



Standardized Precipitation Index (SPI) forecast and its relevance

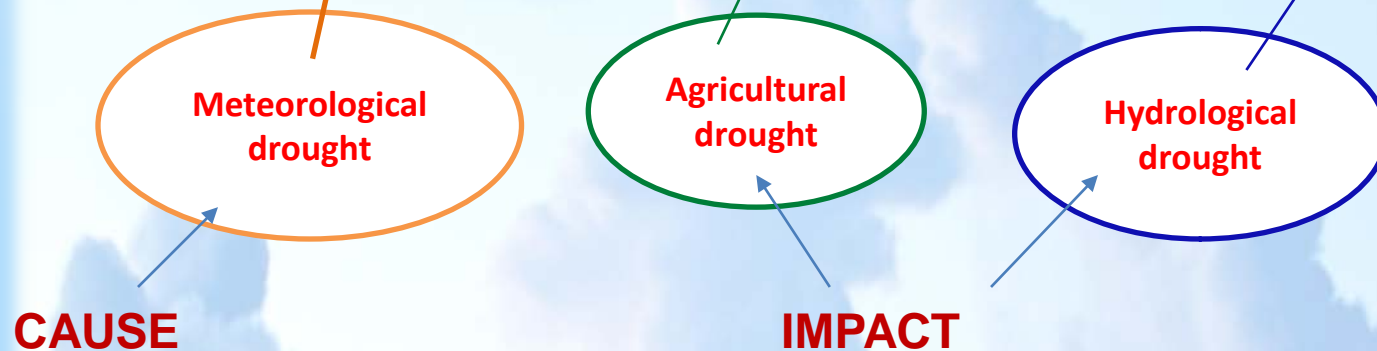
P. Guhathakurta

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INDIA METEOROLOGICAL DEPARTMENT**

SPI and Drought Monitoring

What is Drought?

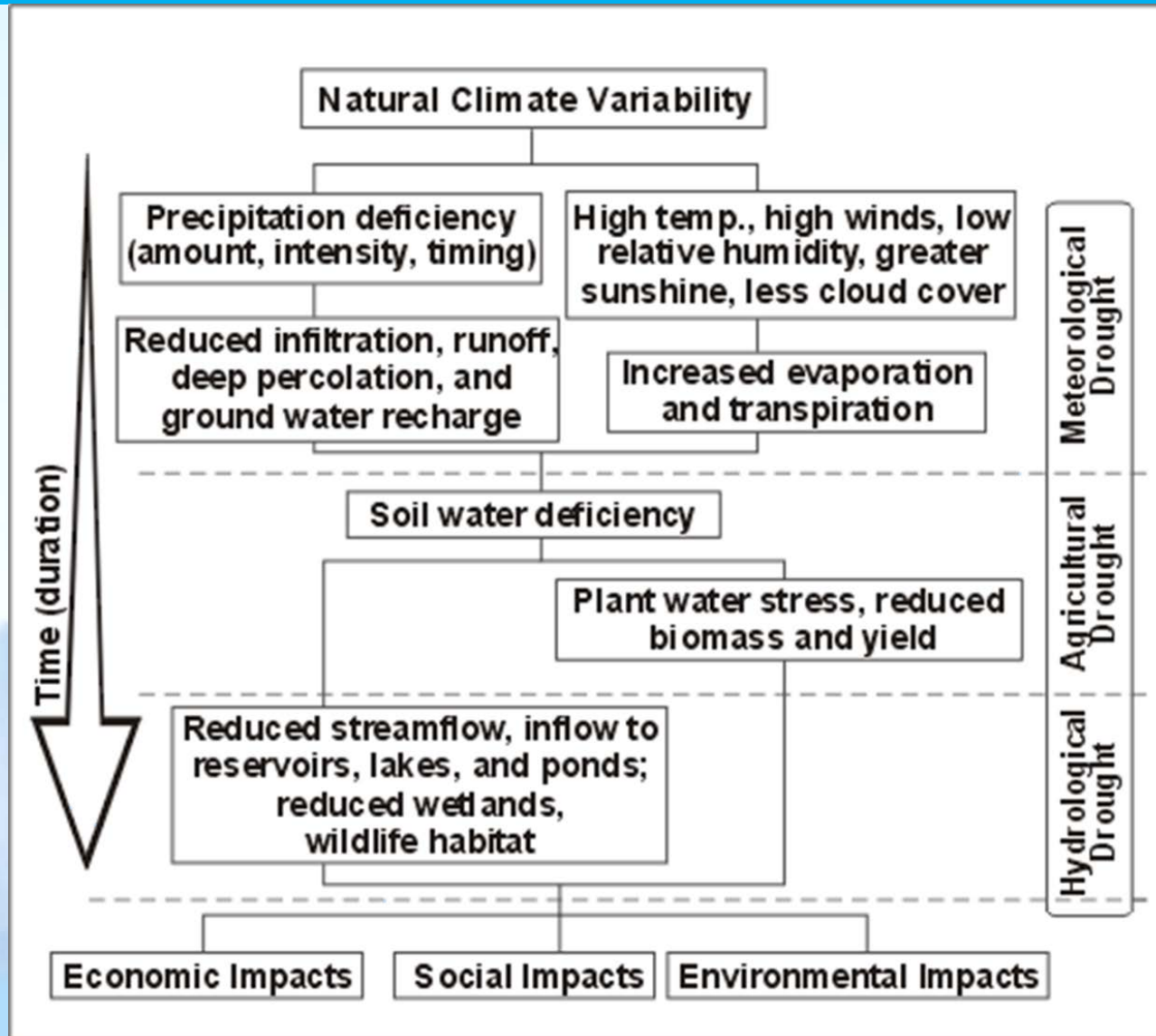
Drought is a deficiency in precipitation over an extended period, usually a month or season or more, resulting in extensive damage to crops, loss of yield, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people.



It is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry.



Type of Drought and time response



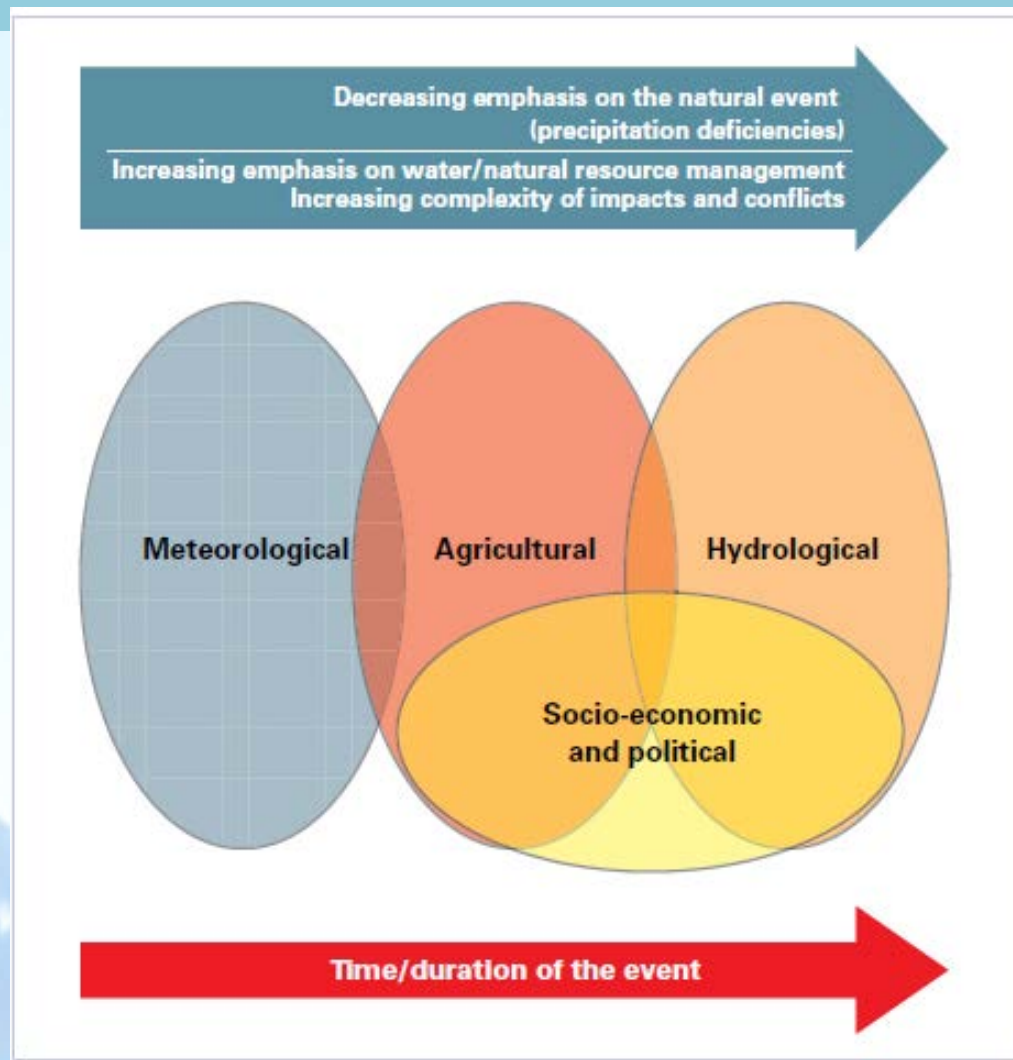
1 to 2-months

1 to 4 months

4 to 12 months or more



Interrelationships between meteorological, agricultural, hydrological and socio-economic drought. Source: National Drought Mitigation Center, University of Nebraska–Lincoln, USA)



