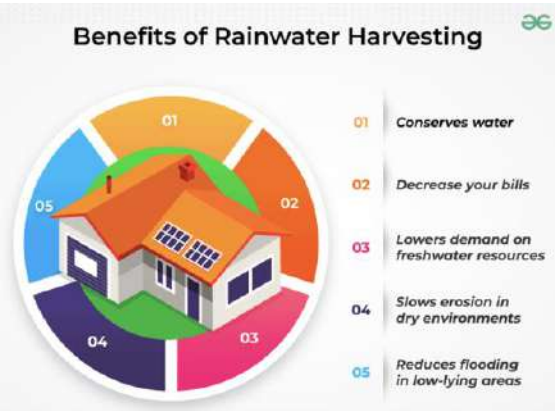
Unit – 2

Introduction: Advantages of Rainwater Harvesting, Natural Water Resources. Agricultural Practices, integrated farming, Soil erosion and conservation techniques. Concept of Arid and Semiarid Regions. Drought Management - introduction, Drought assessment and classification, drought mitigation planning, Concept of watershed, introduction to watershed management.

Advantages of Rainwater Harvesting

- Easy to Maintain - Rainwater Harvesting Systems are based on simple technology. Maintenance of these systems requires little time and energy.
- Reducing Water Bills - Water is required for a lot of non-drinking functions. When harvested rainwater is used for all these functions, it reduces the load on the water supply. This helps to reduce utility bills.
- Suitable for Irrigation - There is little requirement for building new infrastructure for the rainwater harvesting system.
- Most rooftops act as a workable catchment area, which can be linked to the harvesting system.
- This also lessens the impact on the environment by reducing use of fuel based machines.
- Rainwater is free from many chemicals found in ground water, making it suitable for irrigation and watering gardens.
- Reduces Demand on Ground Water - In urban areas, the demand for water is continuously rising. This is catered by extracting ground water leading to the depletion of ground water.
- With the use of rainwater harvesting systems this reliability on ground water can be reduced.
- Reduces Floods - By collecting rainwater in large storage tanks helps reduce chances of flooding in some low lying areas.
- Reduces Soil Erosion - Rainwater Harvesting also helps in reducing soil erosion and contamination of surface water with pesticides and fertilisers from rainwater run-off which results in cleaner lakes and ponds.
- Can be Used for Several Non-drinking Purposes - Rainwater when collected can be used for several non-drinking functions.



