Drought Management

Karnataka

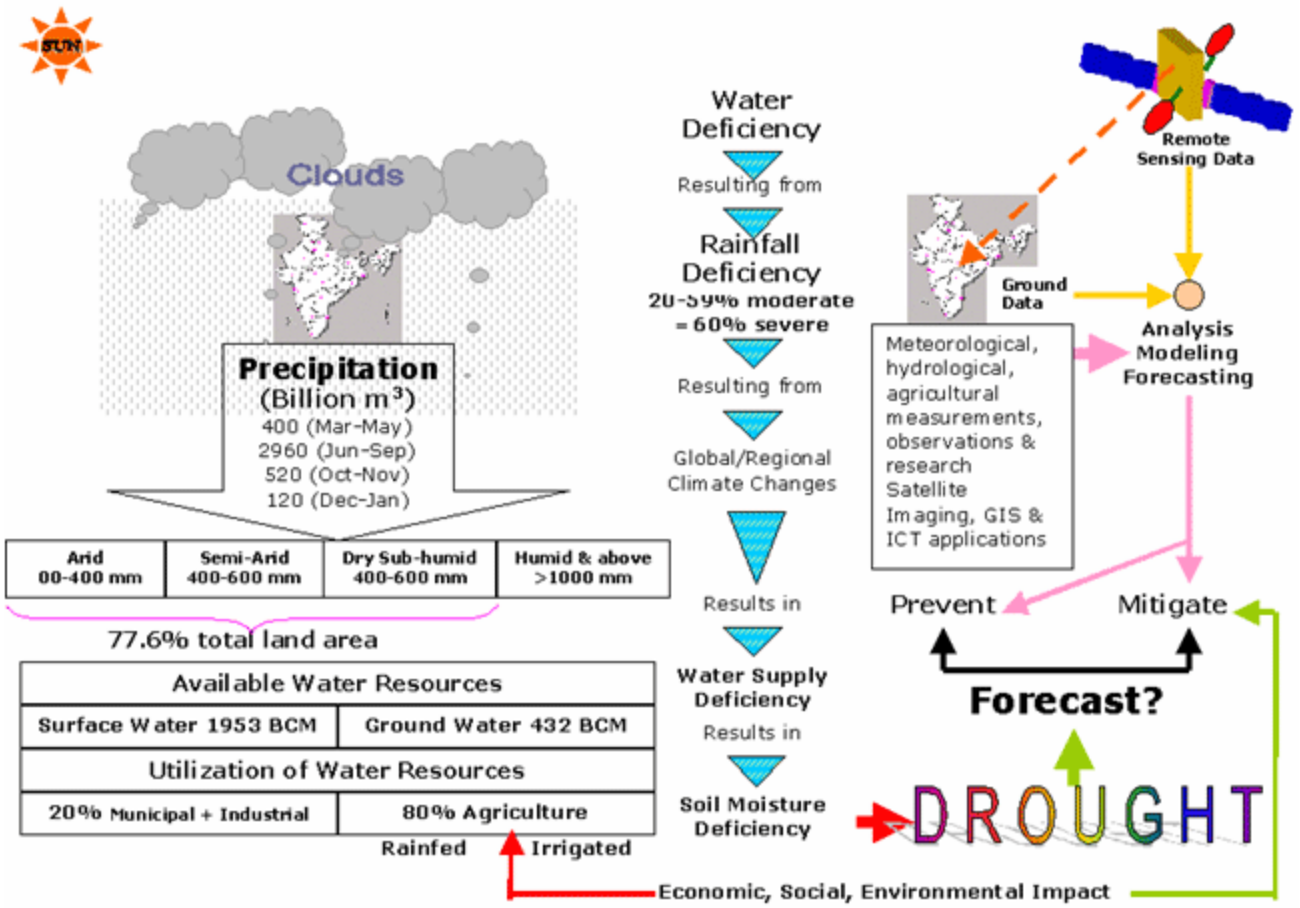

Figure 1: The complex nature of drought management

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1. Executive Summary

1.1. Situation before practice

Prior to independence, measures to tackle famine and minimize deaths due to starvation were evolved and followed. At this time there were no mechanisms to monitor droughts scientifically and technologically. Crisis management was the solution.

1.2. Challenges

a. Developing, and coordinating an institutional mechanism that can monitor/ predict/ warn occurrence of drought; its intensity, duration, area, impact and the immediate and long-term mitigation measures required.
b. Response management that includes assessment of losses, governing relief operations and managing long-term measures for prevention

1.3. Strategy

The strategy has gradually shifted from the crisis management approach of providing relief when the drought occurs to the risk management approach that includes forecasting and early warning, immediate relief in the short-term and drought proofing measures in the long-term.

1.4. Results

- Deaths due to starvation is no longer encountered due to huge buffer stocks of foodgrains and wide public distribution network.
- An early warning system is in place and drought monitoring is done regularly, frequently at GOI and state government levels.
- Institutional mechanisms are in place for measurements, observations, research, forecasting, monitoring based on ground-based data and remote sensing data.
- Institutional mechanisms are in place for disseminating weather forecasts, crop forecasts, contingency crop plans and so on so that they reach the farmers and others affected.
- Institutional mechanisms are in place at the highest executive and political levels in the central and state governments for funding and administration of drought relief operations.

1.5. Sustainability

Successful drought management depends on successful water management and other measures like afforestation, combating desertification and creating conditions of alternative livelihoods for people in drought affected areas. It also depends how successful are our meteorologists, hydrologists and agricultural scientists and their models are in forecasting drought and the EWS they design. Traditional technologies used by our farmers are of immense value in combating drought at less cost.

1.6. Replicability

India's experience in drought management can be used in other countries facing similar situation.

2. Sector

Agriculture

72% of India's population of over a billion are engaged in agricultural occupations that comprise crop farming, livestock farming, fish farming and forestry contributing to about 25% share in GDP. The net sown area (out of a cultivable area of 328.7 million ha) is 142.2 million ha. 55.10 million ha are irrigated. It is often said that Indian agriculture is a *gambling on rains*. India receives annual rainfall in 4 spells.

(a) Pre-monsoon (Mar-May) 10.4%
(b) SW Monsoon (June-Sep) 73.3%
(c) NE Monsoon (Oct-Dec) 13.3%
(d) Winter Rains (Jan-Feb) 3%

Disasters (floods, droughts, earthquakes, cyclones, landslides, volcanoes, tsunamis etc.,) are natural phenomena that occur throughout history and throughout the world resulting in large-scale destruction of life and property, human sufferings and detrimental impact on the economies. India is one of the world's most disaster prone countries. It has witnessed devastating droughts, floods, cyclones, earthquakes, landslides, avalanches and tsunami (in December 2004).

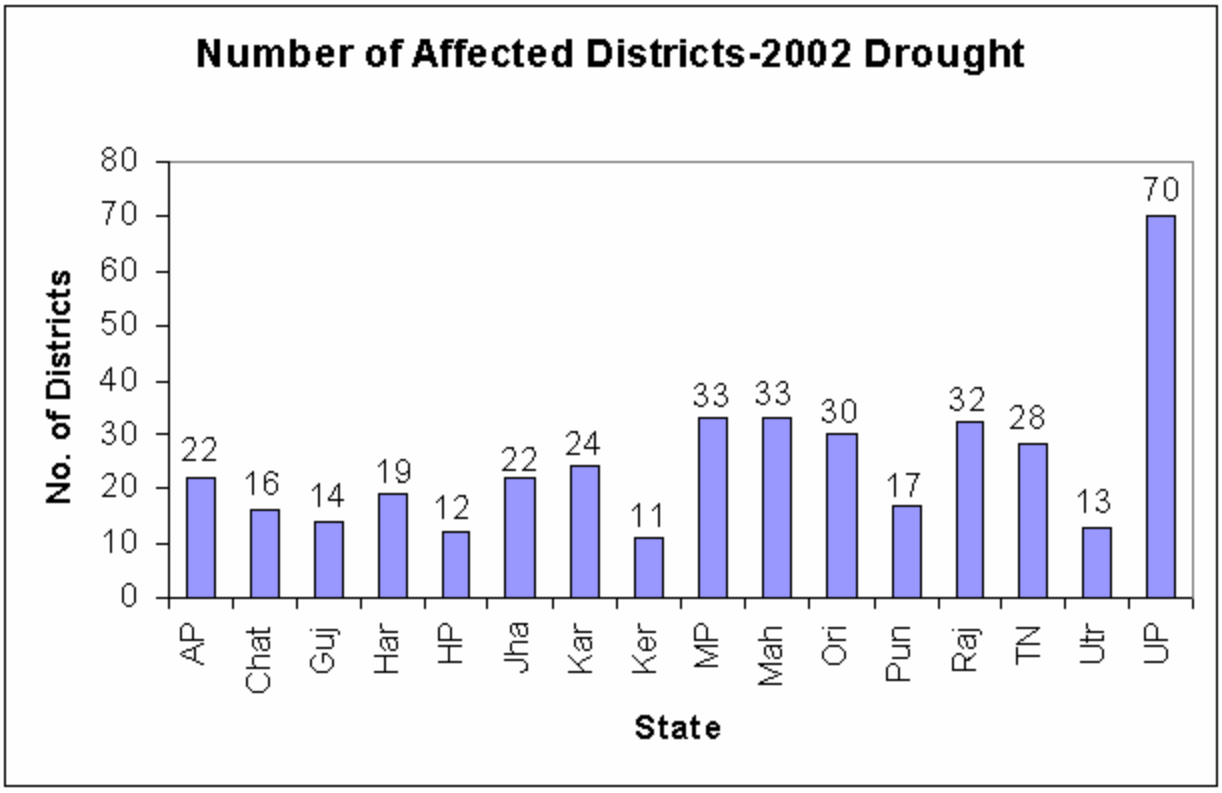

Figure 2: India 2002 Drought-Number of Affected Districts

3. Sub-sector

Water Management

The availability of water is highly uneven geographically and in time. Precipitation is mainly confined to the southwest monsoon months of June-September in the year varying from 100 mm in Rajasthan to over 10000 mm at Cherrapunji in Meghalaya. Rainwater and water in rivers, ponds and lakes and ground water are all part of one hydrological system.

Water is an essential natural resource and to emphasize the serious consideration it deserves, it is often said that the Fourth World War will be fought for water. It is therefore important that the nation endeavours to develop, conserve, utilize and manage water guided by national perspectives. An effective water management system can greatly reduce the probability of occurrence of drought and help mitigate the adverse effects in the event of its occurrence.

4. Policy / Area – Drought Management

Though there is no separate policy on drought, individual ministries/sectors such as agriculture, water, forestry, livestock management, etc., have addressed the issue of drought management in their respective sectors.

Experience in fighting 12 major drought years between 1951 to 2002 has resulted in developing a system of drought monitoring, declaration and response to minimize its adverse effects.

Rainwater Harvesting System in use at Vamdse village in Kundapura Taluk of Udupi District, Karnataka. It uses a saree to collect rainwater and meets the day-to-day drinking water needs of residents.

Courtesy: http://www.indiatogether.org/photo/2004/env-rwhsare

Figure 3: An innovative way of drought proofing

Figure 2 presents states and number of districts affected by 2002 drought.

5. Case / Initiative – Drought Management System in India

5.1. What is drought?

Drought is the single most important weather-related natural disaster. Drought is an extended period–a season, a year, or several years–of deficient rainfall relative to the statistical multi-year (usually 30 year) average for a region. Deficiencies in soil moisture and surface and subsurface water supplies are other indicators of drought

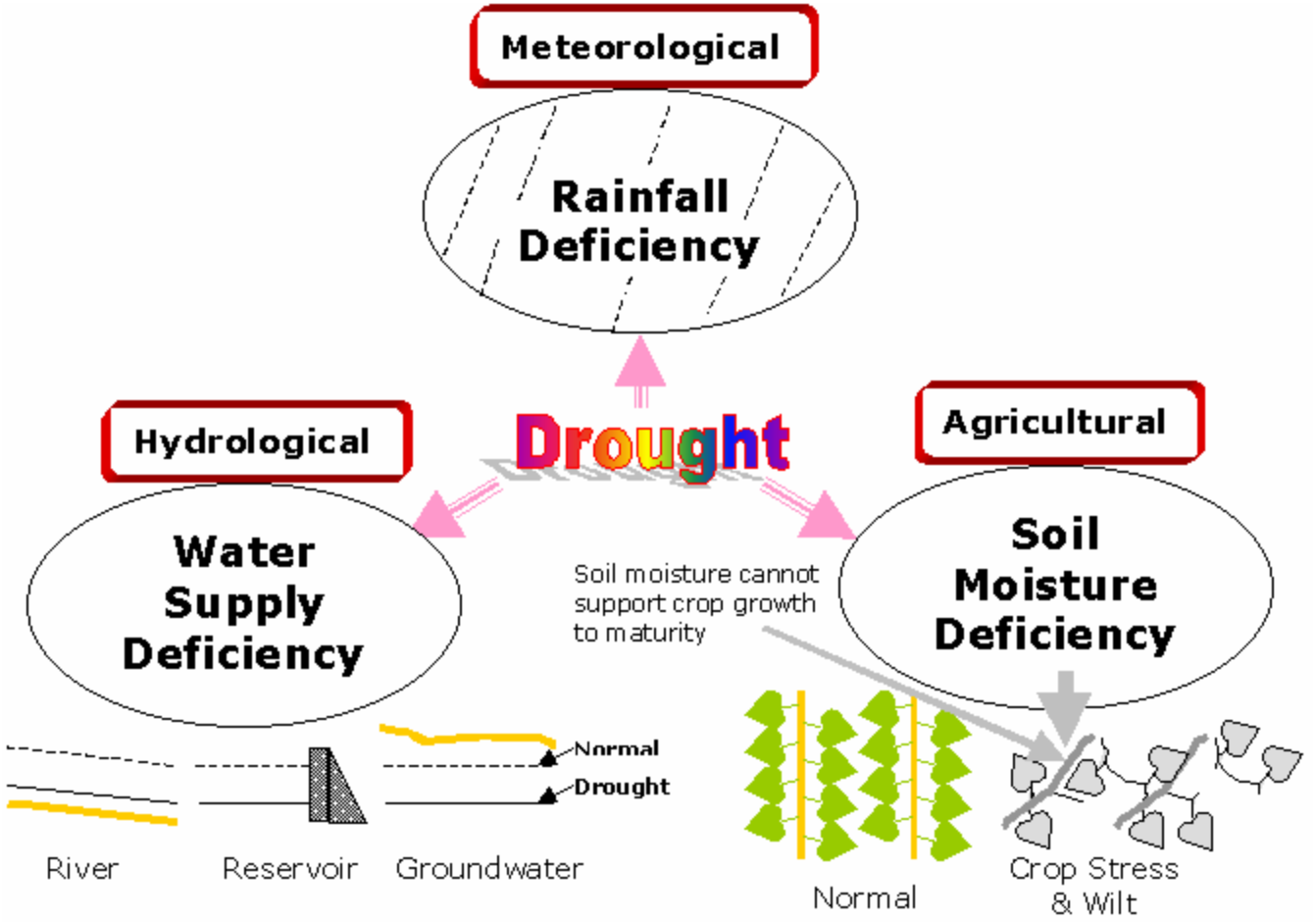

Figure 4: Classification of Drought

Drought may be meteorological, hydrological or agricultural as shown in Figure 4. Figure 5 shows examples of hydrological drought.