Standardized Precipitation Index (SPI) in Drought Monitoring

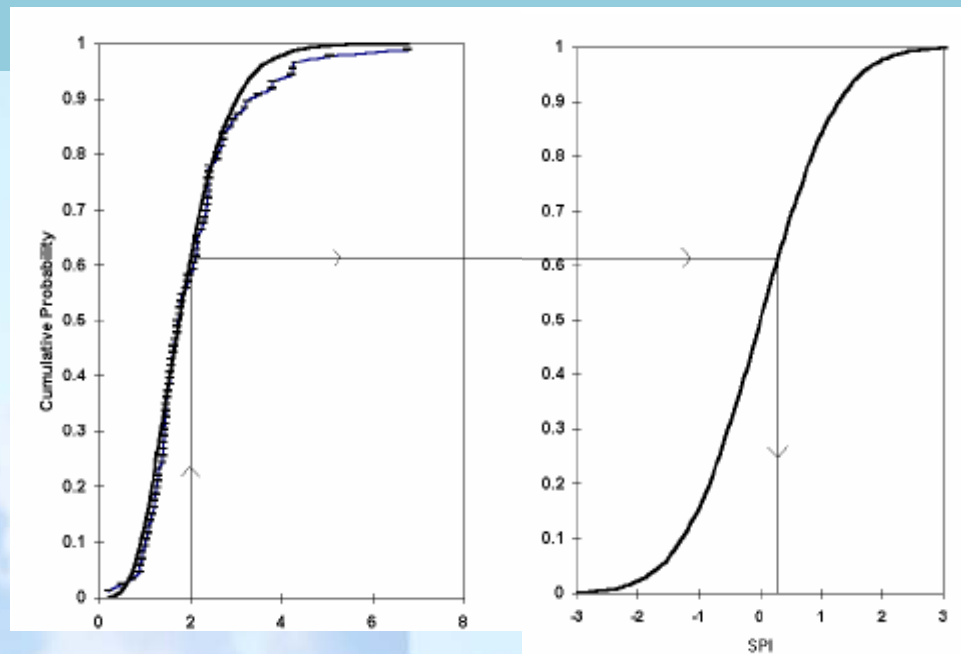
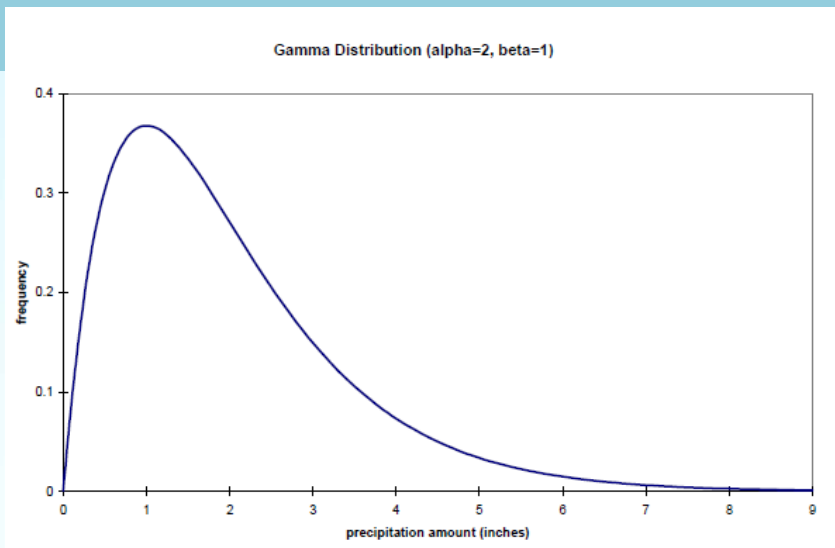
- ❖ The Standardized Precipitation Index (SPI) is a tool which was developed primarily for defining and monitoring drought (McKee et al 1993). It allows an analyst to determine the rarity of a drought at a given time scale (temporal resolution) of interest for any region with historic data. It can also be used to determine periods of anomalously wet events.
- ❖ In 2009, the participants at the Inter-Regional Workshop on Indices and Early Warning Systems for Drought held at the University of Nebraska-Lincoln issued “The Lincoln Declaration on Drought Indices” ([Hayes et al., 2011](#)). There were fifty-four experts from all regions agreed on the use of a universal meteorological drought index for more effective drought monitoring and climate risk and gave recommendation to WMO
- ❖ The World Meteorological Organization (WMO) recommends, that all national meteorological and hydrological services should use the SPI for monitoring of dry spells ([Press report December 2009, WMO No. 872](#)).
- ❖ The World Meteorological Organization (WMO) releases “Standardized Precipitation Index User Guide”, WMO-No. 1090 in 2012 giving details and some key points: about using SPI. It is desirable one should go through this before applying SPI.



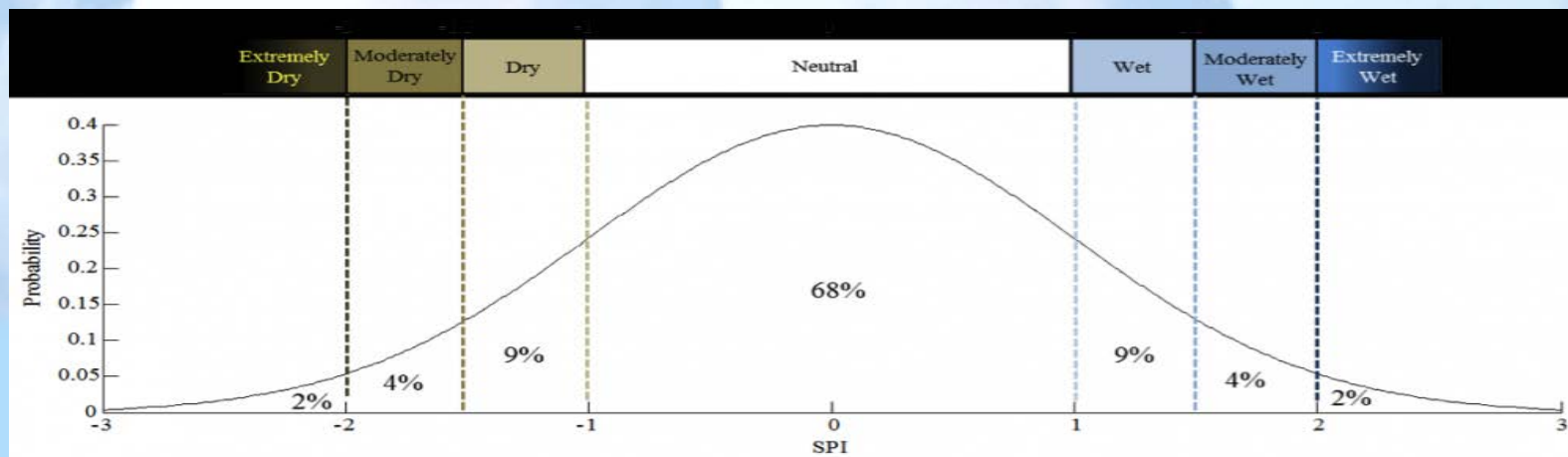
Interpretation:

- ❖ For each time step, precipitation of the preceding t months is accumulated, where t is referred to as the time scale. The time series is first fitted with a model distribution to the data (for precipitation series, the Gamma distribution is typically used) Subsequently it is transformed to values of the standard normal distribution for each calendar month separately.
- ❖ **The resulting time series has no seasonality and takes values of the standard normal distribution, where negative values indicate below average water availability. Positive values indicate greater than median rainfall; negative values indicate less than median rainfall.**
- ❖ The interpretation of SPI is strictly probabilistic. As SPI has units of the standard normal distribution, its values can be directly related to probability of occurrence. **The standardization implies also that SPI is independent of the mean conditions, it does not differ in magnitude between different regions and is thus suitable to analyse the synchronicity of drought events. This enables an easy and direct comparison between locations with different climate.** The possibility to compute SPI for different time scales (t) allows for an adaptation of the index to slowly or fast evolving environmental or societal systems.
- ❖ SPI is straight forward to interpret as negative (positive) values are directly related to a shortage (surplus) of water availability at a given location relative to the normal conditions. As SPI is a probabilistic index it has a straight forward relation to occurrence frequencies. For example, extreme droughts ($SPI \leq -2$), are expected to occur with a chance of 2.3%.





Example of equiprobability transformation from fitted gamma distribution to the standard normal distribution.



- **Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI.**
- **A drought event occurs any time when the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues.**

Category number	Categories	SPI range
8	Extremely wet	2.00 or more
7	Severely wet	1.50 to 1.99
6	Moderately wet	1.00 to 1.49
5	Mildly wet	0 to 0.99
4	Mildly dry	0 to -0.99
3	Moderately dry	-1.00 to -1.49
2	Severely dry	-1.50 to -1.99
1	Extremely dry	-2.00 or less



India Meteorological Department monitors meteorological drought in India using two well defined indices viz.

- 1. Aridity Anomaly Index (AAI)**
- 2. Standardized Precipitation Index (SPI)**

Both the indices can also identifies agricultural drought while the second one can also be considered for monitoring hydrological drought if period consider is 6 –12 months.

- IMD has started monitoring drought situations in district scale using SPI since January, 2013 in monthly scale as a part of climate monitoring.**
- To meet the demand from Agricultural Division of IMD for its National level Weekly agricultural Advisory, we have started producing SPI district map in every week based on cumulative recent 4 weeks since June 2013.**
- Standardized Precipitation Index (SPI) for the cumulative four weeks period is being generated operationally in every week (Thursday/Friday) to identify the districts experiencing moisture stress situation for preparation of appropriate agromet advisories.**
- We have also started generating Standardized Precipitation Index weekly forecast since the 1st week of Southwest monsoon 2014 using IMD GFS/MME weekly district rainfall forecast as input.**



Drought situation during the SW monsoon season 2014 and 2015 : Monthly District SPI maps

SPI maps

JUNE

JULY

AUGUST

SEPTEMBER

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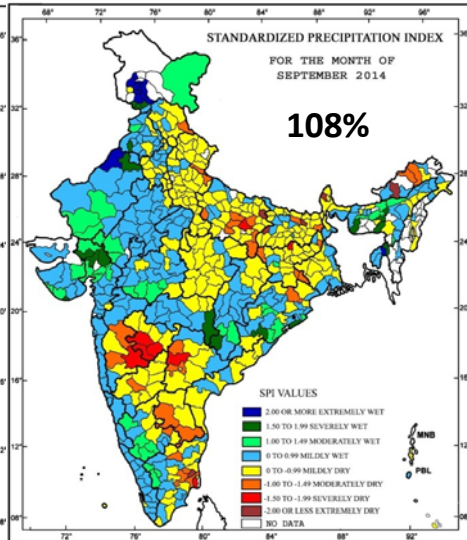
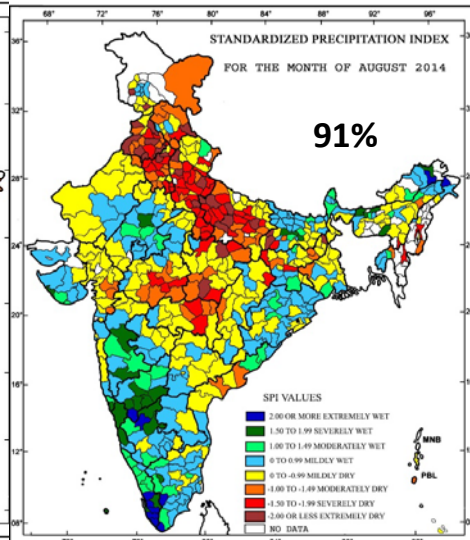
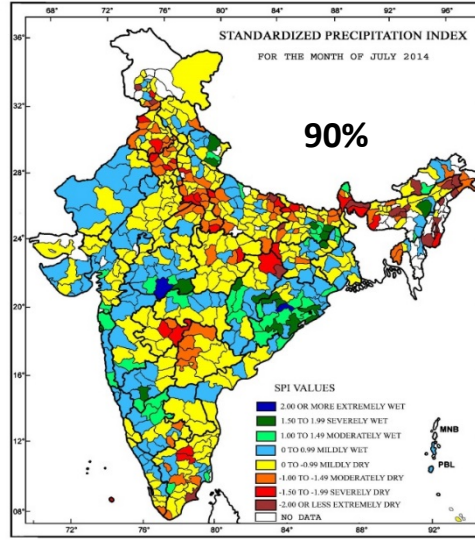
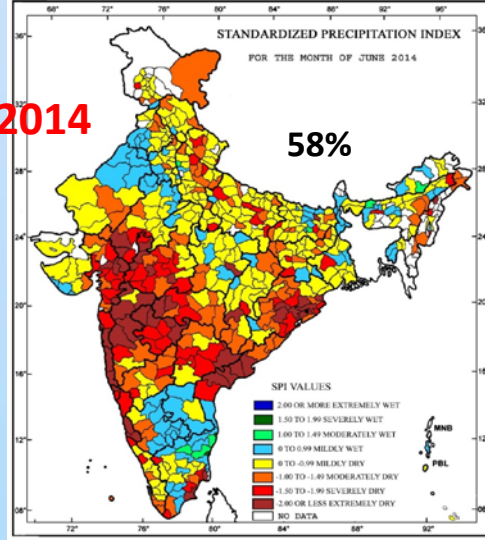
2014

