4.1 INTRODUCTION TO WATER SYSTEMS

Only a small fraction (2.6% by volume) of the Earth's water supply is fresh water. Of this, over 80% is in the form of ice caps and glaciers, 0.6% is groundwater and the rest is made up of lakes, soil water, atmospheric water vapour, rivers and biota in decreasing order of storage size. Irrigation, industrialization and population increase all make demands on the supplies of fresh water. Global warming may disrupt rainfall patterns and water supplies. The hydrological cycle supplies humans with fresh water but we are withdrawing water from underground aquifers and degrading it with wastes at a greater rate than it can be replenished.

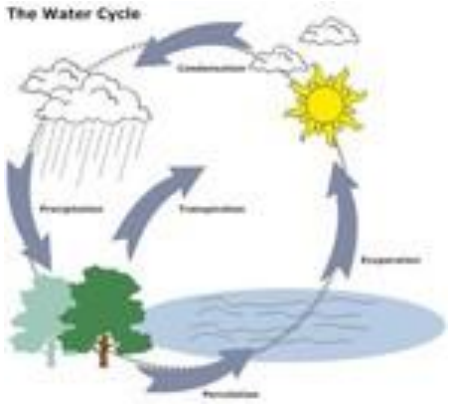
In this unit we will look at the increased demand for fresh water, inequity of usage and political consequences, methods of reducing use and increasing supplies.

Significant ideas:

- The hydrological cycle is a system of water flows and storage that may be disrupted by human activity
- The ocean circulation system (ocean conveyor belt) influences the climate and global distribution of water (matter and energy)

4.1.1 Solar radiation drives the hydrological cycle

- Draw an annotated systems diagram of the hydrological cycle



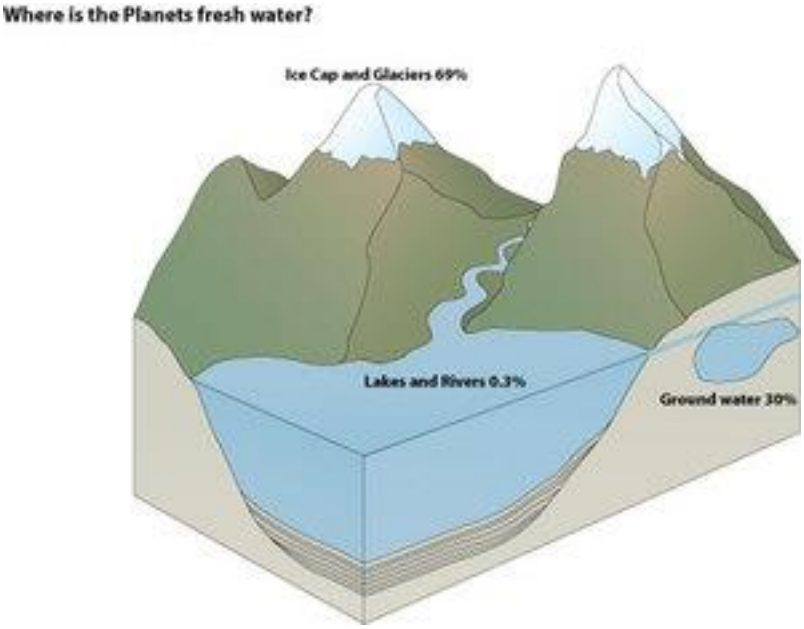
Earth's water is in constant motion as water at the surface exchanges places with the gaseous moisture and water droplets found in the atmosphere. As the sun warms the Earth, liquid water found in lakes and oceans on the planet's surface **evaporates**. Moisture within the atmosphere eventually cools and condenses, until liquid water or snow falls back to the Earth as **precipitation**.

Runoff from rain eventually finds its way back to lakes and oceans, completing the most direct version of the water cycle.

The water cycle is able to move 495,000 cubic kilometers of moisture through the atmosphere each year. Without the sun's heat, there would be no evaporation to power the cycle. The heat of the sun is responsible for the formation of clouds and weather patterns. Without heat from the sun to drive the water cycle, there could be no weather, and all of Earth's water would exist in a frozen state.

