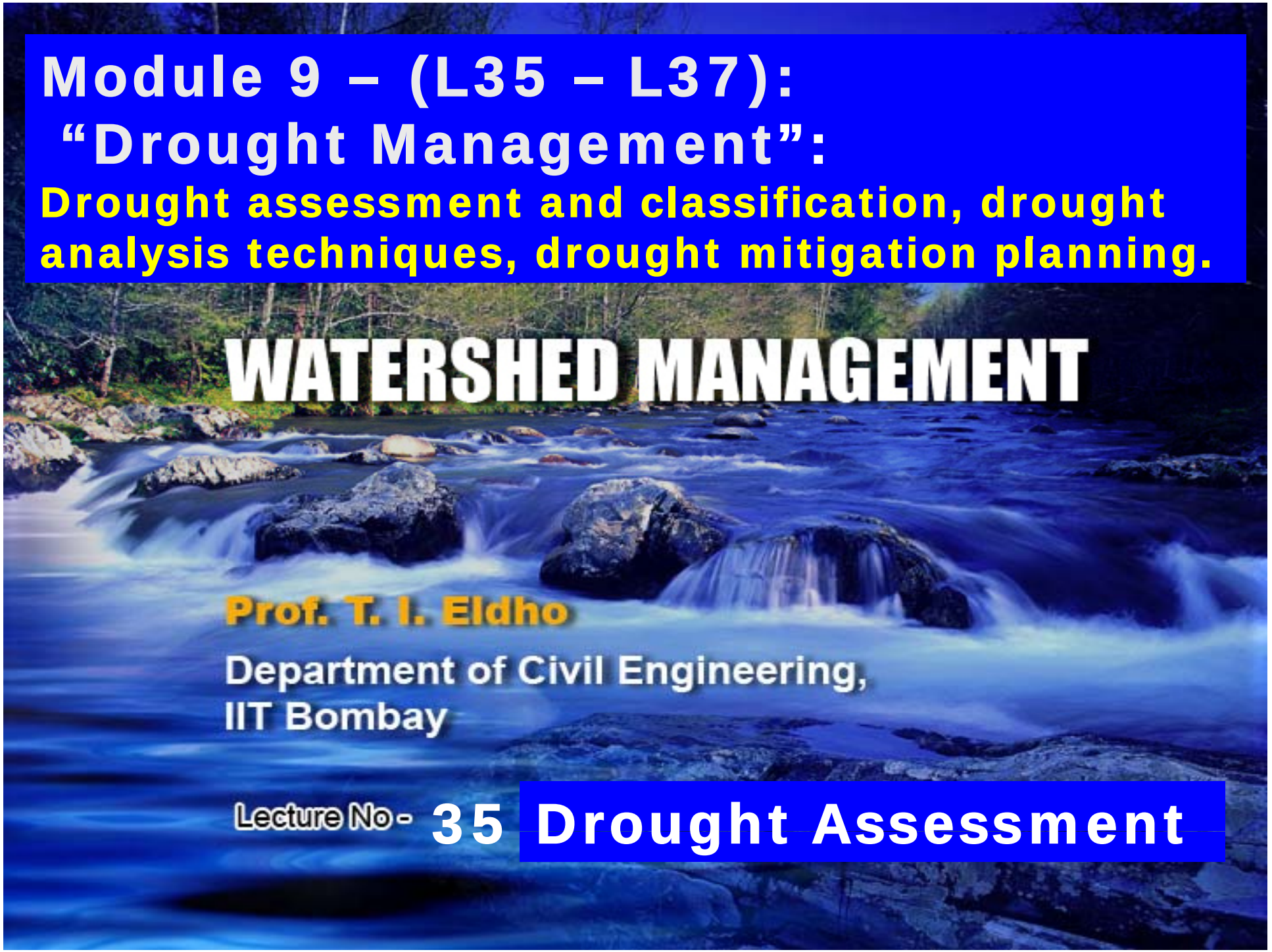
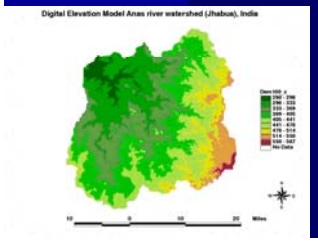
Module 9 – (L35 – L37): "Drought Management":

Drought assessment and classification, drought analysis techniques, drought mitigation planning.



L35– Drought Assessment

- **Topics Covered**
- Droughts, Assessment, Classification, Meteorological droughts, Hydrological droughts, Agricultural droughts, Drought vulnerability
- Keywords: Droughts; Assessment; Meteorological drought; Hydrological drought; Agricultural drought.