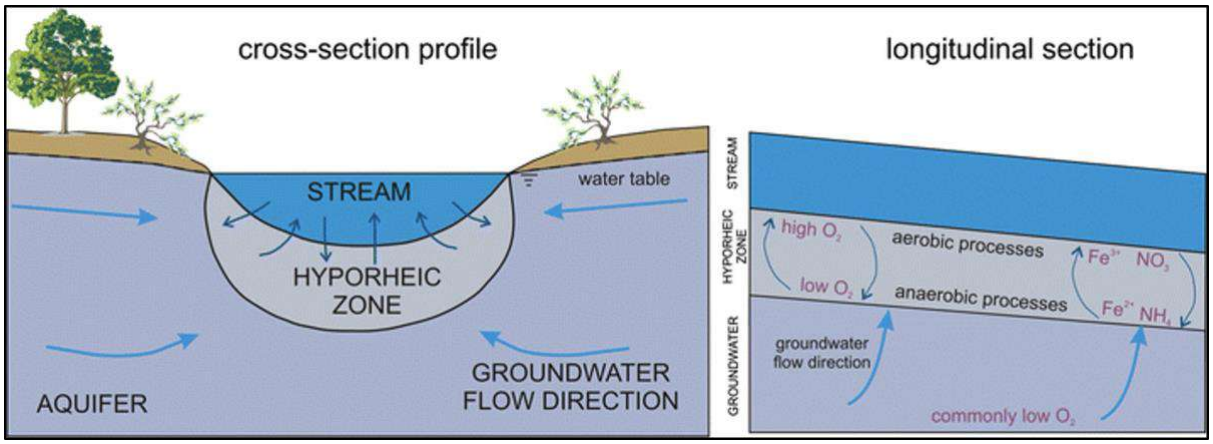
Natural Water Resources - Surface Water

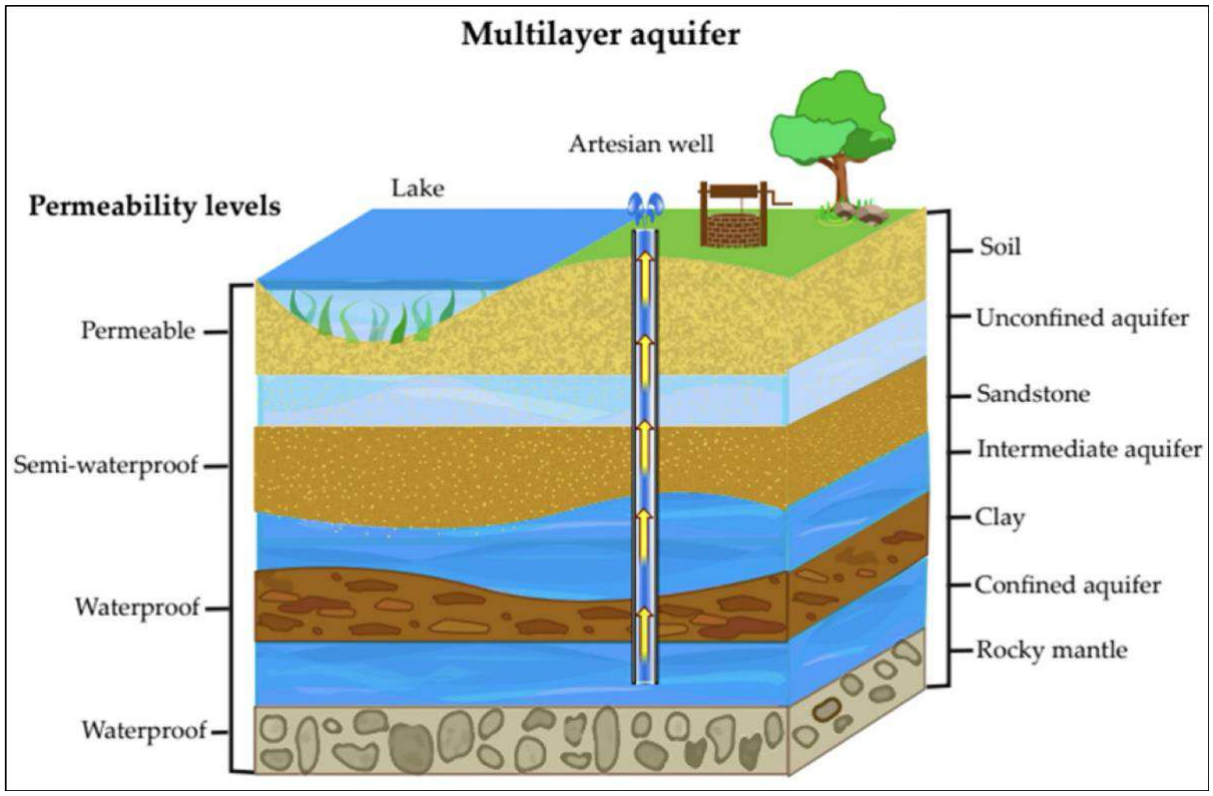
- Water in a river, lake, or freshwater wetland is known as surface water.

- Precipitation refills surface water, while discharge to the oceans, evapotranspiration, evaporation, and groundwater recharge deplete it.
- Although precipitation within a watershed is the only natural input to any surface water system, the overall amount of water in that system at any given time is influenced by a variety of other factors.
- Storage capacity in lakes, marshes, and artificial reservoirs, permeability of the soil underlying these storage bodies, runoff characteristics of the land in the watershed, precipitation timing, and local evaporation rates are among these aspects.

