ENVIRONMENTAL GEOSCIENCES

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Lecture-30

Distribution of Water on Earth

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. We have already covered the module 5, now we are covering the module 6 in which we will discuss about the distribution of water on earth, groundwater provinces of India, hydrological cycle, aquifer, its types and porosity and permeability. Today we will discuss the lecture 1, that is distribution of water on Earth's surface. In this lecture, the important concepts will be covered like introduction to world water resources, factors affecting distribution of water on Earth, water resources of India, water distribution in India, overview of per capita water decline in India, and need for conservation of groundwater resources. Now we will discuss about the introduction of world water resources.

The world's total water resources are estimated at 1.36×10^8 million hectare meter. Out of these global water resources, about 97.2 % is the salt water, mainly remaining in oceans and seas, and only 2.8 % is available as fresh water. Out of this 2.8 % of fresh water, about 2.2 % is available as surface water and 0.6 % as groundwater. Out of this, 2.2 % of surface water, 2.15 % is freshwater in glaciers and ice caps, and only of the order of 0.01 % is available in lakes and streams. The remaining 0.04 % are remaining in other forms.

Out of 0.6 % of the stored groundwater, Only 0.05 % can be economically extracted with the present drilling technology that is remaining being at greater depths. So in this way, the details statistics of the world water resources is given here. Understanding earth water distribution provides an insightful analysis of how water is allocated across the planet's key reservoirs. The different proportions of water has been found in oceans, glaciers, groundwater, lakes, soil and freshwater systems.

Now we will discuss one by one. First is the oceans in which we have seen 97.2 % water were. The vast expanse of oceans constitute the largest reservoir of the water on our

planet holding approximately 97.2 % earth water. Oceans are a vital part of the hydrological cycle, playing a critical role in regulating the global climate. They absorb and store solar energy, which helps in moderating the Earth's temperature.

Additionally, oceans support a diverse range of marine life, making them a crucial ecosystem for sustaining the biodiversity. Now second is the glaciers, 2.1 %. Glaciers and polar ice caps contain around 2.1 % of the Earth's water. Those frozen reserves are significant for maintaining sea levels and controlling the planet's climate. When glaciers melt, they release fresh water, which is essential for various purposes, such as drinking water, agriculture, and industrial uses.

Glaciers also play a role in shaping the landscapes and creating unique geological features. Next is the groundwater. Beneath the earth surface there lies a substantial amount of water known as groundwater accounting for about 0.65 % of the total water distribution. Groundwater is stored in porous rocks and serves as a critical source of drinking water for millions of people around the world. It also supports irrigation for agriculture and provides a stable flow to rivers and streams during the dry periods.

The groundwater potential of the Ganga basin is roughly about 40 times the flow of water in the river Ganga. Next is the freshwater and saline lakes. Lakes, both freshwater and saline, make up a minute portion of the water distribution, amounting to approximately 0.017 %. These bodies of water are essential ecosystems hosting a variety of aquatic species. Freshwater lakes are a vital source of drinking water, while the saline lakes often have unique environments and can support the specialized life forms.

Next is the soil moisture. Water held within the soil accounts for a small fraction of the water distribution, around 0.005 %. Soil moisture is essential for plant growth and sustenance. It provides plants with the necessary hydration and nutrients, contributing to agriculture productivity and supporting the terrestrial ecosystems. Next is the streams, wetlands and swamps.

The smallest fraction of earth's water is found in streams, wetlands and swamps, comprising about 0.001 %. These freshwater ecosystems contain a small quantity of water. They play a very crucial role in supporting the biodiversity. Wetland and swamps act as natural filters, purifying water and providing habitat for numerous plant and animal species. So, earth water distribution is a delicate balance with oceans dominating the majority of the water reserves.

Glaciers, groundwater, lakes, soil moisture, streams, wetlands and swamps each contribute to sustaining life on our planet in their unique ways. Understanding this distribution is essential for managing and preserving this invaluable resource for the well-being of both nature and humanity. Now, the sources of water. In nature, we are getting two sources. First is the surface water.

Second is the groundwater. The sources of surface water are lakes, ponds, streams, rivers, storage reservoir. Now groundwater, the sources are springs, infiltration galleries, dug well, tube well, artesian well. Now uses of water. We are having few uses.

