

REMOTE SENSING FOR NATURAL HAZARD STUDIES

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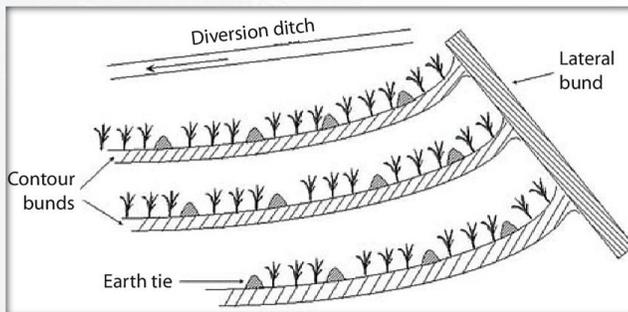
Lec 34b: Introduction to Drought - Part B

Hello, everyone. Welcome back to Lecture 34. This is part 2. So, this is part of Module 10, and we are talking about drought. So, I hope you remember that we started discussing mitigation measures: here we have crop rotation, contoured row crops, and terracing. Tillage practices: this is what we discussed in the first part. Now we will continue with this erosional control structure, water retention and detention structures, and the reclamation of salt-affected soil.

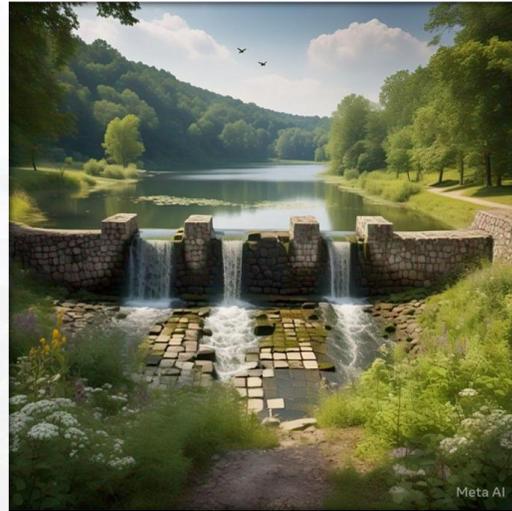
DROUGHT: MITIGATION



Erosion control structures



So, when we talk about these erosion-controlled structures, you will immediately have some images in your mind of how to store the water available on the surface. So, engineering measures differ by location, slope, soil type, and the amount and intensity of rainfall. Commonly used engineering measures include contour bunds, trenches, and stone walls.

Checkdams:

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Then we have check dams, and then we have percolation ponds. These are very popular and commonly used in many areas. So, this is an example of contour bunds. So, here you can see how it looks on the ground. Then check dams; then you have percolation ponds. So, these are manually designed.

Percolation ponds:

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Some of them are natural, but we are not using them. Now we will talk about the preparedness phase. So, early warning and readiness are important. The strategic stockpiling of cereals and grains can be one of the strategies. Rehabilitation of critical Boreholes, livestock marketing, animal and human health support, and supplementary

feeding for livestock are necessary. So, now you can just go back and remember the ENSO. How important is it to know about ENSO? If you have prior information, maybe the farmers can use the appropriate crop types in their area so that there will not be a very high loss during this drought period, or they can utilize some appropriate measures so that a lesser amount of water can lead to higher yields. In water resources, we increase water storage by locating new potential sources. Increase groundwater recharge by constructing small-scale water-collection or harvesting systems. Adjusting the legal framework to help people is necessary.