Parched Bed of a Water Tank, Barotra, Rajasthan

Dry Dam, Gonda Village, Rajkot District, Gujarat

Source: http://www.frontlineonnet.com/fl1712/17121080.htm

Figure 5: Examples of Hydrological Drought

5.2. Drought & Aridity

Drought is a natural, recurring feature of climate which stems from the lack of rainfall over an extended period of time (e.g. a season or several years); it occurs in virtually all-climatic regions. Drought occurs in high as well as low rainfall areas and is a temporary anomaly, in contrast to aridity, which is a permanent feature of the climate and is restricted to low rainfall areas.

Drought differs from other natural disasters in three ways.

a. It's beginning and end is usually unknown.
b. Varying definitions and interpretations make it difficult for decision-makers.
c. Its impacts are spread over a larger area than from other natural hazards.

16% of the country's total area is drought prone and approximately 50 million people are annually affected by droughts. A total of 68% of sown area is subject to drought in varying degrees - 33% of area receiving less than 750-mm rainfall is *chronically drought-prone*. 35% of area that receives between 750-mm and 1125-mm rainfall is *drought-prone*. Most of the drought prone areas lie in the *arid, semi arid and sub-humid areas* of the country that occupy 77.6 percent of its total land area of 329 m ha.

- *Arid Zone* (19.6 percent) Mean Annual Precipitation (MAP) of 100-400 mm (water deficit throughout the year)-Rajasthan, Parts of Haryana and Gujarat. Droughts are severe in this zone.
- *Semi-arid Zone* (37.0 percent) with MAP of 400-600 mm (Water surplus in some months and deficit in other months)- Parts of Haryana, Punjab, West UP, West MP and also most entire peninsular parts of the Western Ghats. Drought can be moderate to severe in this zone.
- *Dry Sub-humid Zone* (21.0 percent) with MAP of 600-900mm in India- Parts of Northern Plains, Central Highlands, Eastern Plateau, Parts of Eastern Ghats and Plains and Parts of Western Himalayas. Droughts are moderate in this zone.

- The *humid and per-humid regions* such as Assam & NE States rarely face drought.

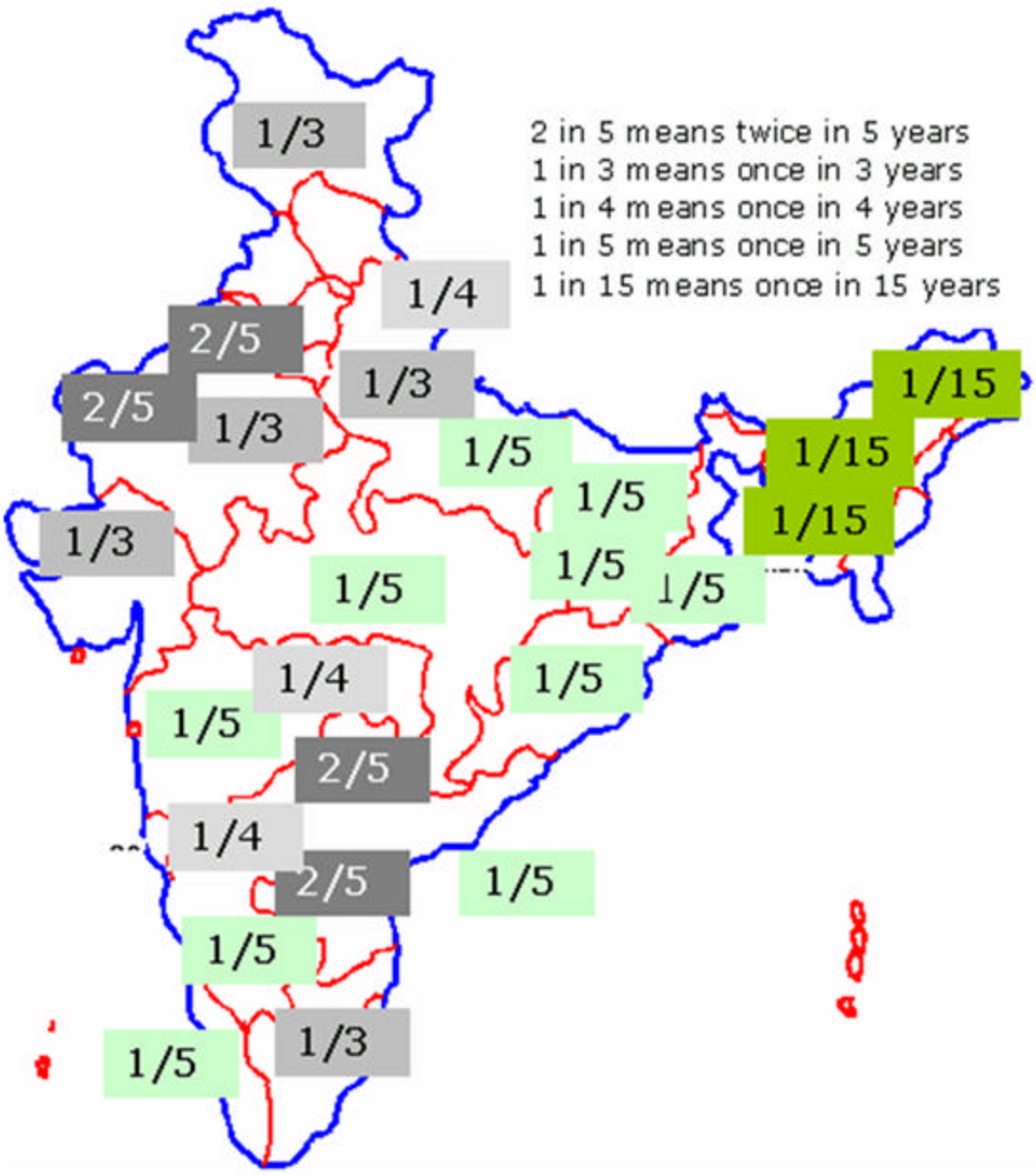

Figure 6: Frequency of Occurrence of Drought in India

The frequency of occurrence of droughts in different parts of India is presented in Figure 6.

5.3. Causes & Effects of Drought in India

Drought is a complex phenomenon, the causes for which are both natural factors (variations in large-scale atmospheric circulation patterns and the locations of anticyclones, or high-pressure systems, climatic variability, sea surface temperature changes such as El Nino) and manmade factors (deforestation, poor land and water management, green house effect). The common causes of drought in India and its effects are shown in Figure 7.

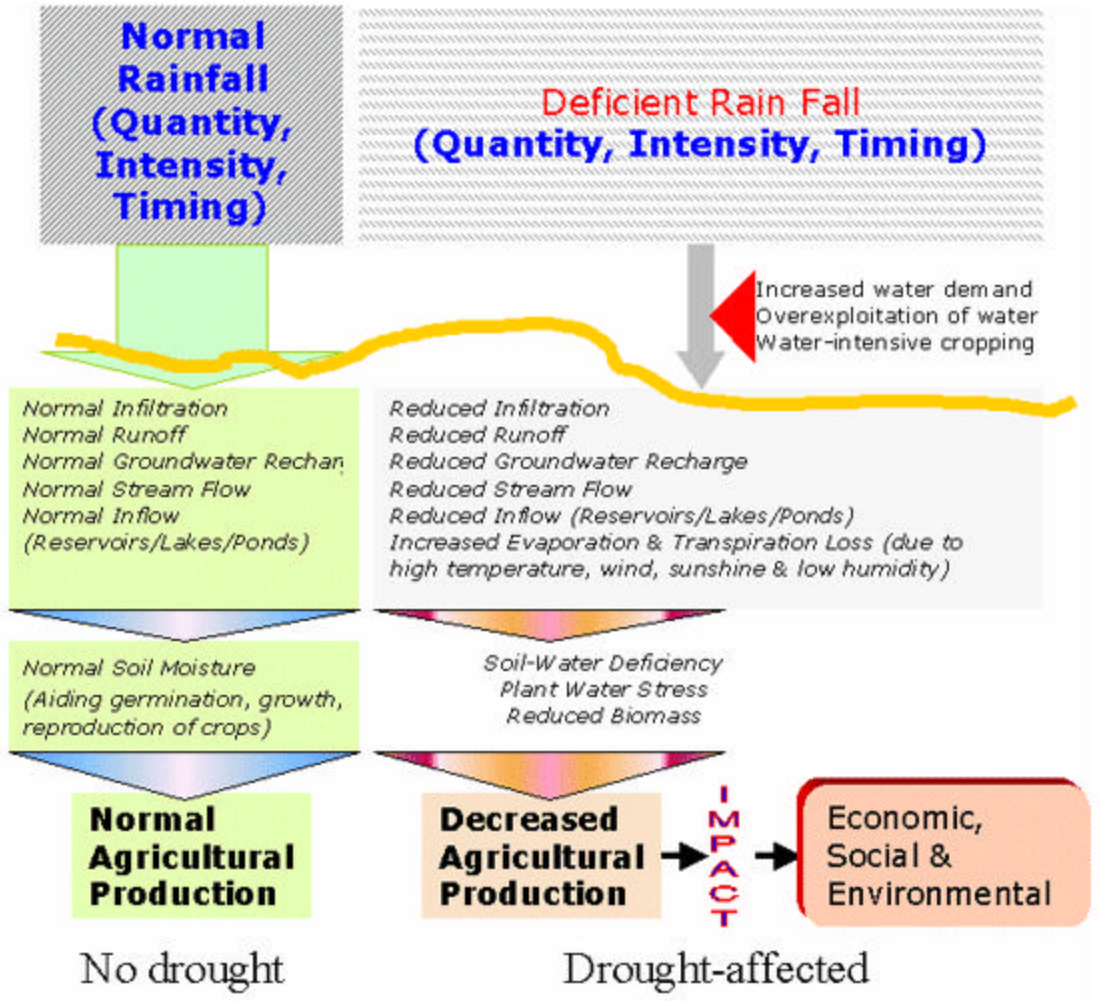

Figure 7: Causes of drought

5.4. Measuring / Quantifying Drought

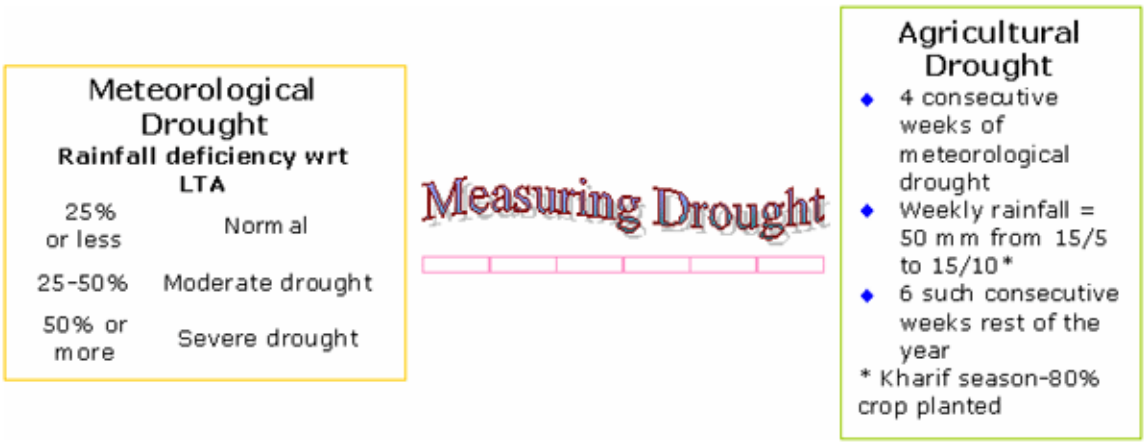

Figure 8: Measuring Meteorological & Agricultural Drought

Operational definitions identify the beginning, end, spatial extent and severity of a drought. They are often region specific and are based on scientific reasoning based on the analysis of hydro-meteorological data. They are beneficial in developing drought policies, monitoring systems, mitigation strategies and preparedness plans. Figure 8 explains the measurement of meteorological and agricultural drought.

Table 1: Drought Indices

Drought Indices		
Agro-Meteorological	**Hydrological**	**Remote Sensing**
Palmer Drought Severity Index (PDSI)	Lower stream flows than normal	Normalized Difference Vegetation Index (NDVI)
Bhalme-Mooley Drought Index (BMDI)	Lower storages in reservoirs/ lakes/ ponds	Enhanced vegetation index (EVI)
Standard Precipitation Index (SPI)	Lower groundwater levels than normal	Vegetation condition index (VCI)
Effective Drought Index (EDI)		Temperature condition index (TCI)
Surface Water Supply Index (SWSI)		
Crop Moisture Index (CMI)		
Deciles		

Drought indices are measures of drought, which are useful in giving an operational definition for drought. Table 1 presents some drought indices in use.