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Droughts - Introduction

- A **drought** - an extended period of months or years when a region notes a deficiency in its water supply whether surface or underground water.
- This occurs when a region receives consistently below average precipitation.
- Substantial impact on ecosystem & agriculture of the affected region.
- Even a short, intense drought can cause significant damage & harm the local economy
- Global phenomena – wide spread impacts on agriculture, migration, human settlement etc.

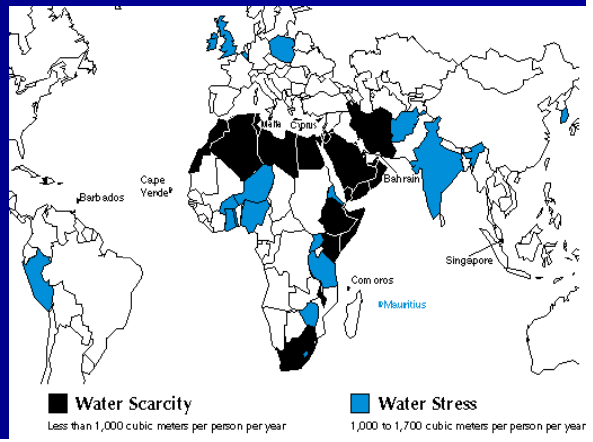
  eg. Many places in Africa

Droughts – Introduction..

- Drought – Deficit supply of moisture
- Drought - Major natural hazard resulting in significant social, economical & environmental costs
- Serious problem in Africa, Asian & Pacific region
- Consequences- on agricultural production, hydro power generation & economy

According to United Nations estimates

- One third of world's population lives in areas with water shortages & 1.1 billion people lack access to safe drinking water - Affected land area - 970 million km^2
- Population - 57.3 billion and
- GDP loss affected- US$110 billion



Droughts - Impacts

- **Drought Contingency Plan:** A document - identifies specific actions that can be taken before, during & after a drought to mitigate some of the impacts & conflicts that result.
- **Drought Impact:** A specific effect of drought. People also tend to refer to impacts as "consequences" or "outcomes." Impacts are symptoms of vulnerability.
- **Drought Impact Assessment**: Process of looking at the magnitude & distribution of drought's effects
- **Mitigation:** Short- & long-term actions, programs, or policies implemented in advance of drought, or in its early stages, to reduce degree of risk to people, property, & productive capacity

Droughts - Consequences

- **Drought -** significant environmental, agricultural, health, economic & social consequences
- Diminished crop growth or yield productions & carrying capacity for livestock
- Dust bowls, Dust storms,
- Famine
- Habitat damage
- Malnutrition, dehydration & related diseases
- Mass migration
- Reduced electricity production
- Shortages of water for industry & domestic supply
- Social unrest
- War, Wildfires etc.

Droughts – Risks & Vulnerability

- **Risk:** **P**otential adverse effects- product of both frequency & severity of the hazard & corresponding vulnerability.
- **Risk Analysis: P**rocess of identifying & understanding components associated with drought risk & evaluation of alternative strategies.
- **Risk Management:** opposite of crisis management - a proactive approach- in advance of drought - mitigation can reduce drought impacts - relief & recovery decisions made timely, coordinated, & effective manner.
- **Vulnerability:** Characteristics, activities, or environment that make them susceptible to effects of drought.
- Degree of vulnerability- depends on environmental & social characteristics of the region & is measured by ability to anticipate, cope with, resist, & recover from drought.

Droughts – Occurrences

- **Droughts –** normal recurring feature of the climate in most parts of the world.
- **Earliest-** documented climate event.
- **Recurring droughts:** In many parts of Africa - eg. Sudan, Chad, Ethiopia, East Africa etc – decades of droughts
- **In Asian region:** Himalayan basins – floods followed by droughts; Gulf Countries, some parts of China.
- In America – west coast of North America; Amazon basins in 2005;
- Largest parts of Australia – deserts or semi arid lands
- Due to climate change impacts – more areas affected by droughts and more frequently

Droughts – Causes

- **Rainfall effects –** changes in normal pattern – reduction in presence of water vapour & its upward movements; above average prevalence of high pressure systems, winds carrying continental, rather than oceanic air masses & ridges of high pressure areas
- Oceanic & atmospheric weather cycles - El Niño-Southern Oscillation (ENSO) make drought a regular recurring feature of the Americas along the Midwest and Australia.
- **Human activities:** Deforestation, over farming, excessive irrigation, soil erosion, urbanization etc. - trigger Droughts
- **Green house gases,** climate change effects, Global warming.
- Environmental degradation