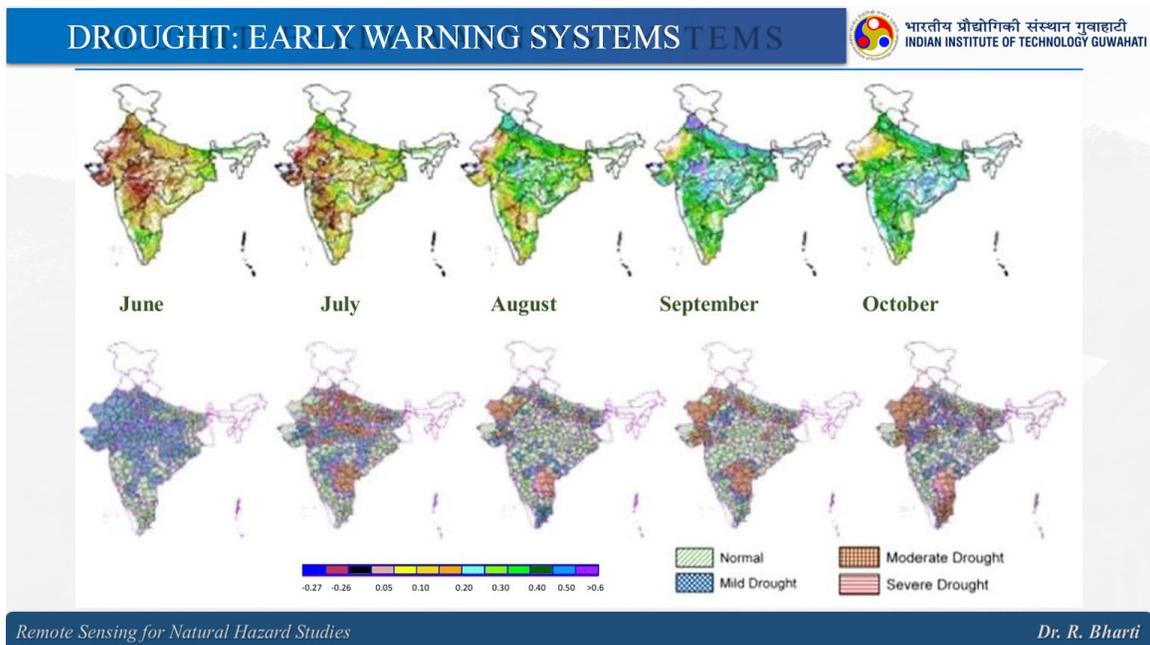
Artificial precipitation is one of the areas, but it is not currently functioning. Desalination of groundwater, especially in the coastal region, saline water treatment, reuse of wastewater, and recycling, etc. And, when we talk about demand management, reduction in use, and losses, once we know that our area is about to receive a lesser amount of water, we can restrict people from using more water and save water. Water allocation policy. So, during the drought conditions, maybe the industries that are using water that is not required or that is not on the primary list can be halted for the time being, or a lesser amount of water can be supplied.

Monitoring and forecasting system: surface groundwater storage review. Adopting and reviewing water tariffs, sensitizing the public, and conducting awareness campaigns are different measures. Now, when we talk about adopting or reviewing the water tariff, it helps because once you increase the tariff, maybe if I am using 100 liters a day, I will definitely opt for the minimum amount that is required. So, in that case, everybody will try to save water directly, indirectly, or perhaps even forcefully. Then, supply augmentation by mixing fresh and low-quality waters in the supply, exploiting high-cost water or deep water, locating new resources for emergencies, and providing permission to exploit additional resources.

Provide a drilling facility that will help people directly extract groundwater. Improving demand management is important for agriculture. Water loss reduction, irrigation schemes, a shift to less water-demanding crops, and cropping systems are important. Research on drought-tolerant crops and species, proper fertilization and pest management, no-till or reduced-tillage systems, crop rotation, cropping systems that definitely help, seeding rates or densities, and soil preparation, etc. Then, the immediate response will include animal and human health interventions, an emergency water supply system, supplementary feeding for vulnerable groups, restoration and stability, restocking livestock, rehabilitation of dams, infrastructure development, food-for-work and cash-for-work programs, and natural resource management interventions. Now we will talk about reconstruction and long-term sustainability. Focusing on rebuilding and strengthening resources post-drought includes continued infrastructure rehabilitation and capacity building. Ensures future drought resilience through natural resource management and integrates lessons learned to improve preparedness and mitigation efforts, as some areas

regularly experience these drought conditions. So, we have some examples, and we have learned from past events that can be used to plan for our future. Slow onset duration ranges from months to years, with an extensive spatial coverage.