Consumptive use, irrigational use is the main one. Partial consumptive use, domestic use, institutional use, industrial use, thermal power plant for firefighting, etc. Non-consumptive use, recreational use, navigational use, pollution counts, hydroelectric power plant, etc. So these are the uses of the water. Now factors affecting distribution of water on earth.

Water distribution on earth is influenced by various factors that play a crucial role in shaping the ability and movement of this essential resource. Understanding these factors help us to understand the complexity of the hydrological cycle and the distribution of water across different reservoirs. Some of the key factors affecting the distribution of water on Earth are: First factor, the climate and rainfall patterns. Second, topography and geology. Third, temperature and evaporation.

Fourth, human activities and water management. Fifth, ocean circulation and currents. Sixth, glacial melting and ice cap dynamics. Seven groundwater recharge and depletion, eight natural disasters and climate extremes, nine water management policies and conservation efforts and ten the global climate change. Now first factor we will discuss climate and rainfall patterns in india

You can see the map also, isohyetal map of India, in which rainfall is one of the key factors affecting water distribution on earth. The average annual rainfall of India is around 114 centimeter. Isohyetal map of India, that is lines joining all places having the same average annual rainfall is shown in the map. This map highlights India's diverse rainfall patterns, crucial for agriculture, water resource management and ecosystem sustenance. In the map, you can see the different different value is given 125 centimetre, 190 centimetre, then 75 centimetre, here you can see five hundred centimetre.

So in this way the different ranges of the average annual rainfall has been given and this is the isohyteal map of India. Based on the provided map of rainfall distribution in India, rainfall regions are, first is the high rainfall regions. Areas receiving over 250 centimetre of annual rainfall are located in north-eastern India, say Assam, Meghalaya, and parts of the western Ghats, particularly in Kerala and coastal Karnataka. Moderate rainfall regions, regions receiving near about 125 to 250 centimetre of rainfall include the eastern coast that is Tamil Nadu, Andhra Pradesh and parts of western Ghats and the Indo-Gangetic Plains in Uttar Pradesh and Bihar. Low rainfall regions, areas having 50 to 125 centimetre of rainfall include parts of central India, western Uttar Pradesh, Gujarat and parts of Tamil Nadu.

Arid and semi-arid zones, regions receiving less than 50 cm of rainfall include the Thar desert in Rajasthan, parts of Gujarat, and the areas in the rain shadow regions of the Western Ghats, that is Maharashtra. Extreme rainfall zones, the highest rainfall occurs in north-eastern India, particularly in Mawsynram and Cherrapunji in Meghalaya, with annual rainfall exceeding 500 centimetre. So in this way, the different regions have been identified. Western coast influence,in the, Western coastal regions influenced by the southwest monsoon receive substantial rainfall with areas like Konkan and Malabar receiving near about 200 to 300 centimeter annually. Himalayan region, the Himalayan foothill experiences significant rainfall ranging from 125 to 190 cm, aiding the flow of perennial rivers like Ganga and Brahmaputra.

Central plateau, the central plateau region, including parts of Madhya Pradesh and Maharashtra, receives moderate rainfall ranging between 75 to 125 cm. Eastern coastal plains, eastern coastal plains, particularly Odisha and West Bengal, receive rainfall ranging from 125 to 190 centimeter, influenced by the northeast monsoon and cyclonic activities. Seasonal variation, the map reflects normal annual rainfall primarily driven by the southwest monsoon, June to September, and to a lesser extent the northeast monsoon, October to December, in the southern peninsular region. So different regions on earth experience varying climates and precipitation patterns resulting in disparities in water availability. Tropical regions often receive abundant rainfall leading to lush rainforest and extensive river networks.

Arid and semi-arid regions like desert receive limited rainfall leading to water scarcity and arid landscapes. Second is the topography and geology. The topography of an area such as mountains, plateaus and valleys influences the flow of water through rivers and

streams. And geological formations like permeable rocks affect groundwater storage and ability. Third is the temperature and evaporation.

High temperature contributes to increased evaporation rates leading to water loss from surface water bodies like lakes and rivers. Warm climates can result in significant evapotranspiration where plants release water vapor into the atmosphere affecting the soil moisture. Next is the human activities and water management. Human activities such as deforestation, urbanization and agriculture can alter the natural water cycles and impact water distribution. Water management practices like dams and reservoirs influence water storage and distribution for human needs.