58%

90%

91%

108%



2015

116%

AIND RF 84%

78%

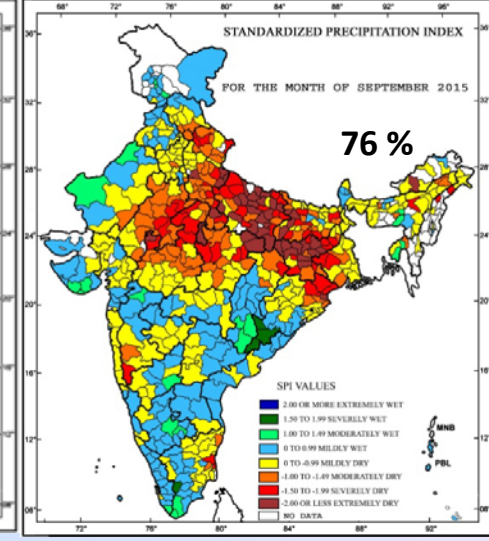
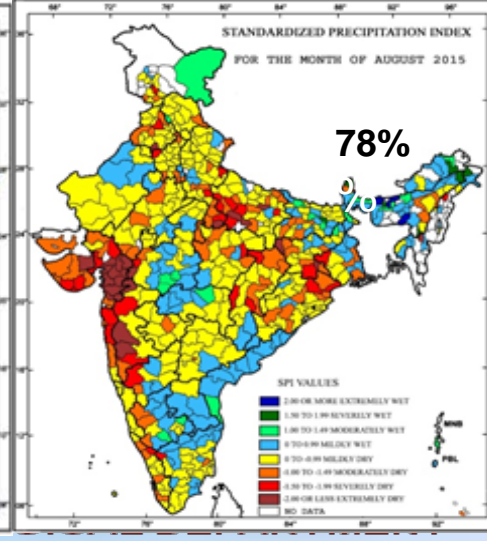
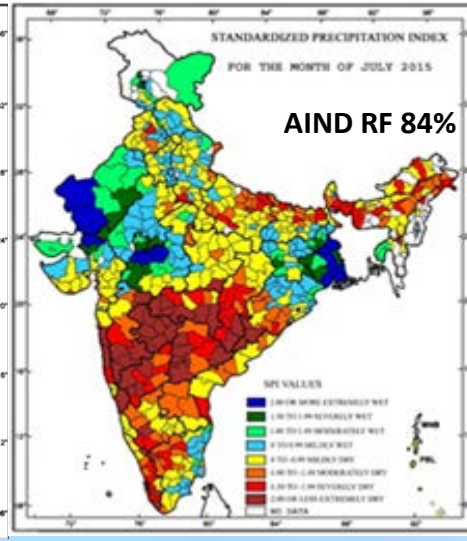
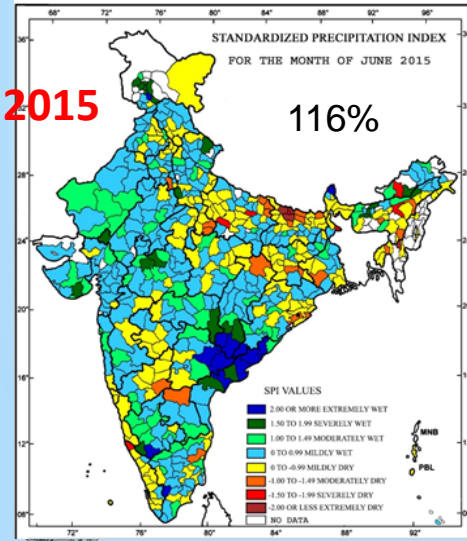
76%

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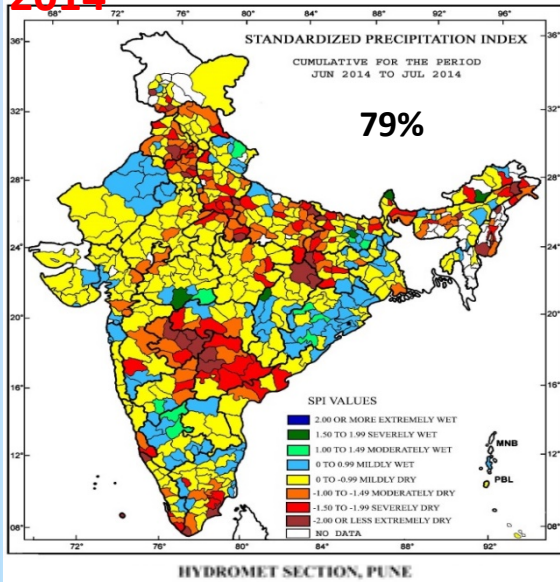


District SPI for the cumulative months during the SW monsoon season 2014 and 2015

2 MONTHS JUNE-JULY

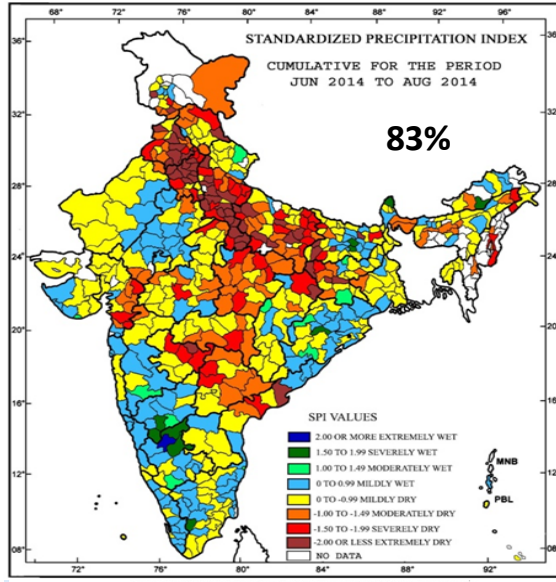
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2014



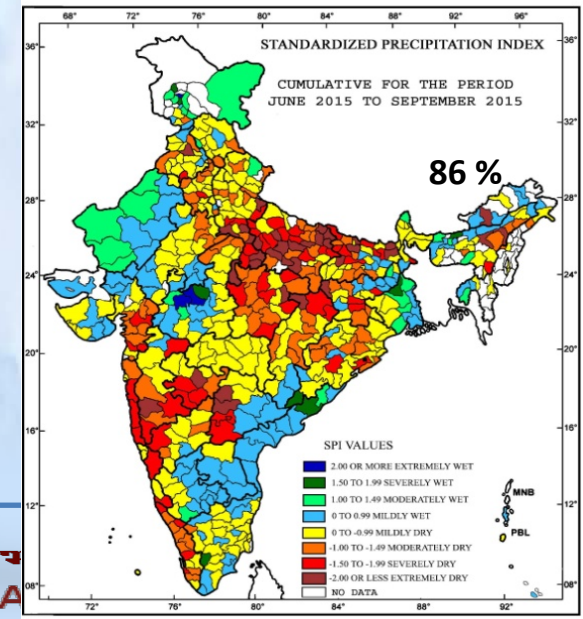
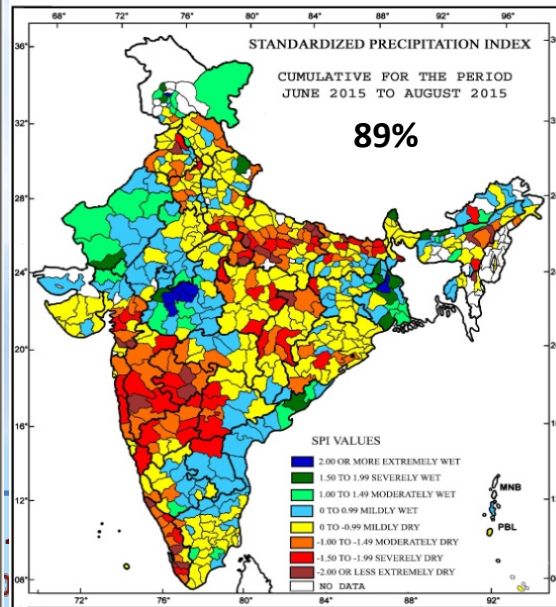
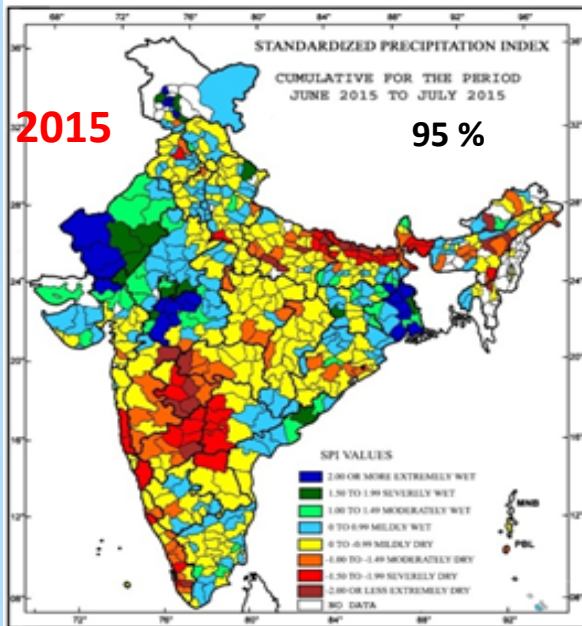
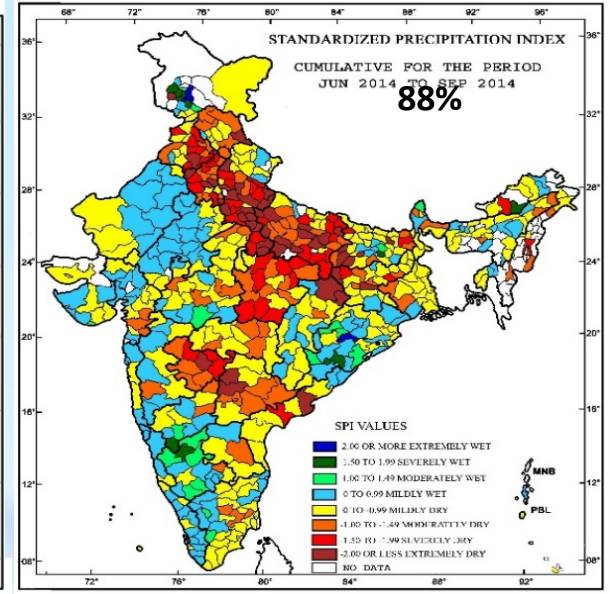
3 MONTHS JUNE TO AUGUST

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4 MONTHS JUNE TO SEPTEMBER

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JUNE

No. of Districts and percentage of area of the country under different categories in 2015

