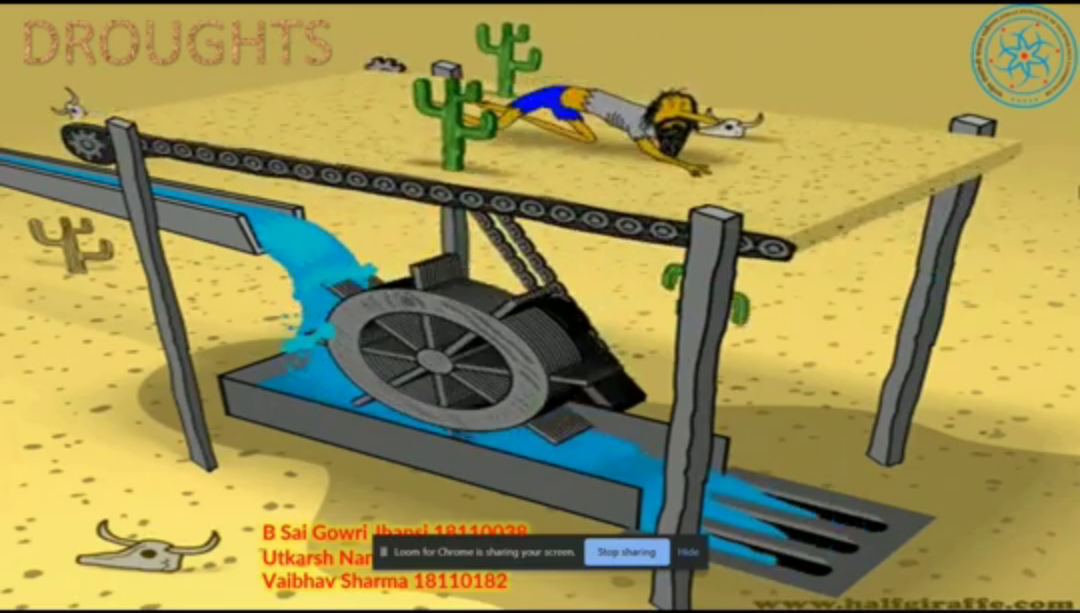
DROUGHTS
B Sai Gowri Jhansi 18110038
Utkarsh Nar
Vaibhav Sharma 18110182
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Droughts : Definition and Understanding

Drought is the phenomenon that occur when region experience lack of water supply which can be associated to surface and groundwater water.

Some important relations for understanding of droughts:

1. Index of wetness = $\frac{\text{rainfall in a given year at a given place}}{\text{average annual rainfall of that place}} \times 100$

2. Rainfall Deficiency = 100 – (Index of wetness)

WHY ----------DROUGHTS ?

1. Lower Rainfall than estimated average rainfall consistently.
2. Deforestation leading to desertification and increased evaporation
3. Higher temperatures $\propto$ probability of drought
4. Downstream regions far from water sources

Types of Droughts

1. Meteorological Drought
2. Hydrological Drought
3. Agricultural Drought

Meteorological Drought

"Reduction in rainfall for a specified period"

- Occurs when the current precipitation decreases more than 25% as compared to average precipitation.
  In Monsoon driven countries like India, it's occurrence depends upon onset, break and withdrawal of the monsoon
- Persisted Metrological drought results into hydrological and Agricultural droughts.
- Region Categorization
  - Probabjlity of occurrence between 0.2and 0.4 => drought prone region
  - Probability of occurrence is greater than 0.4 => chronologically drought prone region.

Seasonal Defeciency in rainfall	Type of Meteorologica Drought
<25%	Mild or no drought
	Moderate Drought
	Severe Drought

Agricultural Droughts

"Happens when atmospheric moisture decreases to the extent that there arise deficiency in soil moisture"

1. Acute deficiency of rainfall and soil moisture content.
2. Estimated by Aridity Index

$$A.I = \frac{PET - AET}{PET} \times 100$$

Where, A.I = Aridity index

PET = Potential Evapo- transpiration

AET = Actual Evapotranspiration

Classification	Aridity Index	Global land area
Hyperarid	AI < 0.05	7.5%
Arid	0.05 < AI < 0.20	12.1%
Semi-arid	0.20 < AI < 0.50	17.7%
Dry subhumid	0.50 < AI < 0.65	9.9%

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Hydrological Droughts

"It occurs when water level in the reservoirs, rivers, lakes and other sources falls below the average value."

