भारतसरकार

Government of India

पृथ्वी विज्ञान मंत्रालय(एम. ओ. ई. एस.)

Ministry of Earth Sciences (MoES)

भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

Climate Research and Services (CRS)

Statement on Climate of India during 2021

HIGHLIGHTS

The annual mean land surface air temperature averaged over India during 2021 was0.44^{0}C above the long period average (LPA) based on 1981-2010 period. The year 2021 was the fifth warmest year since nationwide records commenced in 1901. However, this is lower than the highest warming observed over India during 2016 when it was 0.71^{0}C above the LPA.The winter(January to February) and post-monsoon (October to December) seasons with all Indiamean temperature anomalies(Actual-LPA Temperature) of +0.78^{0}C and +0.42^{0}C respectively mainly contributed to this warming. The all India mean temperatures during the other two seasons; pre-monsoon (March to May) and monsoon (June to September) seasons, were also above normal withanomalies of +0.35^{0}Cand +0.34^{0}Crespectively.

The Global mean surface temperature anomaly during 2021 (January to September as per State of the Global Climate 2021 WMO provisional statement) wasabout 1.08 ±0.13 °C above the 1850-1900 pre-industrial average and the global annual temperature is also likely to be between the 5th and 7thwarmest year on record. (source: https://library.wmo.int/doc_num.php?explnum_id=10859).

The 2021 annual rainfall over the country as a whole was 105% of its LPAbased on 1961-2010 period.The southwest monsoon season rainfall over the country as a whole was 99% of its LPA.

During 2021, five tropical cyclones formed over the north Indian Oceanwith three forming over the Bay of Bengal and 2 forming over the Arabian Sea. In addition to these, extreme weather events likeextremely heavy rainfall leading to floods, landslide, lightning,thunderstorm, droughts etc were also experienced in various parts of the country.

Temperatures

The 2021 annual mean land surface air temperature for the country was 0.44^{0}C above the long period average based on 1981-2010, thus making the year 2021 the fifth warmest year on record since 1901 (Fig. 1).The five warmest years on record, in descending orderwere: 2016 (+0.71^{0}C), 2009 (+0.55^{0}C), 2017 (+0.541^{0}C), 2010 (+0.539^{0}C), and2021 (+0.44^{0}C).It may be mentioned that 11 out of 15 warmest years were during the recent fifteen years (2007-2021).The past decade (2011-2020/ 2012-2021) was also the warmest decade on record with the decadal averaged annual meantemperature anomaly (Actual-LPA) of 0.34^{0}C /0.37^{0}C.The country averaged annual mean temperature during 1901-

2021 showed an increasing trend of 0.63^{0}C/100 years(Fig.1) with a significant increasing trend in maximum temperature (0.99^{0}C/100 years) and a relatively lower increasing trend (0.26^{0}C/100 years) in minimum temperature.

The country averaged seasonal mean temperatures in 2021 were also above the LPA during all the seasons with the winter (January to February), pre-monsoon (March to May), monsoon (June to September) and post monsoon (October to December) seasons recording anomalies of +0.78^{0}C, +0.35^{0}C, +0.34^{0}C and +0.42^{0}C respectively.

The country averaged mean monthly temperatures were warmer than normal during all the months of the year except four months (April, May, June, and November).Among the months, the highest country averaged monthly mean temperatures were recorded in March (1.24^{0}C, third warmestsince 1901),followed by August (0.52^{0}C, third warmest since 1901),January (0.67^{0}C, fifth warmest since 1901), and October (0.77^{0}C, fifth warmest since 1901).

Rainfall

The annual rainfall averaged over the country was 105 % of itslong-period average (LPA). The time series of percentage departure of annual rainfall over the country as a whole since 1901 is shown in Fig. 2.Rainfall over the country as a whole during the southwest monsoon season (June-September), which is the principal rainy season of the country, was normal (99 % of LPA).During this monsoon season, among the four broad geographical regions of the country, South Peninsular India received seasonal rainfall of 111% of its LPA; Central India & Northwest India received seasonal rainfall of 104% & 96%of its LPA respectively while East & Northeast India received seasonal rainfall of 88% of its LPA.

