Module 9 – (L35 – L37): “Drought Management”:
Drought assessment and classification, drought analysis techniques, drought mitigation planning.

WATERSHED MANAGEMENT

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Lecture No - 37 Drought Mitigation
L37 – Drought Mitigation

- **Topics Covered**
  - Drought mitigation & management, warning, monitoring, mitigation & planning,

- **Keywords:** Drought mitigation; Management & Planning
Introduction

- Mitigating drought: Taking actions in advance of drought to reduce its long-term risk
- Involve a wide range of tools: policies, activities, plans, and programs

Components of a drought mitigation plan
- Prediction
- Monitoring
- Impact assessment
- Early-warning systems
- Action plans to deal with severity
- Relief & responses
Introduction - Mitigation

- **Mitigation actions**, programs, & policies are implemented during and before drought to reduce the magnitude of risk to human life, property, and productive capacity.
- **Shift in public policy from drought relief to drought mitigation measures.**
- Important for adapting to climate change, restoring ecological balance, and bringing development benefits to the people
Drought Mitigation - Strategies

- Alternative cropping strategies, soil and water conservation and promotion of water harvesting techniques – examples for emergency drought relief.

Main objectives, to combat drought are:

- (a) To develop national strategies for drought preparedness in both the short and long-term, aimed at reducing the vulnerability of production systems to drought
- (b) To strengthen the flow of early-warning information to decision makers and land users to enable nations to implement strategies for drought intervention
- (c) To develop & integrate drought-relief schemes and means of coping with environmental refugees into national and regional development planning
Drought mitigation commitments

- Improve land and water management – Watershed based scheme – more effective
- Soil management
- Promote agricultural management & provide trainings
- Develop strategies for drought preparedness
- Mobilize Financing
- Afforestation & reforestation
- Necessities of the communities
- Social issues
Drought Monitoring & Early Warning

- Drought - Typically a slow-onset phenomenon
- Often possible to provide early warning of an emerging drought
- Early warning allows for a shift from reactive to proactive hazard management

Drought monitoring techniques across the world

- **China** - Standardized Precipitation Index to monitor drought occurrence
- **United States** - Multiple climate indices and indicators

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<table>
<thead>
<tr>
<th>Country</th>
<th>Drought Monitoring &amp; Early Warning System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Quantifies precipitation percentiles</td>
</tr>
<tr>
<td>Africa</td>
<td>Famine Early Warning System (FEWS NET)</td>
</tr>
<tr>
<td>Afghanistan, Pakistan and western parts of India</td>
<td>South Asia Drought Monitor (SADM)</td>
</tr>
<tr>
<td>SADM</td>
<td>Based on remote sensing data, drought related indices and GIS</td>
</tr>
<tr>
<td>FEWS NET</td>
<td>is mainly focused on Africa, where the majority of food security warning systems operate, but it also covers parts of Central Asia, Central America, and the Caribbean</td>
</tr>
</tbody>
</table>

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Drought Mitigation & Preparedness Measures

Mitigation Measures & Preparedness:

- **Structural/physical** (e.g., appropriate crops, sand dams, engineering projects)
- **Non-structural** (e.g., policies, awareness etc.)
- **Preparedness**: Defined as pre-disaster activities that are undertaken within the context of disaster risk management and are based on sound risk analysis

Examples:

- **Water scarcity during the dry season** (problem) ?- the groundwater dam (Solution)!

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Drought Mitigation & Preparedness Measures

Mitigation Measures & Preparedness:

- Most important steps in lessening the effects of drought though are soil and water conservation.
- By protecting soil, it is better able to absorb precipitation, but it can also help farmers to use less water.
- It also creates less water pollution by the pesticides and fertilizers present in most farm runoff.
- **Water conservation** - public use is often regulated. Water conservation devices like low-flow toilets, shower heads, and washing machines.
- Desalination of seawater, water recycling, & rainwater harvesting.
Drought Mitigation & Protection

**Mitigation Measures & Protection:**

- **Dams** - many dams & their associated reservoirs supply additional water in times of drought.
- **Cloud seeding** - an artificial technique to induce rainfall.
- **Desalination** of sea water for irrigation or consumption.
- **Drought monitoring** - Continuous observation of rainfall levels & comparisons with usage levels- help prevent man-made drought.
- Eg: Analysis of water usage in **Yemen** - revealed that their **groundwater table** - at grave risk by over-use for **Khat** crop.
- **Monitoring of moisture levels** - help predict increased risk for wildfires, using such metrics as **Palmer Drought Index**.

