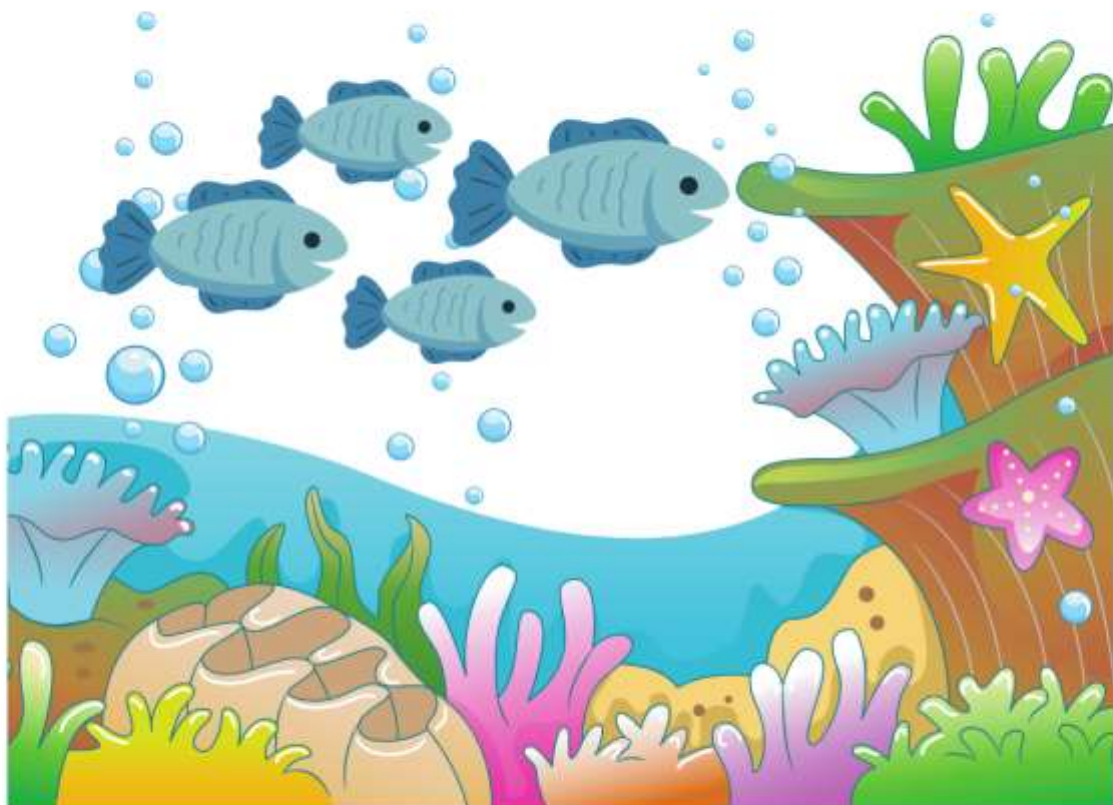




Water and aquatic food production systems and societies



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Water, Aquatic, Food Production Systems And Societies

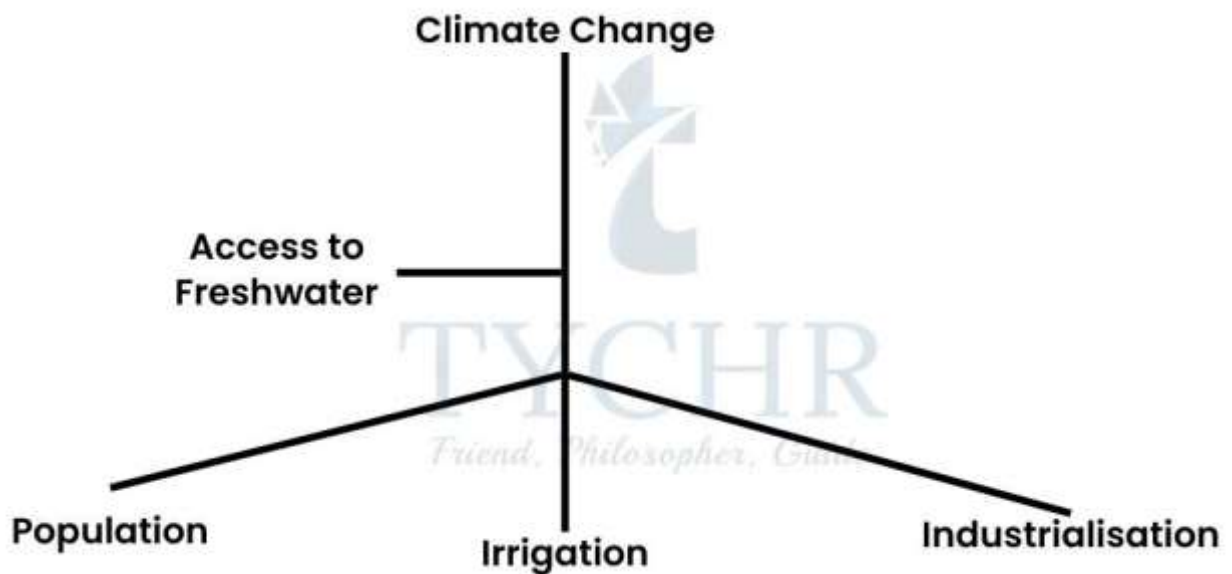


Figure 1 Climate change has a major impact on access to freshwater whose demand increases as population, irrigation and industrialization increases. Figure 1 Climate change has a major impact on access to freshwater whose demand increases as population, irrigation and industrialization increases.