The 2021 Northeast/ post monsoon season (October-December) rainfall over the country as a whole was above normal (144% ofLPA). The seasonal rainfall during the northeast monsoon season over the core region of the south peninsula (comprising of 5 subdivisions viz. Coastal Andhra Pradesh & Yanam, Rayalaseema, Tamil Nadu Puducherry & Karaikal, South Interior Karnataka, and Kerala&Mahe), was exceptionallyabove normal (171% of LPA) and was highest (579.1 mm) since 1901. All the five subdivisions of the core region except Coastal Andhra Pradesh &Yanam received large excess/excess rainfall during season.

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for monitoring drought conditions and is based on precipitation. This index is negative for dry, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Fig.3 gives the district wise SPI values for the year 2021. Cumulative SPI values of the past twelve months indicate extremely wet-severely wet conditions over parts of A & N Islands, Gangetic West Bengal, Odisha, Jharkhand, Bihar, East Uttar Pradesh, Uttarakhand, Haryana, Chandigarh & Delhi, Punjab, East Rajasthan, West Madhya Pradesh, Gujarat Region, Konkan & Goa, Madhya Maharashtra, Marathwada, Andhra Pradesh state, Telangana, Tamil Nadu, North Interior Karnataka, South Interior Karnataka and Kerala. While extremely dry-severely dry conditions were observed over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal & Sikkim, East Uttar Pradesh, Himachal Pradesh and Jammu & Kashmir.

Impacts of Extreme Weather Events 2021

Tropical Cyclones in the Indian Seas:

In2021, five cyclones formed over the North Indian Ocean. These are: (1)Extremely Severe Cyclonic Storm “TAUKTAE”, (2) Very Severe Cyclonic Storm YAAS, (3) Severe Cyclonic StormSHAHEEN(remnant of GULAB), (4) Cyclonic Storm GULAB (pronounced as Gul-Aab) &(5) Cyclonic StormJAWAD (pronounced as JOWAD).Of these, three cyclones (YAAS, GULAB, JAWAD)formed over the Bay of Bengal. & the remaining two cyclones (viz. TAUKTAE&SHAHEEN) formed over the Arabian Sea.

Among these 5 cyclones, the most devastating was Extremely Severe Cyclonic StormTAUKTAE (14 May to 19 May) which formed in the pre-monsoon season over the Arabian Sea, crossedSaurashtra coast on 17th May, claiming 144 lives from across the states in western India stretching from Kerala in the far southern part of the country to Gujarat in the west.

The Very Severe Cyclonic Storm YASS, (23May to 28 May) formed during the pre-monsoon season over the Bay of Bengal, crossed north Odisha coast on 26th May 2021 and claimed 9 lives from Odisha, Jharkhand, West Bengal & Bihar.

The Cyclonic Storm GULAB (24September to 28 September), formed during the southwestmonsoon season &crossednorth Andhra Pradesh – south Odisha coasts on 26thSeptember,claiming 19 lives fromAndhra Pradesh, Telangana, Odisha, Maharashtra.

The Severe Cyclonic StormSHAHEEN(29 September to 4 October) formed over Arabian Sea and moved away from Indian region towards Oman coast.The Cyclonic StormJAWAD (2-6 December) formed over Bay of Bengaland weakened close to Odisha coast.

The tracks of these cyclonic storms formed during the year are shown in figure 4.

Impacted Extreme Weather Events:

In addition to Tropical Cyclones, various parts of the country also experienced other Extreme Weather Events likeextremely heavy rainfall leading to floods, landslide, lightning, thunderstorm, etc

Major Extreme Weather Events & associated loss of life, distribution of the number of deaths & its percentage, and State-wise Distribution of the number of deaths &State-wise Number of Districts during 2021 areshown in Fig.5, 6, 7, 8 respectively.The causalities caused by these extreme events mentioned here are based on the media and the government reports from disaster Management Authorities.

Maharashtra is the most adversely affected state during 2021, which reportedly claimed more than 340 deaths mainly due to extremely heavy rainfall, floods, landslide, lightning, cyclonic storms andcold-wave events.

Heavy rainfall andflood-related incidents claimed over 750 lives from different parts of the country. Of these, 215 lives were lostfrom Maharashtra, 143 from Uttarakhand, 55 from Himachal Pradesh, 53 from Kerala and46 from Andhra Pradesh.