Drought Management

Intensity, duration and spatial extent are the three main features of drought. To reduce drought consequences, India has evolved a drought management system.

Its main components are shown in **Figure 9**. Since agriculture is the most affected activity, which in turn affects the livelihood of the majority of population in India (as seen in **Figure 10**), drought management's major thrust is on agriculture.

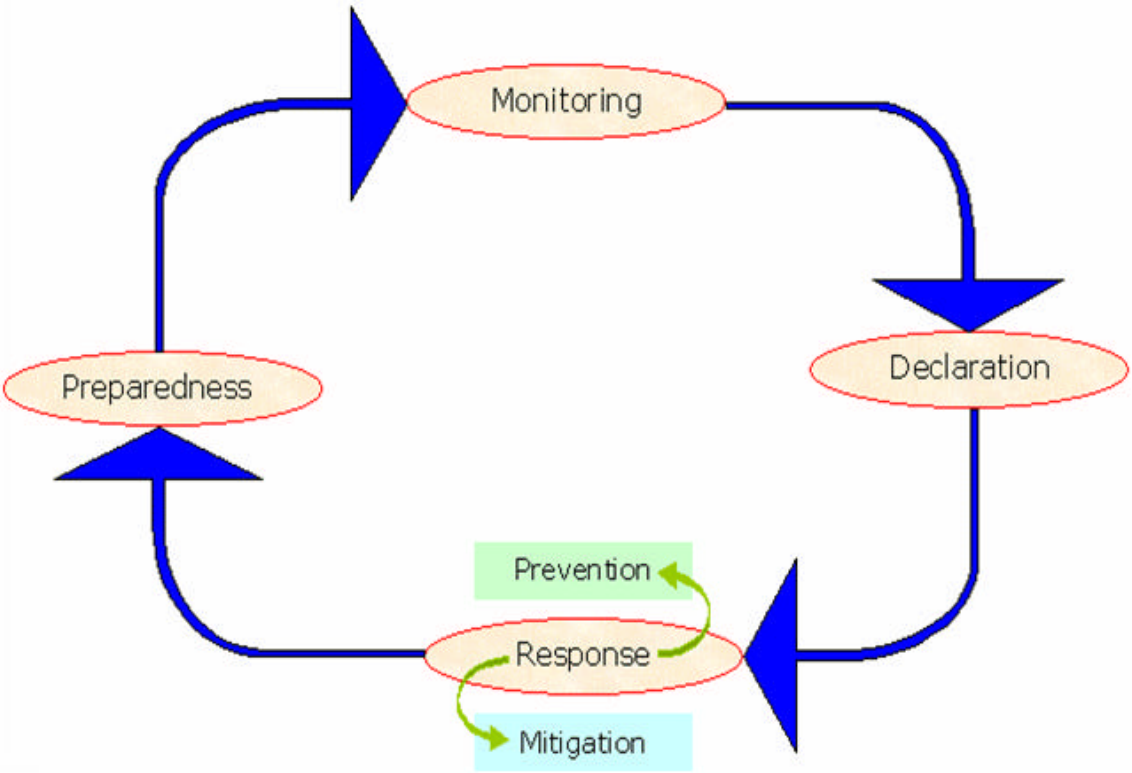

Figure 9: Elements of Drought Management System in India

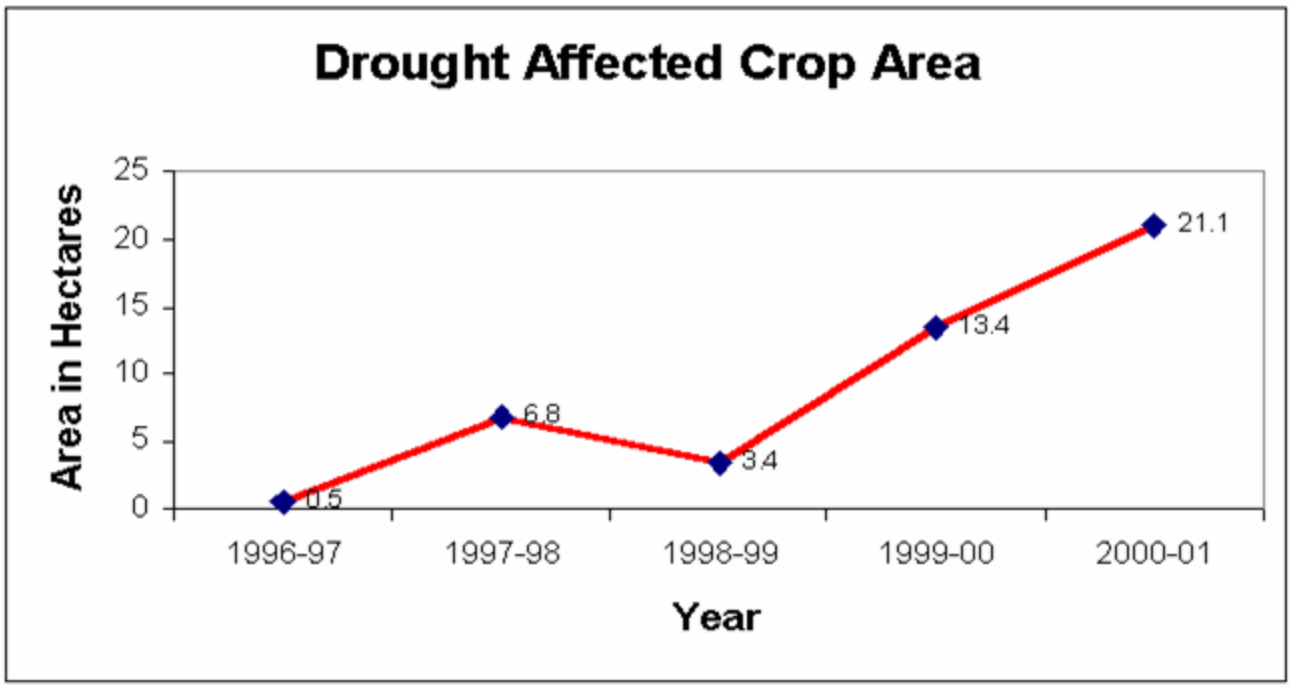

Figure 10: Crop Area affected by drought in India 1996-2001

6. Contributors and References

6.1. Key Architects

- Ministry of Agriculture and Cooperation, Government of India
- India Meteorological Department

6.2. Implementers/ Stakeholders

Government of India

- Department of Agriculture & Cooperation (CWWG, NCFC)
- Department of Science & Technology (IMD, NCMRWF)
- Departme nt of Water Resources (CWC)
- Crop & Agricultural Extension Specialists
- Department of Space (NRSI, NADAMS)
- Indian Council of Agricultural Research and its Research Institutes

State Governments

- State Agricultural Department
- State, District, Tehsil and Village Level Administration
- Agricultural Universities

Non-Government Organizations

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7. Organization

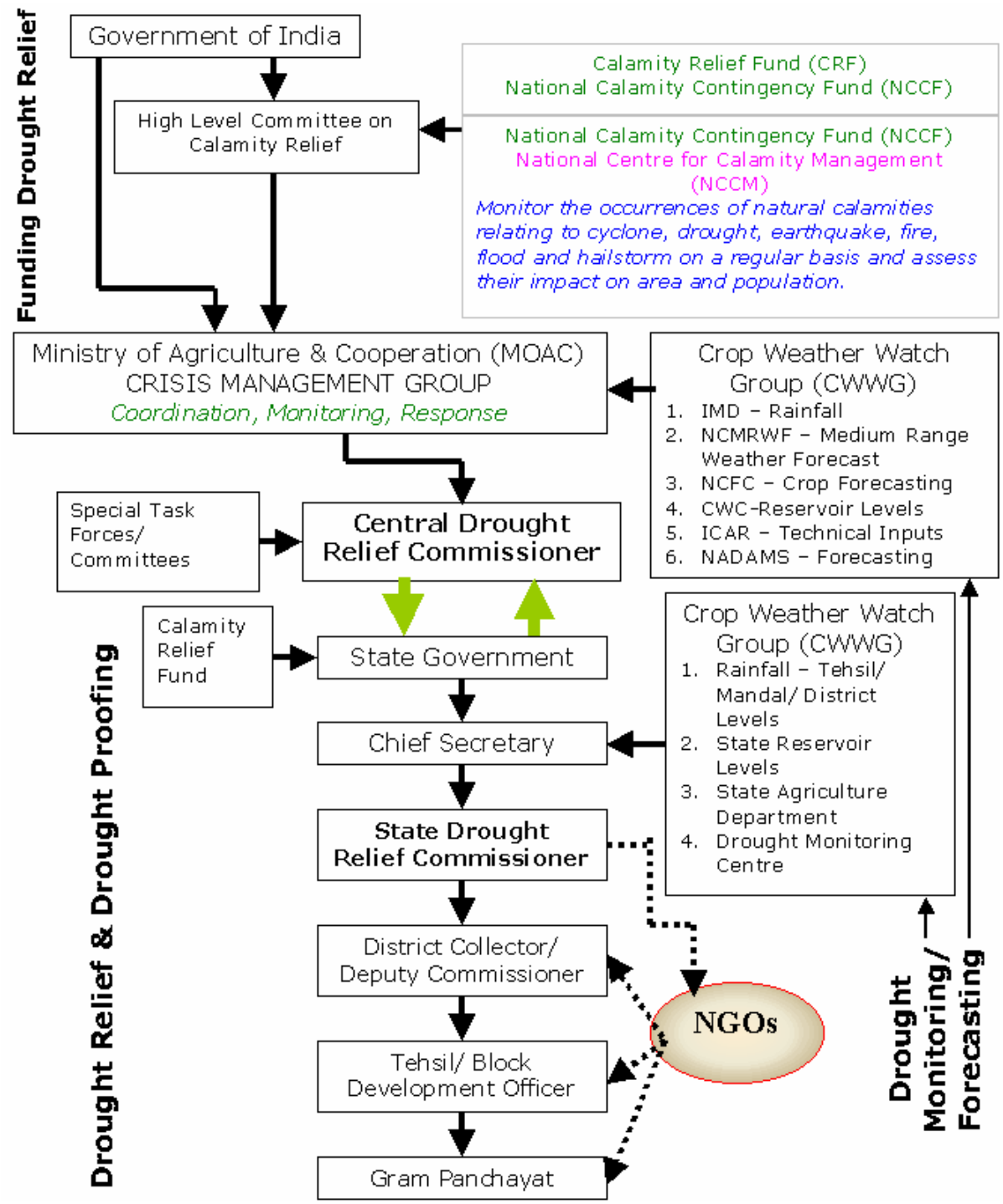


Figure 11: Organization for Drought Management

Monitoring of and responding to drought are the two major functions of the Crisis Management Group. Based on the information provided by the National Crop Forecasting Centre (NCFC) of the MOAC, the Crop Weather Watch Group (CWWG) meets every week to monitor weather and drought.

Annex 1 gives the list of information discussed and provided by CWWG. Annex 2 is a sample rainfall distribution map issued by IMD. Annex 3 shows a sample NCMRWF forecast.

The Central Relief Commissioner is responsible for providing relief measures. Some states have set up Drought Monitoring Cells of their own to monitor/forecast drought. State governments are responsible for carrying out the drought relief operations at district, tehsil and village levels.

8. Project Design

8.1. Key Objectives

a. Predicting drought using scientific methods and tools and data to prevent its occurrence
b. Responding timely and effectively to mitigate the effects of drought through drought relief and drought proofing measures

8.2. Outcomes

a. A multilevel institutionalized drought monitoring and early warning system during normal and drought periods is in place. Monitoring, prevention, mitigation, preparedness, vulnerability mapping, declaration, funding, relief and impact analysis are the elements of this system.
b. Ground-based data and data obtained from space technologies (Remote Sensing, Vegetation Mapping) are being analyzed to monitor/ predict drought and estimation of losses. ICT is being increasingly used in drought management.
c. Improved drought management system has resulted in reducing poverty levels in drought-affected states as compared to those in least drought-affected states.
d. Weather forecasting by IMD and deliberations of CWWG has enabled states in declaring drought.
e. During very severe droughts, special task forces at the central level and additional mechanisms at the states level reinforce the regular drought monitoring system.
f. Some states like Karnataka have set up a Drought Monitoring Cell with state –of-the art technologies providing rainfall information.
g. Socioeconomic impact of drought (on crops, water & power availability, livestock, fodder availability, market responses and employment) is being monitored by the Central/ State Relief Commissioners and Special Task Forces.
h. The Relative Drought Vulnerability Index (Persons killed per million exposed) is 0.58 for India which is very low compared to 6 for China and 16847 for DPR Korea.
i. A *National Disaster Management Authority* is soon to be set up by the Government of India under the proposed Disaster Management Bill to be tabled in the parliament in the 2005 Budget Session and install an early warning system for taking precautionary measures in the event of natural disasters.