Droughts - Classification

- **Meteorological drought:** Defined by climatic variables (precipitation, humidity) and the duration of the dry period
- **Hydrological drought:** Associated with effects on surface or subsurface water supplies (i.e., stream flow, reservoir, lake levels, and ground water)
- **Agricultural drought:** Links impacts of meteorological drought to agriculture, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, crop failure, etc
- **Socio-economic drought:** Occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply

Meteorological Droughts

- Prolonged period with less than average precipitation
- More than 25% decrease in precipitation from normal over an area
- Defined on the basis of degree of dryness (in comparison to some "normal" or average amount) & duration of the dry spell
- India Meteorological Department (IMD) has adopted the following criteria for sub-classification of meteorological droughts

✓ Total seasonal rainfall is less than 75% of normal value- affected by drought

✓ Moderate drought: If seasonal deficiency is between 26% to 50%

Meteorological Droughts..

- Drought prone area: An area with probability of drought occurrence is $0.2 \leq P \leq 0.4$
- Chronically Drought Prone Area: Probability of drought occurrence is more than 0.4
- India: 33% (108Mha) of the total geographical area (329Mha) comes under drought prone area
- Meteorological drought - Depends on the onset, breaks and withdrawal times of monsoon
- Prediction of occurrence of drought - Related to forecast of deficient monsoon season and its distribution

Meteorological Droughts…

- Severe Drought: If deficiency is above 50% of the normal value
- Drought Year: The area affected by moderate or severe drought either individually or collectively is more than 20% of the total area of the country
- In India 1875 to 1991: Total 23 drought years
- 1918 being the worst year – 70% of the area of the country was affected
- Occurrence of two concurrent drought years – (1904-1905) and (1965-66) very rare

Hydrological Droughts

- Hydrological droughts - brought about when the water reserves available in sources such as aquifers, lakes & reservoirs fall below the statistical average
- Meaning: Below average values of stream flow, contents in tanks and reservoirs, groundwater and soil moisture
- Four components of hydrological drought
  - Magnitude = (amount of deficiency)
  - Duration
  - Severity (= cumulative amount of deficiency)
  - Frequency of occurrence
- Hydrological Drought Techniques:
  1) Surface water deficit
  2) Groundwater deficit

Hydrological Droughts..

- Surface water aspect of drought studies related to stream flow and following techniques are commonly adopted
  - low flow – duration curves
  - low flow – frequency analysis
  - Stream flow modeling

Importance:

- - Design and operation of reservoirs
- - Diversion of streams for Irrigation
- - Power and drinking water
- - Water quality
- Groundwater aspects

Agricultural Droughts

- Droughts that affect crop production or the ecology of the range
- Principal Criteria: Deficiency of rainfall
- Variety of definitions for drought studies at plant level, root level or regional level
- Not only regional specific, but also crop & soil specific
- Considers crop growth and water requirements
- Time scale for water deficiency in agricultural drought is shorter than in hydrological drought studies

Agricultural Droughts..

- Aridity Index - numerical indicator of the degree of dryness of the climate at a given location
- Aridity Index (AI) = ((PET – AET)/ PET) x 100
- PET = Potential Evapotranspiration
- AET = Actual Evapotranspiration
- AI calculated on weekly basis is used as an indication of possible moisture stress experienced by crops
- AI anomaly: Departure of AI from its corresponding normal value represents moisture shortage

Lysimeter

Agricultural Droughts..

- Palmar Index (PI) (how monthly moisture conditions depart from normal (short-term drought and wetness)), Moisture Availability Index (MAI) – for characterizing agricultural drought
- IMD – Produces AI anomaly maps of India on a weekly basis based on data from 169 stations (agro climatic zones)
- Useful in planning & management of agricultural operations
- Recent development: remote sensing techniques for monitoring agricultural droughts.

AI Normally	Severity class
1-25	Mild arid
26-50	Moderate arid
>50	Severe arid

Socio-economic Droughts

- Socioeconomic drought - associate the supply & demand of some economic good with elements of meteorological, hydrological, & agricultural droughts
- Occurrence depends on the time & space processes of supply & demand to identify or classify droughts
- Water, forage, food grains, fish, & hydroelectric power, depends on weather
- Demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply – Occurrence of Socio economic drought

Socio-economic Droughts..

- Consequences: Reducing hydroelectric power production required the government to convert to more expensive (imported) petroleum & stringent energy conservation measures to meet the power needs
- Demand for economic goods increases – when population or per capita consumption increases
- Increase in supply – By adopting efficient technologies for production, construction of reservoirs
- Relative rate of change (critical factor) – If both are increasing (Ex: Is demand increasing more rapidly than supply?)
- Above criterion for future predictions.