Categories(SPI range)	Percentage Area	No. of Districts
Extremely wet(2.00 or more)	3.40%	13
Severely wet(1.50 to 1.99)	3.96%	24
Moderately wet(1.00 to 1.49)	15.84%	72
Mildly wet(0 to 0.99)	46.77%	250
Mildly dry(0 to -0.99)	25.48%	192
Moderately dry(-1.00 to -1.49)	3.53%	23
Severely dry(-1.50 to -1.99)	0.63%	7
Extremely dry(-2.00 or less)	0.35%	4

CUMMULATIVE 2 MONTHS JUNE-JULY

Categories(SPI range)	July		June-July	
	Percentage Area	No. of Districts	Percentage Area	No. of Districts
Extremely wet(2.00 or more)	5.07%	18	5.33%	22
Severely wet(1.50 to 1.99)	3.6%	19	3.78%	14
Moderately wet(1.00 to 1.49)	8.19%	37	8.89%	39
Mildly wet(0 to 0.99)	14.18%	107	21.56%	149
Mildly dry(0 to -0.99)	33.66%	227	40.87%	246
Moderately dry(-1.00 to -1.49)	13.86%	81	10.17%	61
Severely dry(-1.50 to -1.99)	9.34%	52	6.5%	35
Extremely dry(-2.00 or less)	12.09%	45	2.91%	19



AUGUST

	August		June-August	
Categories(SPI range)	Percentage Area	No. of Districts	Percentage Area	No. of Districts
Extremely wet(2.00 or more)	0.38%	4	0.93%	6
Severely wet(1.50 to 1.99)	0.66%	7	2.33%	14
Moderately wet(1.00 to 1.49)	2.81%	22	8.32%	34
Mildly wet(0 to 0.99)	23%	122	24.58%	130
Mildly dry(0 to -0.99)	48.24%	281	36.21%	245
Moderately dry(-1.00 to -1.49)	14.97%	90	14.54%	82
Severely dry(-1.50 to -1.99)	6.2%	35	10.54%	52
Extremely dry(-2.00 or less)	3.74%	25	2.55%	22

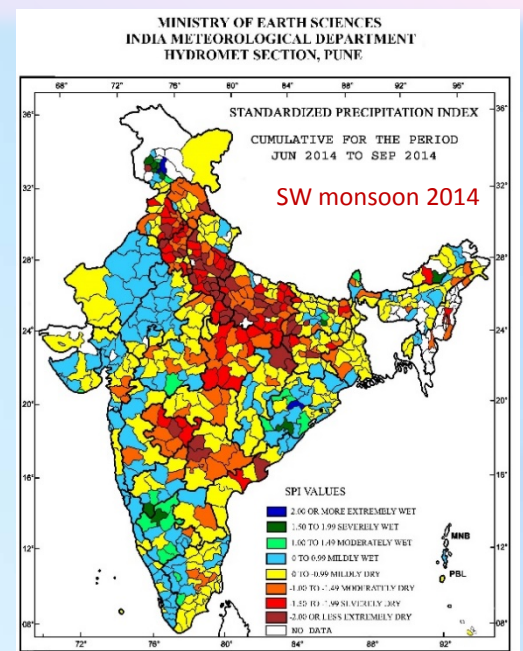
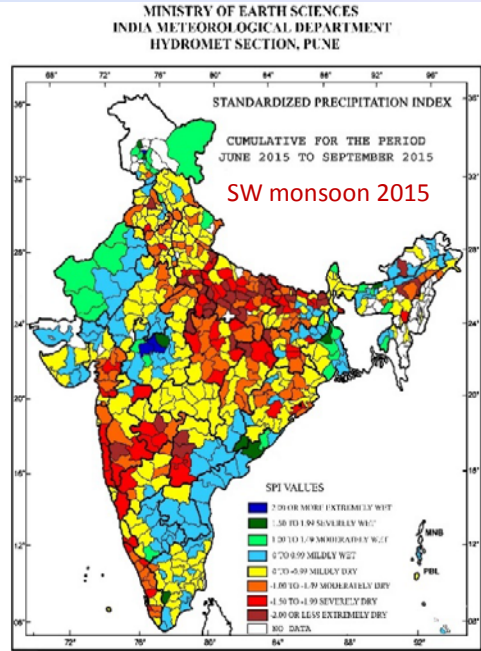
No. of Districts and percentage of area of the country under different categories in 2015

SEPTEMBER

	September		June- September	
Categories(SPI range)	Percentage Area	No. of Districts	Percentage Area	No. of Districts
Extremely wet(2.00 or more)	0 %	0	0.45%	3
Severely wet(1.50 to 1.99)	0.75%	4	1.22%	8
Moderately wet(1.00 to 1.49)	4.69%	22	6.60%	27
Mildly wet(0 to 0.99)	30.54%	142	24.19%	114
Mildly dry(0 to -0.99)	35.76%	225	37.12%	234
Moderately dry(-1.00 to -1.49)	13.72%	88	14.62%	99
Severely dry(-1.50 to -1.99)	8.7%	59	11.02%	63
Extremely dry(-2.00 or less)	5.84%	44	4.77%	35



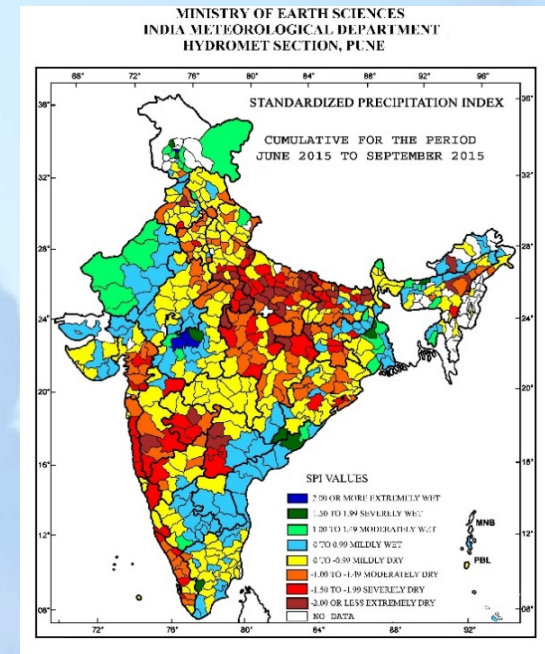
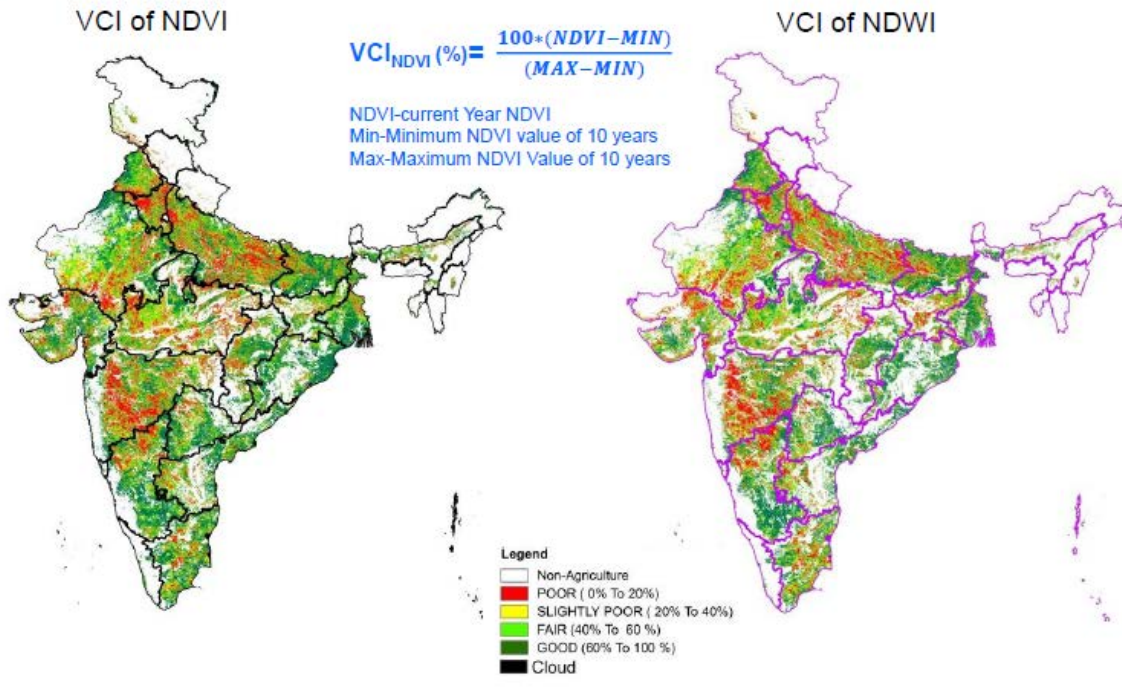
Comparative Statistics for the Southwest monsoon 2014 & 15



Categories(SPI range)	June- September 2015		June- September 2014	
	Percentage Area	No. of Districts	Percentage Area	No. of Districts
Extremely wet(2.00 or more)	0.45%	3	0.27%	3
Severely wet(1.50 to 1.99)	1.22%	8	1.27%	11
Moderately wet (1.00 to 1.49)	6.60%	27	2.84%	18
Mildly wet(0 to 0.99)	24.19%	114	26.61%	137
Mildly dry(0 to -0.99)	37.12%	234	40.89%	228
Moderately dry(-1.00 to -1.49)	14.62%	99	14.02%	88
Severely dry(-1.50 to -1.99)	11.02%	63	7.78%	54
Extremely dry(-2.00 or less)	4.77%	35	6.31%	48

Total 30.4% area of the country was under dry condition during SW monsoon 2015 compare to 28.11% that of 2014.





National Agricultural Drought Assessment and Monitoring (NADAM) Reports of Mahalanobis National Crop Forecast Centre, Department of Agriculture & Cooperation (NCFC) are also using SPI products of IMD for comparison of drought assessment.

Districts experienced two years consecutive drought during 2014 and 2015

There were 190 and 197 districts were under drought conditions (all categories i.e. moderate, severe and extremely severe together) during the year 2014 and 2015. List of the districts which have experienced drought conditions in consecutive two years i.e. 2014 and 2015 is presented in next slide.

