WATER CONSERVATION AND RAIN WATER HARVESTING
(BCV654A)

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COURSE OBJECTIVES

- Appreciate basic concepts of Water and its importance.
- Learn elementary knowledge of ground water.
- Conceptually learn various theories related to Groundwater recharge.
- Study about Subsurface investigation of Ground water.

SYLLABUS

MODULE 1:

Water and its importance Monsoon- types and behavior in India, rainfall — characteristics and distribution, onset and withdrawal of effective rains, dry spells and wet spells, critical dry spells, water loss from the soil, measurement and factors, hydrological cycle, Importance and issues relating water status Scenario of water in Karnataka: sources, geographical distribution, quality. Water (hydrological) cycle, influence of human activity on the water cycle, Surface water resources.

MODULE 2:

Elementary knowledge of ground water: General aquifer. Water quality" and its impact on human beings. Water harvesting: need, principles of water harvesting, general water harvesting methods - rain water harvesting - methods, classes, benefits, approach, rooftop rainwater harvesting, subsurface barrier/dykes, farm ponding, etc mostly used in rural areas.

MODULE 3:

Groundwater recharge: Factors affecting groundwater recharge, Revival of traditional techniques for water harvesting. Calculation of available rain water for harvesting. Preparation of suitable technical drawing and design of rain water harvesting structure.

MODULE 4:

Elementary conservation of water: Importance, knowledge regarding conservation/saving of water in daily use, in agriculture, in industries. Water Conservation strategies- Limiting the consumption, Reuse and recycling, Elimination of losses, Pollution prevention.

MODULE 5:

Subsurface investigation of Ground water: General, geophysical methods and its importance. Present law regarding water management Water footprints- blue water footprint, green water footprint, grey water footprint. Sustainability assessment.

TEXTBOOKS

1. Ground water Hydrology, David K Todd & Larry W Maya, Edition 1980,WiIey India Specifications
2. Hydrology, H M Ranganath, Forth edition 1990, New age publications.
3. Rain water Harvesting, P K Singh, and second edition 2009, Macaillan India ltd.
4. Ground water Prospecting & Management, H P Patra, Second edition 2010,Springer publication.

Continuous Internal Evaluation (CIE)

1. Three Unit tests will be conducted for 40 marks and will be reduced to 25 marks (20*2 = 40 marks).
2. Assignments (2)/ Quiz/ Group Discussion/ Seminar/ Mini Project – Any of the 2 has to be conducted for 15 marks each.
3. 10 Marks for Certificate Exams

Total CIE Marks = 1 + 2 + 3= 25 + 15 + 10 = 50

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Semester End Examination (SEE)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.

* The students have to answer 5 full questions, selecting one full question from each module.

Water and its Importance

Water is essential for life and plays a crucial role in the survival of all living organisms. Its importance is vast and can be summarized in several key areas:

1. **Supports Life:**

Hydration: Water is vital for maintaining hydration, which is essential for the proper functioning of cells, tissues, and organs.

Cell Function: Water makes up about 60% of the human body, and it helps in processes like nutrient transport, waste removal, and temperature regulation.

2. **Regulates Temperature:**

Thermoregulation: Water helps to regulate body temperature through sweating and evaporation. This keeps organisms from overheating in hot climates and helps maintain internal balance.

3. Facilitates Metabolism: Chemical Reactions: Water is a medium in which many biochemical reactions take place, including digestion, energy production, and protein synthesis.

4. Cleansing and Detoxification: Waste Removal: Water is critical in the excretion of waste from the body, mainly through urine, but also through sweat and breathing. It helps to flush out toxins from the body.

5. Transportation:

Blood Circulation: Water is a primary component of blood and helps in the transport of nutrients, oxygen, and hormones to different parts of the body. Nutrient Absorption: It is also essential for the absorption of nutrients in the digestive system.

6. Agriculture and Food Production: Crop Growth: Water is essential for the irrigation of crops and supports food production globally. Without sufficient water, crops cannot grow, leading to food shortages.

7. Ecosystem Balance: Habitats for Wildlife: Water bodies like rivers, lakes, and oceans provide ecosystems for aquatic animals and plants, which are integral to biodiversity.

8. Industrial Use: Manufacturing: Water is a key component in various industrial processes, from power generation to food production and textiles. Cooling: In many industries, water is used for cooling machinery and preventing overheating.

9. Public Health:

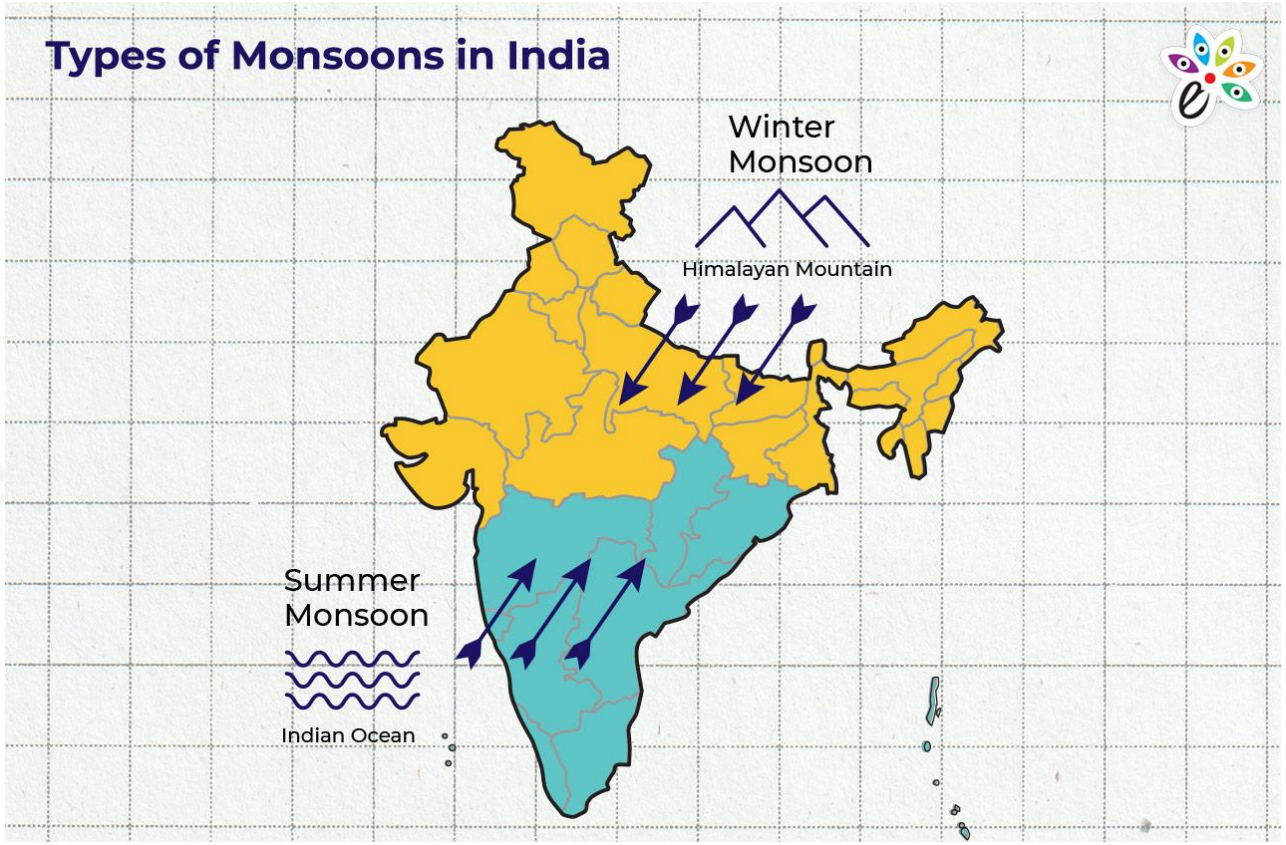
Clean Drinking Water: Access to clean water is essential for preventing waterborne diseases. It plays a crucial role in public health by ensuring safe hygiene and sanitation.

Distribution of water on Earth

- Over 70% of our Earth's surface is covered by water (we should call our planet "Ocean" instead of "Earth"). Although water is seemingly abundant, the real issue is the amount of fresh water available.
- 97.5 % of all this water is salt water, leaving only 2.5 % as fresh water
- Nearly 70% of that fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater not accessible to human use.
- < 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human uses. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow