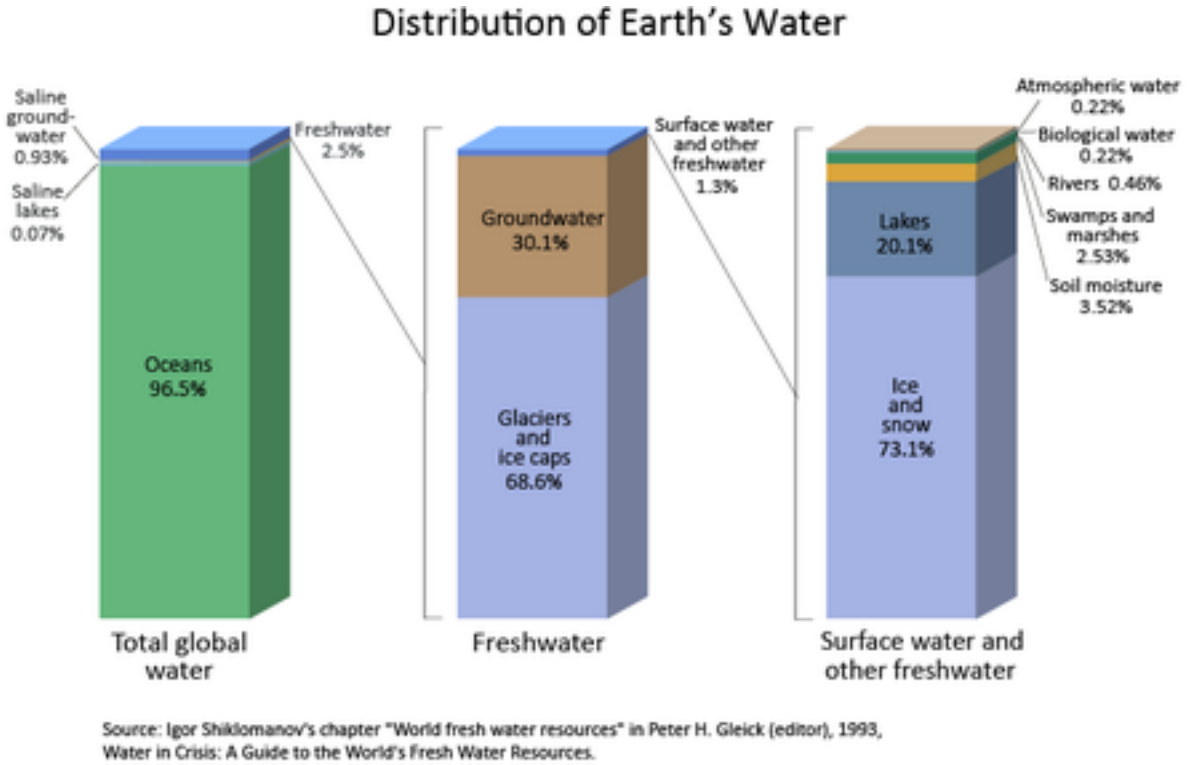
4.1.2 Fresh water makes up only a small fraction (approximately 2.6% by volume) of the Earth's water storages

- Outline the amount of freshwater that is part of the Earth's water storages.



Only a small fraction (2.6% by volume) of the Earth's water supply is fresh water. Of this, over 80% is in the form of ice caps and glaciers, 0.6% is groundwater and the rest is made up of lakes, soil water, atmospheric water vapour, rivers and biota in decreasing order of storage size.

The degree to which water can be looked at as renewable or non-renewable depends on where it is found in the hydrological cycle. Renewable water resources are renewed yearly or even more frequently, however groundwater is non-renewable resource.



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

4.1.3 Storage's in the hydrological cycle include organisms, soil and various water bodies, including oceans, groundwater (aquifers), lakes, rivers, atmosphere, glaciers and ice caps

→ Storages within the hydrological cycle:

The water cycle is dynamic and always active, but that doesn't mean every molecule of water is constantly moving through the system. In fact, water is stored in various parts of the cycle, often referred to as reservoirs. These might be as large as water in the oceans, or, on a smaller scale, water can be 'trapped' in an iceberg or a lake.
Much more water is in storage than actively moving through the water cycle.