Next is the ocean circulation and currents. Ocean currents play a vital role in distributing heat and nutrients across the globe, impacting weather patterns and influencing water distribution. Ocean circulation can affect coastal climates and ecosystems. Glacial melting and ice cap dynamics. The melting of glaciers and ice caps due to climate change affects sea levels and releases fresh water into the oceans, impacting the water distribution.

Groundwater recharge and depletion. The replenishment of groundwater is influenced by factors like rainfall and land use. Excessive groundwater extraction can lead to depletion and reduce the ability of this vital water source. Next is the natural disasters and climate extremes. Natural disasters like floods and droughts can cause significantly impact water distribution in affected regions.

Climate extremes such as El Nino, La Nina events can disrupt the normal precipitation patterns and affect water availability. Water Management Policies and Conservation Efforts. Governed policies and conservation efforts can influence water allocation and distribution for various purposes, including domestic, agriculture and industrial uses. And the last is the global climate change. Climate change has far-reaching effects on water distribution, including the alteration of precipitation patterns, increasing the frequency of extreme weather events, and accelerating the glacial melting. Therefore, understanding the interplay of these factors is vital for sustainable water management and conservation efforts.

As we continue to face challenges like water scarcity and climate change, responsibly managing this precious resource becomes crucial for the well-being of both nature and humanity. Now, Water Resources of India The following table highlights the water potential of major river basin in India, showcasing their contributions to the country's

total water resources. The total water potential from all listed river basins amounts to 188.14 million hectare meter. Now we will see the different river basins.

First is the west flowing rivers like Narmada and Tapti. These rivers contribute thirty point five million hectare meter originating from central and western parts of India and flowing towards the Arabian Sea. Now east flowing rivers Mahanadi, Godavari, Krishna, Cauvery, Penar etc. These rivers collectively have a water potential of 35.56 million hectare meter and flow eastward into the Bay of Bengal supporting extensive agriculture in peninsular India. Next is the Ganga and its tributaries.

The Ganges is a vital lifeline for northern India. Along with its tributaries, it has the highest water potential at 65.01 million hectare meter, sustaining a significant portion of India's population and agriculture. Now next is the Indus and its tributaries. These rivers flowing through northern India contribute a smaller share of 7.95 million hectare meter due to their arid and semi-arid basin regions. Then the Brahmaputra river known for its vast catchment area and high discharge rates.

The Brahmaputra has a water potential of 59.07 million hectometer primarily concentrated in the northern eastern states. Now river basins of India. The rivers of North India are perennial that is the water in sufficient quantity flows in them throughout the year since they receive the snow melt runoff in summer also. Rivers of Peninsular India that is South India receive only runoff due to rainfall and have a good flow only during the monsoons. Many of them are either dry or have negligible flow during most of the remaining part of the year.

Here you can, the map also you can see the different river basins have been located. Tapti is here, Narmada, then Mahanadi is here, Ganga, river Ganga is flowing. So in this way, throughout the India, we are getting the different river basins. Based on the map of the Indian river basins provided here, is a description of major river systems in brief. Indus river system originates in Tibet and flows through Jammu and Kashmir, Punjab and Pakistan before draining into the Arabian Sea.

Major tributaries include Jhelum, Chenab, Ravi, Beas and Sutlej. Ganga river system originates from Gangotri glacier in Uttarakhand and flows through Uttar Pradesh, Bihar and West Bengal before merging into the Bay of Bengal. Major tributaries of Gang, river Ganga are Yamuna, Ghaghara, Gandak and Kosi. Now Brahmaputra river system originates in Tibet as Tsangpo river and flows through Assam in India before entering the Bangladesh.

Known for its large discharge and significant contribution to the north eastern region's water resources. Mahanadi River Basin originates in Chhattisgarh and flows through Odisha, draining into the Bay of Bengal. It is a vital river for irrigation and hydropower projects in eastern India. Godavari River Basin, the Godavari known as the Dakshin Ganga, originates in Maharashtra and flows through Telangana, Andhra Pradesh and other states before draining into the Bay of Bengal. It is the second longest river in India.