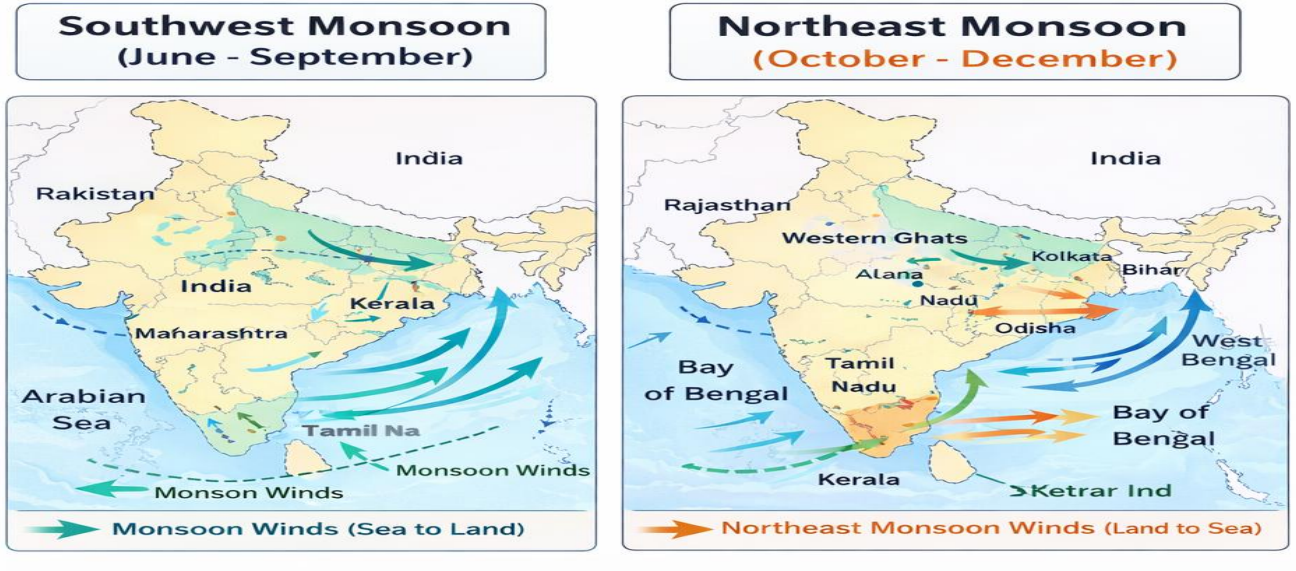
Monsoon- types and behavior in India

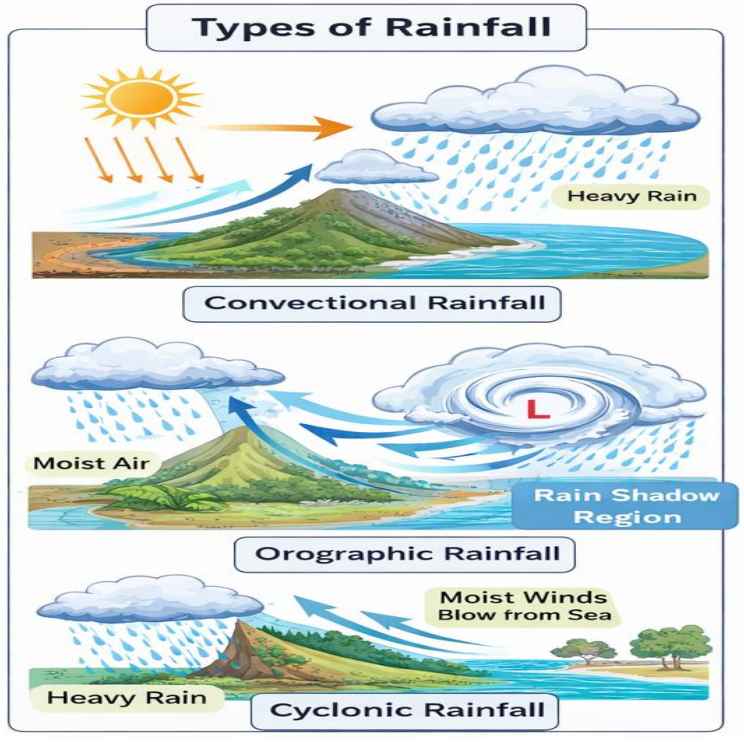
- A monsoon is a seasonal pattern of dominant winds that exhibits a noticeable change in direction, resulting in discrete periods of precipitation and drought in the impacted areas. The word is most frequently connected to the heavy rainfall patterns accompanying the seasonal reversal of winds in tropical and subtropical regions.
- The Southwest (summer) monsoon and the Northeast (winter) monsoon are the two main monsoon kinds that affect India. Every one of them is essential to the nation's environment,



Rainfall — Characteristics and distribution

Rainfall in India varies significantly across different regions, influenced by several factors such as geography, altitude, distance from the sea, and wind patterns.





1. Southwest Monsoon (June to September)

This is the primary monsoon in India and brings the majority of the annual rainfall. It is the most important for agriculture and water resources in the country.

- **Origin**: The winds come from the southwest, driven by the differential heating of land and ocean. The Indian Ocean and the Arabian Sea play a crucial role in gathering moisture, which is then carried inland.
- **Behavior**:
  - It arrives in the southern part of the country (Kerala) in early June and gradually moves northwards.
  - By mid-July, it reaches the northern plains and the Himalayas, bringing heavy rainfall to most of the country.
  - The western coast (especially Kerala, Maharashtra, Gujarat) and the Himalayan foothills receive the heaviest rainfall.
  - Areas like Rajasthan, Punjab, and parts of Uttar Pradesh experience relatively lesser rainfall.
- **Rainfall Distribution**:
  - The Western Ghats and the northeastern regions get intense rainfall (up to 5000 mm in some areas), whereas the

2. Northeast Monsoon (October to December)

This monsoon affects the southeastern coast of India, particularly Tamil Nadu, Andhra Pradesh, and parts of Kerala.

- **Origin:** The winds come from the northeast, influenced by the retreating southwest monsoon and the shifting of the Inter-Tropical Convergence Zone (ITCZ).
- **Behavior**:
  - The northeast monsoon is not as intense or widespread as the southwest monsoon.
  - It is primarily confined to the southeastern coastal areas of India. It typically starts around October and continues into December.
- **Rainfall Distribution:**
  - Tamil Nadu, Andhra Pradesh, and parts of Kerala receive substantial rainfall.
  - The rest of the country, especially the central and northern regions, experience relatively dry conditions during this period.

Characteristics of Rainfall in India

1. Seasonal Variations:

• **Monsoon Rainfall**: The most significant rainfall in India occurs during the **Southwest Monsoon (June to September)**. This is the primary rainy season, contributing around **75-90%** of India's annual rainfall.

• **Northeast Monsoon (October to December)**: This brings additional rainfall to the southeastern coastal regions, though it is less intense and widespread than the southwest monsoon.

• **Winter Rainfall**: During the **winter months** (December to February), rainfall is generally low, except in the northwest (Rajasthan and Punjab) where **western disturbances** bring light rain and snow.

• **Summer Showers**: Short, localized rainfall often occurs during the **pre-monsoon season (March to May)** due to intense heat, creating conditions for thunderstorm and convective rain.

Characteristics of Rainfall in India

2. Intensity and Duration:

- Heavy Rainfall: Some regions, like the Western Ghats and Northeastern India, receive heavy rainfall due to their proximity to the coast and orographic factors (rainfall caused by the windward side of mountains).
- Light Rainfall: Interior areas, especially in the northwest (Rajasthan), tend to experience lighter, more sporadic rainfall.

3. Irregular Distribution: Rainfall in India is highly uneven in both space and time, meaning some areas may receive abundant rainfall, while others may face severe droughts or irregular rainfall patterns.

Distribution of Rainfall in India

1. Areas Receiving Heavy Rainfall:

• **Western Ghats** (Kerala, Karnataka, Goa, Maharashtra): The **windward slopes** of the Western Ghats receive extremely heavy rainfall due to the southwest monsoon winds. Some places, like **Mawsynram** in Meghalaya, are among the wettest on Earth, with annual rainfall exceeding **11,000 mm**.

• **Northeastern India** (Assam, Arunachal Pradesh, Nagaland, Meghalaya): This region, especially **Cherrapunji** and **Mawsynram**, receives very heavy rainfall during the monsoon due to the orographic effect.

•**Coastal Areas** (Konkan coast, parts of Odisha, and West Bengal): These areas experience consistent rainfall from the southwest monsoon.

2. Areas Receiving Moderate Rainfall:

• **Himalayan Foothills**: Regions like **Uttarakhand** and **Himachal Pradesh** receive moderate rainfall due to the southwest monsoon and winter western disturbances.

• **Eastern India** (West Bengal, Jharkhand, Bihar): These areas receive moderate rainfall during the monsoon season but not as heavy as the coastal regions or the Ghats.

Distribution of Rainfall in India

3. Areas Receiving Light to Very Light Rainfall:

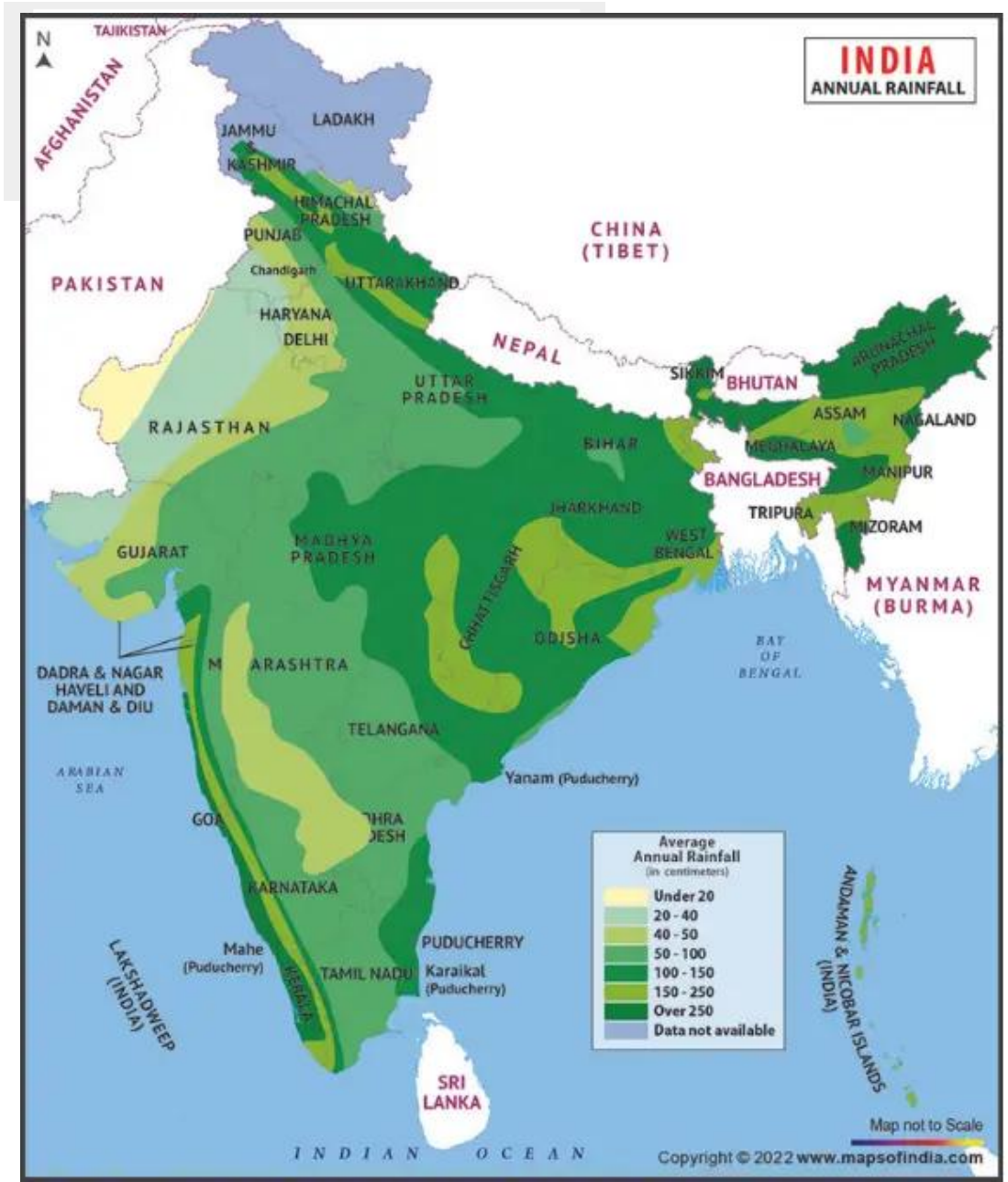
• **Northwestern India** (Rajasthan, Punjab, Haryana, Delhi): The northwest is arid and semi-arid, with regions like Rajasthan receiving little rainfall (less than **250 mm** annually). The **Thar Desert** is a prime example of a very dry area.

• **Deccan Plateau** (Maharashtra, Telangana, Karnataka): While these areas do receive monsoon rains, they often experience a **rain-shadow effect**, especially in the **interior regions**, which causes them to receive less rainfall compared to the coastal areas.

4. Rainshadow Zones:

• The **rain-shadow effect** occurs when mountains block the monsoon winds, causing one side (windward) to receive heavy rainfall and the other side (leeward) to remain dry. For example:

- **Leeward side of the Western Ghats** (parts of Maharashtra, Karnataka, and Goa) receives much less rainfall compared to the windward side.
- **Leeward side of the Eastern Ghats** also experiences reduced rainfall.



