



NAVODAYA INSTITUTE OF TECHNOLOGY, RAICHUR

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

WATER CONSERVATION & RAIN WATER HARVESTING

Module - 1

Monsoon, its types and behaviour in India:

In India, the monsoon is a seasonal wind pattern characterized by distinct wet and dry periods, with two main types: the southwest monsoon (June-September) bringing heavy rainfall and the northeast monsoon (October-December) primarily impacting the southeastern coast.

Types of Monsoons in India:

- **Southwest Monsoon (June-September):**

- This monsoon is characterized by winds blowing from the southwest, picking up moisture from the Indian Ocean and Arabian Sea.
- It is responsible for the majority of India's rainfall, especially in the western and central regions.
- The southwest monsoon is divided into two branches: the Arabian Sea branch and the Bay of Bengal branch.
- The Arabian Sea branch causes orographic rainfall along the western slopes of the Western Ghats.
- The Bay of Bengal branch moves over the Bay of Bengal, collecting moisture on the way, and strikes the northeastern part of India.

- **Northeast Monsoon (October-December):**

- This monsoon is characterized by winds blowing from the northeast, originating from the Bay of Bengal.
- It primarily affects the southeastern coast, particularly Tamil Nadu and Andhra Pradesh.
- The northeast monsoon is also known as the "winter monsoon" or "retreating monsoon".

Factors Influencing the Indian Monsoon:

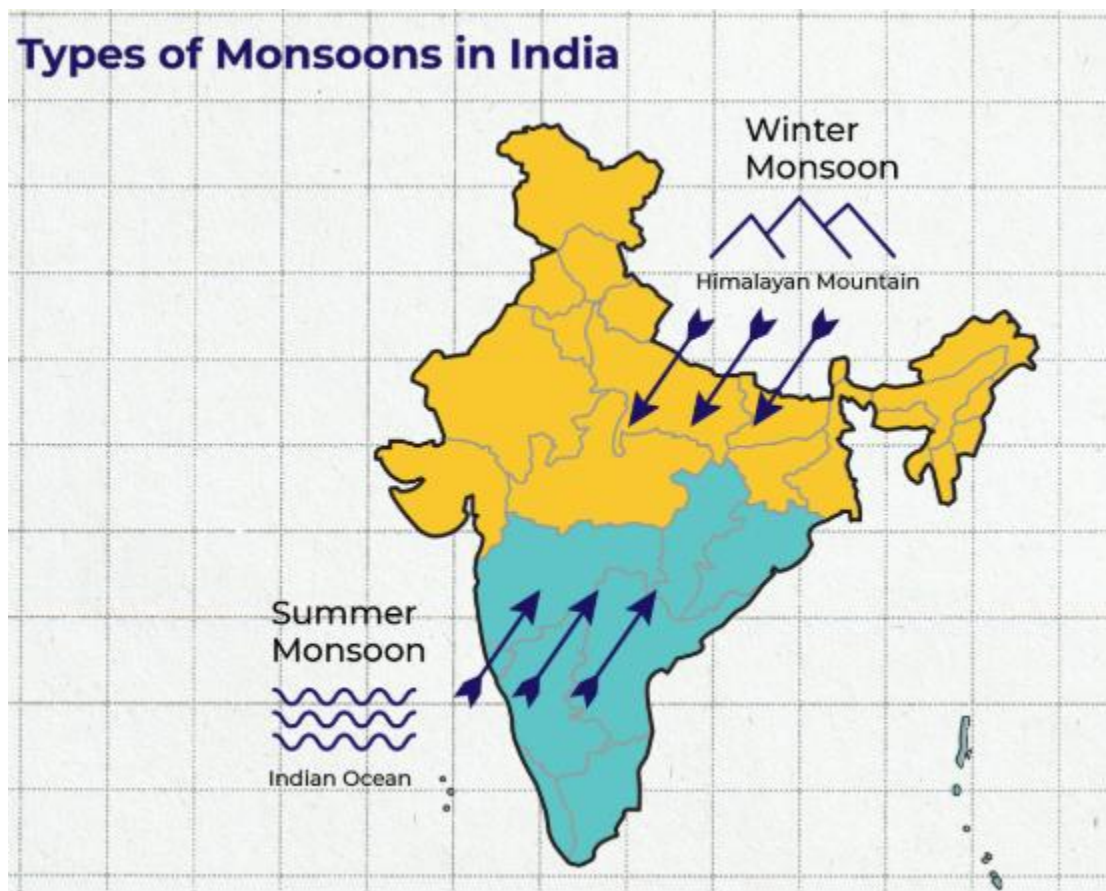
- **Differential Heating of Land and Water:** The landmass of India heats up faster than the surrounding oceans during summer, creating a low-pressure area over the land.
- **Intertropical Convergence Zone (ITCZ):** The ITCZ, a region of low pressure near the equator, shifts northward during the summer, influencing the direction of monsoon winds.
- **Tibetan Plateau:** The high altitude and intense heating of the Tibetan Plateau create a low-pressure area that draws in moisture-laden winds from the Indian Ocean.
- **Topography:** The Himalayas and the Western Ghats act as barriers, influencing rainfall patterns and causing orographic rainfall.
- **Ocean Currents:** The Indian Ocean currents also play a role in the monsoon system, influencing the moisture content of the winds.
- **El Niño-Southern Oscillation (ENSO):** ENSO events, particularly El Niño, can have a significant impact on the Indian monsoon, potentially leading to weaker or stronger monsoons.