Then the Krishna River basin originates in Maharashtra, flows to Karnataka and Andhra Pradesh before entering into the Bay of Bengal. Major tributaries includes, Tungabhadra and Bhima. Cauvery River basin originates in Karnataka and flows to Tamil Nadu before draining into the Bay of Bengal. Known for its importance in agriculture and interstate water disputes. Narmada River Basin originates from Amarkantak Plateau in Madhya Pradesh and flows westward into the Arabian Sea.

The river forms the Narmada Valley and is a significant source of hydroelectric power. Then the Tapti River Basin originates in Madhya Pradesh, flows through Maharashtra and Gujarat before draining into the Arabian Sea. Similar to the Narmada, it flows westward. The Penner and other South Indian rivers, the Penner originating in Karnataka and small rivers like Pallar and Vaigai flow through southern India, mostly into the Bay of Bengal. These rivers support local agriculture and are critical for regional water supply.

The map illustrates the significant spatial variation in river system across India, emphasizing their importance in agriculture, hydropower and water resource management. Now here you can see the water budget and utilization in india its annual estimates. The first is the annual rainfall over the entire country approximate 370 million hectare meter. Evaporation loss is near about 123 million hectare meter. Runoff from rainfall in rivers 167. Seepage into subsoil by balance, balance near about 80. Water absorbed in topsoil layers, that is contributions of soil moisture, 43. Then recharge into groundwater, thirty-seven.

Annual groundwater recharge from rainfall and seepage from canals and irrigation system, 45. Groundwater that can be economically extracted from the present drilling technology, 27. Present utilization of groundwater, 13.5 and available groundwater for further exploitation and utilization 13.5. Now, overview of per capita water decline in India. Water availability per person is dependent on population of the country and for India, per capita water availability in the country is reducing due to increase in the population.

As per Ministry of Housing and Urban Affairs, one thirty five litre per capita per day has been suggested as the benchmark for urban water supply. The average annual per capita water ability in the years 2001 and 2011 was assessed as 1816 cubic meters and 1545 cubic meters respectively, which may lead to further reduced to 1486 cubic meters and 1367 cubic meters in the years 2021 and 2031 respectively. For rural areas, minimum service delivery of 55 LPCD has been fixed under Jal Jeevan mission, which may be enhanced to higher level by states. As mentioned in the report of National Commission for Integrated Water Resource Development, NCIWRD, the percentage of water used for irrigation out of the total water used for the year 1997-98 was 83.30 %. Further, as per NCIWRD report, the percentage of water used for irrigation out of the total water used for the year 2025 under high demand scenario was estimated as 72.48 %.

Now, need for conservation of groundwater resources. Water is literally the source of life on earth. Plants, animals and microbes all takes water. All metabolic activities required water. The human body is having seventy percent of water.

People begin to feel thirst after a loss of only one percent of bodily fluids and risk death if fluid loss nears to ten percent. Sources of water are river, lakes, ponds, well, rainwater, streams. Factors affecting the water stress are population, inappropriate agriculture patterns, industrialization, urbanization, leaky municipal pipes, improper pricing of municipal water, poor watershed management, pollution due to untreated municipal sewage, toxic industrial effluents and harmful chemicals from agricultural activities. The various types of water conservation measures are indoor conservation, outdoor conservation, industrial conservation, and agricultural conservation. Indoor conservation can be done by shortening the shower time by a minute, monitoring water bill for usually high use.

Bill and water meter are tools that can help you to discover the leaks. Grabbing a wrench and fix that leaky faucet. It's simple, inexpensive and can save 140 gallons a week. Use of conserving appliances like low volume shower heads, inefficient dishwasher and washing machines, etc. Use of low flow toilets and flush the toilet only when really necessary.

Now for outdoor conservations, the points are that we should use a bucket of water to clean our car instead of a hose. Sweep sidewalks, driveways and patios instead of hosing. Clean gutters and downspouts manually without using a hose. Cultivate the soil regularly so water can penetrate and develop a good root system. In arid and semi-arid regions, replace lush green lawns with decorative rock garden.

