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Drought analysis of Haryana for Kharif season of 2017 (as per parameters of "Manual for Drought Management, 2016)

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Abstract
State of Haryana received its rainfall majorly from South West Monsoon. But State does not majorly dependent on rainfall for agriculture. State has a self-sufficient irrigation system through canals, tube wells and wells. State Government have committed considerable resources in strengthening resilience to droughts through the creation of irrigation potential, promotion of conservation and efficient harvesting of water. However, drought is acknowledged as a phenomenon characterized by a high degree of complexity and, therefore, the challenges related to prevention, mitigation and management of this calamity require scientific appreciation of the symptoms, careful planning, concerted action and coordination on the part of the Central and State Governments.

Keywords: drought, mitigation, monsson, resilience

Introduction
Drought has been described as a "creeping disaster" by United Nations. Thus, emphasizing that a situation of drought develops gradually which offers little time and opportunity for immediate planning and preparedness. It is a slow onset disaster with duration from months to years, can be on large special extent giving sufficient warning of its coverage, extent and intensity unlike a flood, cyclones or earthquake.
National Commission on Agriculture (1976) categorized drought into three types, viz., Meteorological Drought, Hydrological Drought and Agricultural Drought. As per the definition adopted by the India Meteorological Department (IMD) for meteorological drought is a situation when the deficiency of rainfall at a meteorological sub-division level is 25% or more of the long-term average (LTA) of that sub-division for a given period. Hydrological drought is a prolonged meteorological drought situation due to which depletion of surface water from reservoirs, lakes, streams, rivers and fall in groundwater levels occurred which will further cause severe shortage of water for livestock and human needs. Agricultural drought is a situation when rainfall and soil moisture are inadequate to support healthy crop growth till maturity during the crop growing season which lead to crop stress and wilting.

Initiatives for Systematic assessment of drought
A systematic assessment of drought was started after the Manual of Disaster Management, 2009 prepared by Ministry of Agriculture, Government of India. Thereafter, in the backdrop of 2015-16 drought, the Supreme Court of India directed the Central Government, in case "Writ Petition (Civil) no 857 of 2015- Swaraj Abhiyan vs Union of India & others" to revise the manual for drought management by giving due weightage to the four indicators of drought with fixed determinants. The Supreme Court of India has also observed that a delayed declaration of drought adversely affects the people, especially women and children and needlessly postpones the required assistance.
Accordingly, the Government of India, Ministry of Agriculture and Farmers Welfare has revised their Manual for Drought Management (MDM) in December 2016, according to which lots of technical data along with field data is required to collect and analyse for monitoring and declaring of drought. These data include Rainfall, Hydrological, Remote Sensing, crop situation related and other factors.

Result and discussion
Parameters for drought assessment as per "Manual for Drought Management, 2016"
Parameters and their influenced drought conditions for drought assessment as per "Manual for Drought Management, 2016 are depicted in the table below:

Table 1: Parameters for drought assessment as per "Manual for Drought Management, 2016"

Monitoring indices	Drought conditions
Rainfall related Indices 1. Rainfall 2. Dry Spell 3. Standardized Precipitation Index(SPI)	1 a. The State Government could consider declaring a drought 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, and if there is an adverse impact on area under sowing, vegetation and soil moisture, or 1b. The State Government could consider declaring a drought 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, and if there is an adverse impact on area under sowing, vegetation and soil moisture, or 2. 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.
Monitoring indices	**Drought conditions**
Remote Sensing based Vegetation Indices 1. Normalized DifferenceVegetation Index(NDVI) 2. Vegetation Condition Index (VCI)	NDVI/NDWI deviation of -20-30% represents moderate drought conditions and that of ‹-30% represents severe conditions. VCI value 0-40 % represent vegetation conditions in the area.
Crop Situation related Indices 1. Area under sowing 2. Soil Moisture based indices 2a.Moisture Adequacy Index(MAI) and Percent or 2b. Available Soil Moisture(PASM)	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 depending upon the schedule for sowing in individual states due to failure of rains or very late arrival of monsoon. In case of Rabi Crops, coverage of sowing of less than 50% of the total normal sown area during October-November 0-25% PASM and MAI denotes severe drought 26-50% PASM and MAI denotes Moderate drought 51-75% PASM and MAI denotes Mild drought
Hydrological Indices 1. Reservoir Storage Index (RSI) or 2. Groundwater Drought Index (GWDI) or 3. Stream Flow Drought Index (SFDI)	›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. Extreme groundwater deficit class denotes to ‹-0.60 Groundwater Drought Index value. 0.2 to 0.5 value of Stream Flow Drought Index (SFDI) is showing Severe drought Severity Class.