Behavior of the Monsoon:

- **Onset:** The southwest monsoon typically begins in early June, with the winds advancing northward and bringing heavy rainfall.
- **Advance:** The monsoon winds advance across the country, reaching different regions at different times.
- **Break:** The monsoon can experience breaks or periods of reduced rainfall, followed by renewed activity.
- **Recession:** The monsoon begins to recede in late September, with the winds shifting towards the northeast.
- **Retreat:** The monsoon winds retreat from the country, marking the end of the rainy season.

Impact of the Monsoon:

- **Agriculture:** The monsoon is crucial for India's agriculture, providing the necessary rainfall for crop cultivation.
- **Water Resources:** The monsoon replenishes rivers, lakes, and groundwater, which are essential for drinking water and irrigation.
- **Economy:** The monsoon has a significant impact on India's economy, affecting agricultural production, trade, and overall economic growth.
- **Floods and Droughts:** While the monsoon brings much-needed rainfall, it can also cause severe flooding in some regions and droughts in others.



Rainfall characteristics and distribution in India:

India's rainfall is characterized by the monsoon system, with the majority (75%) received during the southwest monsoon season (June-September), and exhibits significant spatial and temporal variability.

Rainfall Characteristics:

- **Monsoon System:** India's rainfall is primarily driven by the monsoon system, which brings heavy rainfall during the southwest monsoon season (June-September).
- **Spatial Variability:** Rainfall distribution varies significantly across India, with the highest rainfall occurring in the northeastern regions and the windward slopes of the Western Ghats.
- **Temporal Variability:** Rainfall also varies significantly over time, with the monsoon season bringing the majority of rainfall, while other seasons experience less precipitation.
- **High Rainfall Zones:** Areas like the west coast, Western Ghats, and the sub-Himalayan areas in the northeast receive over 200 cm of rainfall annually, with some parts of the Khasi and Jaintia hills receiving over 1000 cm.

- **Low Rainfall Zones:** Regions like western Rajasthan, Gujarat, and the Deccan Plateau experience less than 50 cm of rainfall annually.
- **Snowfall:** Snowfall is limited to the Himalayan region.

Rainfall Distribution:

- **Northeast India:** This region experiences very high rainfall, with some areas like Mawsynram in the Khasi hills receiving the highest average rainfall in the world.
- **West Coast:** The western coast, particularly the windward side of the Western Ghats, receives heavy rainfall due to the orographic effect.
- **Eastern India:** Most of Eastern India experiences heavy precipitation, with rainfall ranging from 200 to 300 cm.
- **Peninsular India:** The southern peninsula experiences moderate to heavy rainfall, with areas like Tamil Nadu and Kerala receiving significant rainfall.
- **Northern Plains:** The northern plains receive moderate rainfall, with areas like the Ganga plain experiencing rainfall between 100 to 200 cm.
- **Desert and Semi-desert Regions:** The states of Rajasthan, Gujarat, and adjacent areas are classified as desert or semi-desert based on the amount of rainfall they receive.