Distribution of Rainfall in India

Annual Rainfall Patterns in Key Regions of India

Wettest Regions

The highest rainfall in India—and globally—is recorded in **Mawsynram and Cherrapunji** in the state of **Meghalaya**, where average annual rainfall exceeds **11,000 mm**. These regions experience intense monsoonal precipitation due to favorable topography and moisture-laden winds.

Moderately Wet Regions

The **Western Ghats**, along with parts of **Kerala, Coastal Karnataka, and West Bengal**, receive **2,000 to 3,000 mm** of rainfall annually. The Western Ghats act as a major barrier to monsoon winds, resulting in heavy orographic rainfall along the western coastal belt.

Moderately Dry Regions

Regions such as **Uttarakhand, Himachal Pradesh, and Eastern Uttar Pradesh** receive **800 to 1,500 mm** of rainfall per year. Rainfall in these areas is seasonal and influenced by both southwest monsoon and local topographic conditions.

Dry Regions

The **Thar Desert**, **western Rajasthan**, **Delhi**, and parts of **Gujarat** receive **less than 500 mm** of annual rainfall. These areas are characterized by arid to semi-arid climatic conditions and are highly prone to droughts.

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Factors Influencing Rainfall Distribution in India

Latitude

Latitude influences the amount of solar radiation received across the country, which affects temperature gradients and atmospheric circulation patterns. These variations play a crucial role in determining the intensity and distribution of rainfall.

Topography

Major landforms such as the **Western Ghats, Himalayas, and Eastern Ghats** significantly affect rainfall patterns. The **orographic effect** causes heavy rainfall on the windward side of these ranges, while the leeward side experiences reduced rainfall or rain-shadow conditions.

Monsoon Winds

The **Southwest Monsoon** is the primary source of rainfall in India, contributing nearly 75% of the annual precipitation. However, its intensity, onset, and duration vary across regions due to geographical and atmospheric factors.

Proximity to Water Bodies

Coastal regions such as **Kerala, Coastal Karnataka, Odisha, and West Bengal** receive higher rainfall due to their closeness to the **Arabian Sea and Bay of Bengal**, which supply abundant moisture to the monsoon winds.

Onset and Withdrawal of Effective Rains

: The terms onset and withdrawal of effective rains are crucial concepts, especially in the context of agricultural planning and climate studies. They refer to the timing of the start and end of the rainy season in a given region. Here's a deeper explanation of both

1. Onset of Effective Rains:

Definition: The onset of rains refers to the **first significant rainfall** at the beginning of the rainy season. It's the point when a region transitions from the dry season to the rainy season.

Characteristics:

Sustained rainfall: It’s not just a single shower but a period of consistent rainfall that marks the start of the wet season.

Timing: In many regions, the onset of rains is highly predictable and marks the beginning of agricultural activities, especially planting.

Amount of Rainfall: To be considered the onset, the amount of rainfall must be substantial enough to create moisture in the soil and satisfy the water needs of crops.

This is often quantified as a certain amount of rainfall over a specific number of consecutive days.

- **Significance for Agriculture**:
- **Planting**: Farmers rely on the onset to start planting crops. Crops like maize, rice, and beans are often sown after the onset of rains.
- **Water availability**: The timing and intensity of the onset determine how much water will be available during the growing season. If the onset is early, it can lengthen the growing season for certain crops, while a delayed onset can shorten it.
- **Variability**: The onset can vary year to year depending on weather patterns and climate phenomena (e.g., El Niño or La Niña). This makes it challenging for farmers to predict each season's agricultural success.

- **Withdrawal of Effective Rains**
- **Definition**

The **withdrawal of effective rains** refers to the **cessation of the monsoon season**, marked by a sustained and significant reduction in rainfall over a region. It indicates the transition from **wet climatic conditions to the dry season**, typically associated with the retreat of the southwest monsoon.

- **Characteristics of Withdrawal**

Gradual or Abrupt Withdrawal:

The withdrawal of rains may occur **gradually**, with a steady decline in rainfall over several weeks, or **abruptly**, where there is a sudden stoppage of significant precipitation. The nature of withdrawal varies spatially and temporally across different regions of India.

- **Spatial Variation:**
  Withdrawal usually begins in **northwestern India** and progressively advances towards the **southern and eastern parts** of the country.
- **Drought Risk:**
  An **early or rapid withdrawal** of effective rains can result in **moisture stress** and drought-like conditions, particularly if it coincides with **critical crop growth stages** such as flowering or grain filling..

- **Significance for Agriculture**
- **Crop Maturity and Harvesting:**
  Farmers closely monitor the withdrawal phase to determine the **maturity of crops and optimal harvesting time**. Prolonged rainfall during this period can damage standing crops and lead to **post-harvest losses**, especially for cereals and pulses.
- **Water Availability and Management:**
  Following the withdrawal of rains, **surface and subsurface water resources begin to recede**. River discharge decreases, reservoir inflows reduce, and groundwater recharge slows down. This necessitates **efficient water management** to meet irrigation, domestic, and industrial demands during the dry season.
- **Hydrological Importance**
- The timing and pattern of monsoon withdrawal play a crucial role in determining **soil moisture retention, reservoir storage levels, and drought preparedness**, directly influencing agricultural productivity and water security.

Importance of Timing of Onset and Withdrawal of Rains

The **timing of the onset and withdrawal of effective rains** plays a crucial role in **agricultural planning and water resource management**. Any deviation—such as **early or delayed onset**, or **premature withdrawal**—can disrupt cropping calendars, reduce agricultural productivity, and adversely affect **food security and economic stability**. Proper timing ensures optimal soil moisture conditions for sowing, growth, and harvesting of crops.

Prediction of Onset and Withdrawal of Rains

- **Meteorologists and climate scientists** employ a range of scientific tools to forecast the onset and withdrawal of monsoon rains. These include **numerical weather prediction models, satellite-based observations, remote sensing data, and long-term historical climate records**. Accurate predictions assist **farmers, policymakers, and water resource managers** in planning irrigation schedules, managing reservoirs, mitigating droughts and floods, and improving overall disaster preparedness.

Dry Spells and Wet Spells:Dry spells and **wet spells** refer to periods of weather marked by a significant **deficiency** or **excess** of rainfall, respectively. These phenomena play a vital role in understanding **climatic variability**, **agricultural performance**, and **water resources planning and management**, as they directly influence crop growth, soil moisture conditions, and the availability of surface and groundwater.

Dry Spell:

A dry spell refers to a prolonged period with little to no rainfall. This can occur during the rainy season or outside of it (in the dry season). The duration and intensity of a dry spell can vary, but it is typically a period of weather in which the soil moisture decreases, and agricultural activities can be significantly impacted.

- Characteristics
- Duration: A dry spell can last for a few days to several weeks. For agricultural purposes, dry spells lasting more than 5–7 days during the rainy season can have a significant impact on crops.
- Severity: The severity of a dry spell depends on how long it lasts and the state of the crop. If the soil was already moist, a short dry spell might have minimal impact, but if crops are in critical stages (like flowering or fruiting), the effects can be severe.
- Temperature: During a dry spell, temperatures often rise, leading to increased evaporation and higher water stress on crops.

- **Impacts of Dry Spells**:
- **Crop Damage**: During the rainy season, dry spells can cause **water stress**, leading to **stunted growth** or **wilting** of crops. If the dry spell happens during critical growth phases (e.g., flowering, fruiting), it can reduce yields or lead to crop failure.
- **Water Scarcity**: Prolonged dry spells can lower water availability in rivers, lakes, and reservoirs, leading to issues with drinking water supplies, irrigation, and hydropower generation.
- **Soil Moisture Loss**: Crops and plants depend on consistent soil moisture. During a dry spell, soil moisture decreases, which can inhibit root growth and nutrient uptake, making it difficult for plants to thrive.

- Causes of Dry Spells:Atmospheric pressure systems: High-pressure systems can dominate certain regions, leading to clear skies and little to no rainfall.
- Climate patterns: Phenomena like El Niño (warmer ocean temperatures) or La Niña (cooler ocean temperatures) can disrupt usual weather patterns, increasing the likelihood of dry spells.
- Seasonal fluctuations: In regions with seasonal rainfall, dry spells might occur naturally between rainy seasons or during periods of transition (e.g., late-spring dry spells before summer rains arrive).

Wet Spells:

A wet spell refers to a period of sustained, above-average rainfall. Wet spells occur when the rainfall is greater than usual for a specific region during its rainy season. Wet spells can be beneficial for agricultural growth, but if too long or intense, they can also cause problems like flooding.

- **Characteristics**:
- **Duration**: Wet spells can last from several days to a few weeks. In some cases, they may extend longer.
- **Rainfall Intensity**: Wet spells are typically marked by **heavy or frequent rainfall**, often leading to substantial accumulation of water over a short period.
- **Soil Saturation**: Wet spells cause soil to become **saturated with water**, which can be beneficial for crops that require a lot of water but can also create issues if rainfall continues too long.

- **Impacts of Wet Spells**:
- **Crop Growth**: In regions where rainfall is crucial for crop development, a wet spell during the rainy season can lead to **lush crop growth** and high yields. Crops like rice and certain vegetables thrive under such conditions.
- **Flooding**: Excessive rainfall during a wet spell can lead to **flooding**, damaging crops, especially in areas with poorly drained soils or where infrastructure (e.g., drainage systems) is inadequate.
- **Waterlogging**: Some crops, such as maize or beans, do not tolerate **waterlogged** soil. If the soil remains too wet for too long, it can prevent proper root growth and cause **root rot**

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Measurement of Rainfall

Rainfall is measured using instruments called **rain gauges**.
The most common types include:

- **Standard Rain Gauge** — A cylindrical container that collects rain, with measurements marked in millimeters or inches.
- **Tipping Bucket Rain Gauge** — A funnel directs rain into a small bucket that tips when a specific amount is collected, recording data electronically.
- **Weighing Rain Gauge** — Measures the weight of collected rain and converts it into depth measurements.
- **Weighing Rain Gauge** — Measures the weight of collected rain and converts it into depth measurements.
- **Optical Rain Gauge** — Uses laser or infrared beams to detect raindrop sizes and estimate rainfall intensity.

Rainfall is **usually measured in millimeters (mm) per unit time**, such as mm per hour, day, or m onth.

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Water Loss from the Soil

Water loss from soil occurs through various processes that reduce soil moisture.
The major ways water is lost from the soil include:

1 Evaporation

Direct loss of water from the soil surface into the atmosphere due to heat and sunlight. Higher temperatures, wind, and low humidity increase evaporation rates.

2 Transpiration

Water is absorbed by plant roots and released into the atmosphere through stomata in leaves. This process is essential for plant growth.

3 Evapotranspiration

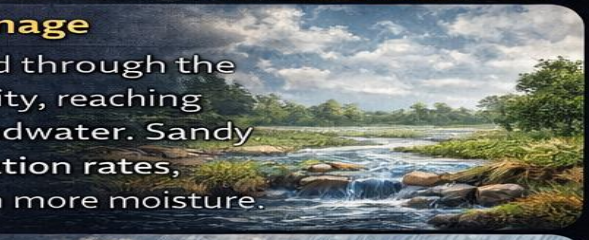
Combination of evaporation (from soil) and transpiration (from plants). Influenced by factors like temperature, wind speed, and vegetation cover.