Example from Uruguay in 1988-89

Impacts & Vulnerability

- **Drought risk** is based on

  - a combination of frequency, severity, & spatial extent of drought (physical nature of drought) &

  - degree to which a population or activity is vulnerable to the effects of drought

- Degree of a region's vulnerability depends on the environmental and social characteristics of the region

Investigation of Drought Vulnerability:

- Identify Relevant Drought Impacts & Trends over Time
- Rank Significant Drought Impacts
- Investigate the Underlying Causes of Drought Impacts

Drought Vulnerability

- **Identify Relevant Drought Impacts & Trends**
- Impacts are often symptoms of other underlying problems (vulnerabilities)
- Ex: Drought impact reporter developed by USA

Ranking Drought Impacts

- Rankings – based on cost, areal extent, trends over time, public opinion, fairness, & ability of affected area to recover
- Ranking - ensure equitable policy formulation – helps of public, community advisory committees, & groups of relevant scientists & policy makers
- Eg: Drought Impact Ranking Matrix - at the State/ Community Level/ Business/Individual Scale

Drought Vulnerability Analysis

Investigate Underlying Cause of Drought Impacts

- **Drought Vulnerability Analysis:** Provides a framework for identifying the social, economic, and environmental causes of drought impacts
- Directs attention to underlying causes than to its result
- Once drought risk assessed - actions to mitigate drought impacts
- Example: Reduced crop yield due to lack of precipitation

  Results of Vulnerability analysis: Farmers did not use drought-resistant seeds because they did not believe them to be useful, costs were too high, or because of some commitment to cultural beliefs

Drought Impact Assessment

- Impact assessment examines the consequences of a given event or change.
- Drought impact assessments – Identification of Direct consequences and Indirect consequences
- Direct consequences of the drought - reduced crop yields, livestock losses, and reservoir depletion.
- Secondary consequences – Social effects
- Initial assessment identifies drought impacts but does not identify the underlying reasons for these impacts

Common Types - Drought Impact

- **Economic** – Agricultural, Industrial, Tourism, Energy, Financial, Transportation
- **Social –** Stress & health, Nutrition, Recreation, Public safety, Cultural & aesthetic values
- **Environmental** – Animal, planet, eco systems, wetland, water quality etc.

Assessment Checklist

- Checklist selections - based on either common or extreme droughts, or a combination of the two
- **Historical Drought:** Identify the "drought of record" for your area & to assess the impacts of that drought
- **Current Drought:** With current knowledge that you have about your local area, if another "drought of record" were to occur tomorrow, what the local impacts may be and record them on the checklist under the "Current" column
- **Potential Drought:** Speculate what the impacts of the same drought would be for your area in five or ten years & record these in the "Potential" column

Assessment Checklist

http://www.fao.org

H – Historical
C- Current
P- Potential

H	C	P	Economic
			Loss from crop production
☐	☐	☐	Annual and perennial crop losses
☐	☐	☐	Damage to crop quality
☐	☐	☐	Reduced productivity of cropland (wind erosion, etc,)
☐	☐	☐	Insect infestation
☐	☐	☐	Plant disease
☐	☐	☐	Wildlife damage to crops
			Loss from dairy and livestock production
☐	☐	☐	Reduced productivity of rangeland
☐	☐	☐	Forced reduction of foundation stock
☐	☐	☐	Closure/limitation of public lands to grazing
☐	☐	☐	High cost/unavailability of water for livestock
☐	☐	☐	High cost/unavailability of feed for livestock
☐	☐	☐	High livestock mortality rates
☐	☐	☐	Disruption of reproduction cycles (breeding delays or unfilled pregnancies)
☐	☐	☐	Decreased stock weights
☐	☐	☐	Increased predation
☐	☐	☐	Range fires

Fig: Checklist for Economic Impacts

Ref: Western Drought Coordination Council (1998)

Assessment Checklist..