Onset and withdrawal of effective rains in India:

In India, the monsoon onset, marked by the start of heavy rains, typically begins in early June over the southern peninsula and advances northward, while the withdrawal starts from the northwest around September and from the south by October.

- **Onset:**
 - The southwest monsoon, which brings the majority of India's rainfall, usually reaches the southern tip of the Indian peninsula (Kerala) in early June.
 - The monsoon then advances northward, covering the rest of the country by mid-July.
 - The onset of the monsoon is declared when there's a significant transition in large-scale atmospheric and ocean circulations in the Indo-Pacific region, and at least 60% of designated meteorological stations in Kerala and Lakshadweep record at least 2.5 mm of rain for two consecutive days.
- **Withdrawal:**

- The monsoon starts to withdraw from the northwest region around the first week of September.
- The withdrawal from the southern peninsula occurs by mid-October.
- The withdrawal of the monsoon is characterized by the retreat of the monsoon winds and a decrease in rainfall.

- **Interannual Variation:**

It's important to note that the onset and withdrawal dates of the monsoon can vary significantly from year to year.

- **Importance of the Monsoon:**

The monsoon rains are crucial for India's agriculture, water resources, and overall economy.

Dry spells and Wet spells in India:

In India, rainfall during the monsoon season occurs in spells, with periods of heavy rain (wet spells) interspersed with periods of less rain or no rain (dry spells). These spells vary spatially and temporally, impacting agriculture, water resources, and other sectors.

What are Wet and Dry Spells?

- **Wet Spells:**

Prolonged periods of wet days, often associated with active monsoon conditions, can lead to heavy rainfall and flooding in some areas.

- **Dry Spells:**

Prolonged periods of dry days, also known as "break in monsoon," can lead to drought conditions and water scarcity.

Rainfall Patterns During Monsoon:

- **Seasonal Phenomenon:**

Rainfall in India is a seasonal phenomenon, with the Indian summer monsoon (June-September) bringing the majority of the country's annual rainfall.

- **Spells, Not Continuous Deluge:**

The monsoon rain doesn't fall continuously; instead, it comes in spells of active and break periods.

- **Spatial and Temporal Variations:**

The frequency, duration, and intensity of wet and dry spells vary significantly across different regions and over time.

- **Definition:**

A wet spell is defined as a period of consecutive wet days, and a dry spell is defined as a period of consecutive dry days.

Impacts of Dry Spells:

- **Agricultural Impact:**

Dry spells can lead to moisture stress for crops, potentially causing significant yield losses, especially in rainfed areas.

- **Water Resource Management:**

Understanding the frequency and duration of dry spells is crucial for planning agricultural activities and managing water resources.

- **Drought Conditions:**

Prolonged dry spells can lead to drought conditions, impacting water availability for human and livestock consumption, as well as for irrigation.

Examples of Dry Spells in India:

- **North-Western India:**

This region, being an arid area, experiences longer and less frequent dry spells.

- **Southern Peninsular India:**

During certain periods, the probability of dry spells remains high over the entire country, except for pockets in Jammu & Kashmir and Southern Peninsular India.

- **Impact on Crops:**

Crops like groundnut and pearl millet are particularly vulnerable to dry spells, experiencing higher durations of moisture stress.

Critical dry spells:

- **Definition:**

Dry spells are defined as extended periods of dry days (days with rainfall below a certain threshold) within a season, indicating moisture stress.

- **Impact:**

These spells can lead to reduced crop yields, water scarcity, and economic losses, especially in rain-fed agricultural areas.

- **Causes:**

In India, dry spells can be caused by delayed or early withdrawal of the southwest monsoon, partial or complete monsoon failure, and the lack of strong western disturbances during the winter months.

Water loss from soil:

Water loss from soil occurs primarily through evaporation (direct loss from the soil surface) and transpiration (water uptake by plants and release as vapor through leaves).

- **Evaporation:**

This is the process where water at the soil surface changes from a liquid to a gaseous (vapor) state and is lost to the atmosphere, driven by factors like temperature, wind, and humidity.