3 Evapotranspiration

Combination of evaporation (from soil) and transpiration (from plants). Influenced by factors like temperature, wind speed, and vegetation cover.

4 Percolation & Drainage

Water moves downward through the soil profile due to gravity, reaching deeper layers or groundwater. Sandy soils have high **percolation rates**, while clayey soils retain more moisture.



6 Leaching

The downward movement of dissolved nutrients and water beyond the root zone.
This can lead to nutrient depletion and reduced soil productivity.

Factors Affecting Soil Water Loss

1. Soil Texture

- **Sandy soils** have large pores → low water-holding capacity → **rapid drainage** and **evaporation**.
- **Clayey** soils have **fine pores** → high water-holding capacity slower **water loss**.
- **Loamy soils** are **ideal** as they balance **retention** and drainage.

2. Vegetation Cover

- **Dense vegetation** reduces direct evaporation by shading the soil surface.
- **However, plants lose water through transpiration,** which can increase total water loss.

3. Temperature & Climate

- **Higher temperatures** increase the **rate of evaporation** from soil.
- **Arid** and **semi-arid climates** experience **greater soil** moisture loss.
- **Cooler** and **humid** climates reduce evaporation losses.

4. Wind Speed

- Wind removes the moist **air layer** above the **soil** surface.
- This accelerates evaporation and transpiration.
- **Open fields** experience more water loss than sheltered areas.

Additional Important Factors (often asked in exams)

5. Soil Structure

- **Well-aggregated** soils reduce water loss by improving **infiltration**
- **Compacted soils** increase **runoff** and evaporation.

6. Slope of Land

- Steeper slopes cause more **runoff** → less water retained in soil.

5. Steep of Land

- Steeper slopes cause more **rrunoff** → less water retained in soil.

7. Organic Matter

- **High organic** content improves **water-holding capacity** and reduces loss.

Karnataka faces significant water scarcity issues primarily due to erratic rainfall patterns, over-exploitation of groundwater, rapid urbanization, encroachment on water bodies, and dependence on distant water sources like the Cauvery River, leading to depletion of both surface and groundwater reserves, particularly in areas like Bengaluru, making it one of the most water-stressed states in India; the major concerns include:

Uneven Rainfall Distribution:

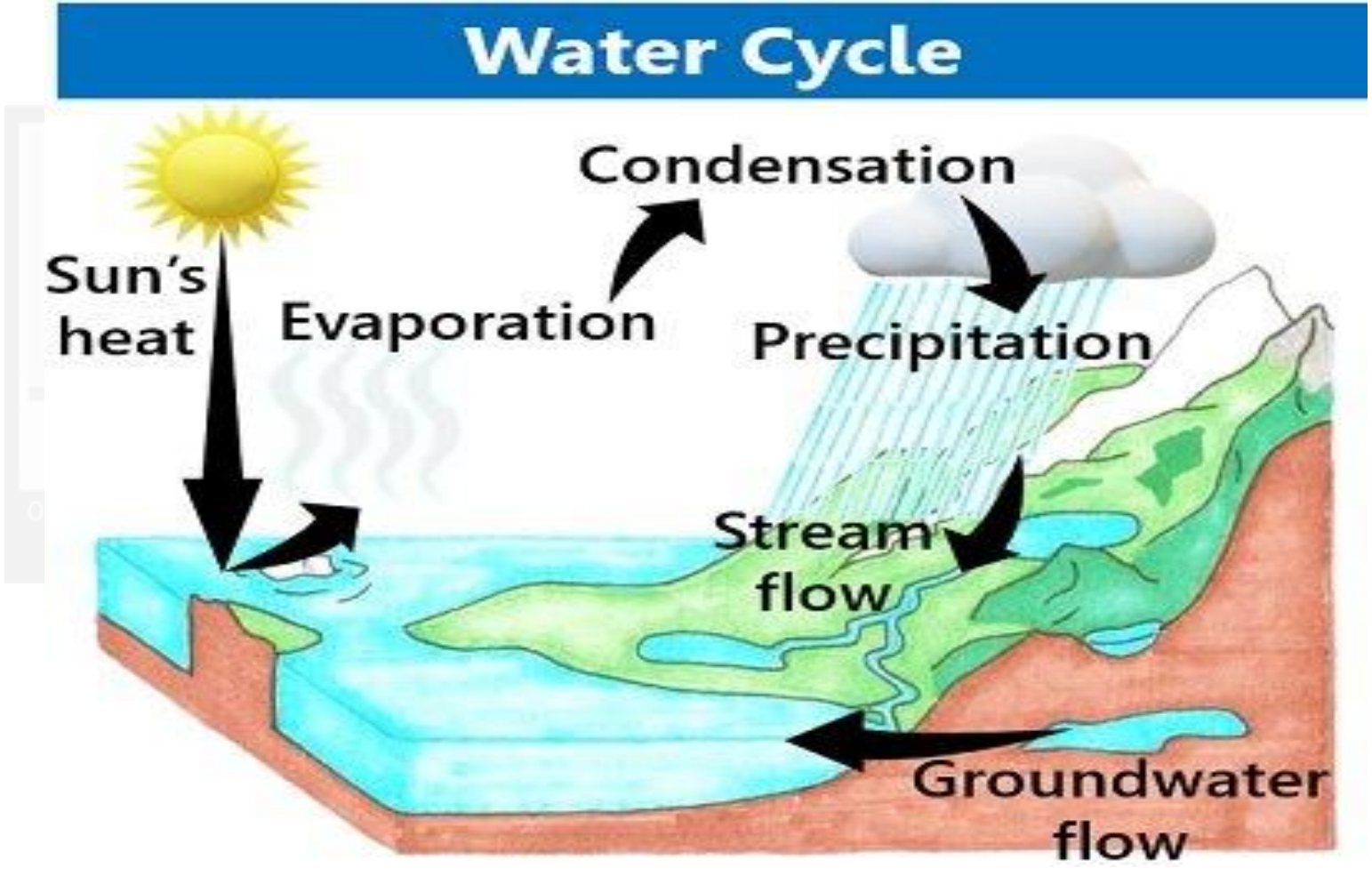
- Large parts of Karnataka receive less than 750mm of rainfall annually, with significant variations across the state, making water availability inconsistent.

Groundwater Depletion:

- Excessive extraction of groundwater through borewells, coupled with limited recharge due to urbanization, has led to a rapid decline in groundwater levels, especially in drought-prone regions.

Cauvery River Dispute:

- Karnataka's reliance on the Cauvery River for water is further complicated by a long-standing dispute with Tamil Nadu over water sharing, causing intermittent water shortages.


Water Cycle
Condensation
Sun's heat
Evaporation
Precipitation
Stream flow
Groundwater flow

Karnataka experiences severe water scarcity mainly due to **erratic rainfall**, **over-exploitation of groundwater**, **rapid urbanization**, **encroachment of water bodies**, and a heavy **dependence on distant river sources such as the Cauvery**. These factors have resulted in the depletion of both surface and groundwater resources, particularly in urban centers like **Bengaluru**, making Karnataka one of the **most water-stressed states in India**. The major concerns include:

Uneven Rainfall Distribution

Several regions of Karnataka receive **less than 750 mm of annual rainfall**, with wide spatial and temporal variations. This uneven distribution leads to unreliable water availability across the state.

Groundwater Depletion

Excessive groundwater extraction through borewells, combined with **reduced natural recharge due to urbanization**, has caused a sharp decline in groundwater levels, especially in **drought-prone areas**.

Cauvery River Dispute

The state's dependence on the **Cauvery River** is further challenged by the long-standing water-sharing dispute with **Tamil Nadu**, resulting in periodic water shortages during deficit years

FORMS OF PRECIPITATION

1. Drizzle (Mist):

It is a **light liquid precipitation** consisting of liquid water drops smaller than those of rain - generally smaller than 0.5 mm (0.02 in) in diameter. Drizzle is normally produced by low stratiform clouds and stratocumulus clouds.

2. Rain:

It is liquid water in the form of droplets that have condensed from atmospheric water vapor and then precipitated—that is, become heavy enough to fall under gravity. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth.

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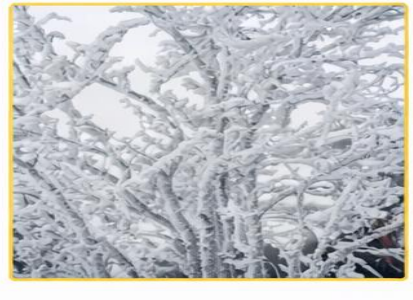
FORMS OF PRECIPITATION

3. Glaze:

It is the **ice coating**, generally clear and smooth, formed on exposed surfaces by the freezing super cooled water deposited by rain or drizzle.
Glaze ice on a blade of grass.

4. Rime:

It is a white ice that forms when the water droplets in fog freeze to the outer surfaces of objects. It is often seen on trees atop mountains and ridges in winter, when low-hanging clouds cause freezing fog. Rime on Trees



5. Snow:

It is precipitation in the form of flakes of crystalline water ice that falls from clouds. Since snow is composed of small ice particles, it is a granular material. It has an open and therefore soft, white, and fluffy structure. Snow (Mountains of South California) Snowflakes.

6. Hail:

It is a form of solid precipitation. It consists of balls or irregular lumps of ice, each of which is called a hailstone. Hailstones are not frozen raindrops. Frozen rain falls as water and freezes as it nears the ground. Hail actually falls as a solid.

7. **Sleet (Ice Pellets):**

This are form of precipitation consisting of small, translucent balls of ice. Ice pellets are smaller than hailstones which form in thunderstorms rather than in winter, and are different from graupel ("soft hail").