Natural Water Resources - Under River flow

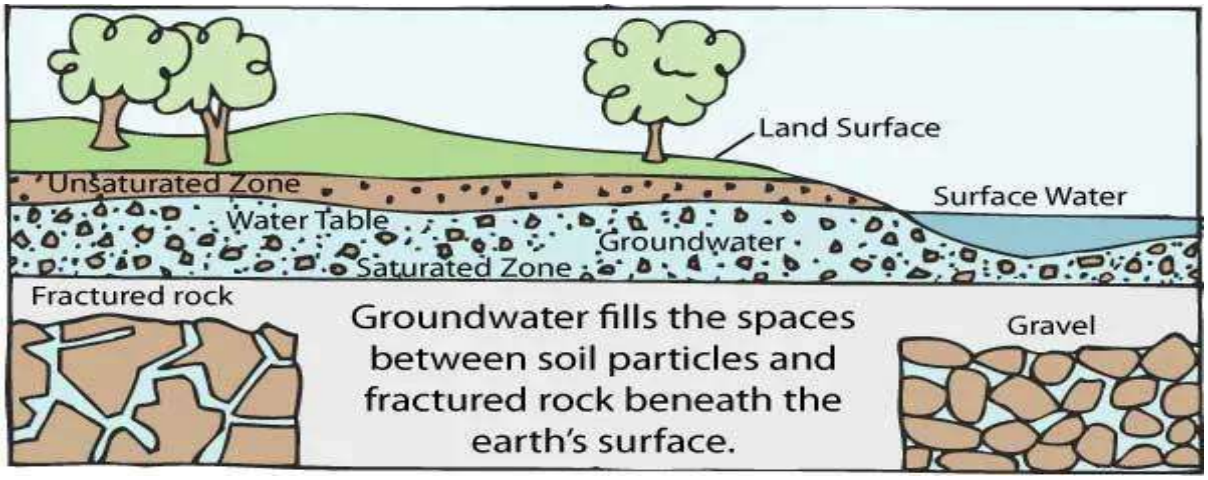
- The total volume of water delivered downstream by a river is typically a combination of visible free water flow and a significant contribution flowing via rocks and sediments that lay beneath the river and its floodplain, known as the hyporheic zone.
- This invisible component of flow may substantially exceed the visible flow for many rivers in big valleys.
- The hyporheic zone is a dynamic interface that exchanges flow between rivers and aquifers that are either fully charged or depleted.
- This is especially true in karst environments, which are prone to potholes and subsurface rivers.





Natural Water Resources – Groundwater

- Groundwater is a type of freshwater that is found in the pore space of soil and rocks under the surface. It also includes water that flows beneath the water table in aquifers.
- It's occasionally helpful to distinguish between surface water-associated groundwater and deep groundwater in an aquifer (sometimes referred to as "fossil water").
- Inputs, outputs, and storage are generally the same for groundwater as they are for surface water.
- The crucial difference is that, due to its slow turnover rate, groundwater storage is often substantially bigger (in volume) than surface water storage when compared to inputs.
- Because of this disparity, humans can utilise groundwater in an unsustainable manner for an extended period of time without suffering serious effects.
- Nonetheless, the average rate of seepage above a groundwater source represents the upper bound for typical water intake from that source over the long run.
- Seepage from surface water is a natural source of groundwater input. Natural groundwater outflows include springs and seepage into the oceans.



Natural Water Resources – Frozen Water

- The Himalayas, dubbed "The Roof of the World," are home to some of the world's most vast and rugged high altitude terrain, as well as the world's largest glaciers and permafrost outside of the poles.
- Ten of Asia's greatest rivers originate there and more than a billion people rely on them for survival.
- To make matters worse, temperatures in the area are rising faster than the world average.
- Over the last decade, the temperature in Nepal has risen by 0.6 degrees Celsius, while the Earth has warmed by about 0.7 °C globally.
- Several strategies to use icebergs as a water source have been proposed, however this has only been done for research purposes so far. Surface water is referred to as glacier runoff.

Integrated Farming

- It refers to an agriculture system that integrates livestock and crop production.
- Integrated farming system is a sustainable agricultural system that integrates livestock, crop production, fish, poultry, tree crops, plantation crops and other systems that benefit each other.

- It is based on the concept that ‘there is no waste’ and ‘waste is only a misplaced resource’ which means waste from one component becomes an input for another part of the system.
- IFS approach is considered to be the most powerful tool for enhancing profitability of farming systems especially for small and marginal farmers to make them bountiful
- Goals of Integrated Farming System • Enhancing productivity per unit area • Proper waste management • Generation of continuous income round the year • Reducing use of chemicals
- Maximization of yield of all component enterprises • Soil health management Components of Integrated Farming System (IFS) • Piggery • Poultry • Duckery • Fishery • Plantation crops • Apiary • Mushroom Cultivation • Vermicomposting • Fruit cultivation