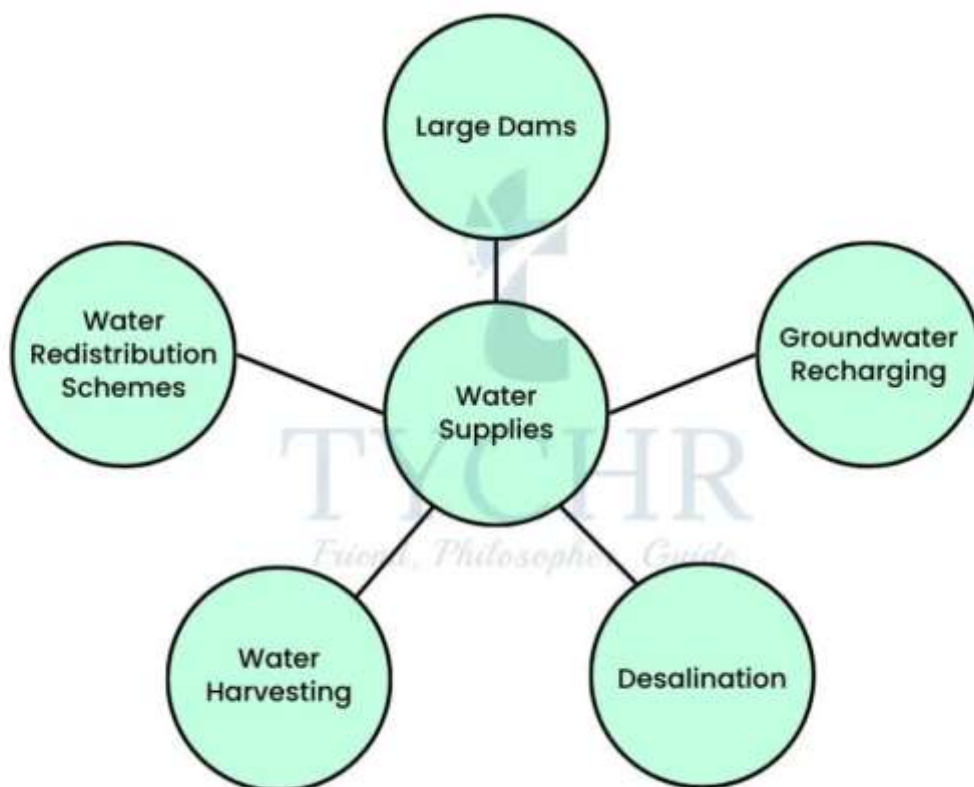


Figure 2 Water Supplies can be enhanced via the mentioned techniques.

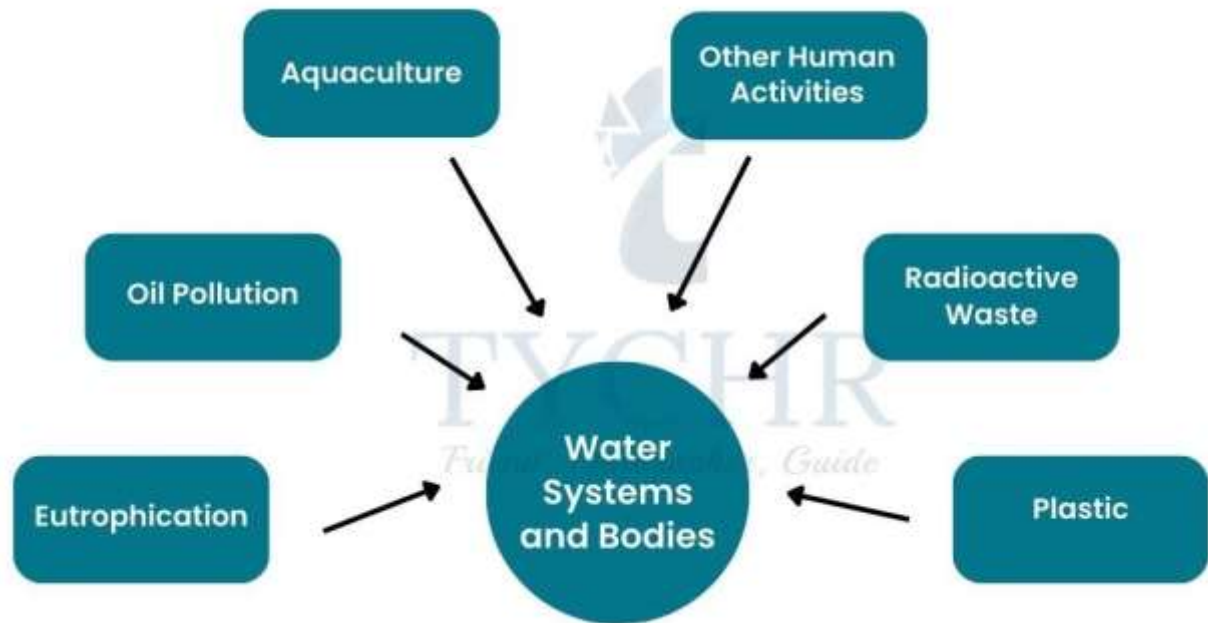


Figure 3 Various Factors that affect water bodies and water systems.

