"A profound change in Drought Assessment Techniques during last decade in India"

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ABSTRACT *Drought is a recurrent calamity due to large dependence of India on monsoon rains and increasing impact of climate change. There has however been greater resilience among the farmer community due to increased investment in irrigation works, availability of quality inputs and focus on research. The schemes such as Pradhan Mantri Krishi Senchai Yojna, Pradhan Mantri Fasal BimaYojna and Soil Health Cards are surely like a boon to help farmers to face the vagaries of nature. In drought management, monitoring and assessment of drought conditions at different time periods and early warning dissemination of prevailing drought conditions are very much crucial. This provoked the need of evolution of mechanism which is economically viable, practically feasible for implementation, helpful in decision making for the management this slow creeping hydro-meteorological disaster.*

Keywords: *Drought assessment, Manual, Normalized Difference Vegetation Index, Rainfall Deficiency, Moisture Adequacy Index*

1. Introduction

Drought, named as "creeping disaster" by United Nations in its publications, has its own characteristics. These characteristics differentiate drought from other hydro-meteorological disasters such as floods, cyclone etc. Drought usually considered as slow onset disaster with wide area coverage, complex nature and unpredictable time span. It has economic, environmental as well as social impacts.

Drought has been categorized into three types viz., Meteorological Drought, Hydrological Drought and Agricultural Drought by National Commission on Agriculture (1976). In the past, India has experienced many large scale droughts in the years 1873, 1877, 1899, 1901, 1904, 1905, 1911, 1918, 1920, 1941, 1951, 1965, 1966, 1968, 1972, 1974, 1979, 1982, 1985, 1986, 1987, 2002, 2009, 2015 and 2015.

2. Evolution of scientific Drought Assessment Techniques

The situation of agricultural drought arises when due to inadequacy of rainfall and soil moisture during the crop sowing and growing season, crop growth get hampered resultantly crop stress and wilting occurred.

A relief based system was practicing in India, since independence for drought management which was not concerned with involving the techniques of mitigation and early warning for drought. Famine codes were prepared for dealing with drought conditions. After independence, different State Governments has prepared their Drought Management or Drought Contingency Plans addresses measures for any exigencies arise from drought conditions. But, they also did not include any scientific parameters for drought assessment.

2.1 National Drought Assessment and Monitoring System (NADAMS)

In 1986, Government of India, created a National Drought Assessment and Monitoring System (NADAMS) later made operational in 1990 by involving National Remote Sensing Agency, Department of Space, Government of India, India Meteorological Department (IMD) and various state agriculture departments. In its initial phase, NADAMS using only one satellite based index i.e. Normalized Difference Vegetation Index (NDVI) and rainfall data from IMD for drought assessment. However, with time, NADAMS project has made many changes for improving their assessment techniques. Multiple indices are being used for drought assessment by NADAMS. Frequency, interpretation and quality of information pertaining to drought assessment has been improved many folds. NADAMS is now providing drought assessment reports upto sub Tehsil level of thirteen agriculturally important and drought vulnerable states of the nation.

2.2 Manual for Drought Management (MDM) 2009, 2016 and further amendments in 2018

As a first defining step towards framing a common document which is applicable for Central and State Governments was taken in 2009 by developing First Manual for Drought Management by National Institute of Disaster Management with support of Department of Agriculture, Farmers Welfare and Cooperation, Ministry of Agriculture, Government of India through a consultative process involving all the stakeholders upto grass root level working for management of drought. It includes planning for all the phases of drought management from early warning and forecast, mitigation upto relief measures. The Manual for Drought

Management, 2009 used various parameters which could be appalled in combination for drought assessment and declaration. The parameters were:-

- Rainfall Deficiency;
- Area under Sowing;
- Normalized Difference Vegetation Index (NDVI) and Moisture Adequacy Index (MAI); and
- Other factors such as fodder and drinking water availability; demand for employment; supply of food grains; agricultural and non-agricultural wages.