Total 105 number of districts which contribute 15 % of country area were affected by consecutive two years of drought situations



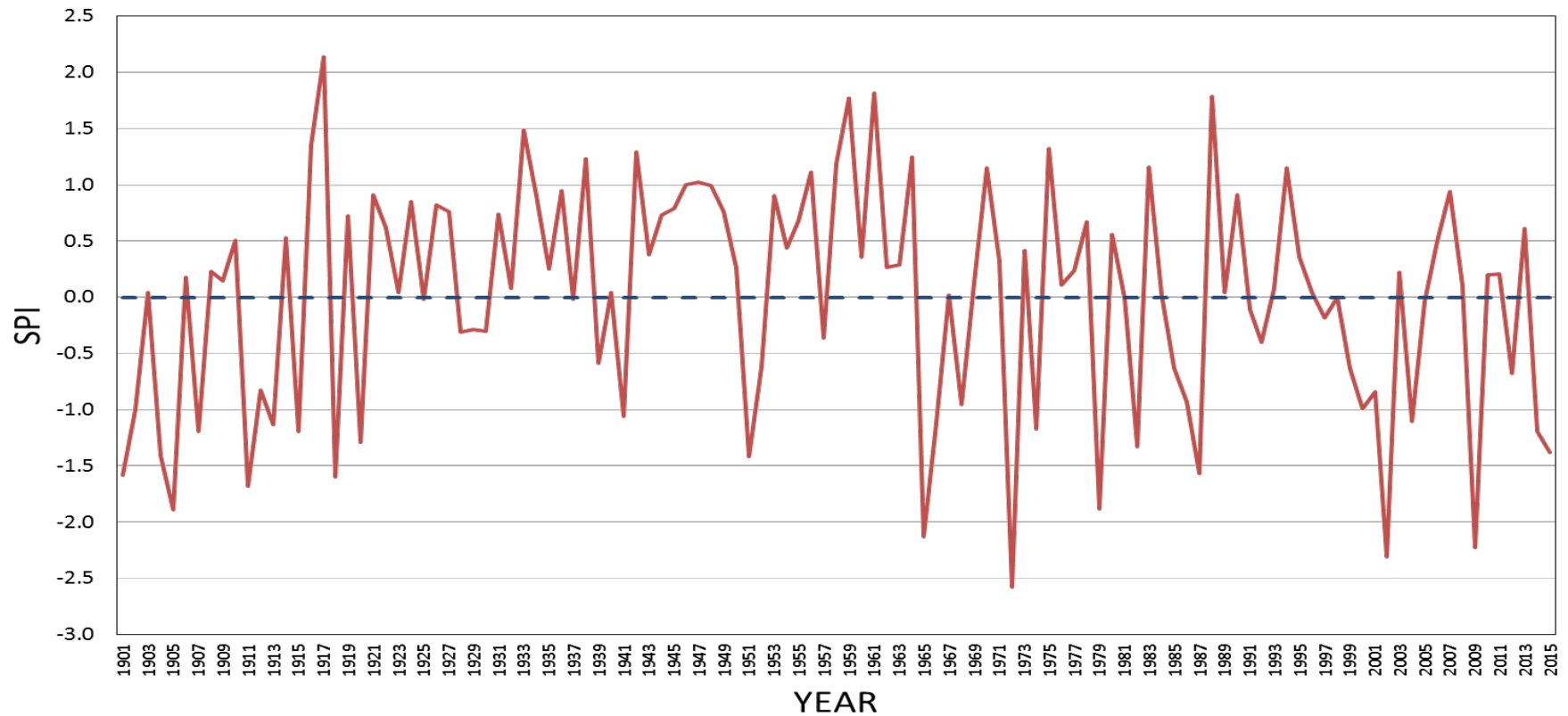
State	No. of districts	District	State	No. of districts	District	State	No. of districts	District
Telangana	4	HYDERABAD	Uttar Pradesh	44	AGRA	Maharashtra	6	BEED
		MEDAK			ALLAHABAD			NANDED
		NIZAMABAD			AMBEDKAR NAGAR			OSMANABAD
		RANGAREDDY			AURAIYA			PARBHANI
EAST KAMENG	AZAMGARH	SATARA						
TIRAP	BALLIA	LATUR						
Assam	1	SIBSAGAR			BARABANKI	Meghalaya	1	RI-BHOI
		ARARIA			CHANDAULI	Punjab	4	FEROZEPUR
GOPALGANJ	DEORIA	HOSHIARPUR						
NAWADA	ETAH	JALANDHAR						
PURNEA	ETAWAH	MANSI						
Gujarat	3	DANGS			FAIZABAD	Jharkhand	5	CHATRA
		NARMADA			FARRUKHABAD			DHANBAD
		TAPI			FATEHPUR			GARHWA
AMBALA	GONDA	PALAMU						
Haryana	9	MAHENDRAGARH			GORAKHPUR			Uttarakhand
		ROHTAK			HAMIRPUR	UDHAM SINGH NAGAR		
		BHIWANI			MAHAMAYA NAGAR	JANJGIR		
		KURUKSHETRA			JALAUN	Chhathisgarh	3	JASHPUR
		KAITHAL			JALAUN			SURGUJA
		PANCHKULA			JAUNPUR			
		FATEHABAD			JHANSI			
		PALWAL			JYOTIBA PHULE NA			
		Himachal Pradesh			2	KINNAUR	KANNAUJ	
SIRMAUR	KANPUR CITY							
Karnataka	2	BIDAR			KANPUR DEHAT			
		YADGIR			KAUSHAMBI			
Madhya Pradesh	13	BALAGHAT			KUSHI NAGAR			
		BHIND			LUCKNOW			
		CHHATARPUR			MAU			
		DAMOH			MAINPURI			
		JABALPUR			MAHARAJGANJ			
		MORENA			MEERUT			
		NARSINGHPUR			MIRZAPUR			
		PANNA			PILIBHIT			
		REWA			PRATAPGARH			
		SAGAR			RAE BAREILLY			
		SEONI			RAMPUR			
		SHAHDOL			SHAHJAHANPUR			
		SINGRAULI			SITAPUR			

Area weighted SPI values of the States for Jun-Sep 2014 & 2015 calculated from the district SPI values

STATE	AREA WEIGHTED SPI		STATE	AREA WEIGHTED SPI	
	Jun-Sep 2014	Jun-Sep 2015		Jun-Sep 2014	Jun-Sep 2015
ANDAMAN & NICOBAR	-0.21	0.02	MADHYA PRADESH	-0.78	-0.47
ANDHRA PRADESH	-0.71	0.34	MAHARASHTRA	-0.60	-1.07
ARUNACHAL PRADESH	-0.17	-0.03	MANIPUR	-1.61	-0.21
ASSAM	-0.21	-0.43	MEGHALAYA	-0.14	-0.23
BIHAR	-0.71	-1.11	MIZORAM	-1.12	-0.53
CHHATHISGARH	-0.37	-0.75	NAGALAND	-0.94	-0.45
DELHI	-1.34	0.27	ORISSA	0.42	-0.55
GOA	0.52	-0.68	PUNJAB	-1.30	-0.64
GUJARAT	-0.05	-0.11	RAJASTHAN	0.13	0.46
HARYANA	-1.59	-0.85	SIKKIM	0.54	0.76
HIMACHAL PRADESH	-1.18	-0.53	TAMILNADU	-0.14	-0.17
J & K	0.79	0.88	TELANGANA	-1.04	-0.70
JHARKHAND	-0.73	-0.66	TRIPURA	0.08	0.18
KARNATAKA	0.36	-0.39	UTTAR PRADESH	-1.74	-1.58
KERALA	0.29	-1.18	UTTARAKHAND	-0.37	-0.43
LAKSHADWEEP	-0.19	-0.53	WEST BENGAL	-0.50	0.27



All India June-September Standardized Precipitation Index (SPI): 1901-2015



All India Drought years based on SPI

- EXTREMELY SEVERE DROUGHT YEAR (4) : 1965, 1972, 2002 AND 2009**
- SEVERE DROUGHT YEAR (5) : 1901, 1905, 1911, 1918, 1979 AND 1987**
- MODERATE DROUGHT YEAR (14) : 1902, 1904, 1907, 1913, 1915, 1920, 1941, 1951, 1966, 1974, 1982, 2004, 2014, 2015**

Consecutive two years : 1901-02 ; 1904 - 05; 1965 -66; 2014-15.



WEEKLY SPI MONITORING AND FORECAST

- In this forecast we have used Actual district rainfall for the past three weeks and the district cumulative rainfall forecast based on IMD Global Forecasting system (GFS)/MME model for the coming week.
- The base period of the SPI computation is 1901-2000.
- Thus SPI forecast is generated every Thursday/Friday for the cumulative four weeks period consisting of one advance week along with past three weeks to identify the regions with prevailing or beginning/ending of the extremely/severely/moderately dry/wet conditions.
- The SPI forecast maps were uploaded in IMD Pune website in every Friday.



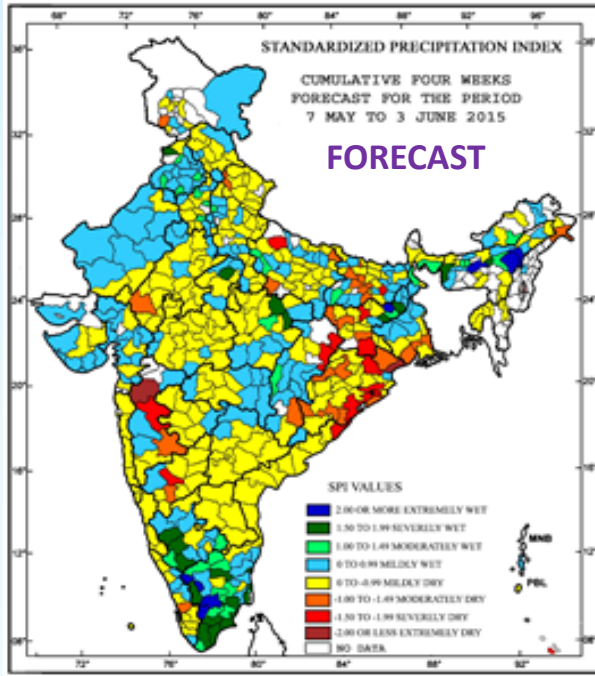
Whether one week can have significant contribution in changing drought situation?

In the year 2015 on several occasions dry/wet conditions largely changes in a week. For example from the **week 32 to 33**, number of extremely severe dry conditions districts decreased from **42 to 20** and severely dry condition from **56 to 45**; from **week no. 36 to 37** opposite happened as number of extremely severe dry conditions districts increased from **24 to 72** and severely dry condition from **84 to 102**. Again next week i.e. **in week no. 38** it decreased to **24 and 52** respectively. The SPI forecast in all these cases has indicated the changes in drought situation one week advance. Thus this type of SPI forecast is particularly helpful in these cases to identify the districts well in advance (one week) for the starting or cessation of drought conditions.