Source: Manual for Drought Management, 2016

Procedure for determination of Agricultural Drought Assessment

Following steps are suggested for the determination of drought in the MDM, 2016.

Trigger 1 is on "if the total rainfall for the entire duration of the rainy season of the State from June to September (the South-West Monsoon), 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 there is an adverse impact on area under sowing, vegetative health and soil moisture, as expressed through the vegetation soil moisture indices". In the event that the first drought trigger is on, Impact Indicators will be examined.

Table 2

Impact Indicators- Trigger 2			
Agriculture	Remote Sensing	Soil Moisture	Hydrology
Crop Area Sown	VCI or NDWI Deviations	PASM/MAI	SFI/RSI/Sgwi

The State may consider any three of the four types of impact indicator (one from each) for assessment of drought, the intensity of the calamity and make a judgment in the flowing manner:

- Severe Drought: if all the selected 3 impact indicators are in severe category
- Moderate drought: if two of the selected 3 impact indicators are in 'Moderate' or 'Severe' Class.
- Normal: for all other cases.

Trigger 2 will be on in the event of a finding of severe or moderate drought. The State has an option to reduce the drought category by one rank (i.e. Severe to moderate) if the irrigation percentage of the administrative region (District/Taluk/Block/Mandal) for which drought is being declared is more than 75%. However, in such a situation of reduction of drought intensity from Moderate to Normal, the State Government will still be required to conduct field verification.

Drought Analysis of Haryana for Kharif season of 2017 as per parameters of "Manual for Drought Management, 2016

State of Haryana received its rainfall majorly from South West Monsoon. But State does not majorly dependent on rainfall for agriculture. State has a self-sufficient irrigation system through canals, tubewells and wells. State Government have committed considerable resources in strengthening resilience to droughts through the creation of irrigation potential, promotion of conservation and efficient harvesting of water.

Analysis of mandatory Indicators viz. rainfall, Standardized Precipitation Index (SPI) and Dry Spell:

It got analyzed that eleven districts namely Ambala, Bhiwani, Fatehabad, Gurugram, Kurukshetra, Palwal, Panchkula, Panipat, Rohtak, Sirsa and Sonepat have rainfall less than 75% of the average rainfall for the season. Simultaneously, 20 districts are recorded with dry spells except Kaithal and Yamunanagar. Hence, trigger 1 is on in all the districts in the State except Kaithal and Yamunanagar. 3.2 Analysis of Impact Indicators i.e. Remote Sensing based Vegetation Indices, Crop Situation related indices, Hydrological indices.

Table 3: Analysis of Mandatory Indicators for Drought Assessment during Kharif, 2017

Name of district	Rainfall			Actual dry/wet conditions based on SPI values	Dry spell	Trigger 1 on
	Actual	Normal	Dep			
Ambala	553.9	916.6	-40	Moderately dry	Yes	Yes
Bhiwani	227	348.5	-35	Mildly dry	Yes	Yes
Faridabad	577.8	600.2	-4	Mildly wet	Yes	Yes
Fatehabad	137.8	283	-51	Moderately dry	Yes	Yes
Gurugram	243	472.3	-49	Severely dry	Yes	Yes
Hisar	247.9	325.1	-24	Mildly dry	Yes	Yes
Jhajjar	385.7	417.3	-8	Mildly wet	Yes	Yes
Jind	327.9	415.6	-21	Mildly dry	Yes	Yes
Kaithal	375.5	384	-2	Mildly dry	No	No
Karnal	557.3	577	-3	Mildly wet	Yes	Yes
Kurukshetra	410.7	563	-27	Mildly dry	Yes	Yes
Mahendragarh	310.3	395.4	-22	Mildly dry	Yes	Yes
Mewat	404.2	501.8	-19	Mildly dry	Yes	Yes
Palwal	284.9	446.9	-36	Severely dry	Yes	Yes
Panchkula	405.3	950.4	-57	Severely dry	Yes	Yes
Panipat	311.7	521.7	-40	Mildly dry	Yes	Yes
Rewari	364.5	435.8	-16	Mildly dry	Yes	Yes
Rohtak	255.1	508	-50	Moderately dry	Yes	Yes
Sirsa	172.2	242.1	-29	Mildly dry	Yes	Yes
Sonepat	380.2	534.3	-29	Mildly dry	Yes	Yes
Yamuna nagar	821.1	892.1	-8	Mildly dry	No	No