8.3. Strategy / Approach

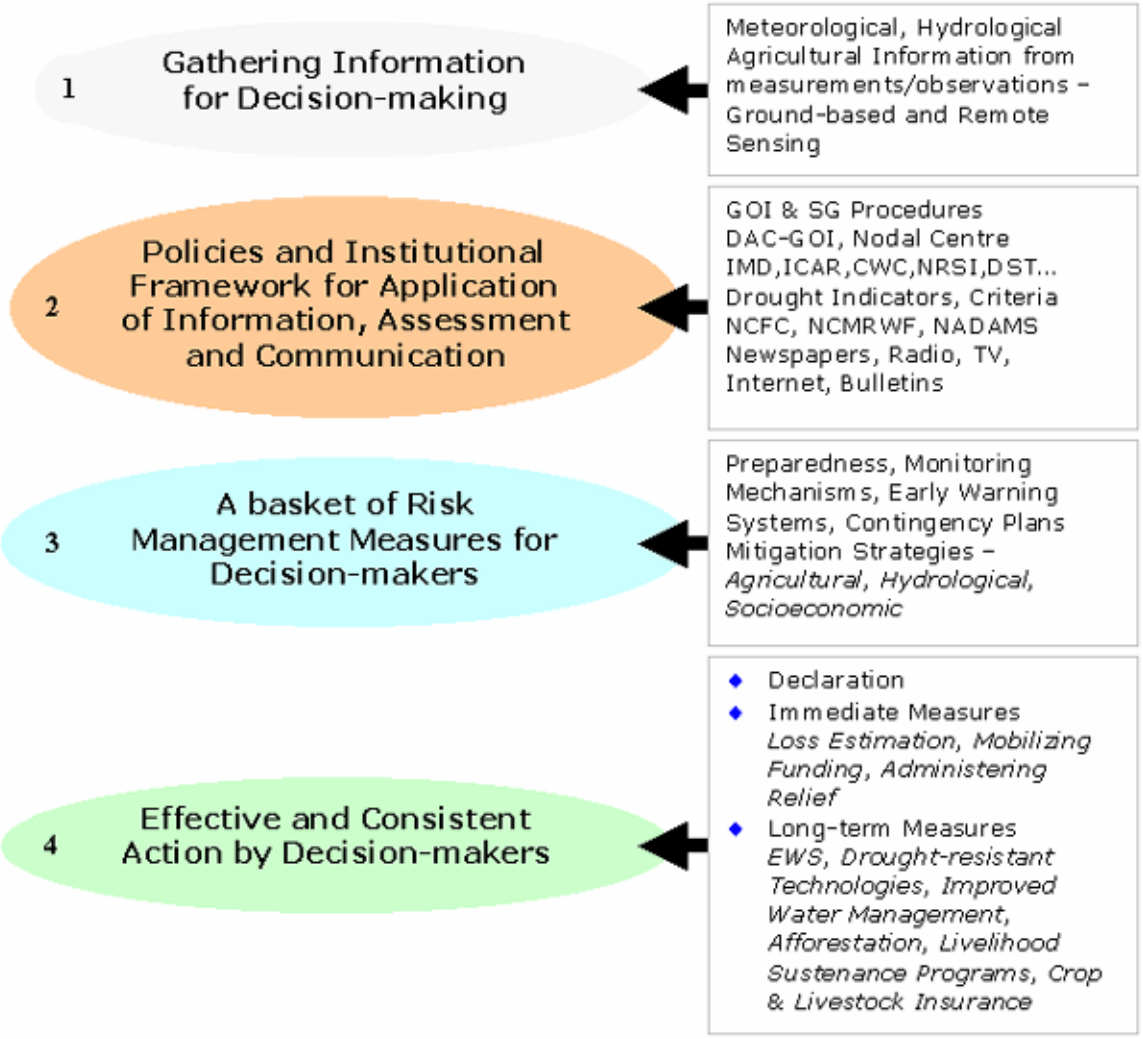


Figure 12: Drought Management Strategy

The traditional approach to drought management has been reactive, relying largely on *crisis management*. This approach has been ineffective because response is untimely, poorly coordinated, and poorly targeted to drought stricken groups or areas. In addition, drought response is post-impact and relief tends to reinforce existing resource management methods that quite often have increased societal vulnerability to drought.

The new strategy emphasizes a shift from *Crisis Management to Risk Management*. It is a holistic approach to drought management involving forecasting, prevention, mitigation and preparedness in pre-drought phase along with the policy practiced so far of post-drought measures of relief and rehabilitation under crisis management. This strategy involves extensive scientific and technological inputs for data collection, analysis, modeling and forecasting drought.

Critical Success Factors

a. Institutional and operational readiness (administrative, financial, logistical) and contingency plans in Central and State Governments to combat drought in the event of its occurrence
b. Effectiveness of monitoring, forecasting and Centre-State coordination
c. State government's readiness to declare drought based on drought monitoring data and prediction
d. Rapidity of responding and mitigating
e. Community participation

8.4. Methodology

The drought management methodology is presented in **Figure 13**.

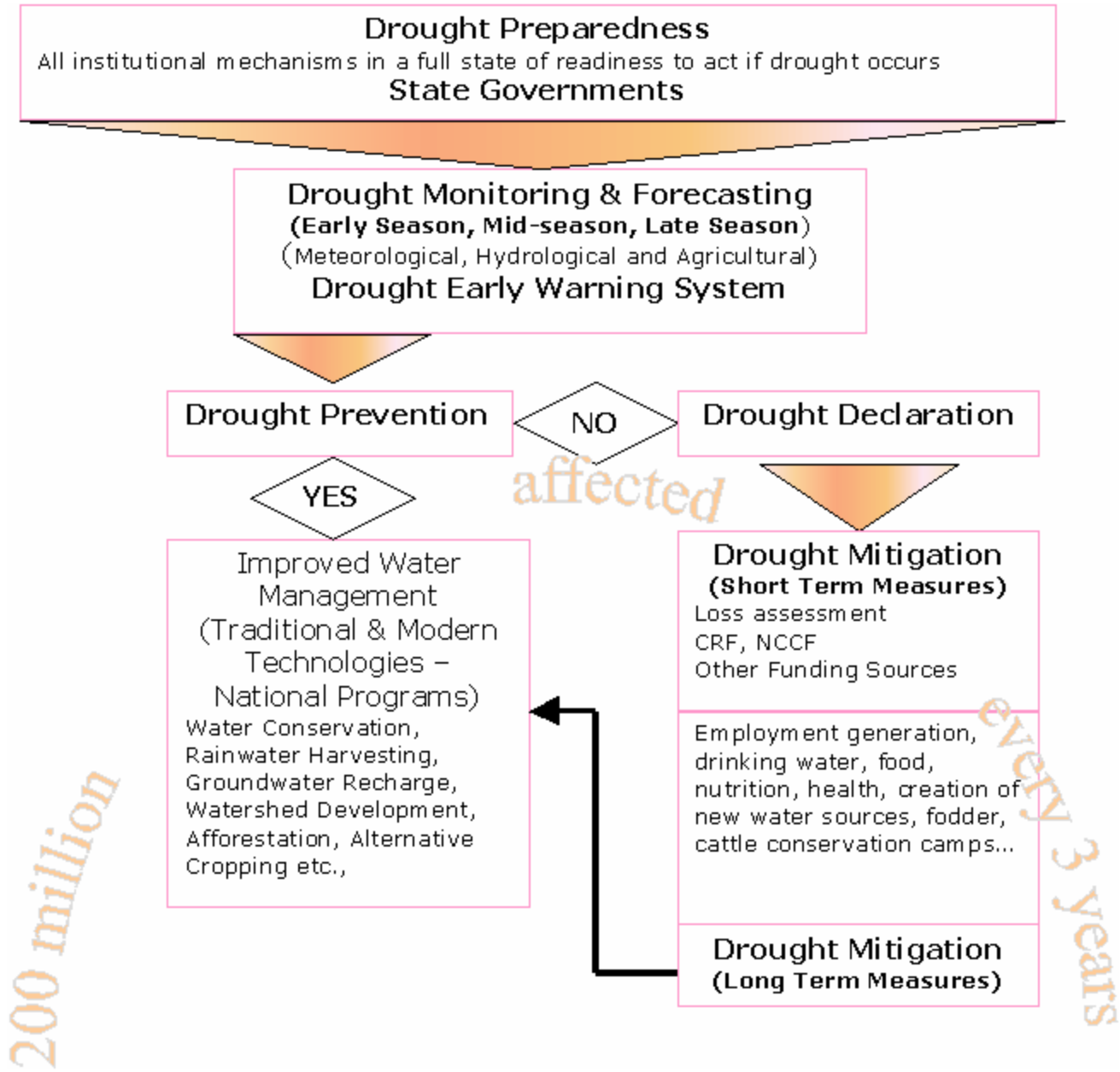


Figure 13: Drought Management Methodology

8.5. Conceptual Framework

Figure 14: Drought Management-a conceptual framework

Conceptually, there are two ways of fighting drought. Replacing/ reducing rain-fed agriculture and animal husbandry by industry and services as contributors to our economy. This almost an impossible task as 75% of India's population is dependent on agriculture-related occupations for their livelihood. The other alternative is to manage drought by improved water management and crop management by monitoring and mitigating its effects by creating livelihood/ income generation alternatives.

8.6. Presumptions & Risk Assessment

Drought onset and end and its severity are often difficult to predict. As the majority of people in India are dependent on agriculture and animal husbandry for their sustenance, drought has serious social and economic consequences.

Unless drought-proofing measures are undertaken and water management is improved, India may face increasing drought-proneness in coming years.

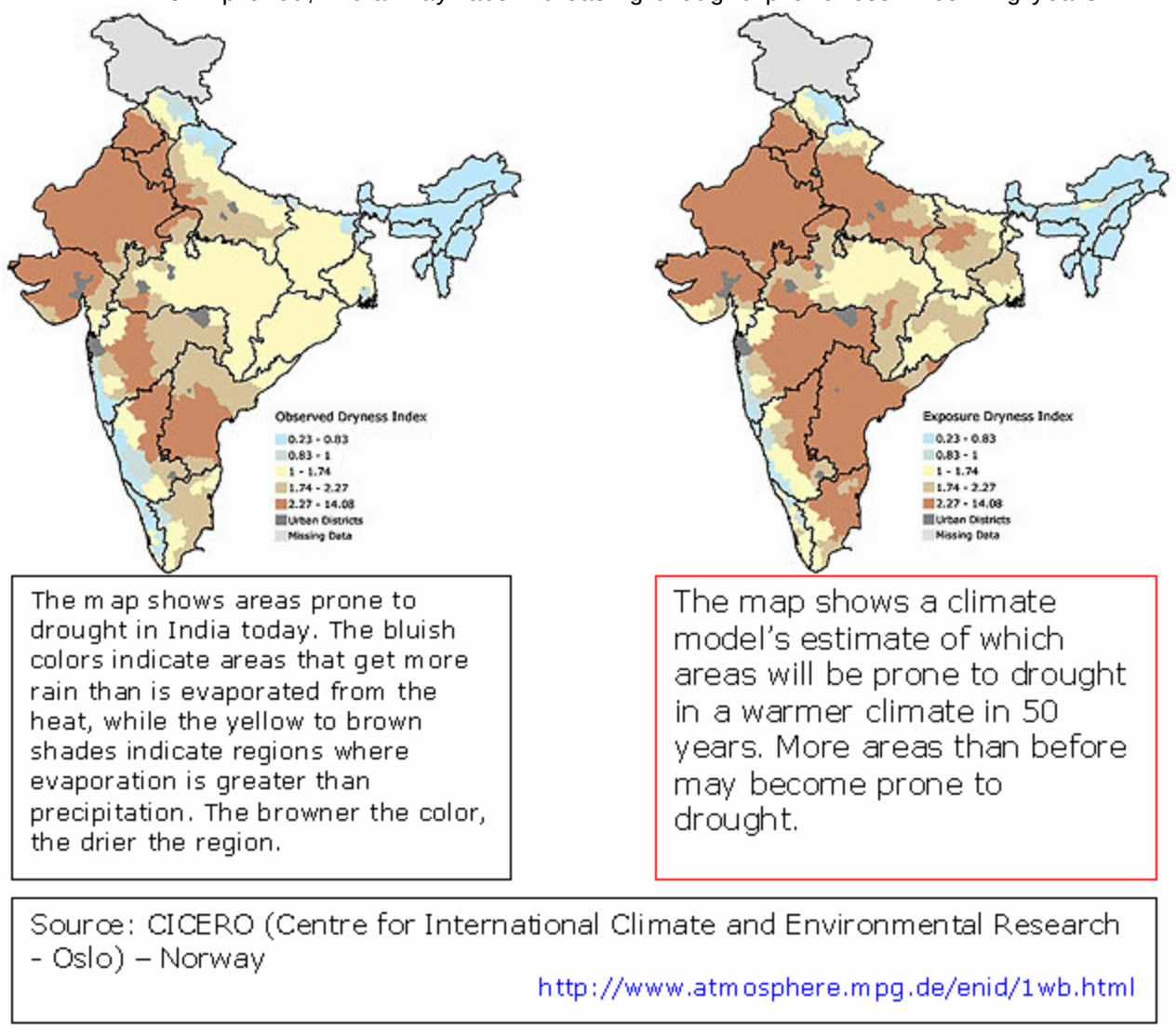


Figure 15: India's Drought-proneness - a prediction

Figure 15 is a prediction of India's drought-proneness after 50 years.

Drought Risk = An area's exposure to drought x Vulnerability

- Better understanding of drought intensity and duration
- Establishing Drought-EWS

- Population migration
- Agricultural practices
- Natural resource management practices
- Desertification

Drought Severity

Depends on

- Intensity
- Duration
- Spatial Extent

Water Demand
- Humans & Animals
- Vegetation

Quantification of impact difficult

Impact of Drought

1. Likelihood of death for humans and animals
2. Loss of agricultural production
3. Short-term reduction in GDP
4. Imbalances in fiscal budget due to emergency allocations for relief
5. Panic/ disruption in lives of people
6. Increasing likelihood of social unrest leading to violent conflicts
7. Damage to natural resource base and environment
8. Migration of people and livestock
9. Slow down in development

The impact of 2002 drought is summarized below.

2002 Drought Impact – Agriculture Production

- 21.53 mha not sown
- 47 mha-sown crops damaged
- 29 million tons less foodgrains production

2002 Drought Impact – Water Resources

- 33% less Storage in 77 reservoirs-33% less than last 10 years average
- Groundwater table by 2-4 m below normal levels in drought affected areas
- 1.5 billion litres of water/day transported to drought affected areas

2002 Drought Impact – Livestock

- 150 million cattle affected
- Less than normal milk procurement - 22% Rajasthan, 8% MP & 7% TN

2002 Drought Impact – Livelihood

- 300 million people in 180 mha affected
- Job loss of 1250 person-days

2002 Drought Impact – Economic

- 3.1 % less agricultural GDP
- Agricultural Income Loss Rs.39000 crore
- Rs.20000 crore relief by GOI
- Rs.2000/ha increase in irrigation in Punjab

The *risk management approach* aims at ensuring food production, relying on leading drought indicators (rainfall, water level in reservoirs and progress of cropping pattern), and detect early signs of a developing drought situation.