4.1 Introduction To Water Systems

4.1.1 Hydrological Cycle

The hydrological cycle refers to the cycle of water between the biosphere, atmosphere, lithosphere, and hydrosphere. At a local scale—the drainage basin—the cycle has a single input (precipitation, and two big losses (outputs): evapotranspiration (EVT) and runoff. A third output (leakage) may also occur from the deeper subsurface to other basins.

Inputs	Outputs
<p>The main input into the drainage basin is precipitation. This includes all forms of rainfall, snow, frost, hail, and dew.</p> <ul style="list-style-type: none"> • The total amount of precipitation • Intensity 	<p>Runoff: Refers to water flowing over the Earth's surface. It increases with gradient, greater proportion of impermeable surface, reduced vegetation cover, during intense rainfall events and when the soil is saturated.</p> <p>Evapotranspiration: The combined effects of evaporation and transpiration are referred to as evapotranspiration (EVT).</p>

- Type (snow, rain and so on)
- Geographic distribution and variability.
- Other inputs could include irrigation water, water transfer schemes and the use of desalinated water.

Transpiration- is the process by which water vapour escapes from living plants, mainly from the leaves, and enters the atmosphere.

Evaporation- is the process by which a liquid or a solid is changed into a gas. It is the conversion of solid and liquid precipitation to water vapour in the atmosphere.

4.1.2 Flows In The Hydrological Cycle

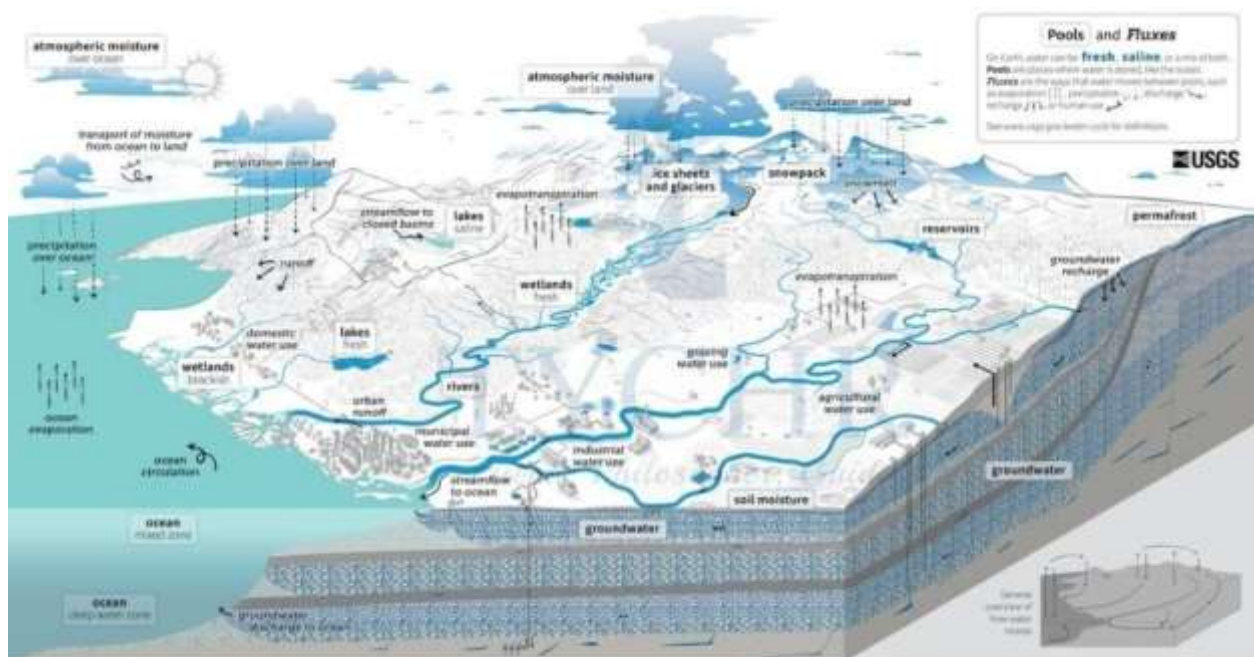


Figure 4 The hydrological cycle as a system.

Infiltration

Infiltration is the process by which water soaks into or is absorbed by the soil.

Overland Flow

It is water that flows over the land's surface. It occurs:

- When precipitation exceeds the infiltration rate.

- when all of the pore spaces in the soil are filled with water and it is saturated.

Base Flow

Base flow relates to the part of a river's discharge that is provided by groundwater seeping into the bed of a river.

Storages in the Hydrological Cycle

- Vegetation- Refers to water that is caught and stored by vegetation.
- Soil- Soil moisture refers to the subsurface water in the soil.
- Aquifers- They are permeable rocks that contain significant amounts of water such as sandstone and limestone. Water moves slowly downwards from the soil into the bedrock – this is known as percolation. The upper layer of this is known as the water table. The water table varies seasonally.
- Cryosphere- The cryosphere is the snow and ice environment. Up to 66% of the world's freshwater is in the form of snow and ice. Some of this may melt seasonally to produce major changes in the hydrological cycle.
- Channel Flow- Channel flow refers to the flow of water in channels such as rivers and streams. Most rivers will eventually transfer water to the ocean, although there are some that drain into inland lakes and seas.

4.1.3 Global Water Stores

Where is Earth's Water?