2.2.1 Values of each parameter for determination of drought as per Manual for Drought Management, 2009

I. Rainfall: Rainfall is the most important indicator of drought assessed by calculating departure in rainfall from its long term averages and drought conditions exist:-
   a) If the total rainfall received is less than 50% of the average rainfall during the months of June and July and vegetation index and soil moisture index depicts adverse impact on vegetation and soil moisture.
   b) If the total rainfall is less than 75% of the average rainfall for the rainy season i.e. from June to September and vegetation index and soil moisture index shows adverse impact on vegetation and soil moisture.

II. Area under Sowing: As per MDM, 2009, if the total sowing area of Kharif crops by the end of July/ August or as the schedule of sowing of individual states, is less than 50% of the total cultivable area then drought condition exist.

III. NDVI and MAI: Drought conditions are prevailing when the deviation in NDVI value from the normal is 0.4 or less. Moisture adequacy index is another indicator which is based on a calculation of weekly water balance, is equal to the ratio of actual Evapo-transpiration to the potential Evapo-transpiration following a soil-water balancing approach during a cropping season. MAI values less than 25% shows severe drought conditions. In the MDM, 2009, MAI values gave more emphasis for ascertaining agricultural drought. However, these values of NDVI and MAI were assessed in conjunction with other parameters for drought assessment.

However, this manual has its own limitations and therefore states Government did not used this manual very rigorously for the declaration and assessment of drought. Thereafter, in the backdrop of 2015-16 drought, in case "Writ Petition (Civil) no 857 of 2015- Swaraj Abhiyan vs Union of India & others", the Supreme Court of India directed the Central Government, to revise the manual for drought management by giving due weightage to the four indicators of drought with fixed determinants.

In 2016, Ministry of Agriculture and Farmers Welfare, Government of India revised their Manual for Drought Management (MDM) in December, 2016, in which technical data synergized with field data for assessment of drought. This manual provided a more scientific ways for drought assessment.

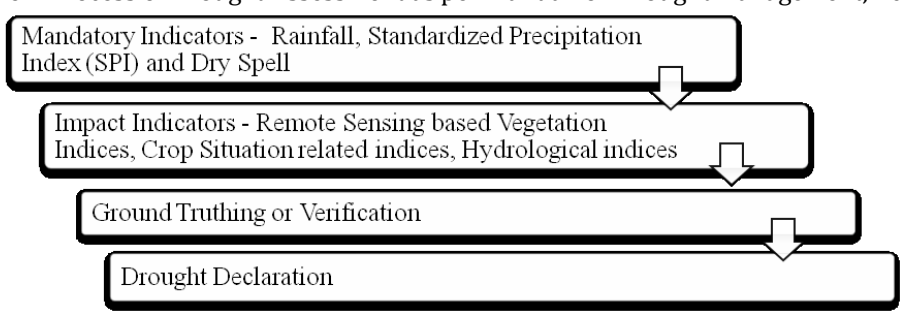
2.2.2 Values of each parameter for determination of drought as per Manual for Drought Management, 2016

Manual for Drought Management, 2016 has provided two parameters namely Mandatory indicators and Impact Indicators for determination of drought conditions which are as follows:-

- Mandatory Indicators - rainfall, Standardized Precipitation Index (SPI) and Dry Spell
- Impact Indicators - Remote Sensing based Vegetation Indices, Crop Situation related indices, Hydrological indices

MDM, 2016 bounded Center Government to constitute Crop Weather Watch Group (CWWG) and to setup Drought Monitoring Centres (DMCs) at State Level to collate information from different sources to monitor drought conditions, coordinate with stakeholders and to issue necessary advisories to mitigate the effect of drought. MDM also provides that any three of the four types of the Impact Indicators (one from each) shall be used for assessment of drought, the intensity of the calamity and make a judgment.

Figure 1 Process of Drought Assessment as per Manual for Drought Management, 2016



I. Rainfall related Indices:

a) if the total rainfall received during the months of June and July is deficient by 50% or more as compared to the normal rainfall accompanied or otherwise with dry spell having an adverse impact on area under sowing, vegetation and soil moisture,
b) if the total rainfall received during the months of October and November is deficient by 50% or more as compared to the normal rainfall accompanied or otherwise with dry spell, posing adverse impact on area under sowing, vegetation and soil moisture, or
c) If the total rainfall during the entire duration of the rainy season of the State, from June to September and/or from December to March, is deficient as measured by either rainfall deviation (less than 75% of the average rainfall for the season) or SPI value less than -1.0 with or without dry spells, and these is an adverse impact on area under sowing, vegetative health and soil moisture, as expressed through the vegetation soil moisture indices.