Figure 16 shows the impact of 2002 drought on sown area, which in turn affected agricultural production.

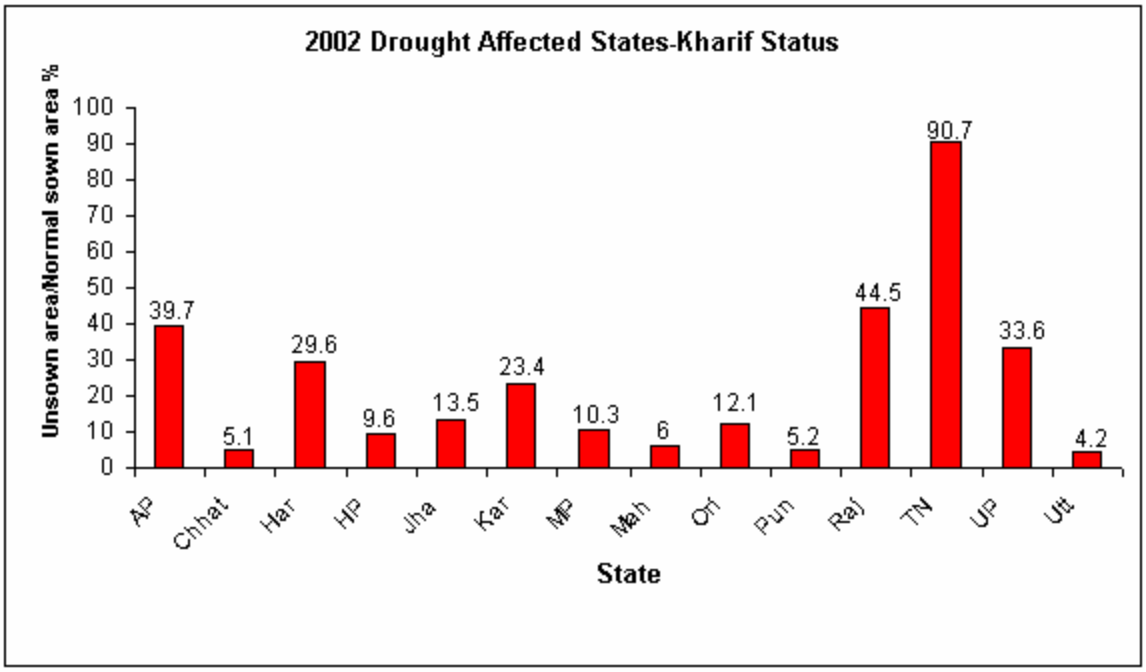


Figure 16: 2002 Drought Impact on Sown Area

CWWG monitors and forecasts drought assesses the impact of the monsoon on crop conditions and suggests corrective measures to minimize crop losses. It meets during the monsoon period from June to September. In case the CWWG anticipates widespread adverse seasonal conditions, it sends out a warning. This triggers the implementation of a contingency action plan for drought management.

Early Warning System plays an important role in risk management of drought.

The IMD and the Department of Agriculture & Cooperation (GOI) issue warnings. Many of the State Governments have their own early warning systems. **Figure 17** is a summary of Drought EWS in India.

Remote Sensing & Drought Management

1. Targeting of potential groundwater sites for taking up emergency well digging programs has been made possible by the use of satellite data.
2. The first phase of the Drinking Water Mission consisted of district-wise groundwater potential maps using high-resolution Landsat/IRS data.
3. An integrated (water, agricultural, land, fodder resources and socioeconomic database) study to combat drought by developing action plan packages was taken up by Department of Space, Govt. of India, in collaboration with concerned State Governments in 21 drought prone districts in different states of the country. Data from IRS satellite, Survey of India Topographic Maps and Census Data were integrated to prescribe appropriate landuse, fodder and water management practices.

Generator → Drought Early Warning System → User

A. **I**ndia **M**eteorological **D**epartment (Network of Observatories, Measuring Stations, Agricultural Meteorology Division and Drought Research Unit at Pune)
   - *Meteorological drought every year*
   - *Drought years for the country*
   - *Drought-prone areas and probability of occurrence of drought*

   Biweekly aridity anomaly reports during:
   - *Southwest Monsoon Season for the whole country*
   - *Northeast Monsoon Season for Coastal AP, Rayalseema, South Interior Karnataka, Tamil Nadu, Pondicherry & Kerala*
   - Monthly forecasts of food production
   - Agrometeorological Advisory Service (AAS) through *Farmers Weather Bulletins*
   - Agricultural advice to farmers on crops through bulletins

B. **N**ational **C**entre for **M**edium **R**ange **W**eather **F**orecasting
   - Medium Range Weather Forecasts (3-10 days in advance)
   - Farmers Advisories

C. **N**ational **A**gricultural **D**rought **A**ssessment & **M**onitoring **S**ystem (NADAMS)
   - Drought assessment based on daily NOAA-AVHRR (1.1 km) and IRS-WIFS (188 m) based biweekly/monthly vegetation index and provides
   - Periodic information on crop conditions at the district and sub-district level in terms of drought bulletin and detail reports.

   This program at present covers AP, Bihar, Gujarat, Haryana, Karnataka, MP, Orissa, Rajasthan, Tamilnadu and UP.

D. **All India Coordinated Research Project Dryland Agriculture** (AICRPDA)
   - Contingent crop planning strategies for early season (transplantation and changing the crop and varieties), mid season droughts (reducing the leaf area by regulating the plant population/ mulching/ weed removal/ water harvesting/ irrigation) and late season droughts (harvesting the crop for fodder may be the only option)

Provide for drought management before planting the crops even if the forecast is for a good year.

Figure 17: Summary of Features of EWS in India

8.7. Using Technology

Several new technologies like the remote sensing, geographical information system and the information & communication are being employed for forecasting, mitigation and governance of drought relief measures. Figure 18, Figure 19, and **Figure 20** show the application of space technology in drought monitoring & forecasting.

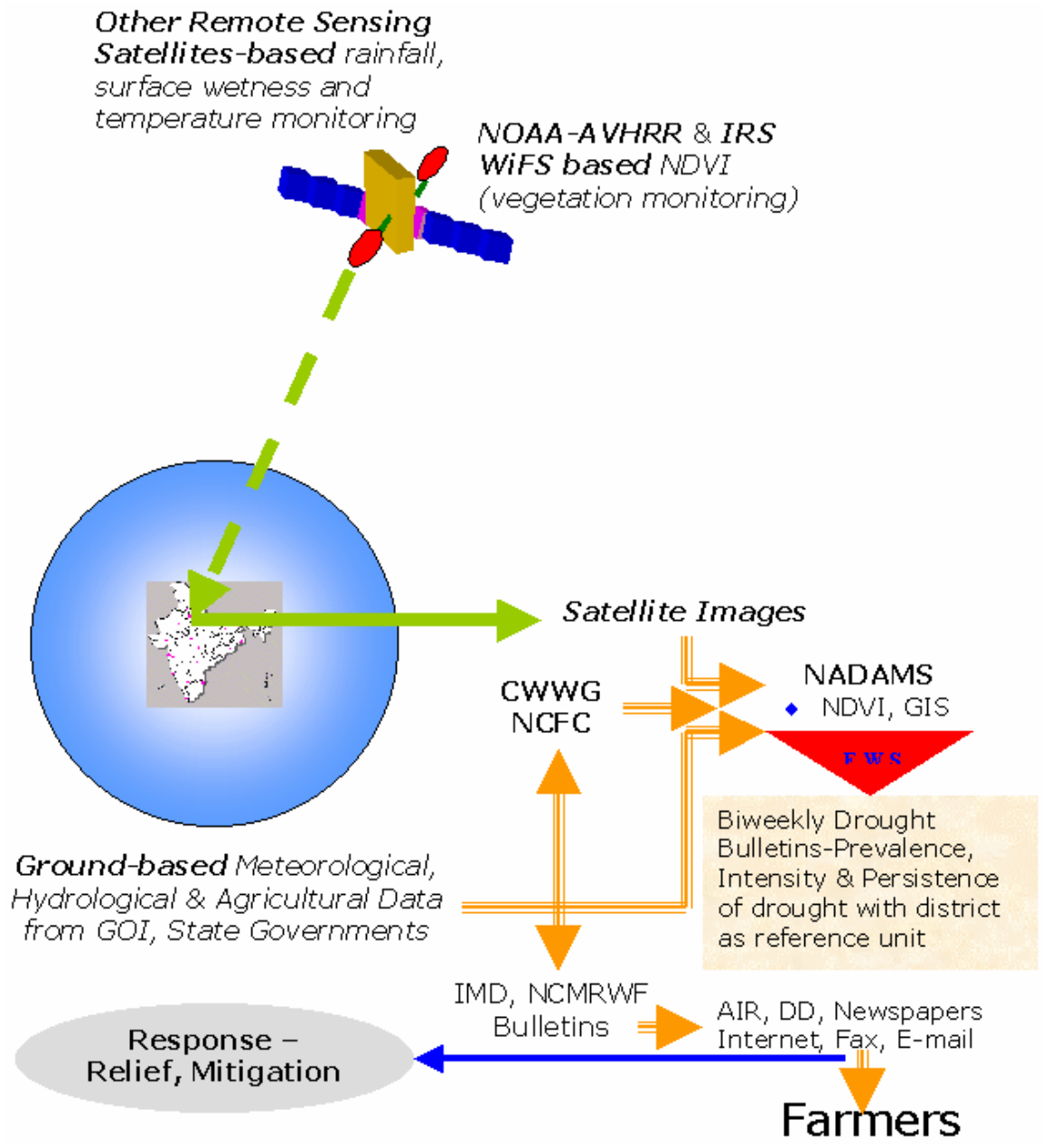


Figure 18: Space to Farms-Technology in Drought Management

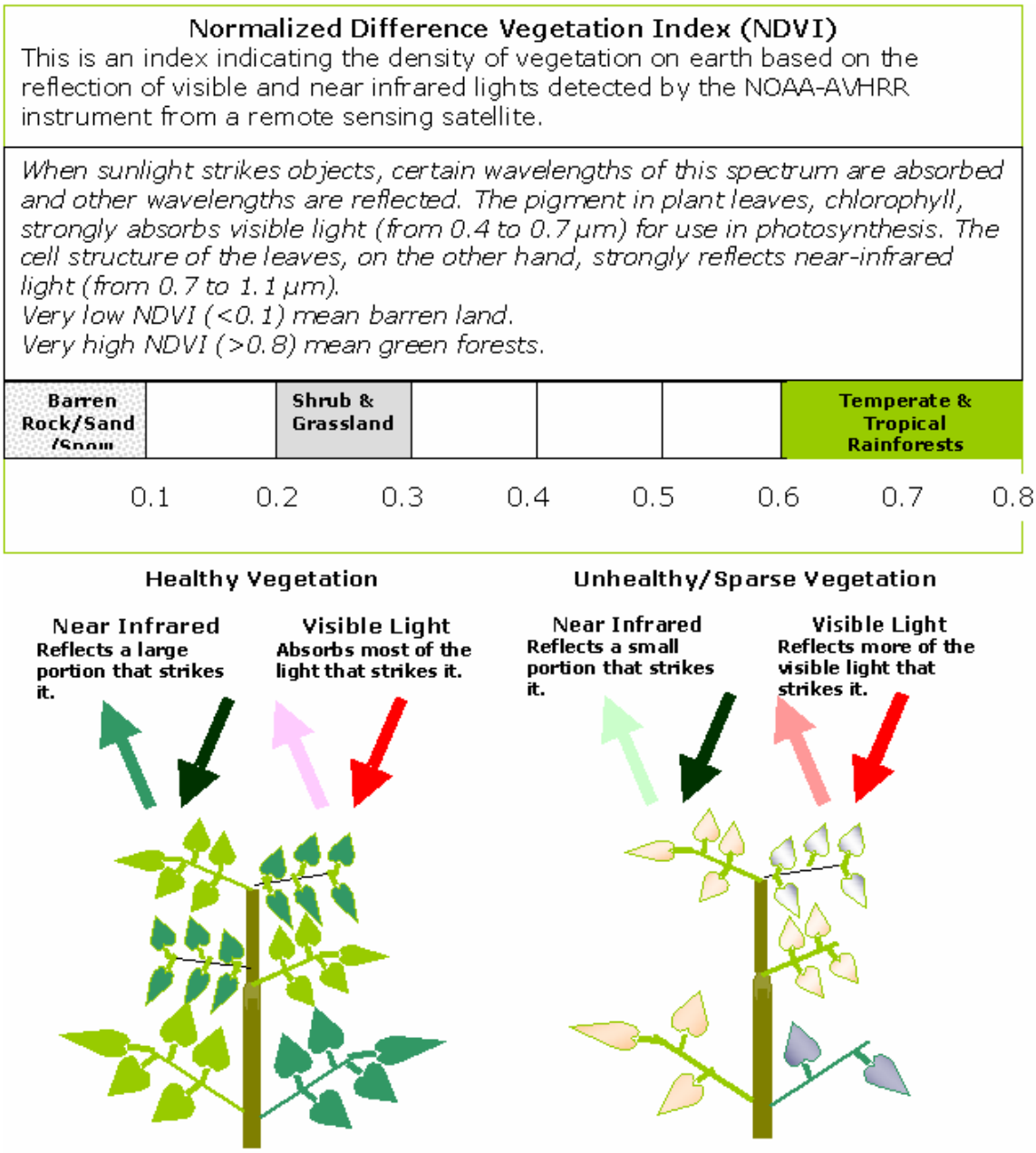


Figure 19: NADAMS Drought Monitoring using NDVI

The lowering of the Vegetation Index means moisture stress in vegetation, resulting from prolonged rainfall deficiency. Combined with a surface water index, the Vegetation Index is a clue to the onset of hydrological and agricultural droughts.