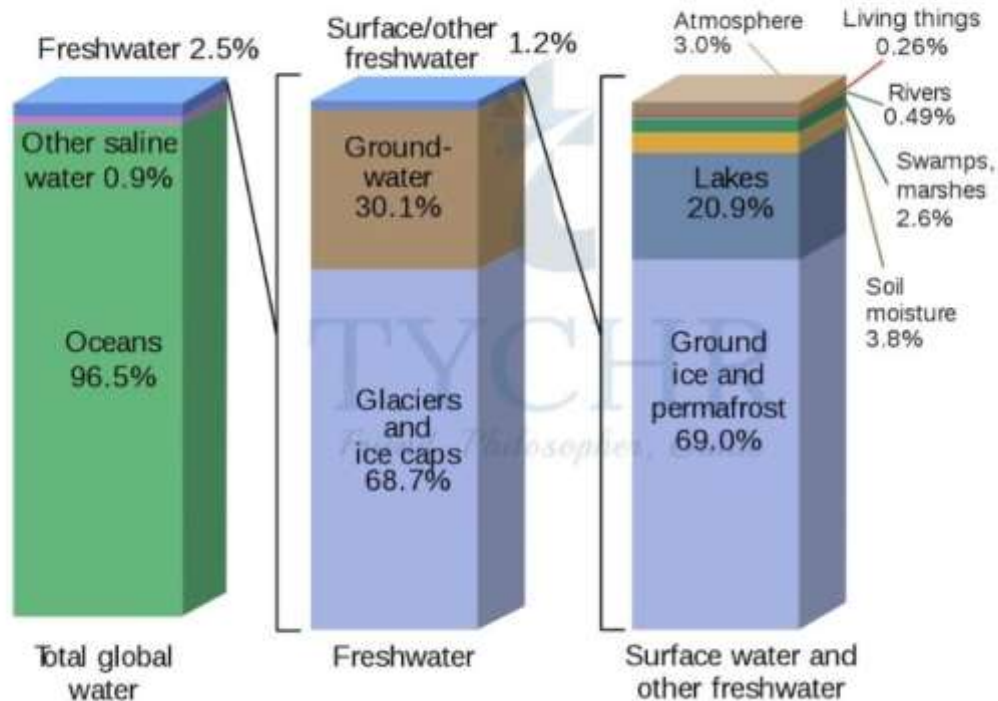


Figure 5 Global Water Store

- The different forms of water in the Earth's water budget are fully recycled during the hydrological cycle but at very different rates.
 - o The time for a water molecule to enter and leave a part of the system is called the turnover time. Turnover time varies enormously between different parts of the system.
- The degree to which water can be seen as a renewable or non-renewable resource depends on where it is found in the hydrological cycle. Renewable water resources are waters that are recycled yearly or more frequently in the Earth's water turnover processes. Thus, groundwater is a non-renewable source of water as turnover time is very long.

4.1.4 Human Influences On The Hydrological Cycle

Agriculture

- Agriculture- decline in infiltration and an increase in overland flow.
- Irrigation- reduces Earth's albedo (reflectivity) by 10%
- Causes changes in precipitation.

The decrease in infiltration and increase in overland flow and soil erosion are due to a number of factors:

- Intensification of agriculture
- Heavier and more powerful machinery.
- Compaction by machines and/or animals
- Field enlargement allowing wind speeds increase.
- Hedgerow removal.

Deforestation

- There are many types of deforestation- total clear felling to selective removal- and the impacts of each type of deforestation varies.
- Following forest regeneration, flood levels and water quality return to pre-removal levels.
- Deforestation is also linked with increases in the sediment load and chemical load of streams.
- Young plants that are growing rapidly take up large amounts of water and nutrients from the soil, thereby reducing the rate of

Urbanization

Building activity:

- Clears vegetation which exposes soil and increases overland flow.
- Increases erodibility.
- Eventually protects the soil with an armour of concrete or tarmac.

Encroachment on the river channel:

- Includes embankments, reclamation, and riverside roads.
- Usually reduces channel width, leading to higher floods.
- Bridges can restrict free discharge of floods and increase levels upstream.

Replacement of vegetated soils with impermeable surfaces:

- Reduces storage and so increases runoff.
- Decreases evapotranspiration because urban surfaces are usually dry.

- Planting of winter cereals, which leaves the soil relatively bare for some months.

overland runoff and the chemical load of streams.

- Increases velocity of overland flow.
- Reduces infiltration and percolation.

4.1.5 Ocean Circulation

Distribution of Oceans and Ocean Currents

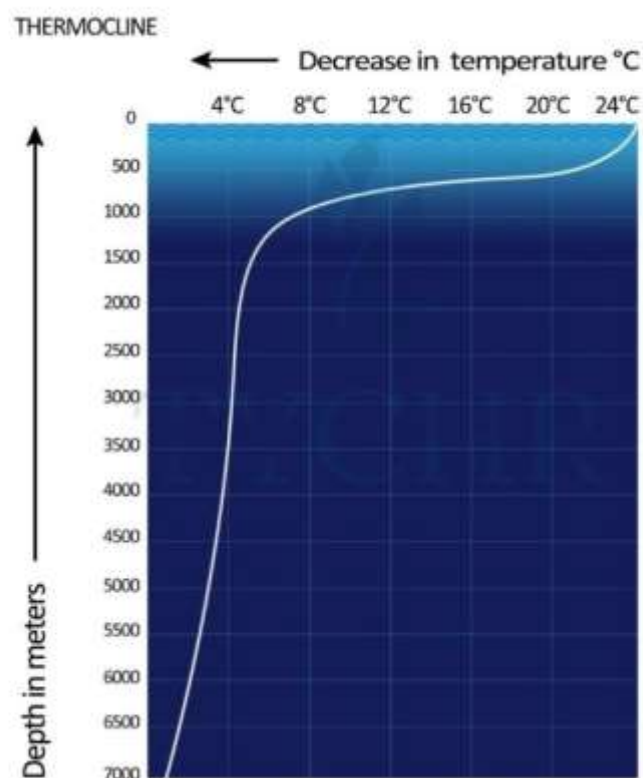


Figure 5 Ocean Temperature and Depth

Oceans regulate climatic conditions through the atmosphere-ocean link. Warm ocean currents move water away from the equator towards the poles, whereas cold ocean currents move water away from the cold regions towards the equator. This deep,

global-scale circulation of the ocean's waters effectively transfers heat from the tropics to colder regions.