So, here you have meteorological: this is due to the rainfall deficiency; hydrological: because of the surface and groundwater deficiencies; agriculture: it is because of the soil moisture and rainfall deficiencies. And the key variables are climate data, soil moisture, streamflow, groundwater, reservoir and lake levels, vegetation health, stress, and fire danger. And there are many Earth observation missions that have been launched, and their datasets can be used in drought analysis; slowly, we will learn about them. So, here you can see an example of satellite image utilization in drought analysis.

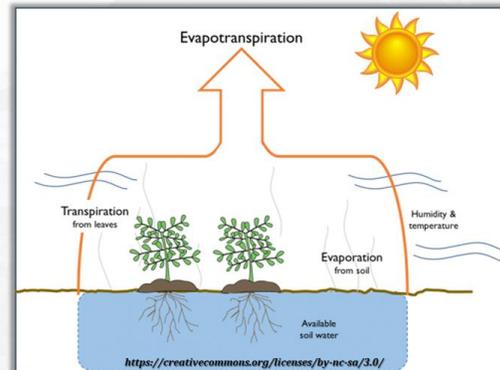


So, this is from June, July, August, September, and October, and this is normal: this is a mild drought, a moderate drought, and a severe drought.

You can see how areas fall into different categories. Rainfall and temperature are two of the major criteria, and we know that satellite images are the main sources of rainfall and temperature data today. Rainfall is measured using gauges and satellite-based estimation methods, and the meteorological department issues forecasts. Analyzing daily, seasonal, and annual rainfall fluctuations helps to understand drought trends. Temperature influences evaporation and plays a crucial role in drought assessment, with deviations indicating climate change. So, we have to keep checking the area parameter to see how the area is moving toward drought because it takes time to develop.

Evaporation and Evapotranspiration:

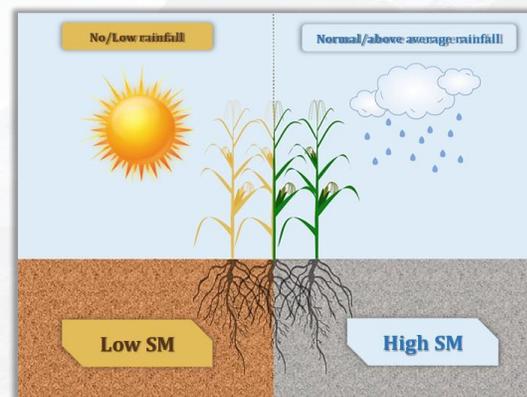
- Evaporation from open water bodies depends on radiation, surface temperature, wind speed, and humidity.
- It varies across regions, with higher evaporation rates in arid zones.
- Evapotranspiration includes both evaporation and plant transpiration, impacting water availability and drought severity.



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Soil Moisture:

- Soil moisture in the top layers of soil determines crop growth and yield.
- It influences water and heat exchange between land and atmosphere.
- Measurement methods include weight-based techniques, microwave sensors, and lysimeters.



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atmosphere; measurement methods include weight-based techniques, microwave sensors, and lysimeters.

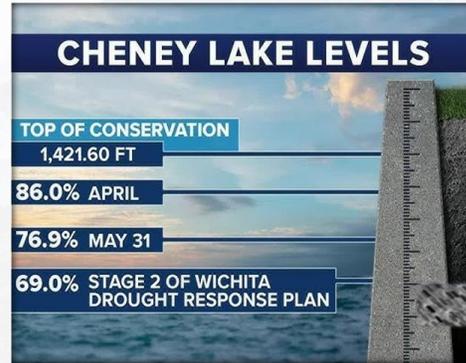
DROUGHT: EARLY WARNING SYSTEMS



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Reservoir Water Levels and River Flow:

- Surface water availability in lakes and reservoirs depends on rainfall, snowmelt, and consumption.
- Governments assess previous drought events before regulating water releases.
- River flow between stations helps determine groundwater contribution and potential drought severity.



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Reservoir water levels and river flow: we all know that many rivers, lakes, and reservoirs have continuous measurements of their water levels. Surface water availability in lakes and reservoirs depends on rainfall, snowmelt, and consumption. Governments assess past drought events before regulating water releases.