Goat-Fish Integration

Biogas plant

Chicken-Fish Integration

Tree Intercropping

Integrated Farm Management

- Organisation & Planning – Effective farm management, staff training, record-keeping and contingency planning ensure efficiency, resilience, and sustainable operations.
- Soil & Crop Health – Maintain fertile soil, optimize water use, and implement Integrated Pest Management (IPM) for sustainable crop protection.
- Pollution & Waste – Reduce, reuse, and recycle by-products to minimize environmental impact, conserve resources, and enhance farm sustainability.
- Animal Husbandry – Ensure animal welfare, optimise feeding, and manage manure efficiently to improve productivity, biodiversity, and cost savings.
- Energy & Water Management – Enhance energy efficiency, adopt renewables, and implement water conservation strategies for sustainable farming and resource optimization.
- Community & Conservation – Engage communities, protect landscapes, and promote biodiversity for stronger connections and long-term environmental benefits.

Soil Erosion - Factors influences

- Water Erosion – Heavy rainfall and surface runoff wash away nutrient-rich topsoil, reducing soil fertility and contributing to land degradation over time.
- Wind Erosion – Strong winds displace loose soil particles, especially in dry regions, causing desertification and loss of agricultural productivity.
- Deforestation – Cutting down trees removes protective vegetation cover, exposing soil to erosion and leading to reduced water retention.
- Overgrazing – Excessive livestock grazing strips land of vegetation, weakens root systems, and accelerates soil degradation and compaction.
- Improper Tillage – Deep plowing and continuous soil disturbance break down soil structure, making it more susceptible to erosion.
- Gully Erosion – Uncontrolled water flow carves deep channels in the soil, creating gullies that expand over time and degrade land.
- Landslides – Unstable slopes, deforestation, and heavy rainfall trigger landslides, leading to large-scale soil displacement. Urbanisation – Construction removes topsoil, compacts land, and increases runoff, exacerbating erosion and soil loss.

- Salinisation – Poor irrigation and drainage practices cause salt accumulation, degrading soil structure and increasing vulnerability to erosion.
- Climate Change – Rising temperatures and extreme weather events intensify soil erosion by altering rainfall patterns and increasing storm frequency.
- The extraction of useful natural resources such as metals, minerals and fossil fuels etc., from the land causes serious disturbance to the land leading to soil erosion and drastic changes in the landscape.
- Agriculture causes the worst type of soil erosion on farmland in the form of wash-off or sheet erosion.
- The amount and intensity of precipitation is the main climatic factor governing soil erosion by water.
- Soil erosion can be defined as a process of detachment and transport of soil particles from one place to another.
- Soil erosion is a natural process which has increasingly been exacerbated by human activities such as agriculture and deforestation.
- While erosion is a natural process, human activities have increased by 10–40 times the rate at which erosion is occurring globally

Soil Erosion - Conservation Methods

- Contour Plowing – Plowing along natural land contours reduces water runoff speed, minimises soil loss, and enhances moisture retention.
- Terracing – Step-like terraces on slopes slow water flow, prevent erosion, and improve agricultural productivity.
- Cover Cropping – Planting cover crops like legumes and grasses protects soil, enhances organic matter, and prevents erosion.
- Mulching – Applying organic or synthetic mulch shields soil, retains moisture, regulates temperature, and suppresses weeds.
- Windbreaks – Rows of trees or shrubs reduce wind speed, preventing wind erosion and protecting crops.
- Agroforestry – Integrating trees with farming enhances soil stability, biodiversity, and long-term sustainability.
- No -Till Farming – Avoiding plowing preserves soil structure, reduces erosion, and improves water retention.
- Rainwater Harvesting – Capturing and storing rainwater reduces runoff, prevents erosion, and improves irrigation efficiency.
- Gully Plugging – Using stones, sandbags, or vegetation stabilises gullies, preventing further soil loss. Crop Rotation – Alternating crops improves soil health, enhances fertility, and reduces erosion risks.

Arid Region

- Definition – Arid regions receive less than 250 mm of annual rainfall, experiencing extreme dryness, high evaporation rates, and minimal vegetation cover, making them prone to desertification.
- Climate – Characterized by scorching daytime temperatures, cold nights, and low humidity, arid regions face extreme temperature fluctuations due to the lack of moisture.
- Soil Conditions – Arid soils are typically sandy, rocky, and nutrient-poor, with low organic matter, making agriculture difficult without irrigation or soil improvement techniques.
- Water Scarcity – With minimal rainfall and excessive evaporation, surface water is rare, forcing reliance on groundwater sources, which are often over-exploited.
- Vegetation – Plants such as cacti and succulents have adapted to store water, develop deep roots, and minimize transpiration to survive long dry periods.
- Ecologically, an arid region, also known as desert, is an area having an annual rainfall of 10 inches (25 cm) or less.
- Cold deserts are caused by extreme cold. They are often covered with perpetual snow or ice and are quite distinct from the deserts of warm regions.
- Wildlife Adaptations – Animals like camels, desert foxes, and scorpions have developed water conservation techniques and nocturnal habits to survive extreme heat.