Methods to harvest rainwater should be provided. Industrial conservation, water conservation measures that can be taken by industries and manufacturing units include using dry cooling systems or cooling towers that use less water, reuse the cooling water for irrigation and other purposes. Industries and manufacturing units should curb water withdrawals wherever possible by increasing in-plant treatment and recycling of water or by developing new equipment and processes that require less water. Recycled water should be used for floor washing and other such purposes. Agriculture conservation.

Agriculture is the biggest water user and perhaps half of all the agricultural water used is lost to leaks in irrigation canals and application to areas where plants do not grow, run off and evaporation. The agriculture conservation measures like use lined or covered canals that reduce seepage and evaporation, use improved irrigation techniques such as sprinklers or drip irrigation, irrigate fields in early morning and at night when evaporation is minimal, adopt better farming techniques such as tillage, leaving crop residue on fields and ground cover on drainage waste, intercropping etc. Use mulch to help retain water around plants. Price agriculture water to encourage conservation. In arid and semi-arid regions, encourage the development of crops that require less water and are drought resistant.

Now strategies to support water conservation. We have seen already that 97 % of all the water on earth is salt water, which is not suitable for drinking purposes. Only 3 % of all the water is fresh water and only 1 % of it is available for drinking water. The other 2 % is locked in ice caps and glaciers. We must all make changes in our lifestyles that will change the course of our water and its quality.

Water conservation means using our water widely and caring for it properly. Water conservation is not a job that is just for soil scientists, hydrologists, foresters, wildlife managers or farmers alone. It is a job for every person who just likes to have access to the life-sustaining resources of water. Some of the strategies that can support water conservation activities to tackle the water scarcity problem include First is the rainwater harvesting.

Rooftop rainwater harvesting is one of the important methods through which we can harvest the water, we can conserve the water resources. Revival of traditional water harvesting structures is also needed as per the time. Micro-catchment water harvesting strategies should be adopted and recharge structures for wells and bore wells should be increased. Sustainable water utilization is the another factor For it, minimizing of the

domestic water consumption, recycling of wastewater and improving the different irrigational methods are required.

Encourage natural regeneration of vegetation and supplementing with artificial regeneration. Maintain and improve the quality of water, that is collection of and treatment of wastewater effluents. Pollution check is needed periodically. Decreasing runoff losses. Huge water loss occurs due to runoff on most of the soils, which can be reduced by allowing most of the water to infiltrate into the soil.

Terrace farming. Terrace fields decrease erosion and surface runoff and are effective for growing crops requiring much water such as rice. Reducing irrigation losses. Use of lined or covered canals to reduce the seepage. Irrigation in early morning or late evening to reduce evaporation losses.

Sprinkling irrigation and drip irrigation to conserve water by about 30 to 50 %, growing hybrid crop varieties with less water requirements and tolerance to saline water help to conserve the water resources. Now, just summarizing the chapter, Introduction to world water resources has been discussed in the beginning. We have seen that the earth's water resources are primarily saline, 97.2 %, with only 2.8 % as fresh water, of which 0.25 % of groundwater can be economically extracted. Secondly, we have discussed the factors affecting distribution of water on earth.

We have seen the distribution of water on earth is shaped by factors like climatic patterns, topography and human activities influencing its ability and movement. Key elements include precipitation, evaporation, ocean currents, glacial dynamics and water management amid global climate change. Then we have discussed the water resources. We have seen the India's annual rainfall is high, limited storage sites and uneven temporal distribution constrain the actual usable surface water. India's annual rainfall varies widely with regions like Meghalaya receiving over 500 centimeter while arid zones like Rajasthan receive less than 50 centimeter.

India's rivers are categorized as perennial in the north and rain-fed in the south, emphasizing the spatial and seasonal diversity of water ability. Then we have discussed about the overview of per capita water decline in India in which we have seen the water availability per person in India is decreasing due to population growth with per capita annual availability dropping from 1816 cubic meter in 2001 to a projected 1367 cubic meter by 2031. While urban water supply is benchmarked at one thirty litre per capita per day, rural areas aim for 50 litre per capita per day under the Jal Jeevan mission and

irrigation remains the dominant water use through its share is projected to decline. Lastly, we have discussed about the need for conservation of the groundwater resources in which we have seen about the conserving groundwater is crucial to ensure sustainable water availability, prevent over exploitation and project against ecological and economic consequences of water scarcity. Thank you very much to all.