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Mitigation measures & Protection:

- **Land use** - planned crop rotation - minimize erosion & allow farmers to plant less water-dependent crops in drier years.
- **Outdoor water-use restriction** - Regulate use of sprinklers, hoses or buckets on outdoor plants, filling pools, & other water-intensive home maintenance tasks.
- **Rainwater harvesting** - Collection & storage of rainwater from roofs or other suitable catchments.
- **Recycled water** - wastewater (sewage) treated & purified for reuse.
- **Transvasement** - Building canals or redirecting rivers as massive attempts at irrigation in drought-prone areas.
Drought Mitigation & Preparedness Measures

- **Examples:**
  - **Groundwater dams:** Store water underground, rather than on the surface.
  - **Ex:** "Mother's Water Cellar" project launched in August 2000 by China Women Development Foundation - Now, provides readily accessible potable water for about one million people in rural China.
  - **Percolation tanks:** for Groundwater Recharge.
  - **Survival of about 15 million farmers living in the semi-arid basaltic plateau in Western India.**

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Drought Mitigation – Groundwater Dams

- **Groundwater dams** - structures that intercept or obstruct natural flow of groundwater & store water underground
- Basic principle: instead of storing the water in surface reservoirs, water is stored in underground - less contamination
- No problem of submergence of land

**Sub-surface dam:**
- Intercepts or obstructs the flow of an aquifer
- Reduces variation of level of groundwater table upstream of the dam.
- It is built entirely under the ground

[http://www.rainwaterharvesting.org/rural/Contemporary_more.htm](http://www.rainwaterharvesting.org/rural/Contemporary_more.htm)
Drought Mitigation – Groundwater Dams

Sand storage dam:
- Constructed above ground
- Sand & soil particles transported during periods of high flow are allowed to deposit behind the dam
- Water is stored in these soil deposits (figure)
- Sand storage dam - constructed in layers to allow sand to be deposited & finer material be washed downstream

http://www.rainwaterharvesting.org/rural/Contemporary_more.htm

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Technology for Drought Reduction

Field agricultural technology:
- Straw or plastic film mulch, conservation tillage and rainwater harvesting
- Water saving technology such as hole irrigation, surge flow irrigation, micro-irrigation and drip-irrigation

Water-saving technology of chemistry
- Drought-resistant and water save technologies
- For preserving soil moisture and reducing crop transpiration

Water storage cellar, sea water desalination, wastewater treatment
- Water cellar - digging cellar to collect rainwater
Technology for Drought Reduction

- Development of drought plans or reporter on drought impact
- **Ex:** “Drought monitoring index on the national and global basis”
- Implemented by Beijing Climate Centre (BCC), China Meteorological Administration (CMA)
- Several routine products for China and the globe are produced on a daily basis from real-time station-based and satellite-derived data
- **Available for free downloading from the web page of BCC**

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Impact Sectors

Mitigation actions can be categorized according to 11 impact sectors:

- Water Availability,
- Municipal Water,
- Water Shortage/Conservation Activities,
- Agricultural Industry,
- Public Information and Education,
- Fish/Wildlife Preservation,
- Health,
- Commerce and Tourism/Economy,
- Wildfire Protection/Forestry/Public Lands,
- Energy, and Social

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Mitigative strategies

Mitigative strategies be divided into 9 categories:

- **Assessment Programs**
- **Legislation/Public Policy**
- **Water Supply Augmentation**
- **Public Awareness/Education Programs**
- **Technical Assistance**
- **Demand Reduction/Water Conservation Programs**
- **Emergency Response Programs**
- **Water Use Conflict Resolution**, and
- **Drought Contingency Plans**
Specific actions taken by Government:
- Prepare position papers for legislature on public policy issues
- Examined statutes governing water rights for possible modification during water shortages
- Pass legislation to protect instream flows
- Pass legislation providing guaranteed low-interest loans to farmers
- Impose limits on urban development
<table>
<thead>
<tr>
<th>Challenges of Drought Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meteorological and hydrological</strong> data networks are often inadequate in terms of the density of stations</td>
</tr>
<tr>
<td>Data quality is also a problem because of missing data or an inadequate length of record</td>
</tr>
<tr>
<td>High cost of data limits their application in drought monitoring, preparedness, mitigation and response</td>
</tr>
<tr>
<td>Information delivered through early warning systems is often too technical and detailed, limiting its use by decision makers</td>
</tr>
<tr>
<td>Forecasts are often unreliable on the seasonal timescale and lack specificity, reducing their usefulness for agriculture and other sectors</td>
</tr>
<tr>
<td>Drought indices are sometimes inadequate for detecting the early onset and end of drought</td>
</tr>
</tbody>
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Challenges of Drought Monitoring

- **Drought monitoring** systems should be integrated, coupling multiple climate, water and soil parameters and socio-economic indicators.