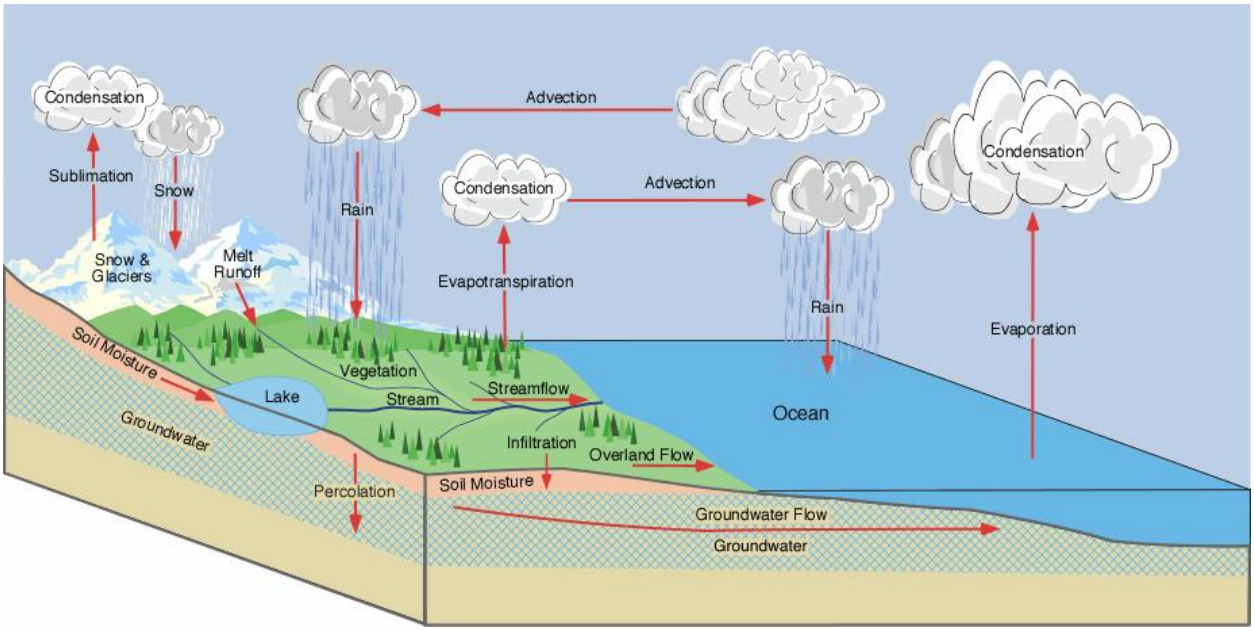
How long water spends in each reservoir is called **'residence time'**. These are some estimated average residence times, but it's important to remember that some water will spend much longer or shorter time than this.

4.1.4 Flows in the hydrological cycle include evaporation, sublimation, evaporation, condensation, convection (wind-blown movement), precipitation, melting, freezing, flooding, surface runoff, infiltration, percolation, and stream-flow or currents

→ Distinguish between transformation flows and transfer flows within the hydrological cycle:

As water moves through the cycle, it changes state from liquid (rainwater, seawater) to gas (water vapour) and back to liquid. Liquid can also freeze and become solid (ice or snow). This natural process removes some of the water's impurities, constantly refilling Earth's fresh water supplies – it is our planet's way of recycling water.

1. **Evapotranspiration** - water evaporates from plants, mainly through their leaves. This gets water vapor back into the air.
2. **Sublimation** - the conversion between the solid and the gaseous phases of matter, with no intermediate liquid stage. Used to describe the process of snow and ice changing into water vapor in the air without first melting into water.
3. **Evaporation** - the process of changing water from liquid to gas. Only fresh water makes its way up to the clouds, as ocean water leaves behind salt, minerals and metals when it evaporates.
4. **Condensation** - the process of changing water from gas to liquid.. As water vapour rises, it becomes cooler and changes back into tiny liquid water droplets. These merge together to form clouds.
5. **Advection** - Transport of an atmospheric property by the wind. This horizontal transport or transfer of a quality such as heat and cold from one point to another. Advective transfers occur either in the oceans by currents of seawater or by large-scale movement in the atmosphere where humidity (atmospheric moisture) is another important property. In both cases a major example is the transport of cold air or water masses from the polar regions to lower latitudes.
6. **Precipitation** - when rain, snow or hail falls from the sky. Depending on the air temperature, water can take a liquid form (rain), or a solid form (snow or hail).
7. **Melting** - the process by which ice or snow changes into water
8. **Freezing** - the process by which water changes from liquid to solid



Source: www.eoearth.org

4.1.5 Human activities such as agriculture, deforestation, urbanization and irrigation have a significant impact on surface runoff and infiltration.