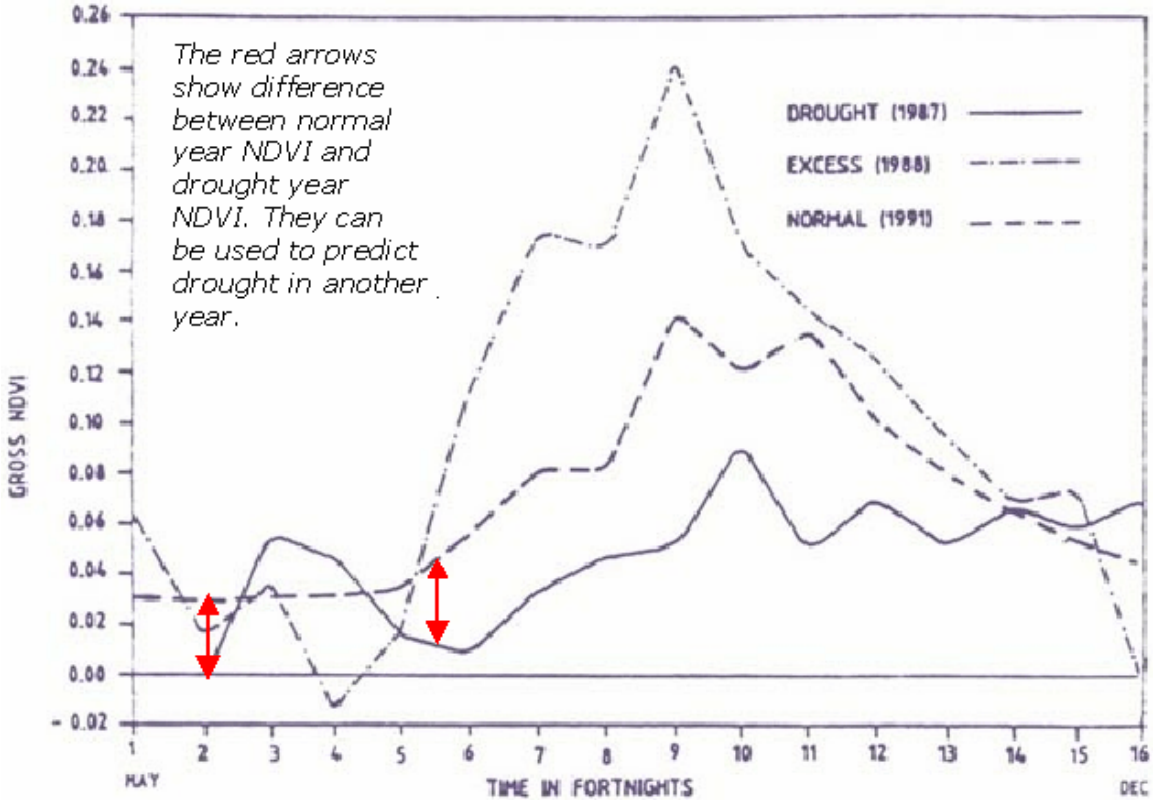


Figure 20: NDVI indicating seasonal vegetation conditions (Bhiwani Dist.India)

9. Drought Management - Key Processes and Activities

9.1. Preparedness

a. Appointing a Drought Task Force
b. Developing a Drought Plan
c. Enlisting stakeholder participation
d. Publicize the Drought Plan
e. Updating and evaluating the Drought Plan

9.2. Monitoring

a. Meteorological Data – India Meteorological Department, Indian Institute of Tropical Meteorology, State Governments
   - ❑ Daily Rainfall
   - ❑ Wind Velocity
   - ❑ Drought Indices
   - ❑ Temperature
   - ❑ Snow Fall/Fog

b. Hydrological Data – Central Water Commission, Central Ground Water Board, State Governments (Irrigation Departments, Groundwater Agencies, Water Resources Departments/ Projects)
   - ❑ Runoff
   - ❑ River Flow
   - ❑ Water Level - Reservoir/Ponds/Lakes
   - ❑ Groundwater Level
   - ❑ Yield and Draft from Aquifers
   - ❑ Water Demand & Supply
   - ❑ Water Loss (Evaporation, Leakage, Seepage)

c. Agricultural Data – Indian Council of Agricultural Research, State Government Departments of Agriculture, Agricultural Universities
   - ❑ Soil Moisture
   - ❑ Type of Crop and Area

- ❑ Crop Water Requirement
- ❑ Mode of Watering & Loss
- ❑ Status of Growth
- ❑ Crop Yield
- ❑ Alternative Cropping Possibilities

d. Data from Space – National Remote Sensing Agency
- ❑ Vegetation Monitoring
- ❑ Rainfall, surface wetness and temperature monitoring

e. Socioeconomic Data – Revenue Department
- ❑ Population Growth Rate
- ❑ Economic Status
- ❑ Food Needs
- ❑ Nutrition Needs
- ❑ Fodder Needs for Animals
- ❑ Vulnerable Areas/ Villages, Area, Population, Livestock

f. Logistics
- ❑ Public/ Private Civil Supplies Distribution System
- ❑ Mode of Transport to Drought-hit Areas
- ❑ NGOs
- ❑ Beneficiaries of Drought-relief Programs

g. Analysis of data from ground and remote sensing sources

h. Prediction/ Forecasting Drought using appropriate models – 48 hours & 3-7 days

i. Operating the Drought Early Warning System

j. Training Emergency Workers

9.3. Responding

a. Risk Management
- ❑ Water Management
  - ✓ Water Harvesting
  - ✓ Development of Common Property Resources for water & fodder
  - ✓ Groundwater Sources
  - ✓ Watershed Development & Groundwater Recharge
  - ✓ Minimizing Evaporation & Evapotranspiration Losses
  - ✓ Water Conservation (Microirrigation-sprinkler, drip)
  - ✓ Inter-linking of river basins for even distribution of country's water resources.

  } Local Practices + Conventional and Modern Technologies

- ❑ Crop Management
  - ✓ Crop-Weather Modeling (Advisories through Bulletins)
  - ✓ Contingent Crop Planning (AICRPDA)
  - ✓ Corrective measures-early season, mid-season and late season droughts
  - ✓ Less-water consuming crops, drought-resistant crops
- ❑ Income Generation Activities in Drought Prone Areas
  - ✓ Non-farm activity, especially small-scale and cottage industry, to open up alternative employment avenues.

b. Crisis Management (Decisions for mitigation and alternative strategies)
- ❑ Establishing Control Room for Monitoring the Drought Situation
- ❑ National Calamity Management Committee Meetings
- ❑ Crisis Management Group Meetings
- ❑ Estimating Loss and Impact
- ❑ Requesting Relief Assistance
- ❑ Calamity Relief Fund (Release from GOI and States)
- ❑ National Calamity Contingency Fund (Release from GOI)

- ❑ Funding from other sources (Prime Minister's Relief Fund, External Sources)
- ❑ Executing Relief Operations
  - ✓ Drinking Water
  - ✓ Food Security (Buffer Stock, Subsidy, Public Distribution System)
  - ✓ Nutrition Security (Lactating Mothers, Children)
  - ✓ Health Security (Vulnerable Sections, Diseases)
  - ✓ Livestock Security (Cattle Camps, Water, Fodder, Veterinary Services)
  - ✓ Crop Insurance
  - ✓ Special Programs/ Projects
- ❑ Employment Generation Programs
  - ✓ Food For Work Program (FFWP)
  - ✓ Employment Assurance Scheme (EAS)
  - ✓ Jawahar Gram Samridhi Yojana (JGSY)
  - ✓ Pradhan Mantri Gram Sadak Yojana (PMGSY)
  - ✓ Swaranjayanti Gram Swarozgar Yojana (SGSY)
- ❑ Social Security Program
  - ✓ Antyodaya Anna Yojana (AAY)
  - ✓ National Old Age Program (NOAP)
  - ✓ Annapurna Scheme
  - ✓ Integrated Child Development Scheme (ICDS)
  - ✓ Mid Day Meal - School children

10. Time Frame

There is no time frame for drought management activities. Since the beginning and the end of this natural disaster are difficult to forecast, everyone concerned has to be alert always, particularly in severe drought areas. All drought management activities should aim at finding answers to the following questions.

Where will the drought occur? When will the drought occur?
What will its severity? How long will it be? Is the EXS operational?
Are the Risk Management and Crisis Management Plans ready?

An approximate time frame for drought management activities is shown in Table 3.

Table 2: Change in farm practice suiting to drought

Crop Stages ➔ Rain Deficiency ?	**Sowing**	**Growth**	**Reproductive**
Upto 19% Rainfall Deficiency	Normal operations/ Slight changes	Normal operations/ Slight changes	Normal operations/ Slight changes
20-59% Rainfall Deficiency-Moderate Drought	Contingency Plan, Crop changes, Irrigation, Some relief to affected areas		
= 60% Rainfall Deficiency-Severe Drought	Extensive and speedy relief measures		

Activity	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Initiating Drought Preparedness Plan												
Monitoring a. Rainfall b. Temperature c. Evaporation												
Monitoring a. Surface Water Levels b. Groundwater Levels												
Assess water availability a. Surface Water b. Groundwater												
Estimate crop type, area & water requirement												
Contingency Crop Plan												
Assess drinking water requirement												
Assess potential water deficit												
Initiate water conservation practices a. Rain Water Harvesting b. Groundwater Recharge c. Afforestation												
Assess food & fodder requirement												
EWS (CWWG) a. Forecasting using Ground-based & RS data b. Communicating through media												
Declaring drought												
Mitigation a. Obtaining assistance from CRF b. Employment c. Drinking Water, Food & Nutrition, Health d. Fodder, Veterinary Services												

Table 3: Approximate Time Frame for Drought Management Activities

The impact of agricultural drought depends on a number of factors such as intensity, timing, duration, frequency of rainfall deficits, differing responses of various soils, plants, and animals to water stress. A good drought management practice is to use this range of responses to best advantage.

For instance, breaks in monsoon rains of shorter duration, like 5 to 10 days, may not be of serious concern. But prolonged breaks of more than 2 weeks can lead to plant water stress, thereby reducing crop productivity. Based on meteorological data, crop combinations can be selected to take care of the time lag. Table 2 is illustrative of responses to drought situation.

2002 Drought Management Summary

1. In July 2002, IMD reported failure of monsoon beyond last week of June 2002
2. CWWG meets. Review of situation by Union Agriculture Minister, Cabinet Secretary.
3. Agriculture Ministers of 12 states and GOI meet. National Task Force set up.
4. 1st installment under CRF released by GOI.
5. IMD continued reporting dry spells in Northwest & central India, West Rajasthan; rainfall in South and East India; and withdrawal of SW monsoon in other parts.
6. GOI Team set up to assess drought impact, visits states. GOI Team reports.
7. IMD reports normal Northeast monsoon rains in AP, Kerala and Tamilnadu.
8. National Task Force deliberated on Team Reports and decides to release assistance.
9. States complain of inadequate central assistance.
10. IMD reports satisfactory winter rains in December 2002 in many states and deficiency in January 2003.
11. GOI teams for assessing drought following winter rain deficiency.
12. Severe cold wave in North India damages orchards, sensitive crops and inland fisheries.
13. GOI Teams reports and recommends assistance to Rajasthan.
14. Rajasthan High Court orders fresh survey.
15. GOI Team conducts fresh survey.
16. National Task Force approves special assistance to Rajasthan.

The box above is a summary of major decision-support inputs and responses to 2002 drought.

11. Key Stakeholders, Implementers and Agencies

The responsibility for managing disasters belongs to concerned state governments. Government of India provides policy/ guidelines, disaster warning, supplements physical and financial resources. DAC in the Ministry of Agriculture GOI is the central coordinating and advisory agency. The Central Relief Commissioner at the Department is the focal point for interaction with state government and central agencies/departments. NGOs are also involved when required.

Table 4 is a list of stakeholders and their responsibilities.

Table 4: Key Stakeholders/Agencies

Government of India	
Department/Agency	**Major Responsibility**
National Crop Forecasting Centre (NCFC) Crop Weather Watch Group (CWWG) Department of Agriculture & Cooperation	Evaluating drought-relevant information Assessing impact on agriculture Activating drought-response System
India Meteorological Department	Drought monitoring and forecasting Information sharing
National Centre for Medium Weather Forecasting (NCMWF)	Medium-range weather forecasting
National Agricultural Drought Assessment and Monitoring System (NADAMS)	Assessment of agricultural drought based on vegetation index
Department of Space	Integration of remote sense/ satellite data with GIS/ Socioeconomic data for evolving action plans to combat drought
Calamity Relief Fund (CRF) National Calamity Management Committee (NCMC)	Funding drought relief
Crisis Management Group Department of Agriculture & Cooperation	Regular monitoring of crop security, food security, nutrition security, health security and livestock security-all related to drought
Relief Commissioner, Drought Task Forces - DAC	Drought monitoring & management (India)
National Disaster Management Division (DAC)	Awareness creation Training
State Government	
Calamity Relief Fund	Financial Assistance
Drought Monitoring Centre/ Cell	Monitoring rainfall, reservoir water levels
Relief Commissioner (State Level)	Watch on drought, Estimation of losses Drought declaration, Requesting assistance
District Collector NADAMS	Rainfall & drought monitoring at district, tehsil/block levels; Estimating agricultural losses; Declaring drought; Requesting relief assistance; Administration of relief measures

The CWWG was able to assess the potential impact of the severe drought of July-August 2002 and suggested appropriate measures such as contingency crop planning and water conservation to mitigate the impact.

Contribution of Academic Institutions in Drought Monitoring – An example

GIS is used to integrate of meteorological, hydrological and physical nature of Palar and Thamiravaruni river basins, located in Northeast and Southwest parts of Tamil Nadu, to map the drought risk areas.

Relevant hydrological and other data were collected for the period 1971- 2000.

