted as the water is in situ for a longer length of time.
 | StoreResidency TimeFlux | * Links to GCSE rivers and coasts module. Limited prior knowledge available.
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| **EQ 1**The drainage basin is an open system within the global hydrological cycle | * The drainage basin is a subsystem within the global hydrological cycle. It is an open system with eternal inputs and outputs that cause the amount of water in the basin to vary over time.
* A drainage basin is often referred to as the catchment (the area of land drained by a river and its tributaries).
* The hydrological cycle is a system of linked processes: inputs (precipitation patterns and types: orographic, frontal, convectional) flows (interception, infiltration, direct runoff, saturated overland flow, throughflow, percolation, groundwater flow) and outputs (evaporation, transpiration and channel flow).
* Physical factors within drainage basins determine the relative importance of inputs, flows and outputs (climate, soils, vegetation, geology, relief).
* Humans disrupt the drainage basin cycle by accelerating processes (deforestation, changing land use) and creating new water storage reservoirs or by abstracting water.
* In China groundwater irrigates 40% of farmland and provides 70% of drinking water in the north-west and north. Groundwater dropped by a metre per year between 1974-2000.
* Cloud Seeding: The is the attempt to change the amount or type of precipitation by dispersing substances into the air that serve as cloud condensation nuclei (hygroscopic nuclei).
* China used cloud seeding in Beijing just before the 2008 Olympic Games to create rain to clear the air of pollution.
 | Interception Transpiration Drainage Basin Cloud Seeding | * The GHC is the circulation of water around the Earth. It is a closed system of linked processes so there are no external inputs or outputs. The only thing that changes is the state in which the water exists.
* The cycle involves stores, flows and fluxes. Stores are reservoirs where water is held.
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| **EQ1**The hydrological cycle influences water budgets and river systems at a local scale. | * Water budget: This is the annual balance between inputs (precipitation) and outputs (the channel flow and evaporation).
* We can use the following equation to calculate a water budget: Precipitation (P) = channel discharge (Q) + evapotranspiration (E) ± change in storage (S)
* When there is more than enough water (this is called a positive water balance)
* When there is not enough water (this is called a negative water balance)
* Water budgets are viewed by constructing line graphs. Using the line graphs, you can see:
* There is more input than output and so more water is available. Water runs off into streams, and groundwater levels are topped up.
* Evapotranspiration increases until it is higher than precipitation so water is drawn up from the soil and starts to get used up
* The point where evapotranspiration is highest and precipitation is lowest due to hot weather conditions. River levels fall, plants use up soil moisture and crops need irrigation.
* Soil water is used up and only specially adapted plants survive.
* Precipitation is higher than evapotranspiration so the amount of soil moisture starts to increase again
* Soil is saturated and cannot hold any more moisture. This is also known as field capacity.
* The shape of storm hydrographs depends on physical features of drainage basins (size, shape, drainage density, rock type, soil, relief and vegetation) as well as human factors (land use and urbanisation).
* These factors influence the lag time, peak discharge and potential to cause flooding.
 | Water Budget Hydrograph | * The drainage basin is a subsystem within the global hydrological cycle. It is an open system with eternal inputs and outputs that cause the amount of water in the basin to vary over time.
* A drainage basin is often referred to as the catchment (the area of land drained by a river and its tributaries).
* The hydrological cycle is a system of linked processes: inputs (precipitation patterns and types: orographic, frontal, convectional) flows (interception, infiltration, direct runoff, saturated overland flow, throughflow, percolation, groundwater flow) and outputs (evaporation, transpiration and channel flow).
* Physical factors within drainage basins determine the relative importance of inputs, flows and outputs (climate, soils, vegetation, geology, relief).
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| Enquiry question 2: What factors influence the hydrological system over short- and long-term timescales?Deficits within the hydrological cycle result from physical processes, but can have significant impacts. | * The causes of drought are both meteorological (short-term precipitation deficit, longer trends, ENSO cycles) and hydrological.
* El Nino and La Nina can cause significant changes to temperature and precipitation patterns.
* Evidence can be seen via drought in East Africa and wildfires in California.
* Human activity makes a large contribution to the risk of drought: over-abstraction of surface water resources and groundwater aquifers.