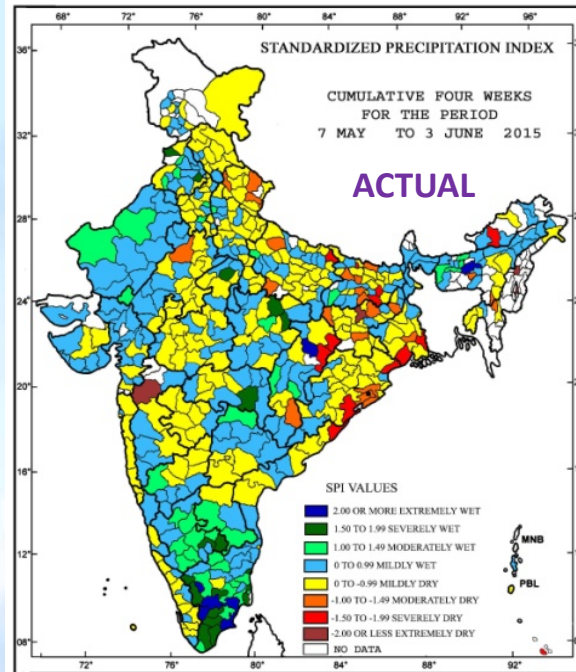


Week No. 22 (Input rainfall forecast GFS)

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Categories		Forecast								Total
		1	2	3	4	5	6	7	8	
Actual	1	2	1	0	0	1	0	0	0	4
	2	1	6	4	2	0	0	0	0	13
	3	0	3	11	10	0	0	1	0	25
	4	0	4	11	198	18	3	1	1	236
	5	0	0	3	61	136	9	3	2	214
	6	0	0	0	4	16	16	3	0	39
	7	0	0	0	0	2	4	11	1	18
	8	0	0	0	1	0	0	2	4	7
Total		3	14	29	276	173	32	21	8	556

Percentage of Forecast within ± 1
Category : 95.0%

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	384	144	21	3	4	0	0	0
%	69.1	25.9	3.8	0.5	0.7	0.0	0.0	0.0

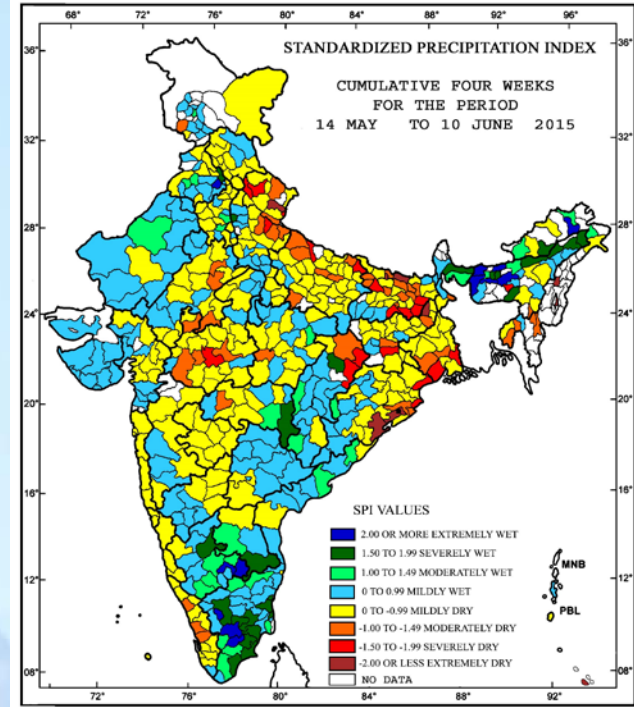
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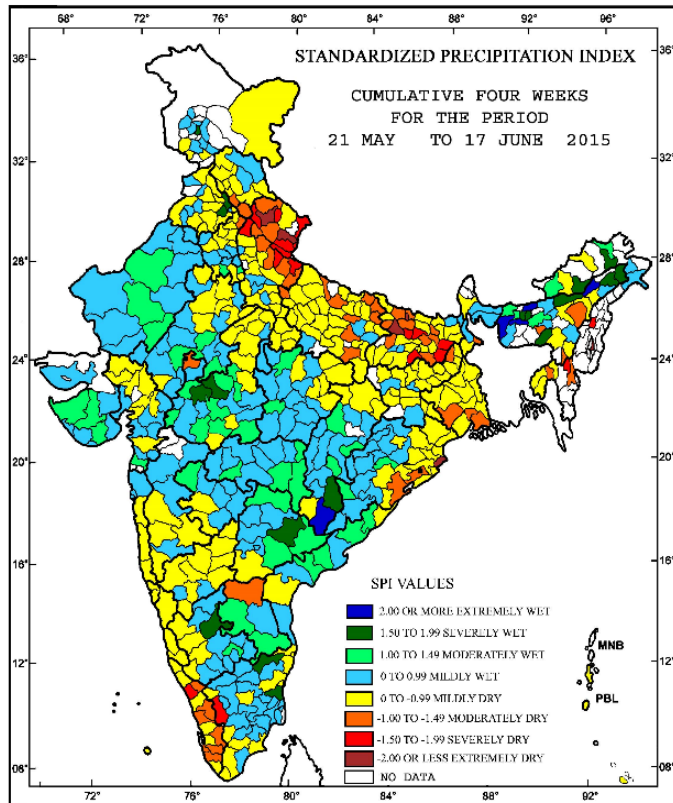
Week No. 23 GFS rainfall Forecast was not available

Week No. 24 GFS rainfall Forecast was not available

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Week No. 25 (Input rainfall forecast MME)
FORECAST

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HYDROMET SECTION, PUNE

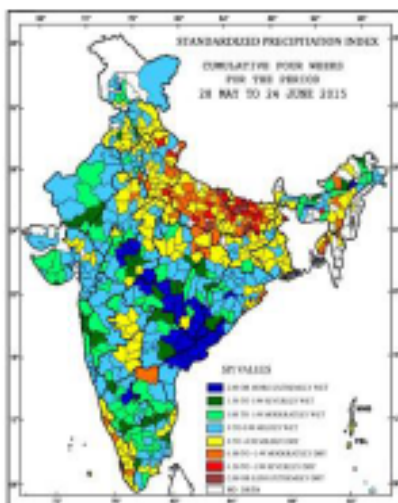
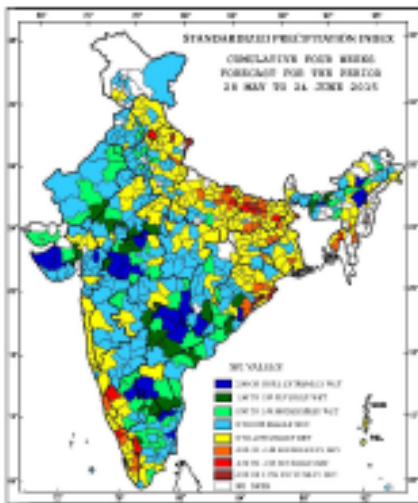


Table 2.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	2	4	1	3	0	0	0	0	10
	2	1	1	6	9	3	0	0	0	20
	3	2	3	7	34	5	1	0	0	52
	4	2	2	14	106	49	2	1	3	179
	5	0	1	2	38	100	18	7	3	169
	6	0	0	0	12	31	18	9	6	76
	7	0	0	0	3	9	8	5	5	30
	8	0	0	0	0	6	8	5	7	26
Total	7	11	30	205	203	55	27	24	562	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 2.2

Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	246	225	65	23	3	0	0
%	43.8	40.0	11.6	4.1	0.5	0.0	0.0

Percentage of Forecast within ± 1 Category : 83.8%

Week No. 26 (Input rainfall forecast MME)
FORECAST

MINISTRY OF EARTH SCIENCES
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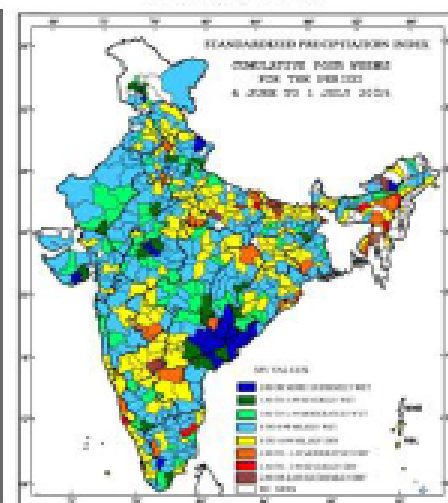
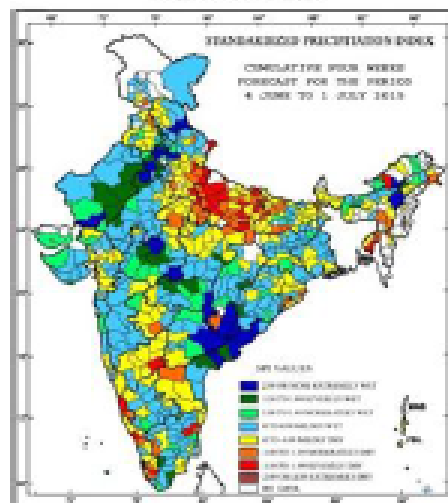


Table 3.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	2	4	2	2	0	0	0	0	10
	2	1	1	2	3	0	0	0	1	8
	3	1	3	10	7	3	0	0	1	25
	4	0	12	19	108	34	3	2	2	180
	5	0	5	13	61	126	23	7	4	239
	6	0	0	2	5	29	14	11	3	64
	7	0	0	0	2	6	4	7	3	22
	8	0	0	0	0	2	0	1	11	14
Total	4	25	48	188	200	44	28	25	562	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 3.2

Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	279	202	58	19	2	1	0
%	49.6	35.9	10.3	3.4	0.4	0.2	0.0

Percentage of Forecast within ± 1 Category : 85.6%



Week No. 27 (Input rainfall forecast MME)

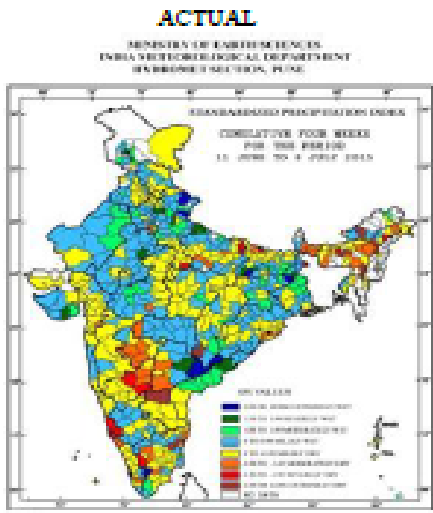
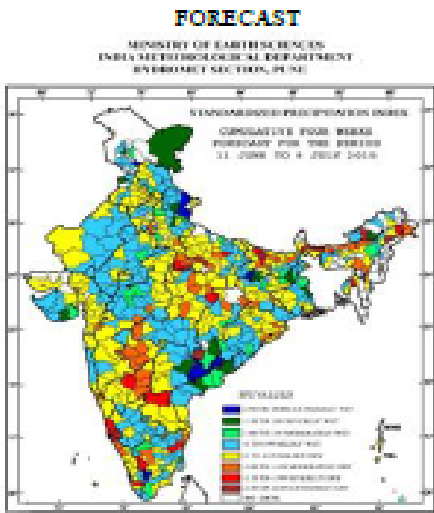


Table 4.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	4	3	2	1	2	0	0	0	12
	2	3	3	2	3	0	0	0	0	11
	3	2	3	18	7	0	1	0	0	33
	4	1	4	23	170	28	1	2	0	231
	5	0	0	3	58	143	4	3	0	211
	6	0	0	0	1	21	18	4	3	47
	7	0	0	0	0	1	3	6	0	10
	8	0	0	0	0	0	0	1	6	7
Total	10	13	50	240	195	27	16	9	562	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 4.2

Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	368	164	23	5	2	0	0
%	65.5	29.2	4.1	0.9	0.4	0.0	0.0

Percentage of Forecast within ± 1 Category: 65.5%

Week No. 29 (Input rainfall forecast GFS)