- Human Settlements – Sparse populations rely on deep wells, rainwater harvesting, and oasis-based agriculture to sustain life in arid environments.
- Economic Activities – Limited agriculture, livestock rearing, tourism, and mining (for resources like oil and minerals) dominate arid region economies.
- Desertification – Overgrazing, deforestation, and climate change accelerate land degradation, turning once-productive land into barren deserts with poor biodiversity.
- Mitigation Strategies – Afforestation, controlled grazing, improved irrigation techniques, and sustainable water management help combat desertification and support livelihoods in arid regions.

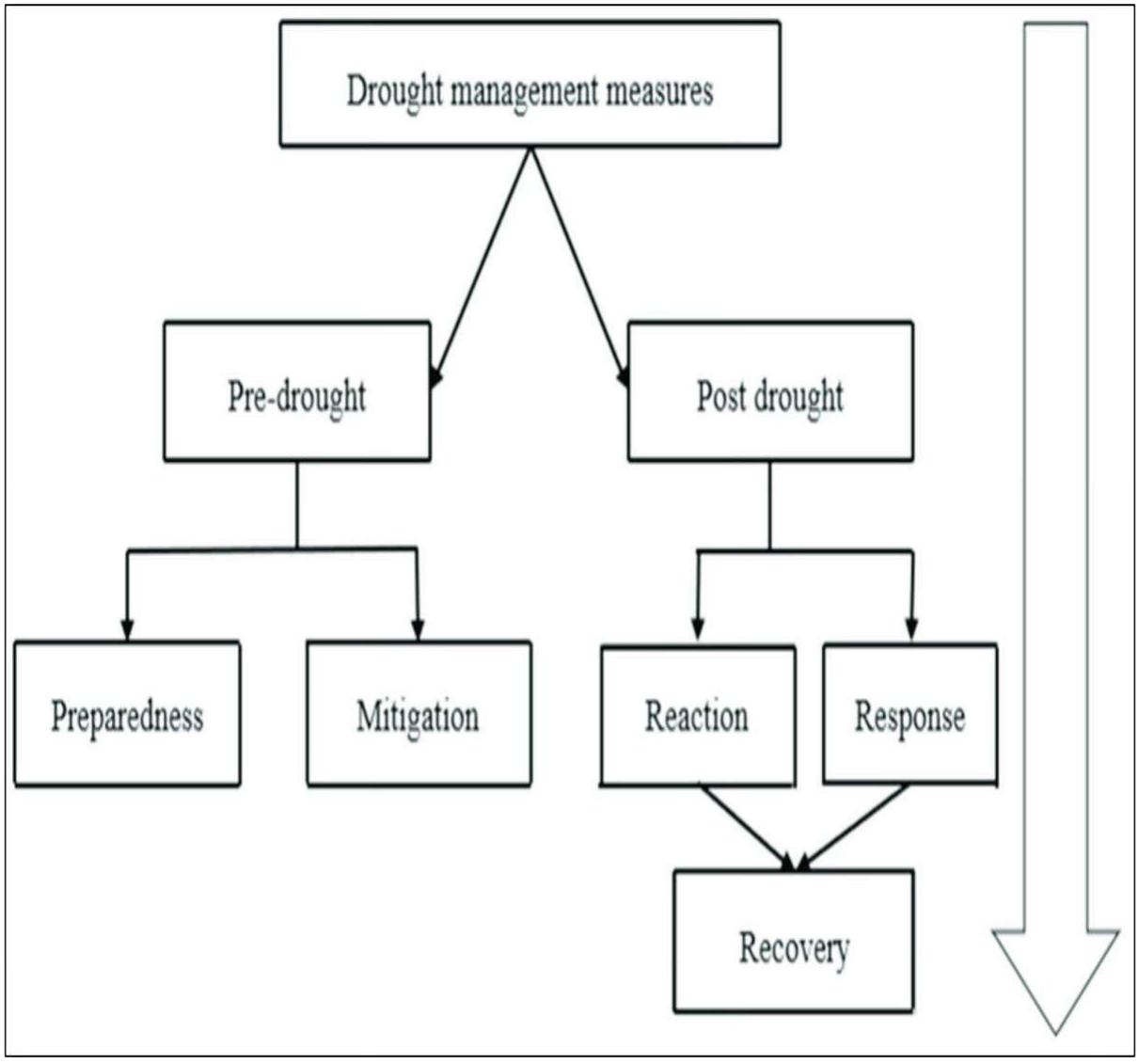
Semi – Arid Region

- Definition – Semiarid regions receive 250–500 mm of annual rainfall, experiencing seasonal dry spells and water scarcity, though they support more vegetation than arid zones.
- Climate – While drier than humid regions, semiarid areas experience moderate rainfall variability, leading to prolonged droughts and occasional heavy downpours.
- Soil Fertility – Semiarid soils contain more nutrients than arid regions but are prone to erosion, compaction, and degradation due to water stress.
- Water Resources – Rainfall is intermittent and unreliable, requiring careful water conservation techniques such as reservoirs, check dams, and rainwater harvesting.
- Vegetation – Grasses, shrubs, and scattered trees dominate, with species like acacia and baobab adapted to withstand long dry periods.
- Agriculture – Farmers cultivate drought-resistant crops such as millet, sorghum, and pulses, relying on irrigation and conservation farming practices.
- Livestock Farming – Semiarid regions support extensive livestock grazing, but overgrazing can lead to land degradation and soil erosion.

Drought Assessment and Classification

- Definition - Drought is a prolonged period of insufficient rainfall, causing water shortages, reduced crop yields, and negative impacts on ecosystems, economies, and human livelihoods.
- Causes - Drought occurs due to climate variability, deforestation, poor water management, and changing weather patterns influenced by global warming and regional atmospheric conditions.
- Types of Drought - Droughts are classified into meteorological, agricultural, hydrological, and socio-economic types, each affecting different sectors and requiring specific mitigation strategies.
- Impact on Agriculture - Drought reduces soil moisture, stunts plant growth, lowers crop yields, and leads to food insecurity, especially in rain-fed farming regions.