Salinity: Average salinity is about 35 parts per thousand (ppt). Concentrations of salt are higher in warm seas, because of the high evaporation rates of the water. The freezing and thawing of ice affects salinity. The thawing of large icebergs decreases salinity, while freezing of seawater increases the salinity temporarily. Salinity levels increase with depth.

Temperature: Temperature varies considerably at the surface of the ocean, but there is little variation at depth.

Density: Temperature, salinity, and pressure affect the density of seawater. High temperature- Less density; high salinity, less density; high pressure, more density. When large water masses with different densities meet, the denser water mass slips under the less dense mass.

Specific Heat Capacity: Heat capacity is the amount of energy it takes to raise the temperature of a body. It takes more energy to heat up water than it does to heat land. However, it takes longer for water to lose heat.

The Importance of Ocean Circulation Systems: Surface ocean currents are caused by the influence of prevailing winds blowing steadily across the sea. The dominant pattern of surface ocean currents (known as gyres) is a roughly circular flow. The pattern of these the current is clockwise in the northern hemisphere and anticlockwise in the southern hemisphere.

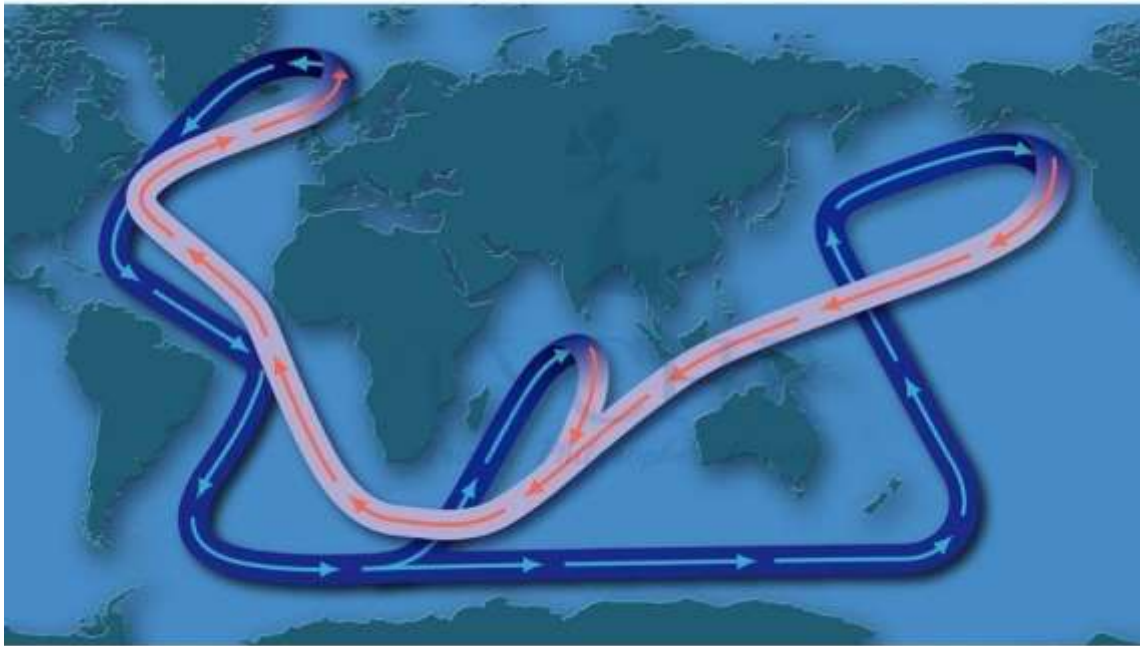


Figure 6 Oceanic Conveyor Belt

4.2 Access To Freshwater



Figure 7 Water Stress around the World (Source: World Economic Forum)

Given the scarcity of freshwater resources, the pressure put on them is great and likely to increase in the future in parts of the world. Without sustainable use it is likely that humans will face many problems. Already 2.6 billion people lack adequate sanitation.

Declining Freshwater Supply

The availability of fresh water is likely to become more stressed in the future. This may be the result of climate change, whereby rising temperatures lead to melting glaciers and increased evaporation. Unequal access to water may cause a conflict between those who have an abundance of water and those who do not.

4.2.1 Changes In Demand And Supply

Unsustainable Demands

More water will be required to produce food for the world's growing population, partly because of changes in diet. Many industries—food, drinks, textiles, and pharmaceuticals industries, need large quantities of water for their products. Irrigation, industrialization, and population increase all demands on the supply of fresh water. Water supplies and rainfall patterns may be altered by global warming. Humans are supplied with fresh water by the hydrological cycle; however, we are draining water from underground aquifers and degrading it with waste at a rate that exceeds its capacity to be replenished.