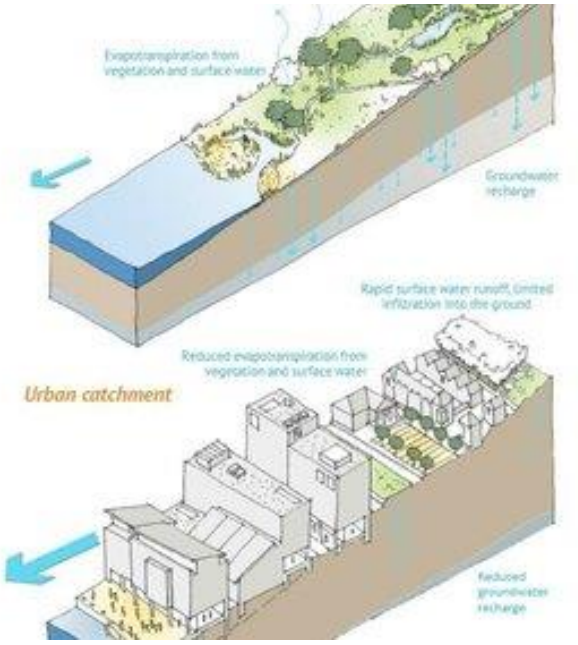
Agriculture has been the cause of significant modification of landscapes throughout the world. Tillage of land changes the infiltration and runoff characteristics of the land surface, which affects recharge to ground water, delivery of water and sediment to surface-water bodies, and evapotranspiration. All of these processes either directly or indirectly affect the interaction of ground water and surface water.

Applications of pesticides and fertilizers to cropland can result in significant additions of contaminants to water resources. Some pesticides are only slightly soluble in water and may attach to soil particles instead of remaining in solution; these compounds are less likely to cause contamination of ground water. Other pesticides, however, are detected in low, but significant, concentrations in both ground water and surface water.

Point sources of contamination to surface-water bodies are an expected side effect of urban development.Point sources of contamination to ground water can include septic tanks, fluid storage tanks, landfills, and industrial lagoons. If a contaminant is soluble in water and reaches

the water table, the contaminant will be transported by the slowly moving ground water. If the source continues to supply the contaminant over a period of time.

Deforestation leads to the decreasing of interception and infiltration, because there are not trees to trap rainfall. It is easily to increase the amount of surface runoff and increase the storm runoff in rivers. The erosive power is enhanced by the running water. Because there are few trees, lesser roots of vegetation bind the soil particles. This makes to the increase of soil erosion. Moreover, sediment yields in rivers increase. The river is silted up. Finally, the river is risk to be flooded. This is the result of the raise of riverbed and reducing carrying capacity of the channel.