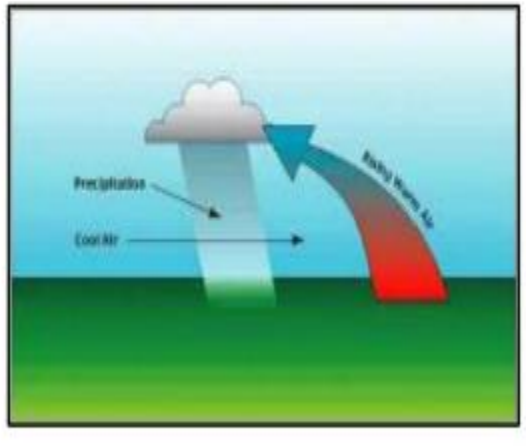
8.Other forms:

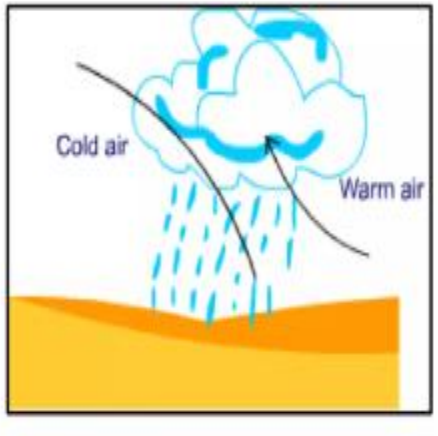
Diamond Dust

Graupel (Snow Pellets)

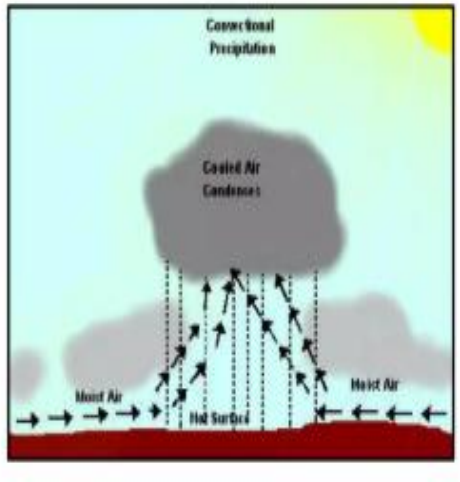
TYPES OF PRECIPITATION:

1. Cyclonic Precipitation results to from the lifting of air converging into low-pressure area, or cyclone. A cyclonic storm is a large, low pressure system that forms when a warm air mass and a cold air mass collide. This collision often occurs under the polar-front jet stream which spreads cold, dry arctic air near warm, moist tropical air. The rotation of the earth causes the air to circulate in a counterclockwise direction around an area of low pressure.

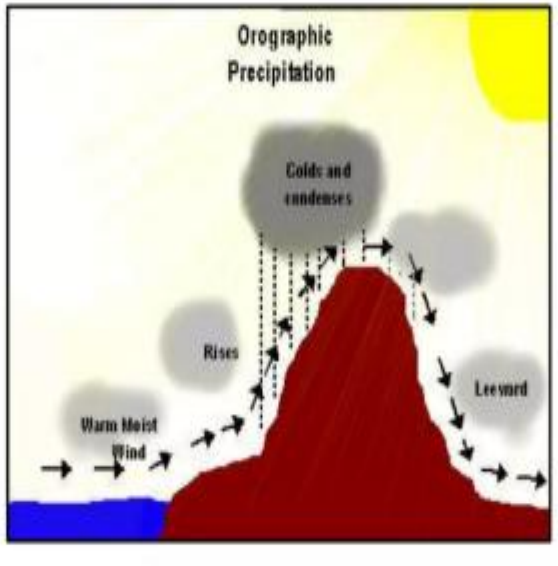




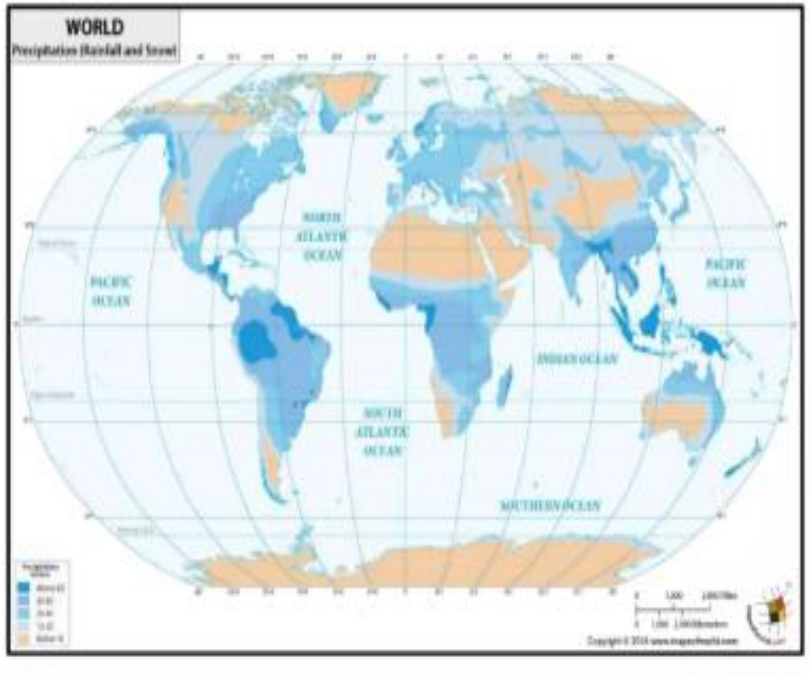
2. Convective Precipitation is caused by rising the rising of warmer, lighter air in colder, dense surroundings. As the air warms, the air molecules begin to move further apart. With increased distance between molecules, the molecules are less densely packed. Thus, the air becomes "lighter" and rises rapidly into the atmosphere. As the air rises, it cools.



3. Orographic Precipitation results from a mechanical lifting over mountain barriers. Orographic precipitation results when warm moist air moving across the ocean is forced to rise by large mountains. As the air rises, it cools.



WORLD PRECIPITATION MAP
SHOWING
THE PRECIPITATION LEVEL (BOTH RAIN AND SNOW) IN DIFFERENT PARTS OF THE WORLD.



IMPORTANCE OF WATER

- Most of the water found on earth is not fit for drinking
- 3% of fresh water is found on earth.
- mportant source of fresh water.
- fall for only 2-3 months.
- We should save water.

Most read

Earth's surface is
ne of the most
HAll living things...

SOURCES OF WATER

- Rain is the main source of water. It fills up the
- Rivers, lakes, ponds, streams, wells which are the other important sources of water.
- Wells- are used mainly in villages. Wells supply underground water.
- Tubewells- it has a tube or a pipe fitted to an underground source of water. An electrical or diesel pump is used to pump the water.



CANALS

- Canals are small channels through which water from rivers or dams are diverted to the fields.
- They are dug to take water to where there is water shortage.
- Example – the Indira Gandhi canal.

DID YOU KNOW?!!!!!!
INDIRA GANDHI CANAL
IS THE LONGEST
IRRIGATION CANAL!!!!!!

RAIN WATER HARVESTING

- Rain water harvesting is process of storing and collecting rain water.
- This stored water is used for drinking, irrigation etc.
- It is usually done in the areas where there is scarcity of water.

DID YOU KNOW?!!!!!
MARCH 22 IS THE WORLD
WATER DAY!!!!!!!!!!

- **Water Availability: Global and Indian Scenarios**
- **Introduction**
- Water is a fundamental resource for life on Earth. It is essential for drinking, agriculture, industry, and ecosystem balance. Despite covering about **71% of Earth's surface**, freshwater availability is limited. Understanding the global and Indian water scenarios helps in managing this precious resource effectively.

- **Global Water Availability**
- **1. Distribution of Water on Earth**
- **97.5% of water** is in oceans (saltwater).
- **Only 2.5% is freshwater**, out of which:
  - **68.7%** is in glaciers and ice caps.
  - **30.1%** is groundwater.
  - **1.2%** is surface water (lakes, rivers, atmosphere, etc.).
- Thus, **only about 0.3% of total global water is directly available for human use** (lakes, rivers, and shallow groundwater).

- **2. Unequal Distribution of Water**
- Water is **not evenly distributed** across the world. Some regions have abundant water (like Canada, Russia, and Brazil), while others face severe shortages (like the Middle East and parts of Africa).
- **Regions facing water scarcity:**
  - The Middle East, North Africa, South Asia, and parts of Australia experience extreme water shortages.
- **Regions with abundant water:**
  - Countries with large rivers, glaciers, and high rainfall, such as Canada, Brazil, and Russia, have ample water resources.

- **3. Causes of Water Scarcity**
- **Climate Change:** Alters rainfall patterns, increasing droughts and floods.
- **Population Growth:** More people demand more water.
- **Over-extraction:** Excessive groundwater pumping leads to depletion.
- **Pollution:** Industrial waste, sewage, and agricultural chemicals make water unusable.
- **Deforestation:** Reduces water retention and increases soil erosion.

- **4. Future Challenges**
- **By 2050**, global water demand is expected to rise by **55%** due to population growth and industrial needs.
- **1.2 billion people** currently lack access to clean drinking water.
- Water conflicts between nations (e.g., Nile River disputes) may increase.

- **Water Availability in India**
- India is home to **18% of the world's population** but has only **4% of the world's freshwater resources**.
- **1. Sources of Water in India**
- **Rivers** (Ganga, Yamuna, Brahmaputra, Godavari, Krishna, etc.)
- **Lakes and ponds**
- **Groundwater (Wells and Tube Wells)**
- **Rainwater (Monsoons)**
- **Glaciers (Himalayan region)**

- **2. Unequal Distribution of Water in India**
- India experiences **high regional variation** in water availability:
- **Water-rich regions**: Northeast India (Brahmaputra basin), Western Ghats, and Himalayan rivers.
- **Water-scarce regions**: Rajasthan, Gujarat, parts of Maharashtra, Tamil Nadu, and Karnataka.

- **3. Reasons for Water Scarcity in India**
- **Monsoon Dependency**: India receives **80% of its annual rainfall in just 4 months (June–September)**.
- **Overuse of Groundwater**: India is the **largest extractor of groundwater** in the world.
- **Pollution**: Rivers like the Ganga and Yamuna are heavily polluted.
- **Deforestation and Urbanization**: Reduces groundwater recharge.
- **Inefficient Irrigation**: Agriculture consumes **85% of India's water**, but much is wasted due to outdated methods.