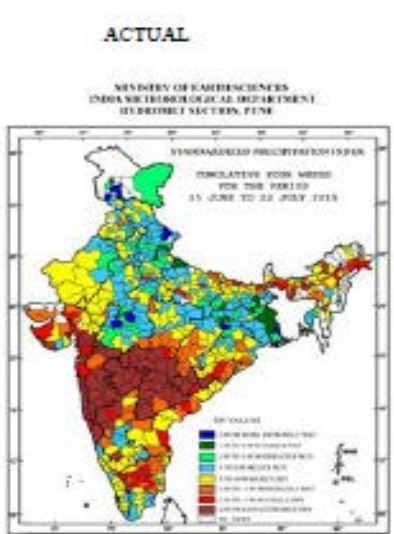
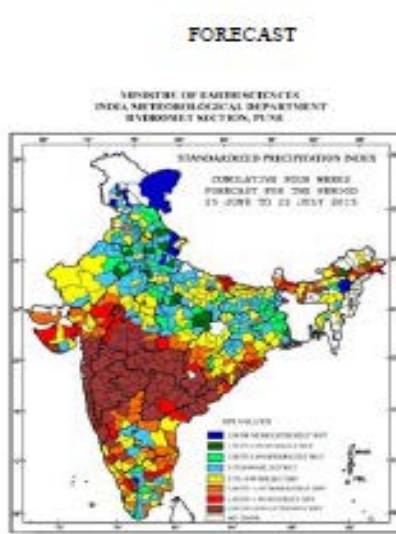


Table 5.1

Categories	Forecast								Total
	1	2	3	4	5	6	7	8	
Actual	1	59	3	1	2	0	0	0	65
	2	10	7	6	7	2	0	0	33
	3	12	11	23	15	3	1	0	66
	4	4	11	27	94	29	6	4	176
	5	3	3	2	38	88	19	6	160
	6	3	1	0	3	14	10	3	38
	7	0	0	0	0	1	9	0	14
	8	1	0	0	0	1	1	2	9
Total	92	36	39	159	138	46	17	14	561

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

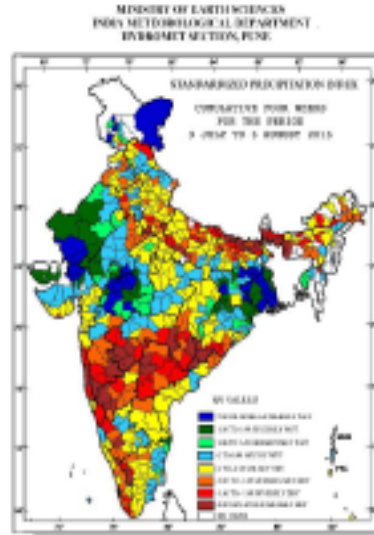
Table 5.2

Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	285	192	55	18	5	4	1
%	50.8	34.2	9.8	3.2	0.9	0.7	0.2

Percentage of Forecast within ± 1 Category: 50.8%



Week No. 30 GFS rainfall Forecast was not available



Week No. 31 (Input rainfall forecast MME)

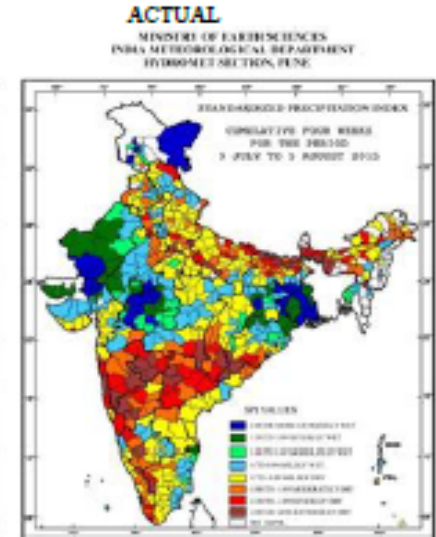
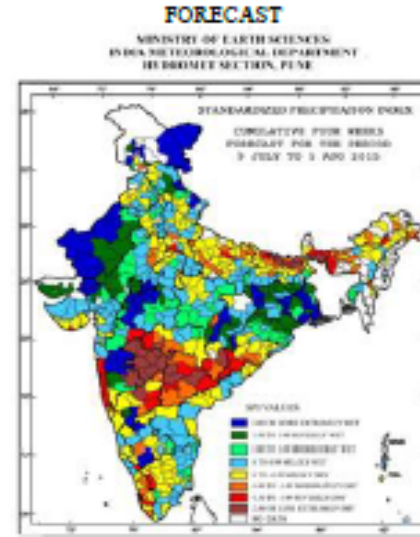


Table 6.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	18	11	5	4	1	0	1	1	41
	2	5	11	15	13	1	1	1	0	47
	3	1	4	19	44	2	0	1	5	76
	4	1	0	5	104	78	5	1	3	197
	5	0	1	1	7	63	27	7	4	112
	6	0	0	0	0	7	11	8	2	28
	7	0	0	0	0	0	7	19	3	29
	8	0	0	0	0	0	1	5	26	32
Total	25	27	45	172	154	52	43	44	562	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 6.2

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	273	226	37	12	6	6	1	1
%	48.6	40.2	6.6	2.1	1.1	1.1	0.2	0.2

Percentage of Forecast within ± 1 Category: 88.8%



From week 32 to 33, number of extremely severe dry conditions districts decreased from 42 to 20 and severely dry condition from 56 to 45

Week No. 32 (Input rainfall forecast GFS)

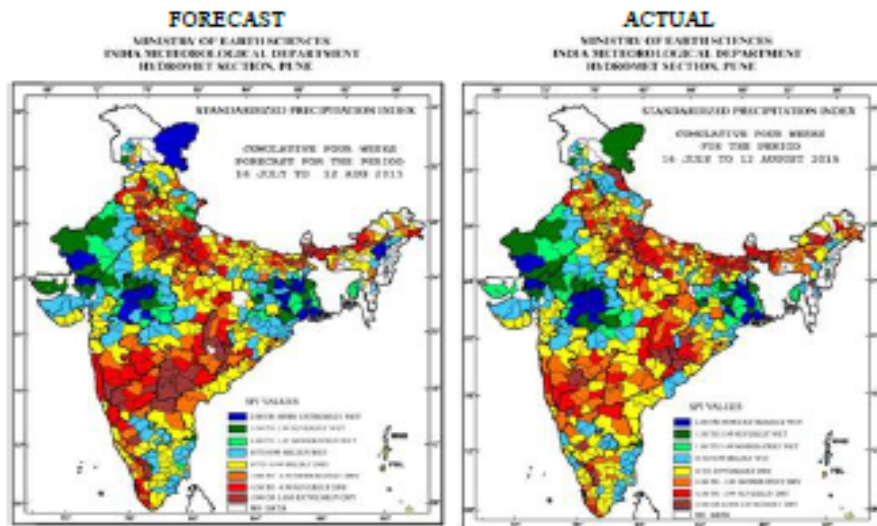


Table 7.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	21	9	7	5	0	0	0	0	42
	2	14	26	10	6	0	0	0	0	56
	3	12	29	28	29	3	0	1	0	102
	4	2	6	35	110	22	1	1	2	179
	5	0	0	1	26	69	6	1	1	104
	6	0	0	0	0	9	15	6	0	30
	7	0	0	0	0	1	8	16	4	29
	8	0	0	0	0	0	0	3	17	20
Total	49	70	81	176	104	30	28	24	562	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 7.2

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	302	210	38	9	3	0	0	0
%	53.7	37.4	6.8	1.6	0.5	0.0	0.0	0.0

Percentage of Forecast within ± 1 Category: 91.1%

Week No. 33 (Input rainfall forecast GFS)

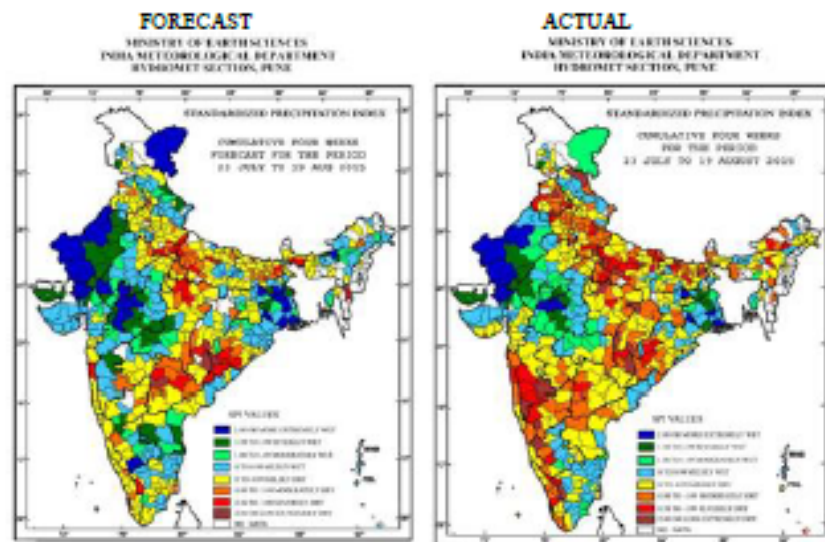


Table 8.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	4	5	7	3	0	1	0	0	20
	2	4	7	15	12	6	1	0	0	45
	3	1	9	16	60	7	0	2	0	95
	4	0	5	13	123	60	8	3	2	214
	5	0	0	0	21	69	18	9	1	118
	6	0	0	0	1	7	14	11	5	38
	7	0	0	0	0	0	0	11	7	18
	8	0	0	0	0	0	0	0	13	13
Total	9	26	31	220	149	42	36	28	561	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

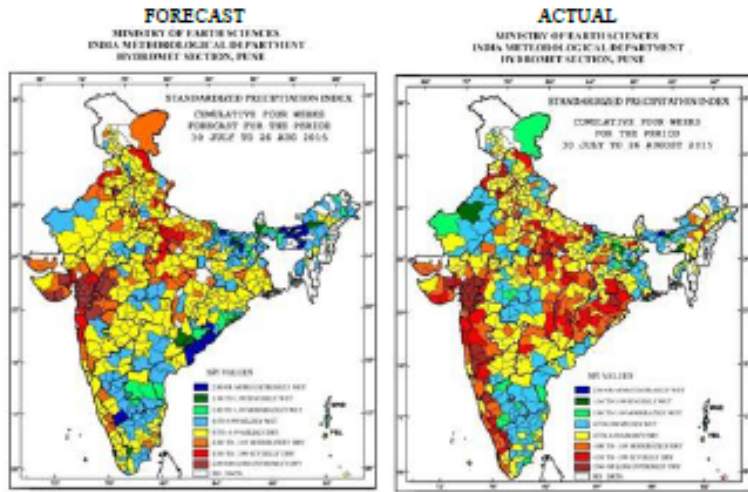
Table 8.2

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	257	230	55	13	5	1	0	0
%	45.8	41.0	9.8	2.3	0.9	0.2	0.0	0.0

Percentage of Forecast within ± 1 Category: 86.8%



Week No. 34 (Input rainfall forecast GFS)



Week No. 35 GFS rainfall Forecast was not available

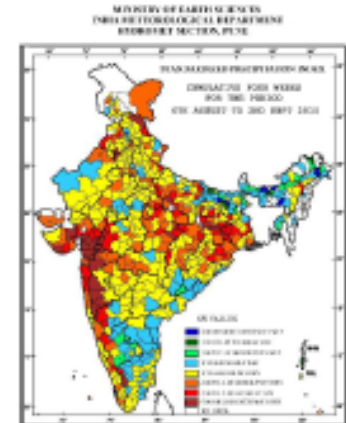


Table 9.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	18	1	4	10	0	0	0	0	33
	2	5	15	13	15	3	0	0	0	51
	3	0	8	43	34	2	0	0	0	87
	4	0	0	9	202	45	3	0	2	261
	5	0	0	0	6	66	9	5	5	91
	6	0	0	0	1	5	4	4	3	17
	7	0	0	0	0	0	2	3	4	9
	8	0	0	0	0	0	1	0	6	7
Total	23	24	69	268	121	19	12	20	556	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 9.2

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	357	145	34	18	2	0	0	0
%	64.2	26.1	6.1	3.2	0.4	0.0	0.0	0.0

Percentage of Forecast within ± 1 Category: 90.3%



From week no. 36 to 37 opposite happened as number of extremely severe dry conditions districts increased from 24 to 72 and severely dry condition from 84 to 102.