- **Transpiration:**

Plants take up water through their roots and release it as water vapor through tiny pores (stomata) on their leaves, a process called transpiration.

- **Evapotranspiration (ET):**

This term combines both evaporation and transpiration to represent the total water loss from the soil and vegetation.

- **Factors Affecting Water Loss:**

- **Soil Type:** Compacted soil loses water more readily than soil with good structure.
- **Temperature:** Higher temperatures lead to increased evaporation.
- **Wind:** Strong winds can accelerate evaporation and transpiration.
- **Humidity:** Lower humidity allows for more water to evaporate.
- **Soil Moisture Content:** Wetter soils evaporate water faster than drier soils.

- **Vegetation:** Plants, including weeds, can significantly increase water loss through transpiration.

- **Minimizing Water Loss:**

- **Mulching:** Covering the soil surface with organic materials (like straw or wood chips) or plastic sheeting can reduce evaporation.
- **Windbreaks:** Structures that reduce wind speed can decrease evaporation and transpiration.
- **Efficient Irrigation:** Applying water only when needed and using methods that minimize evaporation (like drip irrigation) can help conserve water.
- **Weed Control:** Removing weeds reduces transpiration losses.
- **Crop Selection:** Choosing drought-tolerant crops can help reduce water demands.

- **Soil Water Balance:**

Understanding the soil water balance, which considers precipitation, evaporation, and water uptake by plants, is crucial for managing water resources effectively.

Measurement of water loss from soil:

Water loss from soil, or evapotranspiration (ET), can be measured using various methods, including gravimetric analysis, tensiometers, and micro-lysimeters, with ET often expressed in millimeters per day or energy per unit area.

1. Gravimetric Method:

- This method involves weighing a moist soil sample, drying it in an oven, and reweighing to determine the mass of water lost.
- The water content is then calculated as a percentage of the dry soil weight.
- **Formula:** $\text{Water content (\%)} = [(\text{weight of moist soil} - \text{weight of dry soil}) / \text{weight of dry soil}] * 100$

2. Tensiometers:

- Tensiometers are instruments used to measure soil water tension or matrix suction in the unsaturated soil zone.
- They consist of a sealed water-filled tube with a porous ceramic cup at the bottom end, which is inserted into the soil.
- The porous cup allows water to move into or out of the tube, depending on the soil water potential.

3. Micro-lysimeters (MLs):

- MLs are small soil cores installed in bare fields or under crop canopies.
- They are checked daily to detect changes in soil water storage, allowing for direct measurement of soil evaporation.