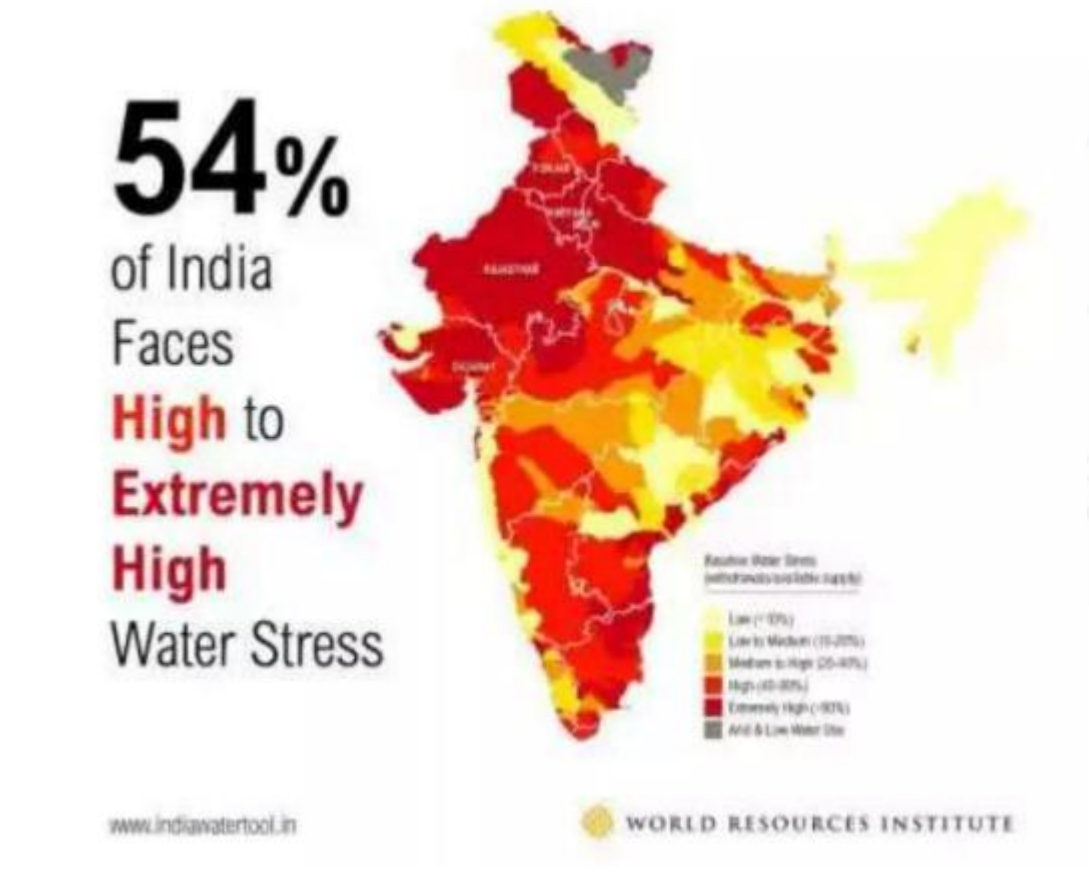
- **4. Government Measures and Solutions**
- **Jal Shakti Abhiyan**: Promotes water conservation and rainwater harvesting.
- **Atal Bhujal Yojana**: Focuses on groundwater management.
- **Namami Gange Programme**: Aims to clean the Ganga River.
- **Interlinking of Rivers**: Proposed project to transfer water from surplus to deficit regions.
- **Watershed Management**: Encourages sustainable water use and conservation.

- **5. Future Challenges for India**
- **Increasing demand**: By 2050, India's water demand will be **twice the available supply**.
- **Urban water crisis**: Cities like Chennai and Bengaluru have faced severe water shortages.
- **Climate change**: Rising temperatures will affect monsoon patterns and glaciers.

- Karnataka, despite being one of the most developed states in India, faces serious water challenges due to geographical and climatic conditions.
- **1. Water Sources in Karnataka:**
- **Rivers:** Major rivers include the **Cauvery, Krishna, Tungabhadra, and Sharavathi**. However, interstate disputes over river water create supply challenges.
- **Lakes & Tanks:** Bengaluru was once famous for its lakes, but many have been encroached upon or polluted.
- **Groundwater:** Over-extraction for agriculture and urban use has caused depletion in many areas.
- **Rainfall Dependence:** The state relies on monsoon rains, which are unpredictable

- **2. Water Issues in Karnataka:**
- **Cauvery River Dispute:** A long-standing conflict with Tamil Nadu over water-sharing.
- **Droughts & Floods:** Many regions face **frequent droughts** (North Karnataka) and **floods** (Malnad, Coastal areas).
- **Urban Water Crisis:** Bengaluru faces severe water shortages due to rapid urbanization and pollution of lakes.
- **Agricultural Dependence:** Farmers in regions like Mandya rely on river water for irrigation, making them vulnerable to shortages.
- **Pollution:** Industrial and urban waste pollutes rivers and lakes, making water unsafe for consumption.

- **3. Measures Taken:**
- **Dams & Reservoirs:** Major ones include KRS, Almatti, and Tungabhadra dams for irrigation and drinking water supply.
- **Rainwater Harvesting:** Government mandates in cities to conserve water.
- **River Linking Projects:** Planned efforts to transfer water from surplus to deficit regions.
- **Groundwater Regulation:** Laws to prevent over-extraction.



India's water future

- By 2050, India's total water demand will increase 32% from now.
- Industrial and domestic sectors will account for 85 per cent of the additional demand.
- Over-exploitation of groundwater, failure to recharge aquifers and reduction in catchment capacities due to uncontrolled urbanisation are all causes for the precarious tilt in the water balance.
- If the present rate of groundwater depletion persists, India will only have 22 per cent of the present daily per capita water available in 2050, possibly forcing the country to import its water.

- Increase population increased to 1.7 billion by 2050 , will have integrated water efficient practices into their daily lives.
- If the ambitious water sustainability goals set by global industries and governments are testament, we dare say that the world has begun to recognise water as a resource after all
- Water-efficient technologies will continue to be developed like they already are today, but more importantly, it is the renewed understanding of water as a shared commodity that will help these technologies find acceptance with industries, agriculture, and individuals alike.

- Agriculture will continue to be the mainstay of India in 2050.
- However, what is going to markedly change is the utilisation of water by the sector – efforts of which have already begun to take shape, reflected in the country's '***per drop-more crop***' mantra.
- Industries will be judged by their shareholders and customers on environmental sustainability practices integrated into core business operations.
- As a result, industries will reduce their dependency on freshwater altogether.

- Human activities have significantly altered the natural water cycle, affecting the distribution, quality, and availability of freshwater resources. Key influences include:
- 1. Land Use ChangesUrbanization: The expansion of urban areas introduces extensive impervious surfaces like roads and buildings, reducing the land's ability to absorb water. This leads to increased surface runoff, elevating the risk of urban flooding and diminishing groundwater recharge. CK12.ORGDeforestation: Removing forests decreases soil moisture and evaporation rates, altering local rainfall patterns and reducing the land's capacity to retain water.
- 2. Agricultural PracticesIrrigation: Extensive irrigation can deplete rivers and lower groundwater levels, disrupting the natural flow of water and affecting aquatic ecosystems. SCIENCE.JRANK.ORGUse of Chemicals: Applying fertilizers and pesticides can lead to runoff that contaminates water bodies, affecting water quality and harming aquatic life.

- 3. Industrial Activities Water Consumption: Industries often consume large amounts of water, leading to depletion of local water resources. CK12.ORGPollution: Discharging industrial waste, including toxic chemicals and radioactive substances, into water bodies contaminates freshwater sources, posing risks to both ecosystems and human health.
- 4. Climate Change Increased Evaporation: Rising global temperatures enhance evaporation rates, altering precipitation patterns and contributing to more extreme weather events. SCIENCELEARN.ORG.NZMelting Ice: Warming leads to the melting of glaciers and polar ice, contributing to sea-level rise and affecting freshwater availability. SCIENCELEARN.ORG.NZThese human-induced changes to the water cycle have profound implications, including water scarcity, reduced agricultural productivity, loss of biodiversity, and heightened vulnerability to natural disasters. Addressing these challenges requires sustainable management practices, pollution control, and concerted efforts to mitigate climate change.

Surface Water

- Water that collects on the Earth's surface
- Examples:
  - *Streams*
  - *Rivers*
  - *Oceans*
  - *Lakes*
  - *Wetlands*

Surface water is replenished by **precipitation** and lost through **evaporation**.

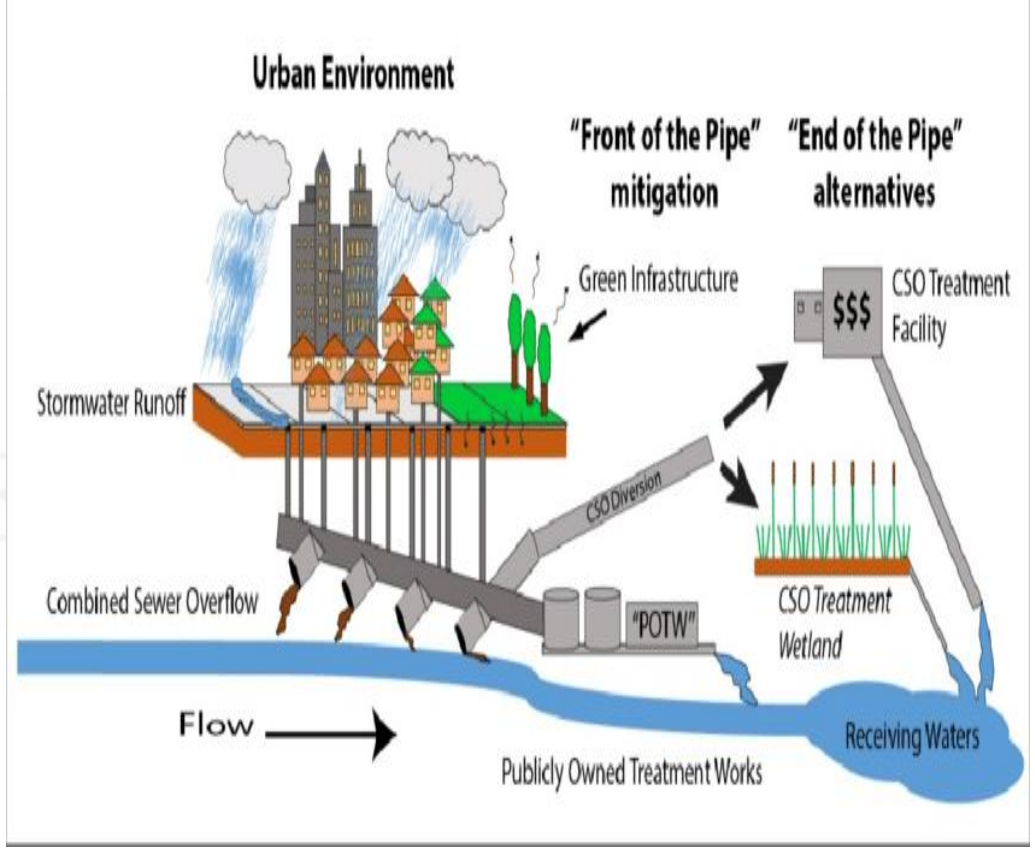
- Surface water refers to all water bodies found above the Earth's surface, including rivers, lakes, streams, ponds, wetlands, and reservoirs. These resources play a crucial role in the hydrologic cycle, contributing to various ecological and human activities.Categories of Surface WaterSurface water can be classified into three main types
- Permanent (Perennial) Surface Waters: These are water bodies present year-round, such as lakes, rivers, and wetlands.
- Semi-permanent (Ephemeral) Surface Waters: These water bodies appear only during certain times of the year, like seasonal streams and waterholes.
- Human-made Surface Waters: These include artificial structures like reservoirs, canals, and ponds created for various purposes, including water storage and irrigation.

- **Sources and Dynamics**
- The primary source of surface water is precipitation, including rainfall and snowmelt. After reaching the Earth's surface, water can follow several paths:
- **Runoff**: Water flows over the land surface, eventually reaching rivers, lakes, or oceans.
- **Infiltration**: Some water penetrates the soil, replenishing groundwater aquifers.
- **Evaporation**: Water returns to the atmosphere from surfaces of water bodies.
- **Transpiration**: Plants absorb water from the soil and release it into the atmosphere.