- Could be caused by low level of precipitation, geographical factors and human errors like non optimal allocation of water through the resources.
- Factors considered for understanding this type of drought are magnitude, duration, frequency and severity of deficiency.
- These can be associated with surface water drought (decrease in water level in river, lakes etc) and ht (decrease in water level of aquifer).

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Question time

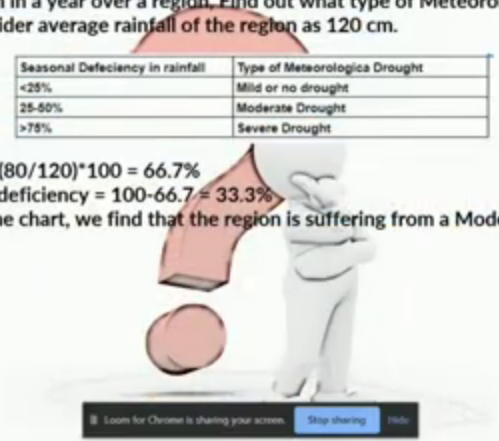
Q) If there is rainfall of 80 cm in a year over a region. Find out what type of Meteorological drought would occur (If occur) in this region. Consider average rainfall of the region as 120 cm.

Seasonal Defeciency in rainfall	Type of Meteorologica Drought
<25%	Mild or no drought
25-50%	Moderate Drought
>75%	Severe Drought

Ans) Index of wetness = (80/120)*100 = 66.7%

Percentage rainfall deficiency = 100-66.7 = 33.3%

Thus, referring to the chart, we find that the region is suffering from a Moderate Meteorological drought.



Droughts Analysis

1. Drought analysis involves complex inter-relationship between climatological and meteorological data
2. Operational definitions are formulated in terms of Drought Indices which typically require quantification of “normal” and “expected” conditions within specified regions
3. Physically based models are more effective
4. Hydrological Drought Analysis is done through hydrological models like water balance models, evapotranspiration studies, groundwater and surface water flow models

   Onset, duration, deficit volumes of the droughts can be analyzed from the hydrographs

Drought Indices

"A single number that is useful for decision making by measuring different drought-causative and drought-responsive parameters, and identify them and classify droughts accordingly. ."

Assimilate thousands of bits of data about rainfall, snowpack, streamflow and other water supply indicators

What

1. Palmer Drought Index **(PDI)**/ Palmer Drought Severity Index **(PDSI)**
2. Crop Moisture Index **(CMI)**
3. Palmer Hydrological Drought Index **(PHDI)**
4. Standardized Precipitation Index **(SPI)**
5. Satellite Vegetation Health Index **(SVHI)**
6. Objective Blended Drought Index **(OBDI)**

Why

1. Used to issue drought warnings
2. Water supply planners use these indices to make a decision for a region by consulting one or more than one indices
3. Management of drought impact and preparedness depends on these indices even though, the occurrence may not be avoided.

Palmer Drought Index or Palmer Drought Severity Index

"Uses the difference between Climatically Appropriate For Existing Conditions (CAFEC) rainfall and actual rainfall as the drought indicator and for the same, depends upon the data of temperature, precipitation and locally available water. It is a long term meteorological drought index that runs on a weekly or monthly basis. PDSI varies from -4.0 (extreme drought conditions) to +4.0 (adequate moisture condition)"

0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

The **PDSI** provides decision makers with a measurement of the abnormality of recent weather events for a region and places current conditions in a historical perspective.

The index values often do no match the situation in many countries.

Calculations

Potential coefficients are computed as the ratio between averages of actual versus potential values for every 12 month. These coefficients are further used to compute the amount of precipitation required for the Climatically Appropriate for Existing Conditions(CAFEC)

Potential values required for calculation are

- Potential evapotranspiration(PE)
- Potential loss(PL)
- Potential runoff(PRO)
- Potential recharge(PR)

Computation of this index incorporates a water balance model using historic records of monthly precipitation, potential evapotranspiration and simple 2-layer soil moisture reservoir

Upper layer → 1 inch of available moisture at field capacity(assumption)