Dry Spell, a situation in which rainfall is 50% less than normal rainfall in each of the weeks and lasts for consecutive three to four weeks. Standardized Precipitation Index (SPI) which shows the actual rainfall as a standardized departure with respect to rainfall probability distribution function is also considered for drought assessment.

II. Remote Sensing based Vegetation Indices:

a) Normalized Difference Vegetation Index (NDVI) and Normalized Difference Wetness Index (NDWI) – NDVI/NDWI deviation of -20 to -30% represents moderate drought conditions and that of ‹-30% represents severe drought conditions.
b) Vegetation Condition Index (VCI) – VCI value 0-40% shows poor vegetation condition in the area.

III. Crop Situation related Indices

a. Area under sowing- Due to failure of rains or very late arrival of monsoon, if the total sown area under Kharif crops was less than 33.3% of the total normal sown area by the end of July/August or as per the schedule for sowing and in case of Rabi crops, coverage of sowing of less than 50% of the total normal sown area during October-November shows drought conditions.
b. Soil Moisture based indices - Moisture Adequacy Index (MAI) and Percent Available Soil Moisture (PASM)- 0-25% PASM and MAI denotes severe drought, 26-50% PASM and MAI denotes moderate drought and 51-75% PASM and MAI denotes mild drought conditions.

IV. Hydrological Indices-

a. Reservoir Storage Index (RSI) - 60 % deficit in live storage volume of minor/ medium reservoir w.r.t. average storage of last 10 years denotes extreme deficit and may lead to hydrological drought.
b. Groundwater Drought Index (GWDI) - Extreme groundwater deficit class denotes to ‹-0.60 Groundwater Drought Index value.
c. Stream Flow Drought Index (SFDI)-0.2 to 0.5 value of Stream Flow Drought Index (SFDI) is showing severe drought.

V. Other factors-

Some other factors also considered such as extent of fodder availability and its prevailing prices compared to normal prices; scarcity of drinking water; supply demand for employment on public works; current agricultural and non-agricultural wages compared with normal times; supply of food grains etc.

VI. Ground Truthing or Verification-

After assessment of Mandatory Indicators and Impact Indicators, MDM, 2016, direct the State Government to conduct Ground Truthing or Verification. The same will be conducted in each of the 10% of the drought affected villages, selected on a random basis. In each of the selected villages, representative locations (about 5 sites for each of the major crops), may be inspected for data collection.

2.2.3Latest amendments in Manual for Drought Management, 2016

On the Manual for Drought Management, 2016, several state governments represented to Ministry of Agriculture and Farmers Welfare that certain provisions of the Drought Manual are difficult to implement for declaration of drought. Hence, Ministry has made some changes in the values of parameters mentioned in the Manual.

2.2.3 Major changes made in the values of parameters for drought assessment

I. Crop Situation related Indices

a) Area under Sowing-

Drought conditions said to be exist if the total sown area under Kharif crops was less than 85% of the total normal sown area by the end of July/August or as per the schedule for sowing and in case of Rabi crops, coverage of sowing of less than 85% of the total normal sown area during October-November shows

drought conditions. However, the conditions will indicate portents for drought of a severe nature, if the area under crop falls to 75% of the normal time.

b) Soil Moisture based indices - Moisture Adequacy Index (MAI) and Percent Available Soil Moisture (PASM)- 0-50% PASM and MAI denotes severe drought, 51-75% PASM and MAI denotes moderate drought and 76-100% PASM and MAI denotes no drought conditions.

3. Conclusion

As per the latest amendments in the Manual for Drought Management the severity of the drought will be contingent upon the values of at least three out of four impact indicators viz, Agriculture, Remote Sensing, Soil Moisture and Hydrology. The severe drought conditions will exist if at least two of the selected three impact indicators are in 'Severe' category and one is in moderate category. The Manual provides a very good scientific base for evaluation of doughty conditions in any area. Periodic data availability is the utmost important factor for successful evaluation of the parameters provided by manual.

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