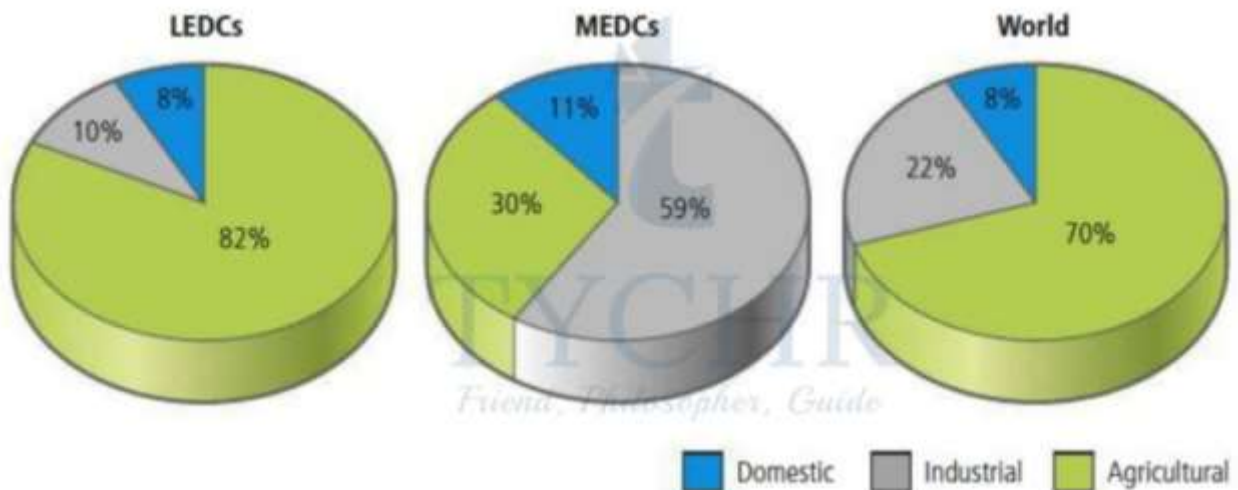


Figure 8 Water Use in Less and More Economically

Concept Link & Recap

- Redistribution is an example of a technocratic environmental value system. The use of engineering and capital to move water from one place to another.
- Water harvesting is an ecocentric environmental value system. It captures rainfall using simple techniques such as water butts to catch and store water.

4.2.2 Enhancing Water Supplies

- Construction of Dams
Advantages of dams- include flood and drought control, irrigation, hydroelectric power, improved navigation, recreation and tourism. Disadvantages- water losses through evaporation, salinization, removal of population, drowning of archaeological excavation sites, seismic stress, channel erosion etc.
- Redistribution schemes
Redistributing water from wetter areas to drier areas.
- Desalination
Desalination removes salt from seawater. This helps produce fresh water fit for human consumption (potable water) and for irrigation.
- Water Harvesting Schemes
Refers to making use of available water before it drains away or is evaporated. Aims to capture and channel a greater share of rainfall

into the soil, and conserve moisture in the root zone where crops can use it.

- **Groundwater Recharge**
It occurs as a result of artificial recharge from irrigation and reservoirs. However, groundwater may be recharged naturally by infiltration of a part of total precipitation at the ground surface; through the banks and bed of surface water bodies.
- **Grey-Water Recycling**
The wastewater that has been produced in homes and offices is known as gray water. It may come from sinks, showers, baths and washing machines, but it does not contain faecal material.

4.2.3 Scarcity And Conflict

Many societies are now dependent primarily on groundwater, which is non-renewable. As societies develop, water needs increase. The increased demand for fresh water can lead to inequity of usage and political consequences.

At the point when water supplies come up short, populations will be compelled to make extreme strides, like mass relocation. War and civil unrest may also result from a lack of water.

The Grand Ethiopian Renaissance Dam

Ethiopia is building Africa's largest dam, on the Blue Nile. This opportunity for Ethiopia is a disaster for Egypt and is building tension in neighboring countries:

- This is no longer enough water to satisfy the growing population and agricultural sector.
- Annual water supply per person has fallen by well over half since 1970.
- The United Nations (UN) has warned of a crisis.
- The stakeholders- the governments of Egypt, Ethiopia and Sudan, as well as the people who will make use of the water.
- Egyptian leaders have been very forceful in the protection of their water supply. This has soured relations with the other countries that share the Nile Basin.

4.3 Aquatic Food Production Systems

4.3.1 Fisheries & Fish Stock

World Fisheries

- There has been a huge increase in the demand for aquatic food resources as the human population grows and diets change.
- World fisheries and aquaculture produced almost 150 million tonnes of fish in 2010. • The world's fish food supply has grown dramatically since 1961.

4.3.2 Fish Stocks

Fish farming continues to grow faster than other major food production sectors.