- Water Scarcity - Prolonged drought depletes surface and groundwater resources, affecting drinking water supplies, irrigation systems, and hydropower generation.§Effects on Biodiversity - Drought disrupts ecosystems, leading to habitat loss, reduced water availability, and increased mortality rates among plants and wildlife.
- Socio-economic Consequences - Drought triggers food shortages, higher commodity prices, economic losses, migration, and conflicts over water resources in affected regions.

- Climate Change Link - Rising global temperatures intensify drought frequency and severity, requiring proactive adaptation and resilience-building measures to mitigate impacts.
- Early Warning Systems - Timely monitoring using satellite data, weather forecasts, and hydrological models helps predict drought onset and guide preparedness strategies.
- Drought Management Strategies - Integrated water resource management, efficient irrigation, afforestation, soil conservation, and community engagement are key to minimising drought impacts.



Water resources	
Enhancing supply	• Storage capacity increase • Water transfers • Locating new potential resources • Aqueducts and canals • Groundwater recharge • Small scale water collection/harvesting • Adjusting legal and institutional framework • Artificial precipitation • Desalination of brackish & saline • Water treatment & reuse of wastewater/recycling
Improving demand management (in all sectors/uses)	• Reducing use • Reducing losses • Reviewing water allocation • Monitoring, metering, forecasting • Conjunctive use (surface-groundwater) • Reviewing education curricula • Adopting/reviewing water tariffs • Adjusting legal & institutional framework • Voluntary insurance, pricing and economic incentives

Agriculture	
Agricultural water management (complying with water resources strategy/plan)	• Irrigation expansion if/where possible • Improving demand management (more efficient systems) ◦ water loss reduction ◦ irrigation scheme modernization/conversion to more efficient systems ◦ shift to less water-demanding crops and cropping systems ◦ research of drought tolerant crops/species/genotypes ◦ adjusting cropping calendars to avoid heat stress ◦ use of non-conventional water resources ◦ deficit irrigation, supplementary irrigation ◦ conjunctive use of surface and groundwater ◦ soil water conservation practices ◦ adopting/reviewing water tariffs
Crop production	• Breeding for drought tolerance species & adaptation to short season • Cultural practices and techniques for conservation agriculture ◦ Proper fertilization ◦ No-till/reduced tillage systems ◦ Crop rotation/cropping systems ◦ Seeding rate/density ◦ Weeding/adapted pest management ◦ Mulching/adapted soil preparation ◦ Strip farming ◦ Crop insurance