Map/Info GIS software, VERTICAL MAPPER version 2.5 and MS Excel were used in analysis. Employing India Meteorological Department (IMD) method carried out the assessment of meteorological drought severity. Hydrological drought analysis was carried out using Herbst method, by executing a program written in C language. Agricultural drought severity assessment was carried out for all blocks using remote sensing data. Satellite based drought assessment and monitoring methodology was applied using IRS WiFS data and satellite based vegetation index NDVI.

Drought Information System (DIS) was developed comprising water related database, meteorological drought, hydrological drought, agricultural drought and drought risk area analysis.

Source:
http://www.gisdevelopment.net/application/natural_hazards/drought/pdf/ma03204.pdf

12. Knowledge Management & Life Cycle Considerations

12.1. Type of Intervention

India relied too heavily on crisis management approaches before and during the pre-independence era (before 1947). Based on the experience of tackling the 1966 drought-induced food crisis, serious efforts were made to replace the crisis management with the risk management approach.

Increasing use of GIS, Satellite Imaging based on Remote Sensing and ICT are being used to improve the drought management in India, more particularly the EWS.

12.2. Organizational Development

The Department of Agriculture & Cooperation in the Ministry of Agriculture, GOI has networked with a number of departments/ agencies to fight drought in India. Some of them are:

OMGOI – Other ministries of GOI
ICAR – Indian Council of Agricultural Research
IMD – India Meteorological Department
DOS – Department of Space
NRSI – National Remote Sensing Institute
DST – Department of Science & Technology
CWC – Central Water Commission
SG – State Government
NGO – Non-Government Organizations

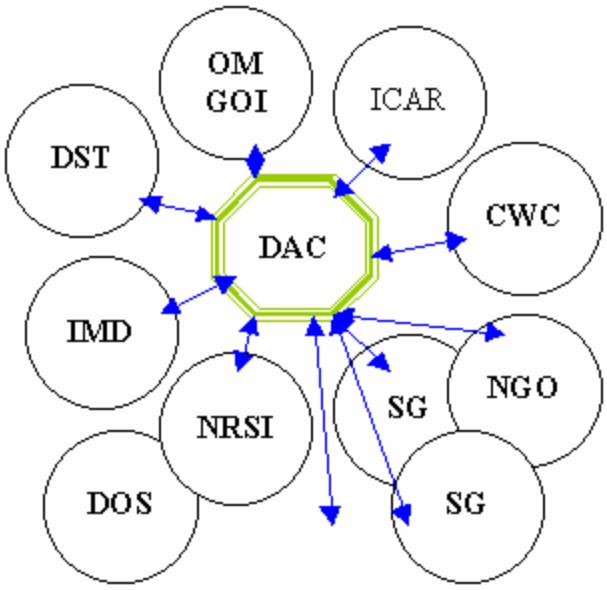


Figure 21: Drought Management Networking

12.3. Lessons Learnt

a. Refinements/improvements in methods and techniques of early drought detection, its intensity, duration and spatial extent and EWS are necessary. More reliable weather forecast for July, the main sowing season is needed.
b. Drought Disaster Recovery Plans are yet to be prepared at the Central and State levels with an in-built mechanism for effective coordination at national, state, district, tehsil and village levels. District-specific standard operating procedures for contingent crop planning are needed.
c. Greater emphasis on better water management practices. Village level water management plans during drought periods are needed.
d. Training of personnel in the risk management approach to the drought problem
e. Quick action studies on effectiveness of governance of relief measures are needed.

13. Unfolding the Story

13.1. Overview of the genesis

Agricultural planning in India is primarily dependent on the prediction of monsoon rains, more particularly the Southwest monsoon.

Drought is a recurrent feature in India. History suggests severe famine continuously struck Chandra Gupta Maurya's Empire during 310-298 BC. During a severe drought in 1917-18, Jhelum River in Kashmir dried up

completely. About 107 million hectares of the country spread over administrative districts in several states are affected by drought. India has experienced 22 major droughts during the last 131 years. The 2002 drought, one of the severest in India affected 56% of its geographical area, livelihoods of 300 million people and 150 million cattle in 18 states, and GOI had to provide relief amounting to Rs.20000 crore.

Prior to 1947 and during early years after independence, famine codes and associated procedures were used to minimize deaths due to starvation resulting from drought.

The magnitude of economic, social and environmental impact resulting from droughts and the developments in Meteorology, ICT, Remote Sensing resulted in changing the mindset of the GOI in gradually shifting over from a crisis management approach to a risk management approach in combating drought.

13.2. Synopsis of the development that led to the initiative

Since 1900 till 2002, droughts in India have resulted in 2,750,430 deaths, affected about 900 million people, apart from huge financial loss. It is the creeping effect of drought extending to long periods and its severity that sensitized the GOI to treat the problem from several angles – scientific, technological, economic, social and environmental. Some of these are:

- Enhancement of the capabilities of IMD from Long Range Forecasts (LRF) to climate modeling and weather forecasting using supercomputer, from meteorology to agrometeorological studies and services.*

  *These include water requirement of crops, pests and diseases, rainfall probabilities in the dry land agricultural areas, crop-weather relationship, application of remote sensing techniques, Farmers Weather Bulletin indicating the onset of rains, probable rainfall – intensity and duration, weak or a break in monsoon conditions, occurrence of frost, hail, squalls, Agromet Advisory Bulletins Scheme and drought research.
- The National Centre for Medium Range Weather Forecasting (NCMRWF) started in 1989 to forecast weather on a medium-term basis (3 to 10 days in advance) and provide agrometeorological advisory service for each of 127 agroclimatic zones of the country.
- The National Agricultural Drought Assessment and Monitoring System (NADAMS) became operational in 1989.
- The Finance Commissions set up by GOI once every five years have been recommending budgetary provisions and guidelines for calamity relief resulting from drought and other natural disasters.
- The National Centre for Disaster Management was set up in 1995 to undertake human resource development, research, building database and providing information services, and documentation on disaster management.
- In the wake of the severe drought in 2000, the Government set up a High-Power Committee (HPC) in the Ministry of Agriculture to look into the problems of man-made and natural disasters and make recommendations.

- Some States (like Karnataka) have set up Drought Monitoring Cells to provide information on agro-meteorology and assistance for drought mitigation and relief.
- GOI has launched many programs aimed as long-term measures to prevent/ mitigate drought. Some of these are:
  - ✓ Drought Prone Areas Program- DPAP
  - ✓ Desert Development Program (DDP)
  - ✓ Indira Gandhi Canal Project (IGNP) in the drought prone areas of Rajasthan
  - ✓ National Watershed Development Project for Rain-fed Areas- NWDPRA,
  - ✓ The Drinking Water Technology Mission (groundwater potential maps at district level, using multi spectral satellite data),
  - ✓ The Integrated Mission for Sustainable Development -IMSD of NRSA (being implemented by the AP Government for combating drought by evolving action plans by integrating satellite derived thematic information on watersheds with socio-economic data)
- GOI is supporting research in ICAR institutes like CAZRI, CRIDA, IARI and IGFRI to provide solutions to drought-related problems.
- A National Data Bank is being set up under the All India Co-ordinated Project on Agro-meteorology at the Crop Research Institute for Dry Land Agriculture (CRIDA), Hyderabad.

13.3. Present status

DAC is the focal point in the GOI to provide monitoring and forecasting services to states and financial assistance for drought relief operations. It is the responsibility of the state government concerned to address the problem of drought at district, tehsil and village levels. Drought Disaster Recovery Plans are yet to be prepared at the Central and State levels with an in-built mechanism for effective coordination at national, state, district, tehsil and village levels. There is a need to strengthen the national climatological, hydrological and agricultural capabilities (in respect of ground-based and remote sensing data interpretation) to ensure establishment of more effective EWS and to suggest measures for strengthening drought preparedness and management. Several refinements are taking place in this direction.

A new method for early drought detection using three spectral channel combination of visible, near infrared and 10.3-11.3 µm infrared, tested in principal agricultural countries enable drought detection 4-6 weeks earlier than before.

14. Audit/ Assessment/ Impact

14.1. Assessment Indicators

- The gaps between forecasting/ prediction of drought-its intensity, duration and impact; and actual occurrence
- The speed with which relief measures are administered, the quantum of relief and the genuineness of beneficiaries receiving such relief are the indicators to assess the effectiveness of drought mitigation.
- Monitoring and evaluation of projects/programs aimed at drought proofing are a part of the overall assessment.

14.2. Impact

- All the monsoon rainfall forecasts by IMD during the last 15 years or so have proved to be fairly accurate. But the climate model needs improvement for application to smaller areas like districts and villages, particularly in drought prone areas.
- The severe drought that struck India in 2002 has taught the need for more refinements in EWS, contingency planning and speedier administration of relief measures. There is a need to strengthen the national climatological, hydrological and agricultural capabilities (in respect of ground-based and remote sensing data interpretation) to ensure establishment of more effective EWS and to suggest measures for strengthening drought preparedness and management. Several refinements are taking place in this direction.
- State governments have started setting up Drought Monitoring Centres to monitor drought at the state level
- While the drought relief approach with a monitoring system enabled the government to intervene only in the months of November-December after the Kharif harvest, the drought management approach with a forecasting system enabled the government to intervene in July-August (within the monsoon season). This early warning system offered a lead-time of five months before the appearance of distress indicators in December-January.
- Implementation of watershed development projects under the Desert Development Program has increased the overall productivity of land and that of the water table, with a positive impact on overall economic development within the project areas. Green vegetation cover has also improved in the desert areas.
- The Drought Prone Area Program has led to evolving time guidelines for watershed development, providing uniform strategy in the development of all drought prone areas covering around 627 blocks in 96 districts of 13 States.

15. Action following Mid-course Evaluation

All stages the drought management system provide for corrective action based on studies, measurements, observations, analysis, surveys, and interaction during visits and meetings.

16. Feedback

The feedback obtained through conferences/workshops/questionnaire studies reveals that the use of modern techniques in agrometeorological analysis has increased the credibility of forecasts among the user community.
NCMRWF obtains feedback about the worthiness of its forecasts and advisories from farmers and agricultural universities.

17. Policy Support & Systemic Changes Implemented

There is no national policy on drought. However GOI intentions are towards sustainable agricultural development using modern technology and traditional knowledge and practices ensuring better risk management. The employment generation programs, the watershed development programs, the desert development program, the drought prone area program are some of the initiatives of the GOI towards fulfilling such intentions.

18. Infrastructure System Support

Central Government	Department of Agriculture & Cooperation ❑ Central Relief Commissioner's Office, NCMC, CWWG, NCFC ❑ ICAR, CAZRI, IGFRI, CSSRI , CRIDA, IARI Department of Science & Technology ❑ IMD & its Units, NCMRWF Department of Space ❑ NRSI, NADAMS CWC, CGWB
State Government	Chief Secretary Revenue Department State Relief Commissioner's Office Drought Monitoring Centre District, Tehsil & Gram Panchayat Offices Department of Agriculture Agricultural Universities

19. HR & Capacity Building

Different ministries have their own programs for capacity building in drought management. Training institutes in states offer training programs.

Under the National Disaster Management Program, training programs are conducted to enhance awareness and capacity to face natural disasters.

Drought Risk Management Program, a new initiative by the Ministry of Agriculture, is under formulation in collaboration with UNDP India. This program aims at reducing the vulnerabilities of communities to drought through:

- Community-based approaches
- Appropriate risk management
- Better decision support systems at state and district levels

The program will focus on most drought-prone 42 districts in 5 states (Rajasthan, Chhatisgarh, Orissa, Gujarat and AP).

The objectives of the program are:

- Strengthen GIS-based decision support systems.
- Prepare community-based and women-led drought preparedness and mitigation plans.
- Establish improved early warning systems through better forecasting and communication.
- Strengthen capacity through training and awareness.
- Develop better systems for providing farmers with efficient advice for drought prevention and response.
- Develop manuals and guideline for drought mitigation at all levels.
- Benchmark risk and vulnerability to assess impact of vulnerability reduction programs.

The Regional Centre for Space Applications Program (RESAP) conducts training workshops on agricultural drought management.

20. Change Management Strategy

The strategy is shifting from relief-oriented approach to drought management approach.

21. Information & Communication Model

- IMD-DRU provides nationwide, monthly Crop Yield Forecasts for the major crops of Kharif (rice) and Rabi (wheat). The first interim forecast for kharif rice is issued in August and the final forecast is given in November/December. For wheat, the first interim forecast is issued in January and the final in March/April/May.

- NCMRWF weather forecast bulletin is disseminated biweekly to AAS units every

- Tuesday and Friday over a telephone, telegram, or VSAT who in turn prepare and disseminate weather advisories twice a week to farmers through mass media.

- The data obtained from six observatories of CRIDA are used for drought assessment, and disseminated to the public and other agencies through the media.

- NADAMS provides early warning on the crop condition and general agricultural drought giving districtwise status through bulletins issued from August to October for AP, Bihar, Gujarat, Haryana, Karnataka, MP, Maharashtra, Orissa, Rajasthan, Tamil Nadu, and UP.

- Meteorological information (delay in onset of monsoon, dry spell during sowing and critical stages of crop growth),

- Hydrological information(water level in reservoirs/lakes/ponds/tanks, stream flow, groundwater level, soil moisture deficit) and

- Agricultural information (delay in sowing, sown area, crop vigor, change in cropping pattern, agricultural inputs-supply & demand) to national, state, district and field agencies are communicated on a daily/weekly/fortnightly/ monthly/seasonal basis through wireless/telephone/fax/e-mail/written reports/ NICNET.

IMD Farmers Weather Bulletins

- Provide a district-wise forecast of weather during the next 48 hours, with an outlook for the following 2 days, taking into account the effects of weather on crops grown in their respective regions.
- Daily for broadcast in different regional languages through the stations of All India Radio in their evening programs for farmers. A second bulletin is issued for broadcast in the morning during the rainy season. Also published in newspapers.