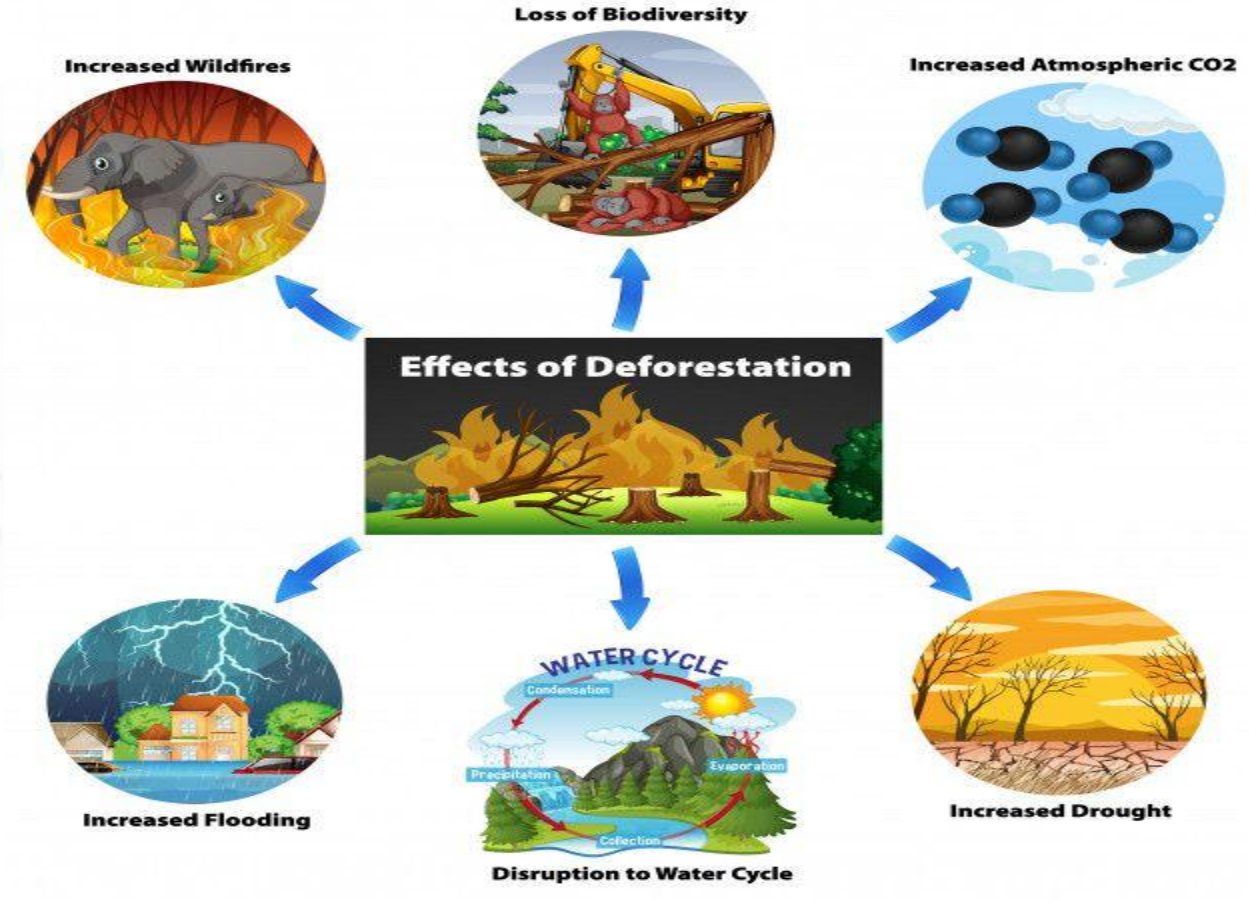
- **Sources and Importance of Surface Water**
- Surface water is primarily replenished by precipitation and water runoff. It serves as a vital resource for various human activities:
- **Agriculture**: Farmers depend on rivers, lakes, and reservoirs for irrigation, especially during dry periods. Techniques such as flood irrigation and drip irrigation utilize surface water to enhance crop yields. waterandwastewater.com
- **Drinking Water Supply**: Many communities source their drinking water from surface water bodies, necessitating effective management to ensure sustainability and quality. waterandwastewater.com
- **Industry and Recreation**: Surface water supports industrial processes and offers recreational opportunities like boating and fishing, contributing to both economic and social well-being.

- **Environmental Significance**
- Beyond human use, surface water ecosystems provide habitats for diverse plant and animal species. They are integral to maintaining ecological balance, supporting biodiversity, and ensuring the health of the environment. profession.americangeosciences.org
- **Challenges and Management**
- Surface water resources face pressures from pollution, over-extraction, and climate change, leading to issues like reduced water quality and availability. Effective management practices are essential to address these challenges and ensure the sustainability of surface water for future generations.

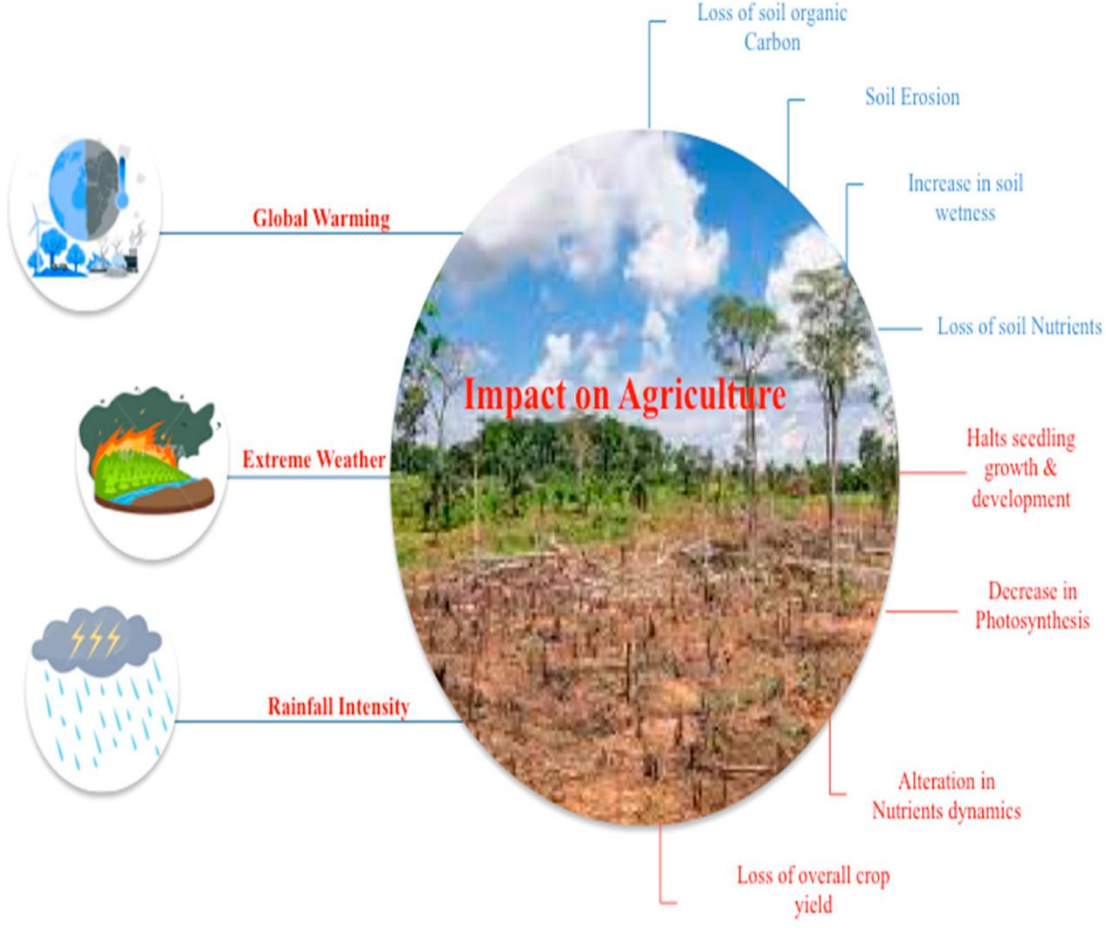
- How Humans Alter the Water CycleHuman activities introduce changes at nearly every stage of this cycle:
- Urbanization Impervious Surfaces: Cities with roads, buildings, and parking lots prevent water from infiltrating the soil. Increased Runoff: This leads to more rapid, and sometimes overwhelming, surface runoff, which can cause flooding and erosion.



- **Deforestation**
- **Reduced Transpiration:** Cutting down trees decreases the amount of water vapor released into the atmosphere.
- **Altered Precipitation:** Fewer trees mean less local humidity, which can reduce rainfall.

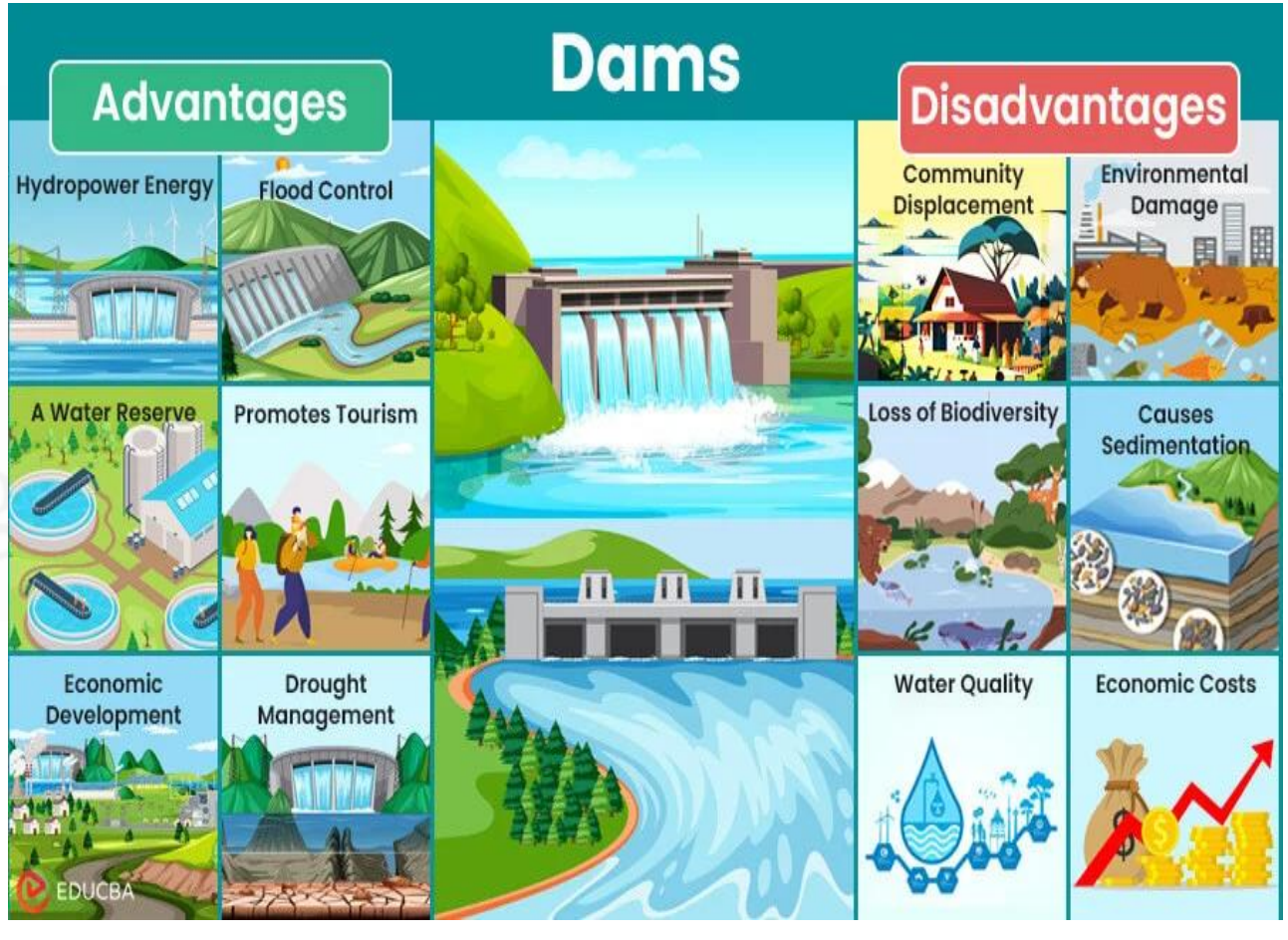


- Agriculture and Irrigation Water Withdrawal: Irrigation diverts water from natural sources, lowering river flows and groundwater levels.
- Chemical Runoff: Fertilizers and pesticides can leach into water bodies, affecting water quality.