* The impacts of drought on ecosystem functioning (wetlands, forest stress) and the resilience of these ecosystems is large scale, and can be environmentally devastating.
 | MeteorologicalENSO | * Water budget: This is the annual balance between inputs (precipitation) and outputs (the channel flow and evaporation).
* When there is more than enough water (this is called a positive water balance)
* When there is not enough water (this is called a negative water balance)
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| EQ2Surpluses within the hydrological cycle can lead to flooding, with significant impacts for people. | * Meteorological causes of flooding, including intense storms lead to flash flooding, unusually heavy or prolonged rainfall, extreme monsoonal rainfall and snowmelt.
* Human actions that can exacerbate flood risk include: changing land use within the river catchment, mismanagement of rivers, using hard engineering systems.
* Damage from flooding has both environmental impacts (soils and ecosystems) and socio-economic impacts (economic activity, infrastructure and settlement).
 | Flash Flooding | * El Nino and La Nina can cause significant changes to temperature and precipitation patterns.
* The shape of storm hydrographs depends on physical features of drainage basins (size, shape, drainage density, rock type, soil, relief and vegetation) as well as human factors (land use and urbanisation).
* These factors influence the lag time, peak discharge and potential to cause flooding.
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| EQ2Climate change may have significant impacts on the hydrological cycle globally and locally. | * Climate change affects inputs and outputs within the hydrological cycle: trends in precipitation and evaporation.
* Climate change affects stores and flows, size of snow and glacier mass, reservoirs, lakes, amount of permafrost, soil moisture levels, as well as rates of runoff and stream flow.
* Climate change resulting from short-term oscillations (ENSO cycles) and global warming increase the uncertainty in the system; this causes concern over the security of water supplies.
* This can lead to uncertainty over future flood and drought risk.
 | Global Local  | * Stores: these are stocks of water, places where the water is held. For example, the oceans.
* Fluxes: this is the measurement of the rate of flow between the stores.
* Processes: the physical factors which drive the fluxes of water between stores.
* The causes of drought are both meteorological (short-term precipitation deficit, longer trends, ENSO cycles) and hydrological.
* El Nino and La Nina can cause significant changes to temperature and precipitation patterns.
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| Enquiry question 3: How does water insecurity occur, and why is it becoming such a global issue for the 21st century?There are physical causes and human causes of water insecurity. | * The growing mismatch between water supply and demand has led to a global pattern of water stress (below 1,700 m³ per person) and water scarcity (below 1000 m³ per person).
* The causes of water insecurity are physical (climate variability, salt water encroachment at coast) as well as human (over-abstraction from rivers, lakes and groundwater aquifers, water contamination from agriculture, industrial water pollution).
* The finite water resource faces pressure from rising demand (increasing population, improving living standards, industrialisation and agriculture), which is increasingly serious in some locations and is leading to increasing risk of water insecurity.
 | Water Stress Water Insecurity Over-abstraction | * The causes of drought are both meteorological (short-term precipitation deficit, longer trends, ENSO cycles) and hydrological.
* Water budget: This is the annual balance between inputs (precipitation) and outputs (the channel flow and evaporation).
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| There are Consequences and risks associated with water insecurity. | * The causes of and global pattern of physical water scarcity and economic scarcity are due to location and level of development/infrastructure.
* The price of water varies globally due to government policy, nationalisation and availability. Water prices in Venezuela are amongst the highest.
* Water supply is vital for economic development (industry, energy supply, agriculture) and human wellbeing (sanitation, health and food preparation).
* Environmental and economic problems result from inadequate water supply.
* There is potential for conflicts to occur between users within a country, and internationally over local and trans-boundary water sources (Nile, Mekong)
 | Water Scarcity Nationalisation Conflict | * The growing mismatch between water supply and demand has led to a global pattern of water stress (below 1,700 m³ per person) and water scarcity (below 1000 m³ per person).
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| **Unit: Physical Systems and Sustainability: The Carbon Cycle and Energy Security** |
| Enquiry question 1: How does the carbon cycle operate to maintain planetary health?Most global carbon is locked in terrestrial stores as part of the long-term geological cycle. | * The biogeochemical carbon cycle consists of carbon stores of different sizes (terrestrial, oceans and atmosphere), with annual fluxes between stores of varying size (measured in Pg/Gt) rates and on different timescales.