http://www.fao.org

H – Historical
C- Current
P- Potential

H	C	P	Environmental
			Damage to animal species
☐	☐	☐	Reduction and degradation of fish and wildlife habitat
☐	☐	☐	Lack of feed and drinking water
☐	☐	☐	Disease
☐	☐	☐	Increased vulnerability to predation (from species concentration near water)
☐	☐	☐	Migration and concentration (loss of wildlife in some areas and too many in others)
☐	☐	☐	Increased stress to endangered species
☐	☐	☐	Damage to plant species
☐	☐	☐	Increased number and severity of fires
☐	☐	☐	Loss of wetlands
☐	☐	☐	Estuarine impacts (e.g., changes in salinity levels)
☐	☐	☐	Increased ground water depletion, land subsidence
☐	☐	☐	Loss of biodiversity
☐	☐	☐	Wind and water erosion of soils
☐	☐	☐	Reservoir, lake and drawdown (including farm ponds)
☐	☐	☐	Reduced flow from springs
☐	☐	☐	Water quality effects (e.g., salt concentration, increased water temperature, pH, dissolved oxygen, turbidity)
☐	☐	☐	Air quality effects (e.g., dust, pollutants)
☐	☐	☐	Visual and landscape quality (e.g., dust, vegetative cover, etc.)

Fig: Checklist for Environmental Impacts

Ref: Western Drought Coordination Council (1998)

Assessment Checklist..

http://www.fao.org

H – Historical
C- Current
P- Potential

H	C	P	Social Impacts
☐	☐	☐	Mental and physical stress (e.g., anxiety, depression, loss of security, domestic violence)
☐	☐	☐	Health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations, reduced fire fighting capability, etc.)
☐	☐	☐	Reductions in nutrition (e.g., high-cost food limitations, stress-related dietary deficiencies)
☐	☐	☐	Loss of human life (e.g., from heat stress, suicides)
☐	☐	☐	Public safety from forest and range fires
☐	☐	☐	Increased respiratory ailments
☐	☐	☐	Increased disease caused by wildlife concentrations
			Increased conflicts
☐	☐	☐	Water user conflicts
☐	☐	☐	Political conflicts
☐	☐	☐	Management conflicts
☐	☐	☐	Other social conflicts (e.g., scientific, media-based)

Fig: Checklist for Environmental Impacts

Ref: Western Drought Coordination Council (1998)

Drought Assessment – Around World

- National Climatic Data Centre – Global Hazards & Extremes: Weekly update of natural disasters occurring around the world
- NCDC – Month in Historical Perspective: Monthly summaries of natural hazards around the world
- International Research Institute for Climate Prediction: Another source for monthly natural hazard occurrences and resulting impacts around the world
- Centre for International Disaster Information CIDI, provides disaster situation reports from events around the world.
- ReliefWeb -UN Office for Coordination of Humanitarian Affairs; online gateway to emergency & natural disaster information
- International Federation of Red Cross & Red Crescent Societies Provides information on appeals for help & disaster situation reports from events around the world

References

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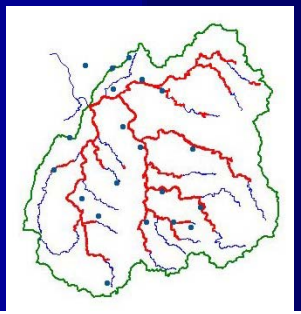
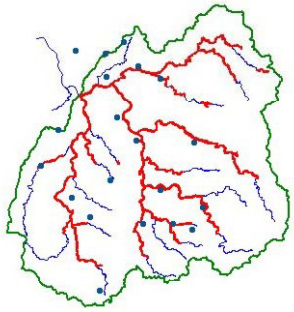
- "How to reduce Drought Risk", 1998, Western Drought Coordination Council, Preparedness and Mitigation Working Group
- Subramanya k(2007), Engineering Hydrology, Second edition, Tata McGraw-Hill
- http://www.epa.gov/oaintrnt/stormwater/index.htm
- http://wrmin.nic.in
- http://www.fao.org/nr/water/issues/scarcity.html

Tutorials - Question!.?.

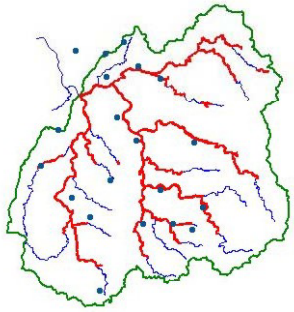
- Study critically the drought problems in India.
- Analyze the causes of droughts in India.
- What are the consequences?.
- How the drought vulnerability can be assessed?.





Self Evaluation - Questions!.

- What is drought and what are its impacts?
- Discuss the drought occurrences at different parts of the World.
- What are the major classifications of droughts?.
- Illustrate hydrological droughts and related issues.
- Describe socio-economic droughts.
- Discuss drought vulnerability analysis.



Assignment- Questions?.

- What are the major consequences of droughts?.
- What are the important causes of droughts?.
- Discuss the meteorological droughts and related issues.
- What is agricultural drought & how to classify it?.
- What are the common types of drought impacts.

WATERSHED MANAGEMENT

THANK YOU

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