River flow between stations helps determine groundwater contributions and potential drought severity in a particular region. Crop area and yield assessment are also important because, ultimately, this agricultural drought will affect the entire population, either directly or indirectly. We are all affected. So, here, the health of the vegetation reflects water availability, and drought-intolerant plants will wilt or die. Ground-based and remote sensing methods assess crop health and shrinkage in vegetation cover, which can easily be accomplished with remote sensing datasets.

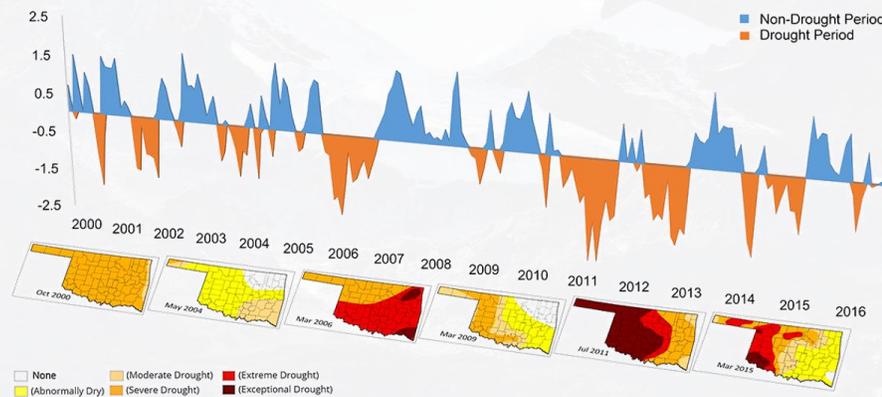
Drought-related crop failures lead to economic challenges, food shortages, and price fluctuations. So, this will directly impact our country's economy. Climate, which is one of the important parameters, includes precipitation deficits, for example, during specific stages of crop growth, in different seasons, or by location. Average temperature, maximum, minimum, and amplitude can be derived, and evapotranspiration can be measured. Soil moisture can be measured, and other hazards can also be monitored so that we can assess the drought conditions in a particular area. In water resources, the reductions in runoff, spring discharge, temporary rivers, and snowmelt are distinct factors. Water storage: the percentage of the reservoir that is filled. Groundwater recharge is necessary. Wells' discharge reduction percentage of dried well drawdown, etc., helps

assess the condition. Water allocation used by different sectors for drinking water, industrial uses, household use, and agriculture can be calculated and released depending on the availability of water in storage. In agriculture, how do we evaluate irrigated and rain-fed areas, failures or delays in crop germination, plant density, the onset of growth phases or stages, and crop yield? This can be monitored, and we can assess the drought conditions in a particular area. Then come the livestock. So, the reduction in range and pastureland production and quality, as well as estimates of quantity or supportive capacity per unit area, vegetative cover, dominant species, and the reduction in the quality of total livestock, along with the reduction in forest production, such as timber, charcoal, and wood, as well as forest fires and other drought-associated hazards, is concerning. So, this will help you assess the drought conditions for livestock.

CHARACTERISTICS OF DROUGHT भारतीय भूधोगिकी संस्थान गुवाहाटी
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The characteristics of droughts are expressed in terms of:

- 1. Drought Index
- 2. Intensity duration-frequency



The characteristics of droughts are expressed in terms of the drought index and intensity-duration-frequency analysis. So, if you see this particular graph here, you can see that two colors are used: one is orange, which represents the drought period, and the other is blue, which represents the non-drought period. So, the blue shows the intensity and duration; this indicates the intensity. So, if the duration is large like this one, this is a non-drought period; but if you refer to this, this drought period is quite long.