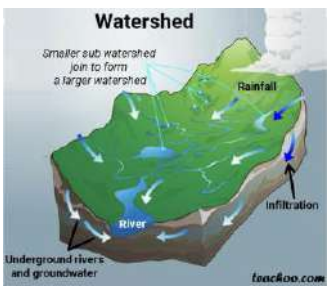
Water	
Supply augmentation (all/specified sectors)	• Mixing fresh & low quality waters • Exploiting high-cost waters • Adjusting legal and institutional framework • Locating new standby resources (for emergency) • Providing permits to exploit additional resources • Providing drilling equipment
Demand management (all/specified sectors)	• Restricting agricultural uses (rationing, subjecting certain crops to stress, ...) • Restricting municipal uses (lawn irrigation, ...) • Reviewing operations of reservoirs • Diverting water from given uses • Over-drafting aquifers (temporarily) • Reviewing water tariffs • Rationing water supply • Sensitising and awareness campaign • Adjusting legal and institutional framework • Negotiating transfer between sectors • Dual distribution networks for drinking water supply • Adopting carry-over storage • Conjunctive use

Concept of Watershed

- A "watershed" is a geographical area where all the land drains into a single body of water, like a river or lake, defined by its highest points and natural boundaries,
- "watershed management" refers to the practice of sustainably managing the land and water resources within that area to ensure the health of the entire watershed ecosystem, including its water quality, quantity, and biodiversity.

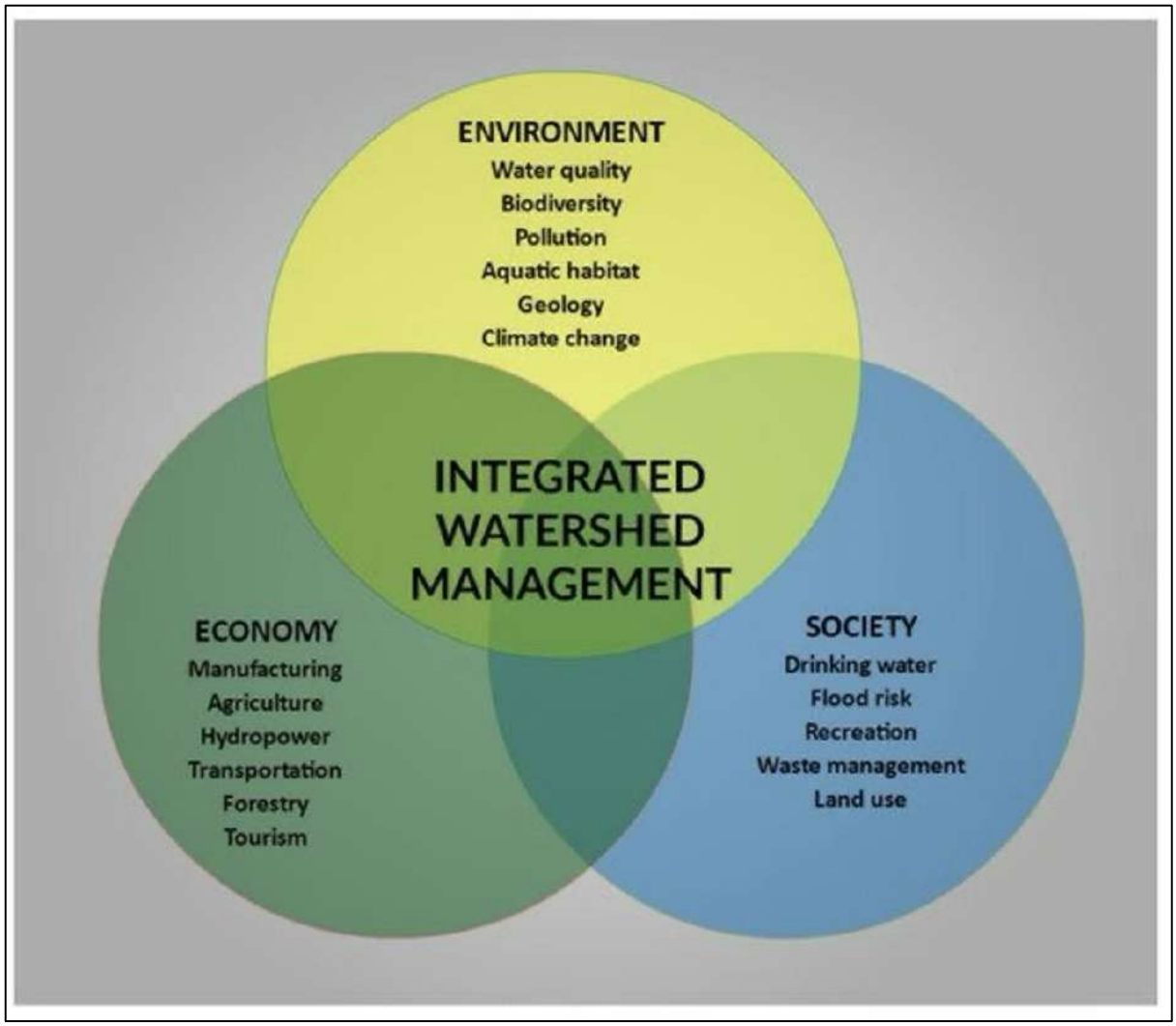
Key points about watersheds:

- Definition - A watershed is a land area where all rainwater runoff flows to a common point, eventually reaching a river, stream, lake, or other body of water.
- Boundaries - The boundaries of a watershed are determined by the topography, with the highest points on the land defining the watershed's perimeter.
- Components - A watershed includes various elements like streams, rivers, lakes, wetlands, forests, agricultural lands, and urban areas, all contributing to the water flow within the watershed.



Introduction to Watershed Management

- Goal - The primary goal of watershed management is to protect and enhance the water resources within a watershed by addressing issues like soil erosion, flooding, water pollution, and degradation of natural habitats.
- Key aspects - Land use planning: Managing land use practices within a watershed to minimize soil erosion and promote water infiltration, including planting trees, implementing sustainable agriculture techniques, and controlling development.
- Water conservation - Strategies to conserve water within the watershed, like rainwater harvesting, efficient irrigation systems, and restoring wetlands.
- Pollution control - Identifying and addressing sources of pollution within a watershed, such as industrial waste, agricultural runoff, and sewage discharge.
- Community engagement - Involving local communities in decision-making and implementing watershed management practices.



Objectives of Watershed Development Programs

- Development of wastelands, areas which are drought-prone, degraded lands and also desert areas while keeping the local needs and site conditions apt.
- It also helps in promoting the on-ground economic development and also in improving the life standard, socially and economically, of the poor and disadvantaged people living near the program areas.
- This also reduces the effect of natural climatic problems such as drought and geologic processes on humans and plantations.
- Restoring ecological equilibrium by utilising, conserving, and developing natural resources (e.g., land, water, and vegetative cover).
- Using a watershed approach, water resource development, conversion, and pasture development.
- Watershed delineation - Accurately mapping the boundaries of a watershed using topographic maps and GIS technology is the first step in watershed management.
- Watershed characterisation - Analysing the physical, biological, and socio-economic characteristics of a watershed to understand its unique challenges.
- Integrated approach - holistically, considering the interactions between land use, water quality, and ecological processes.

Watershed Development

Target Group: Entire Population and Natural System

- Soil and moisture conservation
- Restoration of traditional water bodies and construction of small in situ rainwater harvesting structures
- Development of vegetation and biomass
- Water-saving technologies
- Rain-fed agriculture practices and technologies
- Rain-fed horticulture
- Dairy and livestock development
- Biogas plants
- Development of human capital, institutions, and infrastructure

Advantage of Watershed Management

- Watershed management helps regulate pollution of the water and alternative natural resources within the watershed.
- Identifies and Regulates Ecologically Venturous Activities - The activities which happen at a watershed in regular intervals affect the natural resources and water quality.
- Watershed management comprehensively identifies such activities. It makes recommendations to properly address them so that their adverse impacts are often reduced.
- Enhanced Partnership among the stakeholders is rising, which is crucial for the effective management of the land and water resources.
- It is also an economical solution, due to the implementation of watershed management plans when resources are restricted.