- For fully characterizing drought magnitude, spatial extent and potential impact.

- **Impact assessment methodologies**, a critical part of drought monitoring and early warning systems, are not standardized or widely available.

- Hindering impact estimates and the creation of regionally appropriate mitigation and response programmes.

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Drought Management - Mitigation Strategies

- Drought warning systems - Availability of Inputs
- Judicious use of surface & groundwater
- Cloud seeding in Drought Prone regions
- Micro Irrigation Systems
- Post Harvest Management
- Nutritional Aspects of Food Security
- Water Conservation, Storage Structures & Management
- Afforestation
- Crop Insurance
- Capacity building
- Community participation
- Relief & responses - Public Distribution System
- Appropriate drought management plans - Guidelines

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Case Study: Drought Analysis in Rajasthan

- **Ref:** State Level Analysis of Drought Policies and Impacts in Rajasthan, India, M.S. Rathore, IWMI, 2005, Working Paper 93

- **Rajasthan** - one of the largest State of India - area of 342,000 km² (10%) & population of 56.5 million (5%) & only 1% of India’s water resources – economically backward.

- **Climate** - varies from arid to sub-humid; average rainfall - 574 mm - varies significantly - western Rajasthan, average annual rainfall less than 100 mm

- In Rajasthan, about 50 drought years since 1901

- Detailed analysis - in 9 out of 102 years were none of the districts in the State affected by droughts.

- Every year some part(s) of Rajasthan - affected by drought.

- State considers drought as a transient phenomenon - plan short term relief measures – not solution.

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Drought Analysis in Rajasthan

- **Ref:** State Level Analysis of Drought Policies and Impacts in Rajasthan, India, M.S. Rathore, IWMI, 2005, Working Paper 93

- **Drought Index (DI) =** \((P - X)/ SD\), \(P\)- annual precipitation, \(X\)- long term mean and SD- standard deviation

- **DI - classified into four:** DI =\(<-0.1\) light drought, DI =\(<-0.2\) moderate drought, DI =\(<-0.5\) severe drought, DI =\(<-0.8\) very severe drought.

- **48 out of 102 years were drought years - chance of occurrence of a meteorological drought in the state is 47%**

- **Vulnerability to drought:** both low-income and middle-income households are vulnerable to droughts; **Indicators:** forced migration, borrowings, food shortage, change of occupation, forced unemployment, falling health conditions etc.

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Drought Analysis in Rajasthan

**Ref:** State Level Analysis of Drought Policies and Impacts in Rajasthan, India, M.S. Rathore, IWMI, 2005, Working Paper 93

### Frequency and intensity of droughts in Districts of Rajasthan during 1901-2002

<table>
<thead>
<tr>
<th>Region</th>
<th>Very Severe</th>
<th>Severe</th>
<th>Moderate</th>
<th>Light</th>
<th>% of all drought years in the period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Region</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>45.0</td>
</tr>
<tr>
<td>NE Region</td>
<td>12</td>
<td>8</td>
<td>11</td>
<td>16</td>
<td>46.0</td>
</tr>
<tr>
<td>Southern Region</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>12</td>
<td>42.1</td>
</tr>
<tr>
<td>All Rajasthan</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>13</td>
<td>47.0</td>
</tr>
</tbody>
</table>

**Drought perceptions & implications:**
Perceived as creeping phenomenon- onset & end difficult to identify. Viewed as a transient phenomenon. Direct impacts- withering crops, dry watering points, reduced forage for livestock etc., are obvious.

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### Annual statistics of drought impacts in Rajasthan