This is quite long. So, in such a situation, the problem will be more problems. So, the introduction to drought indicators is necessary because we understand the basics of drought, its characteristics, the different types of droughts, how we mitigate them, and how we evaluate them. Now, let us see how we can identify them. So, we will talk about the drought indicators. Drought indicators simplify complex information and help with decision-making by assessing the severity and impact of drought. So, let's verbally state

that this area is experiencing a drought. So, if I say a particular area is experiencing drought conditions, how will you interpret this statement: Is it severe, in the beginning phase, or normal? So, for that, we need to have some kind of drought indicator that will inform or be used by policymakers and decision-makers, allowing them to mitigate the effects and help local communities. It provides a quantitative basis for monitoring changes in agricultural production, groundwater levels, and social costs. An ideal drought index should integrate biophysical, economic, and social data. Since drought risk is influenced by meteorological, socioeconomic, and technological factors, A well-designed index allows for the comparison of present-day risks with future projections and helps policymakers prepare for increased occurrences of drought. So, it is very important to evaluate and identify what it is. So, we will talk about the indicators. Indicators are essential for detecting and monitoring environmental and social changes caused by drought. They provide a basis for designing disaster risk reduction policies and evaluating their effectiveness. Establishing region-specific thresholds ensures that drought risk assessments reflect market, climate, and socioeconomic conditions.

Early warning systems depend on reliable indicators to predict drought severity and support mitigation strategies. So, we have some drought indices. Drought indices should be universally applicable across different terrains and agro-climatic zones. So, when we are trying to develop a drought index or drought indices, it should apply not only to a given area but also to work for other areas. They must be versatile, adapting to various severity thresholds and scales for national and regional analyses.

Easily interpretable indices, supported by readily available data, improve drought response planning. Because your developed drought index should be very simple to use and should utilize data that is available in the public domain or is easily accessible, it is important to ensure clarity. Only then will you be able to see the effectiveness of this drought index. These indices should assist farmers in land use planning and future scenario projections. So ultimately, we need to inform the farmers, and then our situation will be managed. Key components of effective drought indices include that a good drought index must consider the accumulated water deficit rather than simply a deviation from average conditions. Daily time steps are essential, as a single day's rainfall can significantly impact the water balance. Indices should account for both soil moisture and other water storage resources, such as lakes and groundwater. Time-dependent relaxation functions help track the lasting impacts of past rainfall events.

So, we need to evaluate the situation. Drought triggers are based on threshold values that define when management actions should begin or cease. These triggers specify the period, spatial scale, drought level, and whether the weather conditions are worsening or improving. So, we need to keep monitoring all the parameters. Drought levels are categorized as mild, moderate, severe, and extreme to guide management decisions. A well-defined index helps coordinate drought responses and resource allocation efficiently.

Because, ultimately, what is our aim? We have to mitigate and help the people because we cannot stop droughts, as they are natural phenomena over which we have no control. So, what we can do is try to reduce the severity of the impact. So, we need an indicator. Advances in drought monitoring require improved indices that integrate meteorological, hydrological, and agricultural factors. The use of satellite data and machine learning can enhance the accuracy of drought predictions.

Future indices should incorporate socioeconomic and climate change projections for better long-term planning. Strengthening early warning systems with improved indicators can mitigate the adverse effects of drought on vulnerable communities. So, if a particular community is more vulnerable to this drought, then the government has to focus only on them. As we discussed, the drought index integrates rainfall data, surface runoff, snow cover, and other water supply indicators that serve as inputs for the region. A drought index is typically a single number, but it is far more useful than the raw data for decision-making. Because once you get the number, let's say it is between 0 and 1, 1 represents a severe impact or condition of drought. And maybe 0.5 is moderate, while 0 is a normal condition. So, if your drought index indicates that this region has a value of 1, it means you have to focus on that region immediately, and that area needs immediate help. Several indices measure how much precipitation for a given period has deviated from the average precipitation.

This average precipitation is basically identified historically. Most water supply planners find it useful to evaluate one or more indices before deciding because, for some areas, a particular drought index may be more relevant; let's say these are Drought Index 1 and Drought Index 2. So, both 1 and 2 will be used, and the decision-making process will probably be much easier. So, we will not be biased.

So, there are different drought indices. So, the first one is the percentage of normal precipitation (PNP); then we have a standardized precipitation index, which we call the SPI; and finally, we have the PDSI, which is the Palmer Drought Severity Index. Then we have the Surface Water Supply Index (SWSI), the Reclamation Drought Index, and deciles, which are monthly drought calculations.

These drought indices are very popular, and you will find much literature explaining these methods. So, with this, I will end Lecture 34, and we will continue this discussion in Lecture 35.

Thank you very much.