Week No. 36 (Input rainfall forecast GFS)

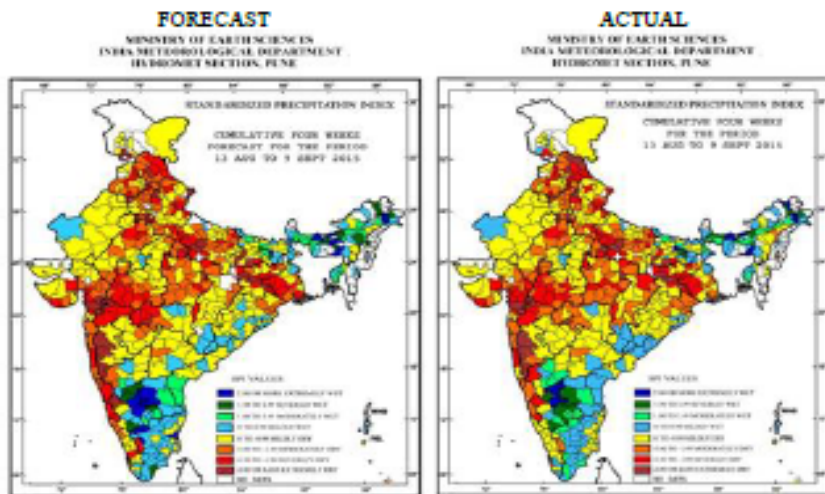


Table 10.1

Categories	Forecast								Total
	1	2	3	4	5	6	7	8	
Actual	1	23	1	0	0	0	0	0	24
	2	6	68	9	0	1	0	0	84
	3	0	9	80	10	0	1	0	100
	4	0	2	13	197	11	0	1	225
	5	0	0	0	12	52	6	3	73
	6	0	0	0	1	12	10	2	25
	7	0	0	0	0	0	3	9	12
	8	0	0	0	0	0	0	3	3
Total	29	80	102	220	76	20	18	13	558

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 10.2

Correct f/c	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	446	99	9	3	1	0	0
%	79.9	17.7	1.6	0.5	0.2	0.0	0.0

Percentage of Forecast within ± 1 Category: 97.7%

Week No. 37 (Input rainfall forecast MME)

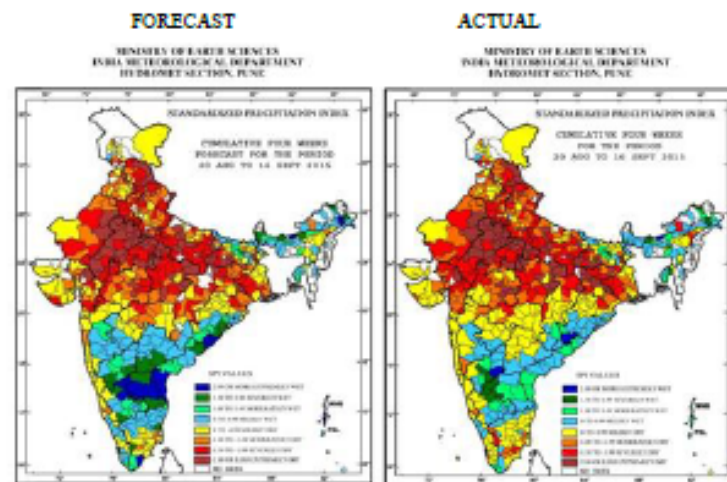


Table 11.1

Categories	Forecast								Total
	1	2	3	4	5	6	7	8	
Actual	1	66	5	1	0	0	0	0	72
	2	9	80	7	6	0	0	0	102
	3	0	11	72	13	1	0	0	97
	4	0	6	18	107	27	0	1	160
	5	0	0	0	4	55	13	11	84
	6	0	0	0	1	3	14	5	23
	7	0	0	0	0	1	2	4	7
	8	0	0	0	0	0	1	1	2
Total	75	102	98	131	87	30	22	12	557

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 11.2

Correct f/c	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	399	121	34	2	1	0	0
%	71.6	21.7	6.1	0.4	0.2	0.0	0.0

Percentage of Forecast within ± 1 Category: 93.4%



Week No. 38 (Input rainfall forecast MME)

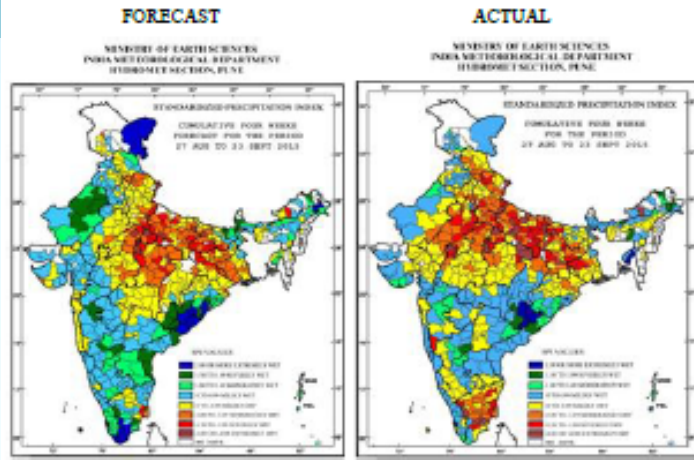


Table 12.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	7	8	5	1	1	0	2	0	24
	2	1	12	25	9	4	0	0	1	52
	3	3	8	23	43	9	2	0	0	88
	4	0	5	23	105	66	10	4	1	214
	5	0	0	2	36	67	24	9	3	141
	6	0	0	1	1	4	7	4	6	23
	7	0	0	0	1	1	0	4	3	9
	8	0	0	0	0	0	2	3	1	6
Total	11	33	79	196	152	45	26	15	557	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 12.2

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	226	248	62	16	2	0	3	0
%	40.6	44.5	11.1	2.9	0.4	0.0	0.5	0.0

Percentage of Forecast within ± 1 Category: 85.1%

Week No. 39 (Input rainfall forecast MME)

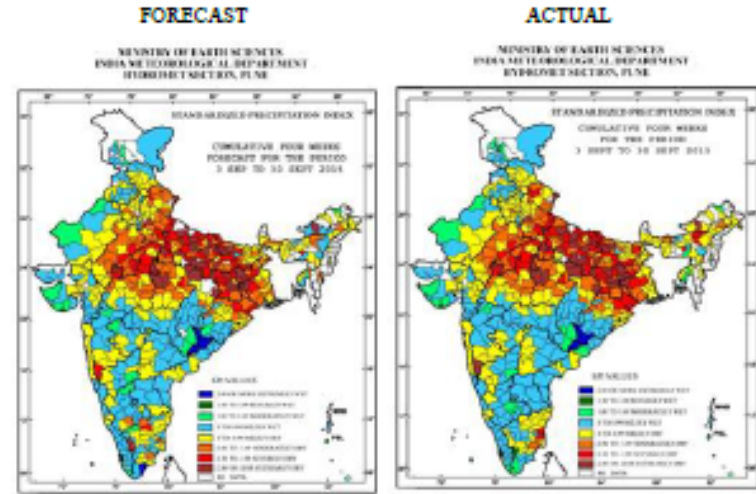


Table 13.1

Categories	Forecast								Total	
	1	2	3	4	5	6	7	8		
Actual	1	40	1	0	2	0	0	0	0	43
	2	2	50	8	0	1	0	0	0	61
	3	0	3	69	7	1	0	0	0	80
	4	1	1	12	177	10	0	0	0	201
	5	0	0	1	11	128	5	0	1	146
	6	0	0	0	0	8	16	0	0	24
	7	0	0	0	0	1	0	1	0	2
	8	0	0	0	0	0	0	0	3	3
Total	43	55	90	197	149	21	1	4	560	

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

Table 13.2

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	484	67	4	5	0	0	0	0
%	86.4	12.0	0.7	0.9	0.0	0.0	0.0	0.0

Percentage of Forecast within ± 1 Category: 98.4%

Performance of SPI forecast was best for the last week i.e. week ending 30th September as the correct forecast was more than 86% and forecast within ± 1 Category was more than 98%. Not only that even out of 43 districts experienced extremely severe drought in that week, 40 districts were predicted one week back when there was only 11 districts under extremely severe drought condition.

Over all performance district SPI forecast for the complete SW monsoon season 2015

Categories		Forecast								Total
		1	2	3	4	5	6	7	8	
Actual	1	266	60	34	26	8	1	3	1	399
	2	61	284	129	81	23	2	1	3	584
	3	35	99	414	320	37	9	7	7	928
	4	12	58	223	1770	476	46	22	18	2625
	5	3	10	28	386	1183	187	68	24	1889
	6	3	1	3	32	165	170	70	39	483
	7	0	0	0	7	29	52	94	35	217
	8	1	0	0	1	10	13	26	100	151
Total		381	512	831	2623	1931	480	291	227	7276

The following table obtained from the above contingency table gives the number and percentage of correct forecast, within ± 1 category, within ± 2 category etc.

	Correct F/C	In ± 1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
Freq	4281	2289	500	146	40	12	6	2
%	58.8	31.5	6.9	2.0	0.5	0.2	0.1	0.0

90.3 % of forecast was within ± 1 Category



Conclusions:

Southwest monsoon rainfall for two consecutive years was below 90 % of LPA (88% in 2014 and 86% in 2015) but their monthly distributions were completely opposite in nature which may have significant effect on crop production activities.

Also there was spatial variation in the dry regions in this two years. Except UP, no other states experienced consecutive two years drought situations but there are many districts which experienced consecutive two years drought like situation. The SPI values computed from all India rainfall for both of these years were in moderate drought category (-1.2 in 2014 and -1.4 in 2015).

The performances GFS /MME based SPI forecast is fully depended on the skill of GFS model. Instead of district rainfall forecast , SPI forecast has better advantage in monitoring dry/wet condition over the region as SPI better represent dry conditions or water stress over a region than than actual/percent departure of rainfall.

The performances of the SPI forecast model was quite good for the season (90.3 % of forecast was within ± 1 Category whereas 59% was correct forecast). Even in some week it was more than 98% within ± 1 Category while more than 86% was correct forecast.

The SPI forecast has rightly detected the sudden changes in the dry/wet conditions along with identifying the regions/districts also.



Thanks



भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