IMD Agrometeorological Advisories

- Information on past and expected weather
- Specific advice to farmers on what agricultural operations they may undertake in the context of these weather conditions.
- Useful to farmers for scheduling of irrigation to save water, and choosing the optimum timing for spraying of pesticides, application of fertilizers, etc.
- Prepared *twice a week* in consultation with experts of the State Agricultural Departments. Broadcast by AIR stations and also telecast by Doordarshan.
- The Service is functioning at 17 IMD Centres: Ahmedabad, Bangalore, Bhopal, Bhubaneshwar, Calcutta, Chandigarh, Chennai, Gangtok, Guwahati, Hyderabad, Jaipur, Lucknow, New Delhi, Patna, Pune, Srinagar, and Thiruvananthapuram .

IMD Agricultural Meteorology Division, Pune

- Prepares crop weather calendars depicting the state and stage of the crop under normal weather conditions and the weather elements detrimental to the crops in various growth stages. The crop weather calendars are periodically revised as new crop varieties are introduced and cropping patterns undergo changes.
- Helps agricultural planning in drought-prone and dry land farming areas of the country. An Agrodimatic Atlas of India has been prepared. Aridity anomaly maps are compiled for the country on a fortnightly basis.
- IMD also estimates the crop yields of principal crops with the help of regression models, which parameterize the effects of various weather parameters during the different growth stages of the crops.

NCMRWF Rabi Crop Advisories (Weekly)

A. District-specific Current Weather Observations (Temperature, Rainfall)
B. Weather Systems
C. Rainfall
D. Temperature
E. Crop-specific and State-specific Farm (including livestock) Advisories

22. Leadership Champion Attributes

The leadership of the DAC, collaborative and cooperative contributions of IMD, DST, DOS, NRSI, CWC and ICAR have played a very significant part in monitoring, forecasting and minimizing the effects of drought in India.

23. Standard Operation Procedures/ Standards

Each state has its own norms/procedures/manuals for drought management covering loss estimation and relief norms.

24. Performance Progress Monitoring

The concerned Departments/Agencies at Central Government & State Government Levels monitor the meteorological, hydrological and agricultural parameters regularly during normal, drought and post-drought periods and more frequently during the SW monsoon period.

25. Resource Mobilization

25.1. Calamity Relief Fund (CRF)

Financing drought relief expenditure is done in accordance with the awards of the Finance Commission appointed every five years. Under the award, two Funds have been set up - constituting the Calamity Relief Fund (CRF) and National Calamity Contingency Fund (NCCF).

The CRF has been in operation for each State with an amount prescribed by the Commission and is maintained outside the government account, receiving contributions from Central and State Government in the ratio of 3:1. CRF is released to the affected states in two half yearly installments-in May and in October.

25.2. National Calamity Contingency Fund (NCCF)

A 'National Calamity Contingency Fund has been constituted by the GOI for dealing with natural calamities (cyclone, drought, earthquake, fire, flood and hailstorm) of severe nature requiring expenditure by the State Government in excess of the balances available in its own Calamity Relief Fund. The initial corpus of NCCF is Rs.500 crore.

The National Centre for Calamity Management (NCCM) which will monitor the occurrences of these natural calamities on a regular basis and assess their impact on area and population must approve the quantum of relief assistance under the Scheme.

The assistance from NCCF will be only for immediate relief and rehabilitation.

25.3. Other Sources of Funding

Funds are also available from many on-going Plan Schemes of the Central and State Governments.
Voluntary help from external agencies (International Red Cross, Donors) are accepted for drought relief programs.

26. Finance & Budget

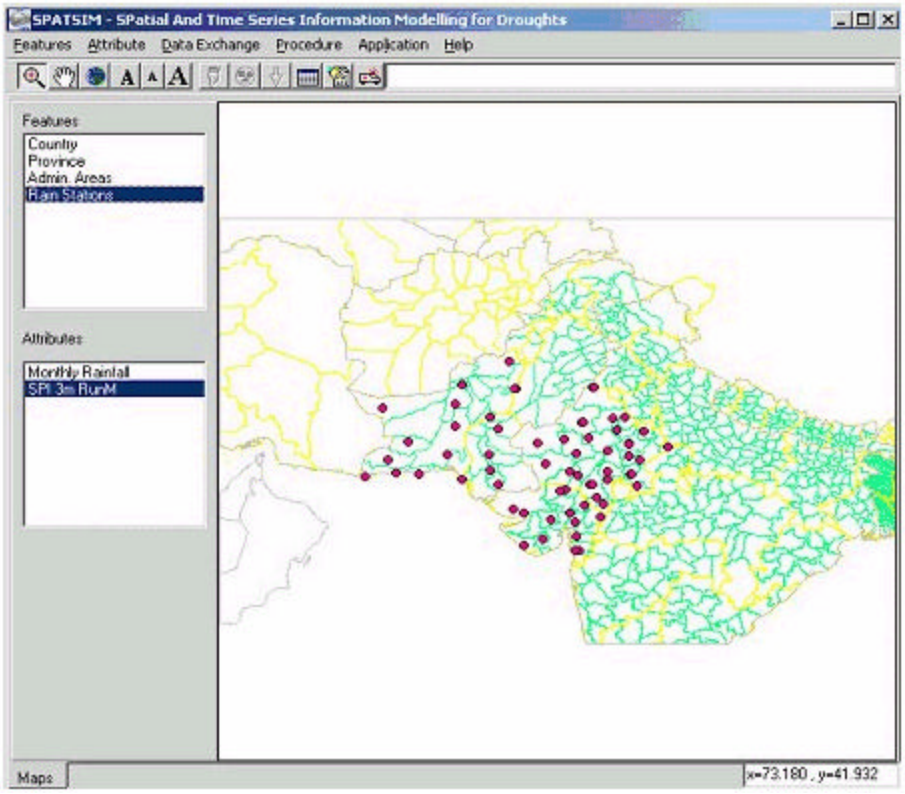
- Statewise allocation in CRF based on the recommendations of the Finance Commissions
- National Calamity Contingency Fund (NCCF)

27. Artifacts

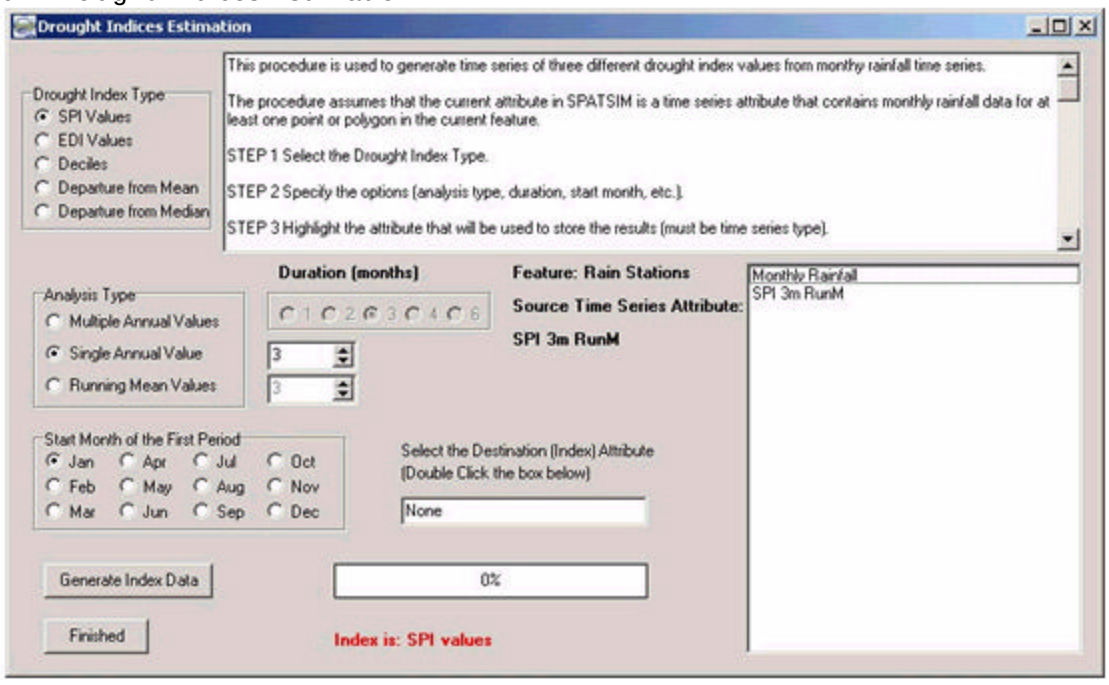
1. The Centre for Science and Environment, New Delhi
   - Rainwater Harvesting – Books and Video Films
   - Videofilms on Drought and Water Management
2. Power Point Slides
   - Disaster Preparedness: Mitigation and Response – New Technologies and Systems,
     PVK Reddy, Director, NISA, Hyderabad
   - Comprehensive Forecasting and Warning Systems for Effective Disaster Preparedness and Response, S.K.Subramanian, Director, Regional Met Centre, Chennai
   - Swami S.K. Director, Natural Disaster Management Division, Ministry of Agriculture, Government of India
3. Bibliography on Drought Indices
   http://www.agric.gov.ab.ca/agdisaster/palmer.html
4. Review of Literature on Drought Science & Indices
   http://www.agric.gov.ab.ca/agdisaster/droughtindex.html

5. Software

a. Spatial and Time Series Information Modeling for Droughts



b. Drought Indices Estimation



Annex 1

List of information discussed and provided by the CWWG

1. Rainfall (For the Week and Cumulative in 36 Meteorological Sub Divisions)– Excess, Normal, Deficient and No Rain
2. Maximum and Minimum Temperatures during the week
3. Weather Forecast for the next 48 hours
4. Rainfall & Temperature Forecast for the week (NCMRWF model prediction)
5. Status of 73 major reservoirs

Period	Current Year's Storage* as a % of FRL	Current Year's storage as % of last year	Current year as a % of 10 years average level
This Week Last Week			
* Live storage as % to Full Reservoir Level (FRL) of 131.70 Billion Cubic Metres (BCM)			

6. Crop Condition

Crop	Normal Area	Area Coverage			Summary of area differences in important states
		This year	Last year	Difference	

7. Crop Performance Report – Affected/ Damaged Crops, Extent, Reasons
8. Price Situation of Essential Commodities at Delhi – Current, Last Week, Last Fortnight, Last Month, Last Year, %Variation of prices of essential commodities
9. Incidence of pests and availability of pesticides
10. Fertilizer availability
11. Procurement of food grains in states

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(Ratna Chaudhuri)

Dy. Director

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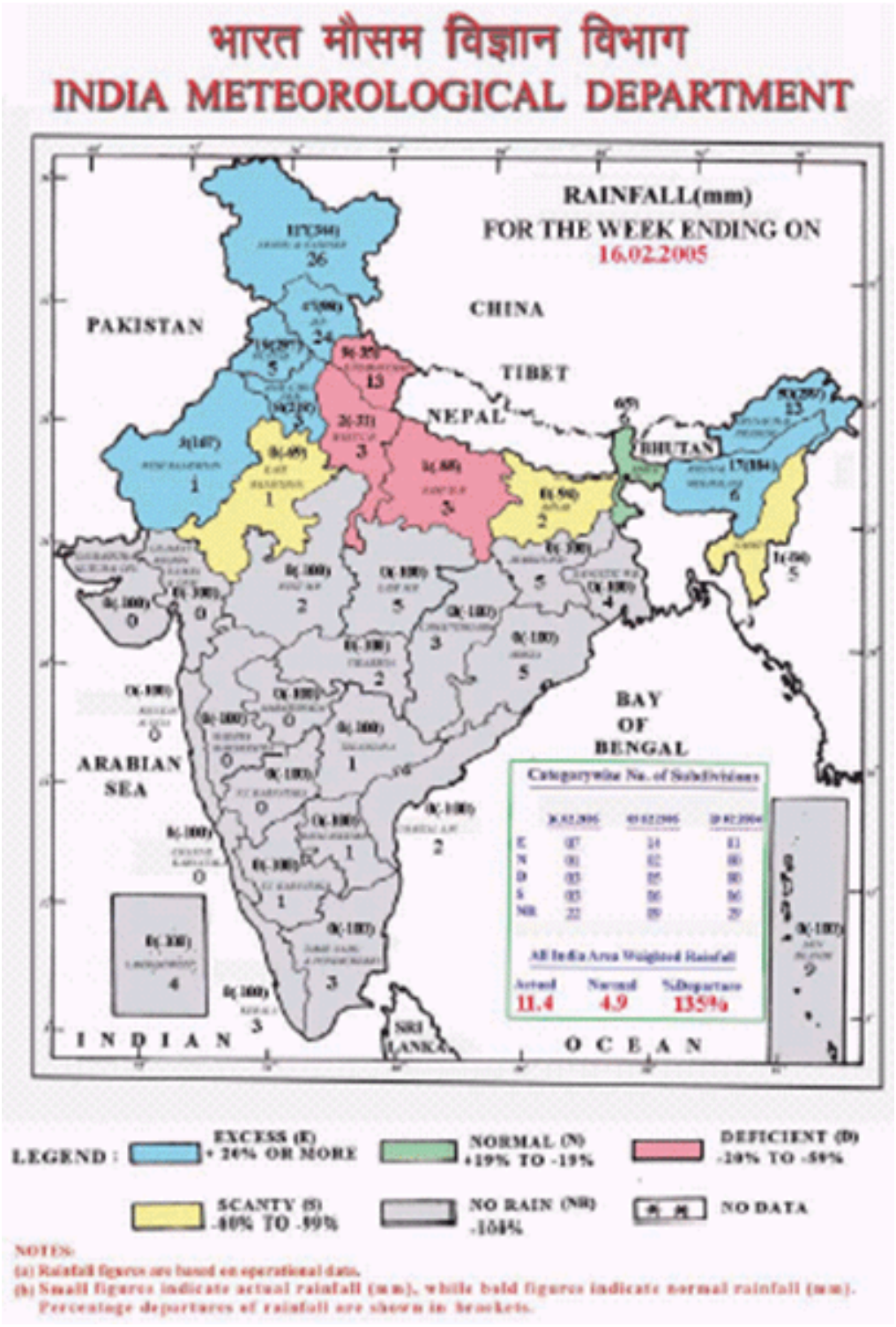
Annex 2

Rainfall distribution for week ending 16.2.2005



Annex 3

Sample NCMRWF Forecast