Underlying layer → available capacity that depends on soil characteristics of the site

$$d = P - \hat{P} = P - (\alpha \cdot PE + \beta \cdot PR + \gamma \cdot PRO + \sigma \cdot PL)$$

$$\alpha = \bar{ET}/\bar{PE}, \beta = \bar{R}/\bar{PR}, \gamma = \bar{RO}/\bar{PRO} \text{ and } \sigma = \bar{L}/\bar{PL} \text{ for 12 months}$$

ET = Actual Evapotranspiration

R, RO and L = Recharge, Runoff & Loss respectively

K = Climatic Characteristicsd = Moisture Departure

K = Weighing factor*

D = Difference between actual (P) and CAFEC precipitation (P^) (Also an indicator of water deficiency)

*Used to adjust 'd' according ot he characteristics of climate to allow for accurate comparison of PDSI values over time and area.

Calculations

Z index can be used to show how wet or dry it was during a single month without regard to past precipitation trends.

$$X_i = 0.897X_{i-1} + \left(\frac{1}{3}\right)Z_i \qquad (4)$$

X_i = Current PDSI value at time t | X_{i-1} = Current PDSI value at time t-1 | 0.897 and (1/3) = Duration factors

PDSI of initial month in a dry or wet spell is equal to Z_i

Z index values for dry and wet periods	
3.50 and above	Extreme wetness
2.50 to 3.49	Severe wetness
1.00 to 2.49	Mild to moderate wetness
-1.24 to .99	Near normal
-1.99 to -1.25	Mild to moderate drought
-2.74 to -2.00	Severe drought
-2.75 and below	Extreme drought

PDSI values for the 11 drought (or wet) categories	
4.0 and above	Extreme moist spell
3.0 to 3.99	Very moist spell
2.0 to 2.99	Unusual moist spell
1.0 to 1.99	Moist spell
0.5 to .99	Incipient moist spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient drought
-1.0 to -1.99	Mild drought
-2.0 to -2.99	Moderate drought
-3.0 to -3.99	Severe drought
-4.0 and below	Extreme drought

Crop Moisture Index

"Intended to be a drought index especially suited to drought impacts on agriculture. It responds quickly to the rapidly changing conditions, and relies on the difference between the potential evapotranspiration and moisture"

** These are usually calculated along with Palmer Drought Severity Index.*

3.0 and above	Excessively wet, some fields flooded
2.0 to 2.99	Too wet, some standing water
1.0 to 1.99	Prospects above normal, some fields too wet
0 to .99	Moisture adequate for present needs
0 to - .99	Prospects improved but rain still needed
1.0 to -1.99	Some improvement but still too dry
-2.0 to -2.99	Drought eased but still serious
-3.0 to -3.99	Drought continues, rain urgently needed
-4.0 and below	Not enough rain, still extremely dry

Responds quickly to changing conditions
Due to the weighed output, it is possible to compare different climate periods

It may show a false sense of recovery from drought due to the short term improvements and thus could be insufficient to offset long-term issues.

Extra info about CMI

1. *Short term weekly index designed to reflect quickly changing soil moisture conditions for agricultural purposes.*
2. *It shows general conditions and not local variations caused by isolated rain*
3. *Based on the concept of abnormal evapotranspiration deficit* computed as difference between PE and moisture to find the deficit.
4. Input parameters are weekly precipitation, weekly mean temperature and previous week's CMI value.

Managing Droughts

"Drought management involves development of short term and long term strategies to minimize the possible impact of the calamity on life and economy."

- Short term strategies focus on early warning, monitoring and assessment of droughts
- Long term strategies attempt drought mitigation by means of proper soil and water conservation, irrigation and cropping patterns.

A few of the common possible measures to make the drought prone areas a bit less vulnerable:

1. Creating storages to hold on to a larger amount of precipitation.
2. Development and management of ground water potential by harvesting the rainwater.
3. Economic use of water in irrigation through practises such as sprinkler or drip irrigation.
4. Transferring water from areas of higher rainfall to areas of lower rainfall.
5. Promoting afforestation, agroforestry (growing shrubs/tress beside crops) and similar practises.

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Unsolved Question

1. *Which of the following are taken into consideration while calculating PDI/PDSI? Choose the best possible option*

A) *Precipitation and Runoff*

B) *Precipitation, Evapotranspiration and Runoff*

C) *Precipitation and Evapotranspiration*

D) *None of the above*