* Most of the earth’s carbon is geological, resulting from the formation of sedimentary carbonate rocks (limestone) in the oceans and biologically derived carbon in shale, coal and other rocks.
* Geological processes release carbon into the atmosphere through volcanic out-gassing at ocean ridges/subduction zones and chemical weathering of rocks.
 | Terrestrial Geological Volcanic Out-Gassing | * The GHC is the circulation of water around the Earth. It is a closed system of linked processes so there are no external inputs or outputs. The only thing that changes is the state in which the water exists.
* The cycle involves stores, flows and fluxes. Stores are reservoirs where water is held.
* Subduction occurs at destructive plate margins.
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| EQ1 Biological processes sequester carbon on land and in the oceans on shorter timescales | * Phytoplankton sequester atmospheric carbon during photosynthesis in surface ocean waters; carbonate shells/tests move into the deep ocean water through the carbonate pump and action of the thermohaline circulation.
* Terrestrial primary producers sequester carbon during photosynthesis; some of this carbon is returned to the atmosphere during respiration by consumer organisms.
* Biological carbon can be stored as dead organic matter in soils, or returned to the atmosphere via biological decomposition over several years.
 | Sequester Decomposition  | * Most of the earth’s carbon is geological, resulting from the formation of sedimentary carbonate rocks (limestone) in the oceans and biologically derived carbon in shale, coal and other rocks.
* Geological processes release carbon into the atmosphere through volcanic out-gassing at ocean ridges/subduction zones and chemical weathering of rocks.
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| EQ1A balanced carbon cycle is important in sustaining other systems but is increasingly altered by human activities. | * The concentration of atmospheric carbon (carbon dioxide and methane) strongly influences the natural greenhouse effect, which in turn determines the distribution of temperature and precipitation.
* Ocean and terrestrial photosynthesis play an important role in regulation the composition of the atmosphere. Soil health is influenced by stored carbon, which is important for ecosystem productivity.
* The process of fossil fuel combustion has altered the balance of carbon pathways and stores with implications for climate, ecosystems and the hydrological cycle.
 | Combustion Carbon Pathway | * Terrestrial primary producers sequester carbon during photosynthesis; some of this carbon is returned to the atmosphere during respiration by consumer organisms.
* Biological carbon can be stored as dead organic matter in soils, or returned to the atmosphere via biological decomposition over several years.
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| Enquiry question 2: What are the consequences for people and the environment of our increasing demand for energy?Energy security is a key goal for countries, most relying on fossil fuels. | * Consumption (per capita and in terms of units of GDP) and energy mix (domestic and foreign, primary and secondary energy, renewable versus non-renewable) vary between LIC’s and HIC’s.
* Access to and consumption of energy resources depends on physical availability, cost, technology, public perception, level of economic development and environmental priorities.
* Energy players (role of TNCs, the Organisation of Petroleum Exporting Countries (OPEC), consumers, governments) have different roles in securing pathways and energy supplies.
 | Energy MixEnergy Players | * The energy mix is the combination of different energy sources used to meet a country's total energy consumption. It's an important part of energy security, and varies from country to country.
* Key players are stakeholders who have a key role in decision making.
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| EQ2Reliance on fossil fuels to drive economic development is still the global norm. | * There is a mismatch between locations of conventional fossil fuel supply (oil, gas, coal) and regions where demand is highest, resulting from physical geography.
* Energy pathways (pipelines, transmission lines, shipping routes, road and rail) are a key aspect of security but can be prone to disruption, especially as conventional fossil fuels deplete (Russian gas to Europe).
* The development of unconventional fossil fuel energy resources (tar sands, oil shale, shale gas, deep water oil) has social costs and consequences for the resilience of fragile environments. (Canadian tar sands, USA fracking, Brazilian deep-water oil.)
 | Conventional Unconventional  | * Access to and consumption of energy resources depends on physical availability, cost, technology, public perception, level of economic development and environmental priorities.
* Energy players (role of TNCs, the Organisation of Petroleum Exporting Countries (OPEC), consumers, governments) have different roles in securing pathways and energy supplies.