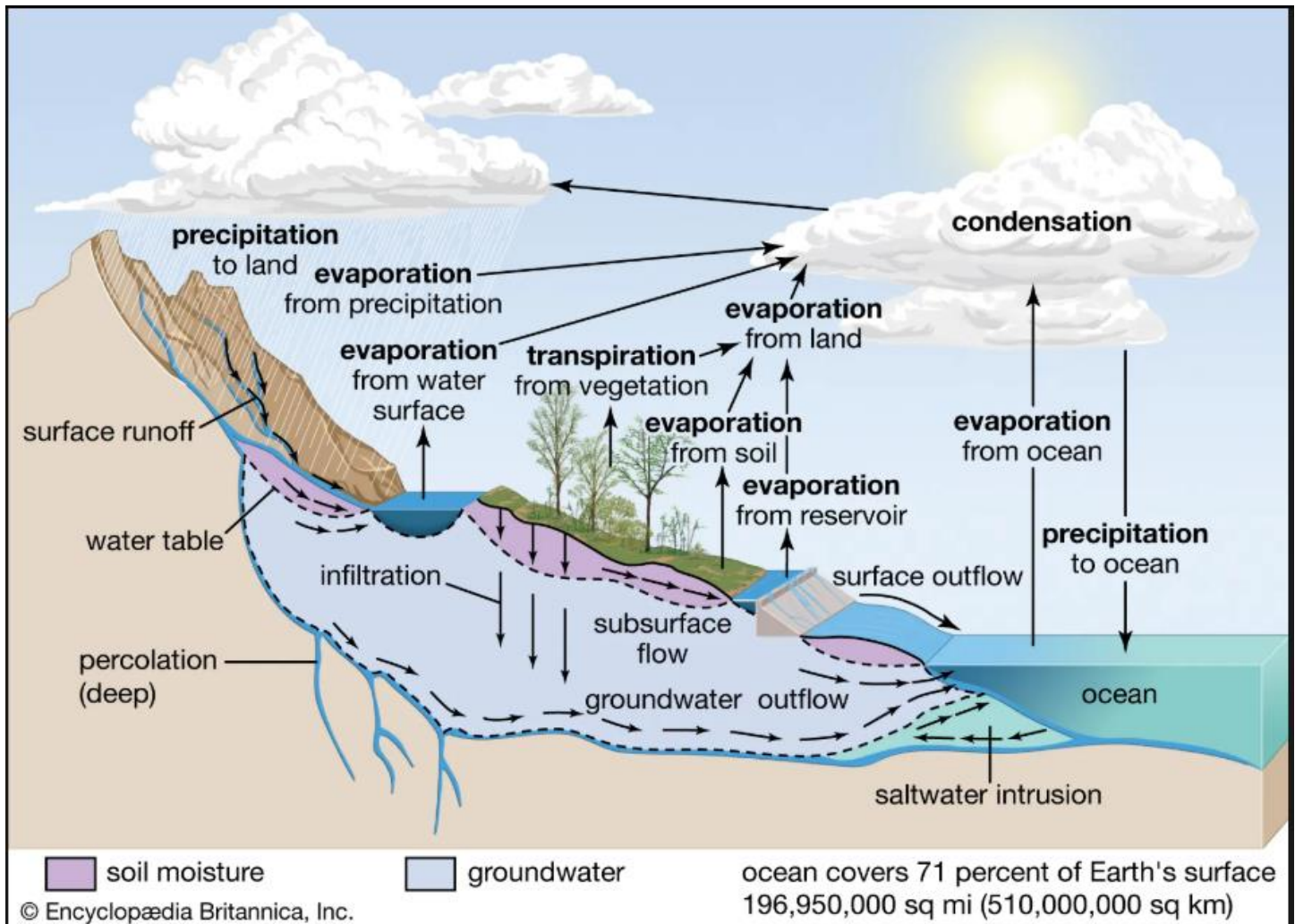
4. Evapotranspiration (ET) Measurement:

- ET accounts for water loss from the soil through both evaporation and transpiration.
- It is often expressed in millimeters per day or energy per unit area (e.g., MJ m⁻² day⁻¹).
- **Example:** 1 mm of water loss corresponds to 10 m³ of water per hectare.

5. Other Considerations:

- **Water Use Efficiency:** This can be measured by the transpiration ratio (total water transpired by a plant to the dry weight of the harvested plant).
- **Crop Water Use Efficiency:** It is the ratio of crop yield (Y) to the amount of water depleted by the crop in the process of evapotranspiration (ET).
- **Field Water Use Efficiency:** It is the ratio of crop yield (Y) to the total amount of water used in the field (WR), which include ET, deep percolation and that used in plant metabolic processes.

Hydrological Cycle:



The hydrological cycle, also known as the water cycle, is the continuous movement of water on, above, and below the Earth's surface, driven by solar energy and gravity, involving processes like evaporation, condensation, precipitation, and runoff.

Key Processes:

- **Evaporation:** The sun's heat causes water from oceans, lakes, rivers, and even soil to turn into water vapor (a gas) and rise into the atmosphere.
- **Transpiration:** Plants release water vapor into the atmosphere through their leaves.
- **Condensation:** As the water vapor rises and cools, it condenses, forming clouds.
- **Precipitation:** When the water droplets in clouds become too heavy, they fall back to Earth as rain, snow, sleet, or hail.

- **Runoff:** Precipitation that falls on land flows over the surface into streams, rivers, and eventually the ocean.
- **Infiltration:** Some precipitation soaks into the ground, becoming groundwater.
- **Sublimation:** Water can also directly change from a solid (ice or snow) to a gas (water vapor) without becoming a liquid, and vice versa.