***Source*:** IMD and Mahanbolis National Crop Forecast Centre, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi

Analysis of Impact Indicators viz. Remote Sensing based Vegetation Indices, Crop Situation related indices, Hydrological indices

Considering the fact that Trigger 1 is on in all the districts in the State except Kaithal and Yamunanagar, analysis of Impact Indicators i.e. Remote Sensing based Vegetation Indices, Crop Situation related indices, Hydrological indices have been made which is showing in the table.

As per the data received from Irrigation and Water Resources Department, Haryana, for Reservoir Storage Index (RSI), State has only one reservoir i.e. Kaushakya Dam at Pinjore in District Panchkula and was started from 2012. It is used for drinking water supply purposes. It has 15.88% deficit this year in storage volume as compared to last five years average value. As per MDM, 2016, this situation removes the possibility of hydrological drought. The limitation of this indicator is that only one reservoir cannot represent the whole State. After analysing VCI, MAI and Crop area sown, it is revealed that since two of the selected 3 impact indicators are in 'Moderate' Class. Districts namely Mahendergarh and Rewari have Moderate drought conditions. But as per Manual for Drought Management, 2016 "The State has an option to reduce the drought category by one rank (i.e. Severe to moderate) if the irrigation percentage of the administrative region (District/Taluk/Block/Mandal) for which drought is being declared is more than 75%", these districts namely Mahendergarh and Rewari can be declared normal since these have 79% and 100% irrigation coverage in total cultivable area respectively.

Table 3: Analysis of Impact Indicators for Drought Assessment for the period of Kharif, 2017

District Name	**Vegetation Condition Index(VCI)**	**Moisture Adequacy Index (MAI)**	**Crop Area Sown Kharif 2017**	
			% as compared to last 4 years average	**Assessment**
Ambala	Mild	Mild	97.98	Normal
Bhiwani	Normal	Mild	107.68	Normal
Faridabad	Normal	Mild	129.55	Normal
Fatehabad	Normal	Mild	93.44	Normal
Gurugram	Mild	Mild	107.22	Normal
Hisar	Normal	Mild	102.19	Normal
Jhajjar	Mild	Mild	107.77	Normal
Jind	Normal	Mild	105.23	Normal
Karnal	Normal	Mild	103.15	Normal
Kurukshetra	Normal	Mild	94.95	Normal
Mahendergarh	Moderate	Moderate	95.10	Normal
Mewat	Mild	Mild	109.03	Normal
Palwal	Normal	Mild	90.59	Normal

Panchkula	Mild	Mild	117.59	Normal
Panipat	Normal	Mild	98.92	Normal
Rewari	Moderate	Moderate	102.03	Normal
Rohtak	Normal	Mild	113.28	Normal
Sirsa	Mild	Moderate	98.57	Normal
Sonipat	Normal	Mild	104.98	Normal

***Source*:** VCI and MAI- Mahanbolis National Crop Forecast Centre, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi and Haryana Space Application Centre, Hisar; Crop Area Sown- Department of Agriculture and Farmers welfare Department, Haryana.

***Source*:** Department of Agriculture and Farmers welfare Department, Haryana, 2017

Some other factors and conclusion

Apart from above, some other socio-economic indicators were also assessed. No shortage of food grains was reported by Department of Food and Supplies, Haryana from any part of the State. There was sufficient drinking water supply in the State. A normal 100 days employment is being provided to one family in the State under MGNREGA. In drought conditions employment days got increased by 150 days, which was not the condition during Kharif 2017 in the State.

From the above analysis, as per the MDM indicators for drought declaration, drought like situation were not existed in Haryana during Kharif, 2017. Districts namely Mahendergarh and Rewari have Moderate drought conditions. But as per Manual for Drought Management, 2016 "The State has an option to reduce the drought category by one rank (i.e. Severe to moderate) if the irrigation percentage of the administrative region (District/Taluk/Block/Mandal) for which drought is being declared is more than 75%", these districts namely Mahendergarh and Rewari can be declared normal since these have 79% and 100% irrigation coverage in total cultivable area respectively.

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