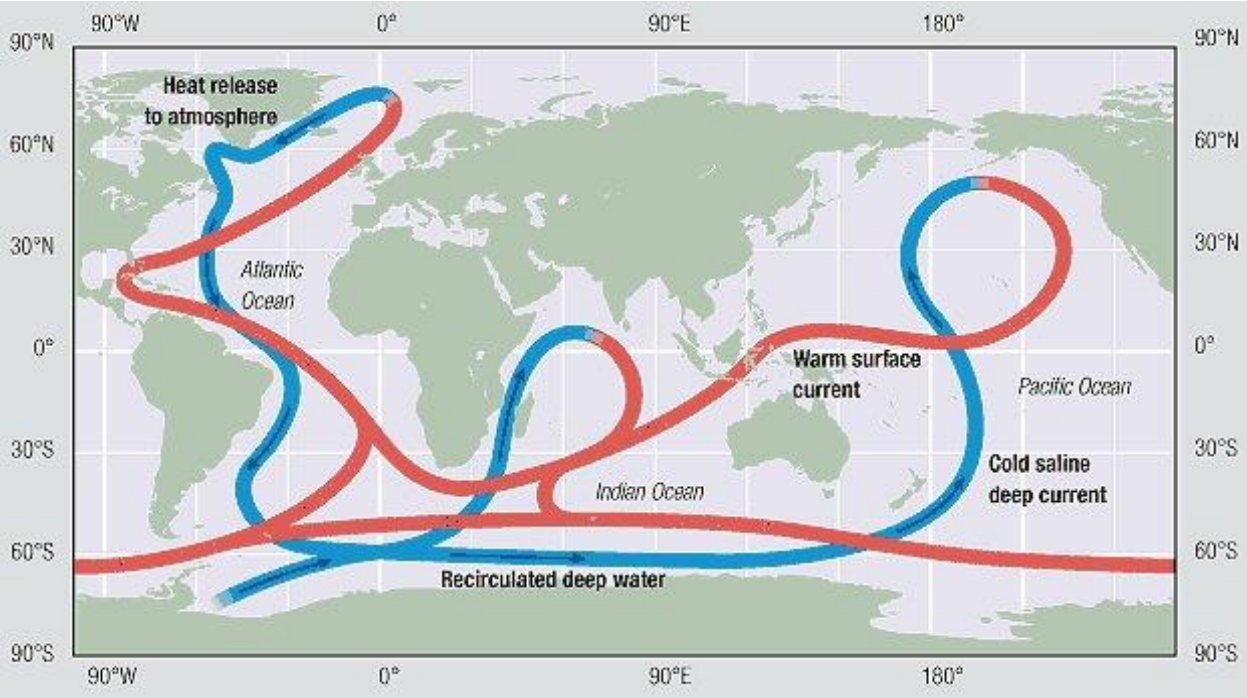


https://www.researchgate.net/figure/Natural-Catchment-vs-Urban-Catchment-wwwtankonyvtarhu_fig2_332044701

4.1.6 Ocean circulation systems are driven by differences in temperature and salinity. The resulting difference in water density drives the ocean conveyor belt, which distributes heat round the world, and thus affects climate

Mass flows of water, or currents, are essential to understanding how heat energy moves between the Earth's water bodies, landmasses, and atmosphere. The ocean covers 71 % of the planet and holds 97 % of its water, making the ocean a key factor in the storage and transfer of heat energy across the globe. The movement of this heat through local and global ocean currents affects the

regulation of local weather conditions and temperature extremes, stabilization of global climate patterns, cycling of gases, and delivery of nutrients and larva to marine ecosystems.



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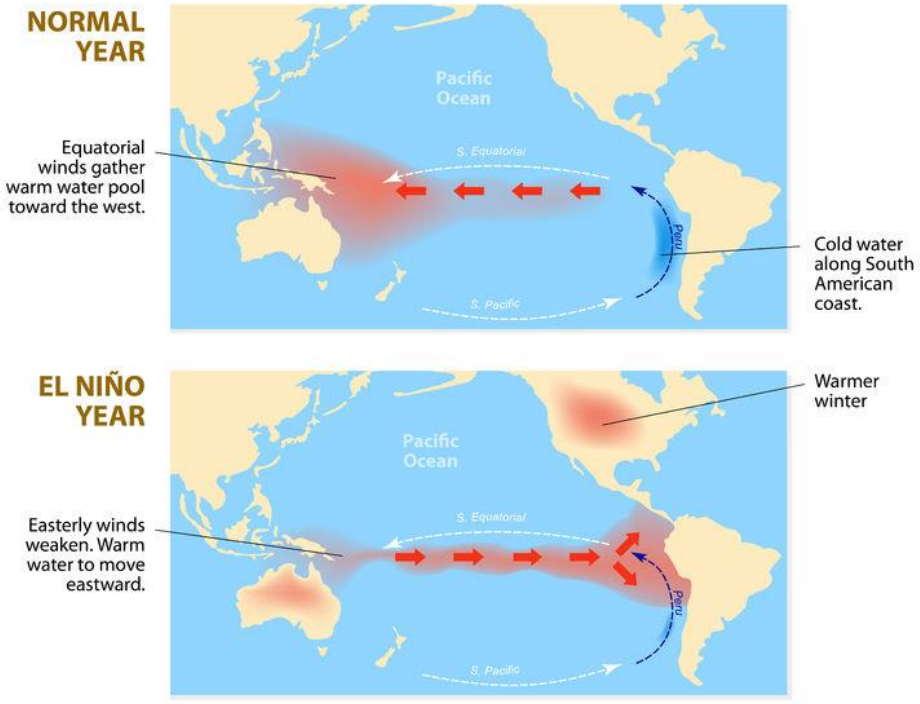