Dams and Reservoirs

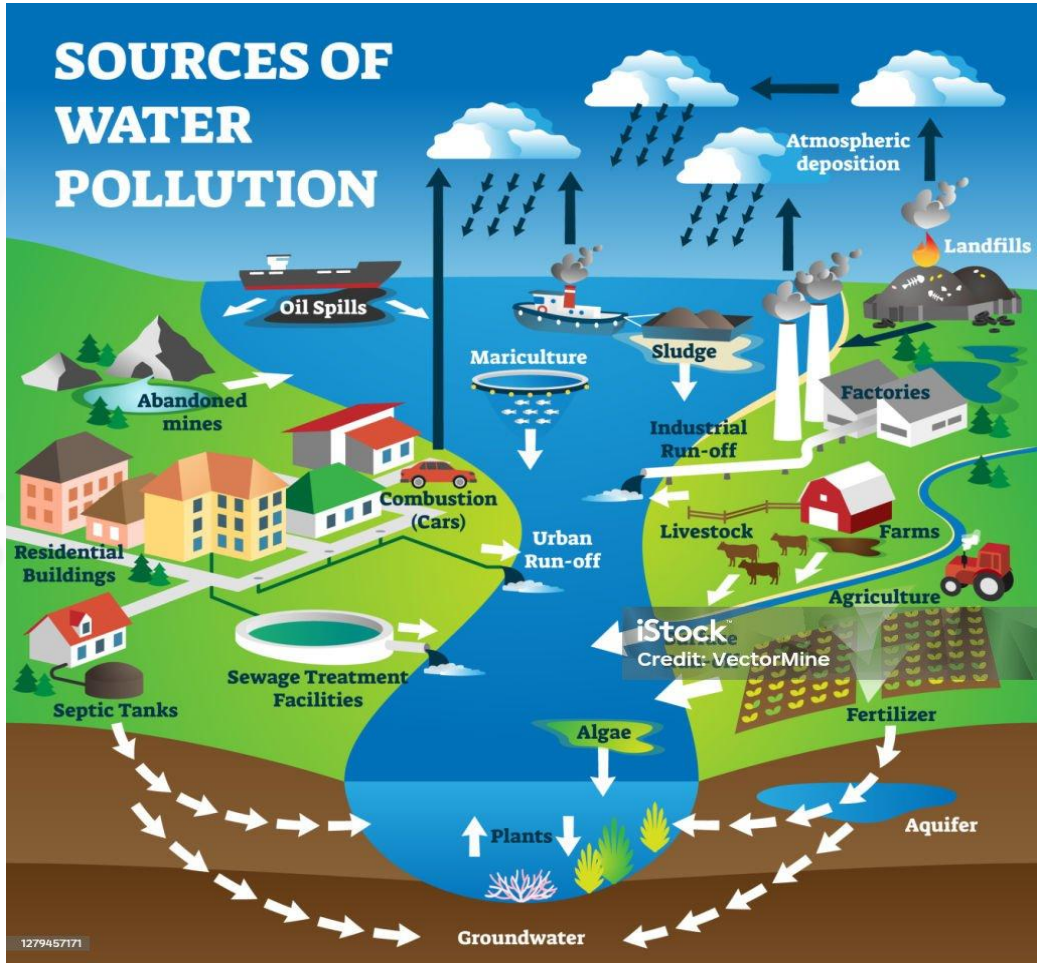
- **Flow Regulation:** Dams store water and alter its natural downstream flow, affecting sediment transport and ecosystem health.
- **Modified Evaporation:** Large reservoirs can increase evaporation losses.



- **Climate Change**
- **Increased Evaporation:** Higher temperatures boost evaporation rates.
- **Shifting Precipitation Patterns:** Changes in climate lead to more intense storms, altered rainfall distribution, and prolonged droughts.

Pollution

•Water Quality Degradation: Industrial discharges and urban runoff introduce pollutants (e.g., heavy metals, organic waste) that harm aquatic ecosystems and human health.



Water quality refers to the characteristics of water that determine its suitability for a particular use, whether that's drinking, swimming, agriculture, or supporting aquatic life. It is typically assessed based on three main categories:

1. Physical Characteristics

- **Clarity/Turbidity:** Indicates how clear or murky the water is.
- **Temperature:** Affects chemical reactions in water and the metabolism of aquatic organisms.
- **Color and Odor:** Can reveal the presence of organic matter or pollutants.

2. Chemical Characteristics

- **pH Levels:** A measure of acidity or alkalinity that influences chemical solubility and biological processes.
- **Dissolved Oxygen:** Essential for the survival of fish and other aquatic organisms.
- **Nutrients:** Such as nitrogen and phosphorus, which in high concentrations can lead to algal blooms.
- **Contaminants:** Including heavy metals, pesticides, and industrial chemicals that can harm health and ecosystems.

3. Biological Characteristics

- **Microbial Content:** Bacteria, viruses, and protozoa in water can indicate pollution and pose health risks.
- **Ecosystem Health:** The presence of various organisms, from plankton to fish, reflects overall water quality.

importance of Water Quality

- **Human Health:** Clean water is critical for drinking, cooking, and sanitation. Contaminated water can lead to various waterborne diseases.
- **Ecosystems:** Healthy water supports diverse ecosystems and maintains the balance of aquatic life.
- **Economic Impact:** Industries such as agriculture, tourism, and manufacturing rely on high-quality water.

- **How Water Quality is Measured**
- **Sampling and Testing:** Water samples are collected and analyzed in laboratories using standardized methods.
- **On-site Monitoring:** Instruments like pH meters, turbidity sensors, and dissolved oxygen probes provide real-time data.
- **Regulations and Guidelines:** Government agencies (such as the EPA) establish standards to protect water quality and public health.

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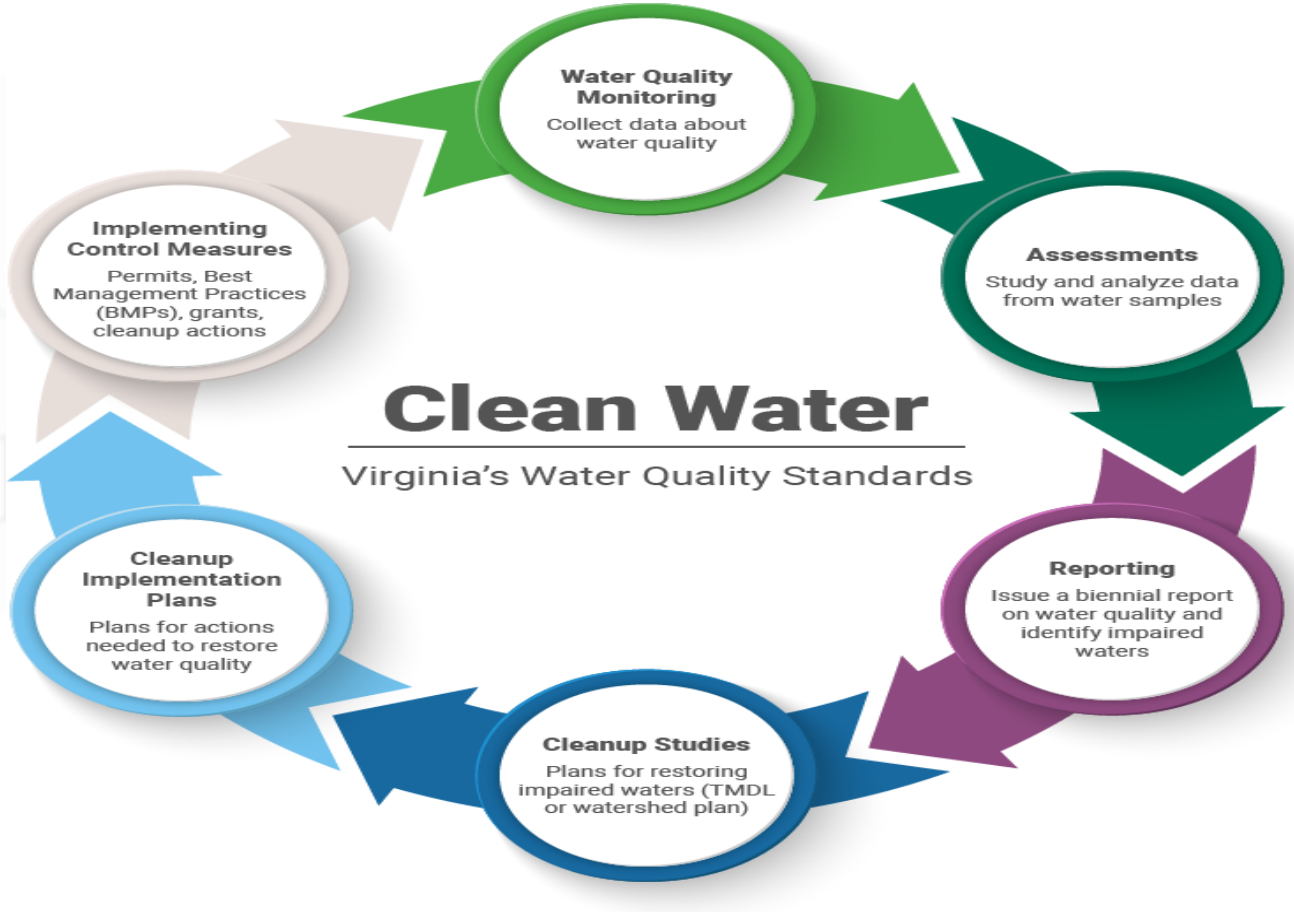

- Thank You