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| EQ2There are alternatives to fossil fuels but each has its costs and benefits. | * Renewable and recyclable energy (nuclear power, wind power and solar power) could help decouple fossil fuel from economic growth; these energy sources have costs and benefits economically, socially and environmentally, and in terms of the contribution they can make to energy security. (changing UK energy mix)
* Biofuels are an alternative energy source that are increasing globally; growth in biofuels however has implications for food supply as well as uncertainty over how ‘carbon neutral’ they are. (Biofuels in Brazil).
* Radical technologies, including carbon capture and storage and alternative energy sources (hydrogen fuel cells, electric vehicles) could reduce carbon emissions, but uncertainty exists as to how far this is possible.
 | Biofuel Recyclable Energy | * The development of unconventional fossil fuel energy resources (tar sands, oil shale, shale gas, deep water oil) has social costs and consequences for the resilience of fragile environments. (Canadian tar sands, USA fracking, Brazilian deep-water oil.)
* Consumption (per capita and in terms of units of GDP) and energy mix (domestic and foreign, primary and secondary energy, renewable versus non-renewable) vary between LIC’s and HIC’s.
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| Enquiry question 3: How are the carbon and water cycles linked to the global climate system?Biological carbon cycles and the water cycle are threatened by human activity | * Growing demand for food, fuel and other resources globally has led to contrasting regional trends in land use cover (deforestation, afforestation, conversion of grasslands to farming) affecting terrestrial carbon stores with wider implications for the water cycle and soil health.
* Ocean acidification, as a result of its role as a carbon sink, is increasing due to fossil fuel combustion and risks crossing the critical threshold for the health of coral reefs and other marine ecosystems that provide vital ecosystem services.
* Climate change resulting from the enhanced greenhouse effect may increase the frequency of drought due to shifting climate belts, which may impact on the health of forests as carbon stores. (Amazonian drought events).
 | Ocean Acidification Carbon Sink  | * Phytoplankton sequester atmospheric carbon during photosynthesis in surface ocean waters; carbonate shells/tests move into the deep ocean water through the carbonate pump and action of the thermohaline circulation.
* Terrestrial primary producers sequester carbon during photosynthesis; some of this carbon is returned to the atmosphere during respiration by consumer organisms.
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| There are implications for human well-being from the degradation of the water and carbon cycles. | * Forest loss has implications for human well-being, but there is evidence that forest stores are being protected and even expanded, especially in countries of higher levels of development (environmental Kuznets’ curve model).
* Increased temperatures affect evaporation rates and the quantity of water vapour in the atmosphere with implications for precipitation patterns, river regimes and water stores (cryosphere and drainage basin stores).
* Threats to ocean health pose threats to human well-being, especially in developing regions that depend on marine resources as a food source and for tourism and coastal protection.
 | Implications | * Ocean acidification, as a result of its role as a carbon sink, is increasing due to fossil fuel combustion and risks crossing the critical threshold for the health of coral reefs and other marine ecosystems that provide vital ecosystem services.
* Climate change resulting from the enhanced greenhouse effect may increase the frequency of drought due to shifting climate belts, which may impact on the health of forests as carbon stores. (Amazonian drought events).
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| Further planetary warming risks large-scale release of stored carbon, requiring responses from different players at different scales. | * Future emissions, atmospheric concentration levels and climate warming are uncertain owing to natural factors (the role of carbon sinks), human factors (economic growth, population, energy resources) and feedback mechanisms (carbon release from peatlands and permafrost, and tipping points, including forest dieback and alterations to the thermohaline circulation).
* Adaptation strategies for a changed climate (water conservation and management, resilient agricultural systems, land use planning, flood-risk management, solar radiation management) have different costs and risks.
* Re-balancing the carbon cycle could be achieved through mitigation (carbon taxation, renewable switching, energy efficiency, afforestation, carbon capture and storage), but this requires global-scale agreement and national actions, both of which have proved to be problematic.
 | Adaptation Thermohaline Circulation  | * Renewable and recyclable energy (nuclear power, wind power and solar power) could help decouple fossil fuel from economic growth; these energy sources have costs and benefits economically, socially and environmentally, and in terms of the contribution they can make to energy security. (changing UK energy mix)
* Adaptation: the process of adjustment to actual or expected climate.
* Climate change mitigation means avoiding and reducing emissions of heat-trapping greenhouse gases into the atmosphere to prevent the planet from warming to more extreme temperatures.
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