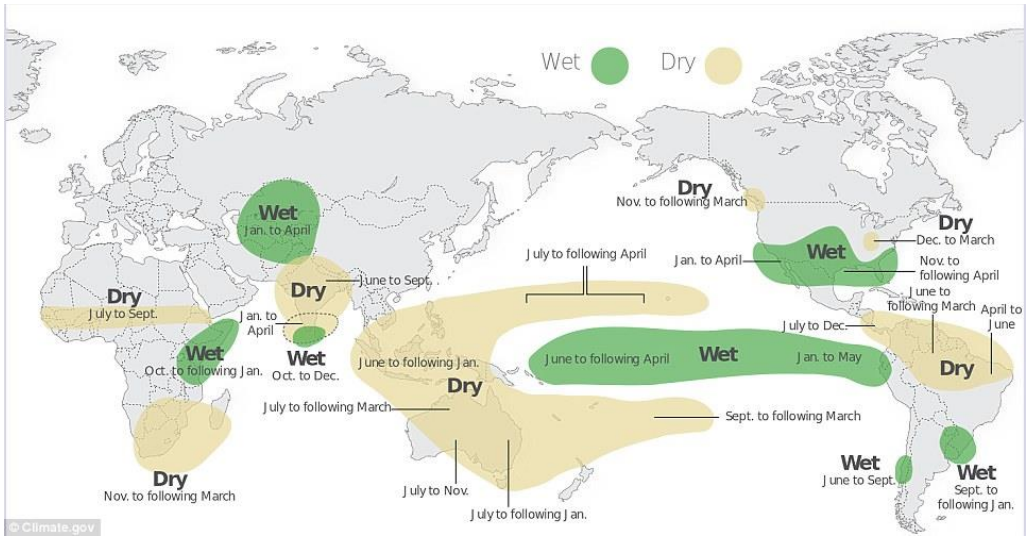

Source: www.dailymail.co.uk

HOMEWORK:

4.1.7 Human impact on the hydrological cycle

Irrigation, industrialization and population increase all make demands on the supplies of fresh water. Global warming may disrupt rainfall patterns and water supplies. The hydrological cycle supplies humans with fresh water but we are withdrawing water from underground aquifers and degrading it with wastes at a greater rate than it can be replenished.

Consider the increased demand for fresh water, inequity of usage and political consequences, methods of reducing use and increasing supplies. A case study must be explored that covers some of these issues and demonstrates either sustainable or unsustainable water use.

The demand of water has increased in both MEDCs and LEDCs, as populations are increasing as well as agriculture changing and expanding industry. MEDCs need more water as they wash more often, water their gardens, and wash their cars.

<u>Managing water:</u>

This can be reached by:

- making new buildings water efficient (rainwater for sanitation and showers)
- fitting new homes with more water-efficient appliances (dishwashers and toilets)
- expand metering to encourage households to use water more efficiently
- in some rural areas drought resistant crops should be planted to reduce the need for irrigation
- organic fertilizers cause less pollution and bio-control measures can be used to reduce crop pests

CASE STUDY

Water shortages in Southwest United States:

Resource managers in the Colorado River Basin are preparing for an unprecedented scenario: By 2015, water in Lake Powell is likely to drop to a level that will trigger mandatory cuts in water deliveries to California, Arizona and Nevada.

About 36 million people in seven states and 20 Native American nations rely on Colorado River water, which is collected in reservoirs like Lake Powell. In addition, diversions from the river irrigate 4 million acres of land, producing about 15 percent of the nation's crops. Water deliveries to California, Arizona and Nevada would be cut by 750,000 acre-feet — about 244,500,000,000 gallons of water. An acre-foot of water is about 325,853 gallons, equal to the average annual household use in the U.S.

If farmers in Arizona and Southern California must find more expensive replacement water, it would affect food prices across the country.

Thoughts?