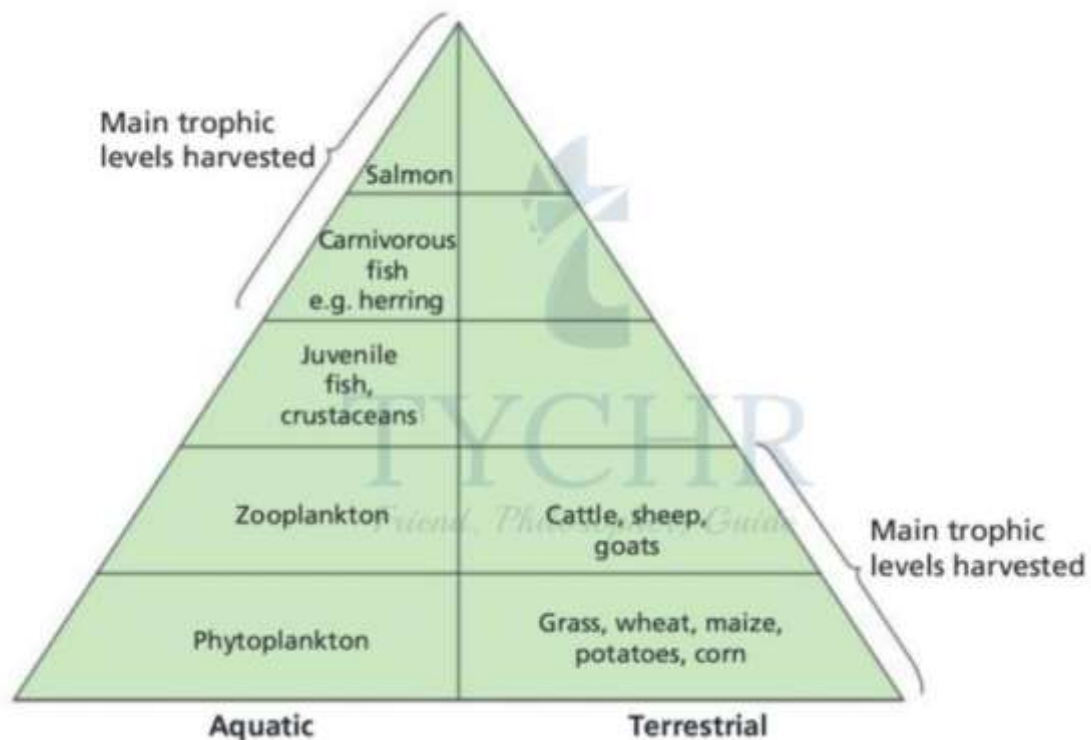


Figure 8 Water Use in Less and More Economically

Terrestrial Systems

- Most food is harvested from relatively low trophic levels (producer and herbivores).
- Systems that produce crops are more energy efficient than those that produce livestock.
- This is because in the former, producers are at the start of the food chain and contain a greater proportion of the Sun's energy than subsequent trophic levels.

Aquatic Systems

- The majority of food is extracted from higher trophic levels with much smaller total storages.
- This is less energy efficient than crop production (i.e. crops capture energy directly from the primary source; fish are several steps away from primary production).

Sustainable Yield

SY is the amount of increase per unit time (i.e. the rate of increase).

Where:

t = the time of the original natural capital

t + 1 = the time of the original capital plus yield,

SY = (total biomass at t + 1) – (total biomass at t)

OR

SY = (total energy at t + 1) – (total energy at t)

The relationship can be simplified as:

SY = (annual growth and recruitment) – (annual death and emigration)

4.3.3 Managing Fisheries

Fisheries Can Be Managed In A Number Of Ways:



- Total allowable catches (quotas for how much can be caught)
- Fishing licences can be issued
- Boat capacity management (only allow a certain number of boats/ size of boats) into an area
- Reducing environmental impact
- Specifying a minimum mesh size on nets
- Closing fishing grounds at different times of the year.

4.3.4 Aquaculture

Aquaculture has increased rapidly since the 1990s. Aquaculture involves raising fish commercially, usually for food.

Issues Around Aquaculture

- Loss of habitats
- Pollution
- Antifouling agents
- Antibiotics which are used to keep fish healthy
- Other medicines added to fish pens such as steroids to improve growth
- Expensive breeding programmes.
- Spread of diseases
- Escaped species (some involving genetically modified organisms).

Environmental Effects

- Salmon are carnivores and need to be fed pellets made from other fish.
- Farmed salmon actually represent a net loss of protein in the global food supply as it takes 2–5 kilograms of wild fish to grow 1 kilogram of salmon.
- Sea lice and diseases are spread from farmed salmon into wild stocks
- Pollution (created by uneaten food, faeces and chemicals used to treat the salmon) contaminate surrounding waters.
- Accidental escape of fish can affect local wild fish gene pools when escaped fish interbreed with wild populations, reducing their genetic diversity and potentially introducing non-natural genetic variations.
- In some parts of the world, fish that have escaped from fish farms threaten native wild fish, as salmon is an alien species.

4.3.5 Biorights



The harvesting of certain species, such as whales and seals, often raises ethical concerns over biorights, the rights of indigenous cultures and international conservation legislation. However, some indigenous communities are permitted to catch a small number of whales for subsistence use.

4.4 Water Pollution

Freshwater and marine pollution sources include run-off, sewage, industrial discharge, solid domestic waste, transport, recreation and tourism, and energy waste. Sources of marine pollution include rivers, pipelines, atmosphere, oil spills, deliberate and accidental discharges from ships, sewage from cruise ships, aquaculture farms, power stations, and industry.

4.4.1 Water Quality

The quality of aquatic systems can be directly evaluated using a wide range of parameters. These include temperature, pH, suspended solids, nitrates, metals, and phosphates.