<table>
<thead>
<tr>
<th>Finance Year</th>
<th>District affected (%)</th>
<th>Human affected (%)</th>
<th>Livestock Population affected (%)</th>
<th>Foodgrain Production Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>26.92</td>
<td>1.35</td>
<td>2.28</td>
<td>140.24</td>
</tr>
<tr>
<td>1971-72</td>
<td>50</td>
<td>17.3</td>
<td>8.79</td>
<td>100.52</td>
</tr>
<tr>
<td>1972-73</td>
<td>100</td>
<td>52.77</td>
<td>47.37</td>
<td>81.84</td>
</tr>
<tr>
<td>1984-85</td>
<td>77.73</td>
<td>27.38</td>
<td>26.74</td>
<td>125.58</td>
</tr>
<tr>
<td>1985-86</td>
<td>76.3</td>
<td>70.44</td>
<td>61.4</td>
<td>125.88</td>
</tr>
<tr>
<td>1986-87</td>
<td>100</td>
<td>82.54</td>
<td>65.96</td>
<td>107.76</td>
</tr>
<tr>
<td>1987-88</td>
<td>100</td>
<td>92.27</td>
<td>74.98</td>
<td>76.25</td>
</tr>
<tr>
<td>1995-96</td>
<td>93.55</td>
<td>62.47</td>
<td>59.09</td>
<td>151.81</td>
</tr>
<tr>
<td>1996-97</td>
<td>67.74</td>
<td>14.37</td>
<td>15.2</td>
<td>203.44</td>
</tr>
<tr>
<td>1997-98</td>
<td>75</td>
<td>11.27</td>
<td>NA</td>
<td>222.67</td>
</tr>
<tr>
<td>1998-99</td>
<td>62.5</td>
<td>48.83</td>
<td>54.42</td>
<td>205.23</td>
</tr>
</tbody>
</table>
Drought Impacts in Rajasthan


<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Villages affected</td>
<td>36,252</td>
<td>20,069</td>
<td>23,406</td>
<td>30,583</td>
<td>7,964</td>
<td>40,490</td>
</tr>
<tr>
<td>Population affected (million)</td>
<td>31.737</td>
<td>21.507</td>
<td>26.179</td>
<td>33.041</td>
<td>6.97</td>
<td>44.8</td>
</tr>
<tr>
<td>Cattle affected (million)</td>
<td>37.23</td>
<td>29.578</td>
<td>34.56</td>
<td>39.969</td>
<td>6.973</td>
<td>45.2</td>
</tr>
<tr>
<td>Crop damage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area (million ha)</td>
<td>7.436</td>
<td>6.496</td>
<td>7.818</td>
<td>8.947</td>
<td>2.653</td>
<td>11.7</td>
</tr>
<tr>
<td>Value (million US $)</td>
<td>539.1</td>
<td>496.4</td>
<td>740.6</td>
<td>763.4</td>
<td>272.2</td>
<td>959.5</td>
</tr>
<tr>
<td>Rainfall deficiency</td>
<td>-45%</td>
<td>-3%</td>
<td>-16%</td>
<td>-29%</td>
<td>-5%</td>
<td>-64%</td>
</tr>
</tbody>
</table>

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Drought Management in Rajasthan

- **Institutions for drought management**: Task force & committees – State Govt. controlled
- **Drought monitoring & early warning** – IMD, Weather Watch Group: Based on Rainfall data, water levels in reservoirs & crop prospects.
- **Drought Mitigation Programmes**: Rural development Programme – Infrastructure, new crop, watershed
- **National Watershed Development Programme for Rainfed Areas (NWDPRA)** and **Integrated Watershed Development Programme (IWDP)**
- **Drought Prone Area Development Programme (DPAP)**
- **Desert Development Programme (DDP)**
- **Employment Generation Programme (EGP)**
- **Rural Poverty Alleviation Programmes** – Food assistance
Concluding Remarks

- Main issues - policy formulation and action:
  (i) understanding the nature of drought, (ii) modifying perception & response to drought, (iii) changing approach - relief to mitigation of drought.
- Identification of vulnerable areas and population.
- Impact of drought is both direct and indirect on most of the economic and social parameters.
- Water availability is the key
- Drought monitoring & management
- Rural development & poverty alleviation programmes
- Efficient management of drought - depend on the organizational structure & policies of the State
References

- http://drought.unl.edu/whatis/what.htm
- http://wrmin.nic.in
- http://drought.unl.edu/whatis/what.htm
- National Disaster Management Guidelines – Management of Drought – NDMA, Gov. India, Delhi, 2010; www.ndma.gov.in
Critically study the Prevention, Preparedness & Mitigation for drought management as suggested by National Disaster Management Guidelines (www.ndma.gov.in)

Study the necessity of capacity development, relief and responses for drought management (Ref: National Disaster Management Guidelines – Management of Drought – NDMA, Gov. India, Delhi, 2010; www.ndma.gov.in)
Self Evaluation - Questions!

- Illustrate components of drought mitigation plans.
- Describe necessity of drought monitoring & early warning.
- Differentiate between structural & nonstructural mitigation measures
- Illustrate groundwater dams & its role in drought mitigation
- What are the classification of mitigation actions according to impact sectors
- What are the challenges of drought monitoring?

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Assignment - Questions?

- What are the important drought mitigation strategies?
- Compare various monitoring & early warning systems used in different countries.
- Discuss drought mitigation & protection.
- Discuss technology for drought reductions.
- What are the categories of mitigation strategies.
- Comment on drought management & mitigation measures.
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