Importance of the Hydrological Cycle:

- **Water Recycling:**

The hydrological cycle is essential for replenishing Earth's water resources, ensuring a continuous supply of fresh water for all life forms.

- **Climate Regulation:**

The cycle plays a crucial role in regulating Earth's climate by influencing temperature, precipitation patterns, and atmospheric circulation.

- **Ecosystem Function:**

The cycle is vital for supporting ecosystems, as it provides water for plants, animals, and humans, and influences soil moisture and nutrient cycling.

Importance and Issues relating water status:

Water is vital for life, supporting human health, agriculture, and ecosystems, but facing significant issues like scarcity, pollution, and climate change impacts, demanding sustainable management and conservation efforts.

Importance of Water:

- **Human Health:** Clean water is essential for drinking, sanitation, and hygiene, preventing waterborne diseases and improving overall health.
- **Agriculture:** Water is crucial for irrigation, crop production, and food security, supporting livelihoods and economies.
- **Ecosystems:** Water sustains diverse ecosystems, including rivers, wetlands, and oceans, providing habitats for wildlife and regulating climate.
- **Economic Development:** Water resources are vital for industries, energy production, and various economic activities.

Issues Related to Water Status:

- **Water Scarcity:** Growing populations, climate change, and unsustainable water use are leading to water shortages in many regions.

- **Water Pollution:** Industrial discharge, agricultural runoff, and untreated sewage contaminate water sources, posing risks to human health and ecosystems.
- **Climate Change Impacts:** Changing rainfall patterns, droughts, floods, and rising sea levels exacerbate water scarcity and pollution.
- **Inefficient Water Management:** Lack of infrastructure, outdated irrigation techniques, and poor water governance hinder sustainable water use.
- **Water Conflicts:** Competition over water resources can lead to conflicts, both locally and internationally.
- **Sanitation Deficiencies:** Lack of access to adequate sanitation facilities exacerbates water pollution and health risks.
- **Water as a Human Right:** Access to clean water and sanitation is a fundamental human right, yet billions lack access.

Scenario of water in Karnataka: Sources, Geographical distribution, Quality:

Karnataka's water scenario involves seven river basins, with the Krishna and Cauvery rivers being major sources, and a significant reliance on groundwater. Geographically, the state has uneven water distribution, with west-flowing rivers carrying a larger share of surface water, and groundwater quality is a concern due to overuse and contamination.

Water Sources:

- **Surface Water:** Karnataka has seven major river basins: Krishna, Cauvery, Godavari, West Flowing Rivers, North Pennar, South Pennar, and Palar.
- **Rivers:** The Krishna and Cauvery rivers, along with their tributaries, are major sources of surface water.
- **Groundwater:** Groundwater is a significant source of water, particularly for irrigation and domestic use.
- **Tanks:** There are 36,753 tanks in the state with a capacity of about 684518 hectares.

Geographical Distribution:

- **Western Ghats:** The Western Ghats act as a major divide for river basins, with rivers flowing westward into the Arabian Sea and eastward towards the Bay of Bengal.
- **West-Flowing Rivers:** Rivers flowing westward into the Arabian Sea carry 40% of the state's surface water, while those flowing eastward carry 60%.
- **Uneven Distribution:** Karnataka receives erratic rainfall, which is unevenly distributed, leading to water scarcity in certain regions.

- **Drought-Prone Areas:** A significant portion of the state is considered drought-prone, highlighting the challenges of water management.

Water Quality:

- **Groundwater Contamination:** Over-extraction of groundwater has led to quality problems, including the depletion of resources and a drop in water levels.
- **Pollution:** Industrial and agricultural activities contribute to water pollution, impacting both surface and groundwater resources.
- **Water Treatment:** There are efforts to improve water quality through treatment and water harvesting techniques.
- **Rural Water Supply:** A significant portion of the rural population relies on untreated surface water, hand pumps, and wells for their daily needs.
- **Jal Nirmal Yojana:** The Karnataka State Government, as part of its World Bank-assisted Jal Nirmal Yojana program, implemented through the Karnataka Rural Water Supply and Sanitation Agency, took an initiative to adopt a Geographical approach to provide safe drinking water to its rural communities.