4.4.2 Biochemical Oxygen Demand

Measuring Biochemical Oxygen Demand

BOD measures the amount of dissolved oxygen needed to break down organic material in water through biological activity. BOD is measured in the following way:

1. Take a sample of water of measured volume.
2. Measure the oxygen level.
3. Place the sample in a dark place at 20°C in an airtight container for 5 days (lack of light prevents photosynthesis which would release oxygen and give an artificially low BOD).
4. After 5 days, re-measure the oxygen level. 5. BOD is the difference be

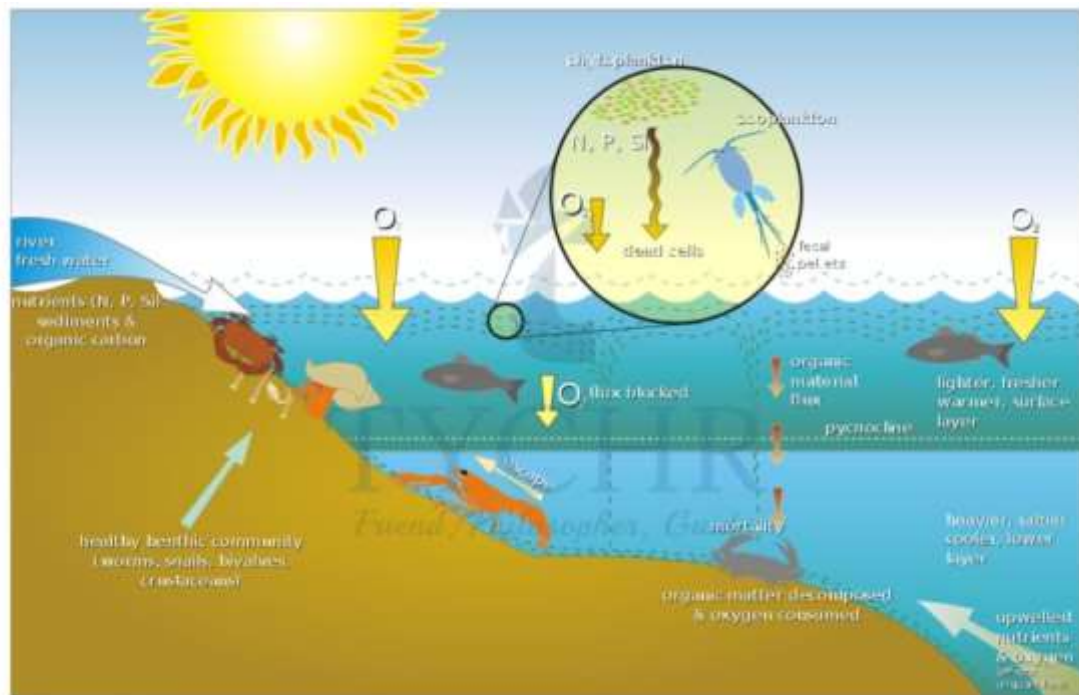
4.4.3 Trent Biotic Index

The decline of indicator species as organic pollution in a river rises is the basis for the Trent Biotic Index. This occurs because the species are unable to tolerate changes in their environment such as decreased oxygen levels or lower light levels. Those species best able to tolerate the existing conditions become abundant – which can lead to a change in diversity.

4.4.4 Eutrophication

Eutrophication refers to the nutrient enrichment of streams, ponds, and groundwater. It is caused when increased levels of nitrogen or phosphorus are carried into water bodies. It can cause algal blooms, oxygen starvation and, eventually, the decline of

biodiversity in aquatic ecosystems.



Did You Know?

Water pollution occurs when natural systems develop a new equilibrium and deviate from the long-term norm. This may result in a loss of biodiversity. Different environmental systems may suggest alternative strategies to manage the situation.

4.4.5 Management Strategies For Eutrophication

There are three main ways of combating eutrophication. These include:

- Using alternative fertiliser and detergent to alter human activities that contribute to pollution
- Regulating and reducing pollutants at the point of emission, for example in sewage treatment plants that remove nitrates and phosphates from waste
- Restoring water quality by pumping mud from eutrophic lakes.

4.4.6 Dead Zones And Red Tides

Dead Zones

Are hypoxic regions on the planet's seas and enormous lakes, which makes these waterways neglect to help the marine life living there. These are areas that are teeming with simple, frequently harmful organisms.

Red Tides

Algal blooms, also known as red tides, are massive concentrations of aquatic microorganisms like protozoans and unicellular algae. They don't always last long and don't cover a lot of the sea's surface, but they are getting bigger and more common: Over 400 locations have been identified as dead zones.



Figure 15 Marine lives at a threat because of Dead Zones.



Figure 13 Dead Zone in the Gulf of Mexico



Figure 15 Marine lives at a threat because of Dead Zones.

4.4.7 Impact Of Waste On The Marine Environment

Oil Pollution

- Shipping is a huge cause of pollution. Ships' burn bunker oil is the dirtiest of fuels, so more carbon dioxide is released and more particulate matter, which may be responsible for about 60,000 deaths each year from chest and lung diseases, including cancer.
- There is evidence, too, that acoustic prospecting for hydrocarbons in these waters may deter or disorientate some marine mammals.

Radioactive Waste

- The nuclear power process, the use of radioisotopes in medical and scientific research, and industrial processes all produce radioactive waste that is also dumped in the oceans.
- The radioactivity of nuclear waste typically lasts for decades.

Plastic

- In 2006, the UN Environment Programme reckoned that every square kilometre of sea held nearly 18,000 pieces of floating plastic.
- As much as 100 million tonnes of plastic waste are believed to be suspended in two distinct gyres in the central Pacific, where most of it was and still is.



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