Influence of human activities on the water cycle:

1. Deforestation and Land Use Changes:

- **Reduced Vegetation:**

Trees and other vegetation play a crucial role in the water cycle by absorbing water, releasing it into the atmosphere through transpiration, and preventing soil erosion. Deforestation, therefore, reduces these natural processes, leading to:

- **Decreased Evapotranspiration:** Less water is returned to the atmosphere, potentially leading to drier conditions.
- **Increased Runoff:** With less vegetation to absorb rainfall, more water flows over the surface, increasing the risk of flooding and reducing groundwater recharge.
- **Soil Erosion:** Loss of vegetation cover exposes the soil to erosion, which can lead to sedimentation of water bodies and decreased water quality.

- **Urbanization:**

The expansion of urban areas, with their impervious surfaces (roads, buildings, etc.), also disrupts the water cycle:

- **Reduced Infiltration:** Impervious surfaces prevent rainwater from seeping into the ground, reducing groundwater recharge.
- **Increased Runoff:** Rainwater flows directly off impervious surfaces, leading to increased runoff and flooding.

- **Water Pollution:** Urban runoff can carry pollutants (e.g., chemicals, sediments, sewage) into water bodies, degrading water quality.

2. Agricultural Practices:

- **Irrigation:**

While essential for food production, irrigation can have significant impacts on the water cycle:

- **Water Depletion:** Irrigation can deplete groundwater and surface water resources, leading to water scarcity in some regions.
- **Waterlogging and Salinization:** Excessive irrigation can lead to waterlogging (saturation of soil) and salinization (accumulation of salts in the soil), making land infertile.
- **Pollution:** Agricultural runoff can carry fertilizers, pesticides, and other chemicals into water bodies, causing pollution and harming aquatic ecosystems.

- **Deforestation for Agriculture:**

Clearing forests to create farmland can have the same negative impacts as deforestation mentioned above, leading to decreased water availability and increased runoff.

3. Industrial Activities:

- **Water Withdrawal:**

Industries, especially those involved in energy production (e.g., power plants) and manufacturing, require large amounts of water for cooling, processing, and other operations.

- **Pollution:**

Industrial wastewater can contain toxic chemicals and heavy metals, which can contaminate water bodies and harm aquatic life.

- **Climate Change:**

Burning fossil fuels for industrial processes contributes to greenhouse gas emissions, which can lead to global warming and changes in precipitation patterns.

4. Other Human Activities:

- **Dam Construction:**

Dams can alter the flow of rivers and create reservoirs, which can have both positive (water storage, hydropower) and negative (habitat destruction, altered water flow) impacts on the water cycle.

- **Groundwater Pumping:**

Overpumping groundwater can lead to aquifer depletion, subsidence (sinking of the land surface), and saltwater intrusion into freshwater aquifers.

- **Waste Disposal:**

Improper waste disposal can contaminate groundwater and surface water, leading to water pollution and health problems.

Surface water resources:

Surface water resources are the water found on the Earth's surface in bodies like rivers, lakes, wetlands, and oceans, vital for human and ecological needs, and replenished by precipitation.

- **Definition:**

Surface water refers to water found on the Earth's surface, including rivers, streams, creeks, lakes, wetlands, and reservoirs.

- **Importance:**

Surface water resources are crucial for various purposes, including drinking water, irrigation, industrial uses, and supporting ecosystems.

- **Examples:**

- **Natural:** Rivers, streams, lakes, wetlands, and oceans.
- **Human-made:** Reservoirs, canals, and artificial ponds.

- **Replenishment:**

Surface water is naturally replenished by precipitation (rain, snow, etc.) and lost through evaporation, discharge to oceans, and groundwater recharge.

- **Hydrologic Cycle:**

Surface water plays a key role in the hydrologic cycle, which involves the movement of water between the Earth's surface, atmosphere, and groundwater.

- **Surface Water vs. Groundwater:**

Surface water is distinct from groundwater, which is water found beneath the Earth's surface in aquifers.

- **Water Quality:**

The quality of surface water is important, and it can be affected by pollution and contamination.

- **Water Management:**

Effective management of surface water resources is crucial for ensuring sustainable water supplies and protecting ecosystems.