Thunderstorms and lightning claimed more than 780lives from different parts of the country. Among these, the significant reported deaths were 213 from Odisha, 156 from Madhya Pradesh, 89 from Bihar,76 from Maharashtra, 58 from West Bengal, 54 from Jharkhand, 49 from Uttar Pradesh & 48 from Rajasthan.

The other events like snowfall, cold wave, dust storm, gale, and hailstorm also affected different parts of the country causing loss of life, injury, loss of livestock & damage to crops & property.

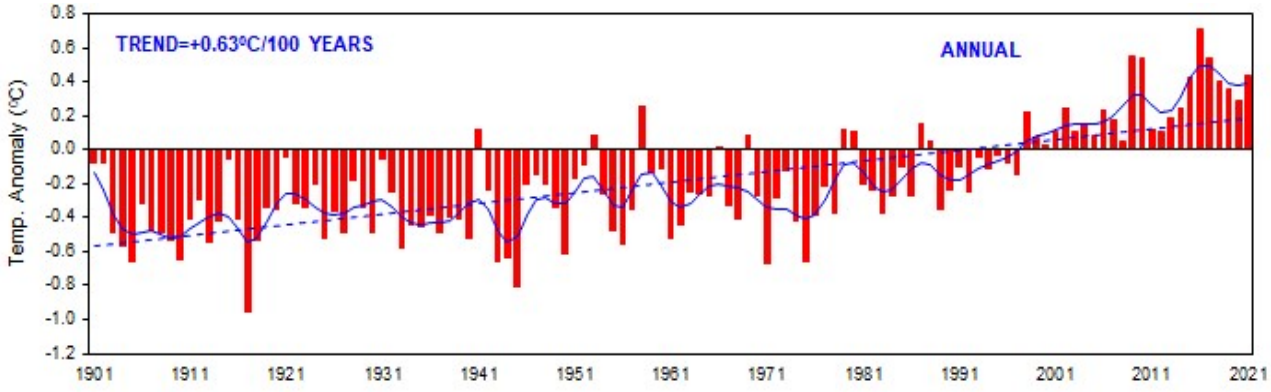

Fig.1: Annual mean land surface air temperature anomalies averaged over India for the period 1901-2021. The anomalies were computed with respect to the base period of 1981-2010. The dotted line indicates the linear trend in the time series. The solid blue curve represents the sub-decadal time scale variation smoothed with a binomial filter.

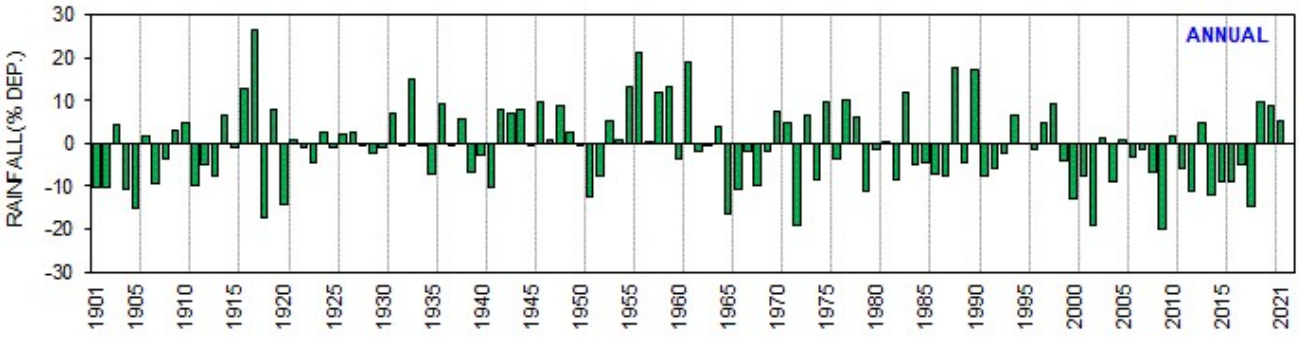

Fig. 2: Time Series of All India Annual Rainfall percentage Departure (Dep) from LPA during 1901-2021. The percentage of departures were computed with respect to the base period of 1961-2010.

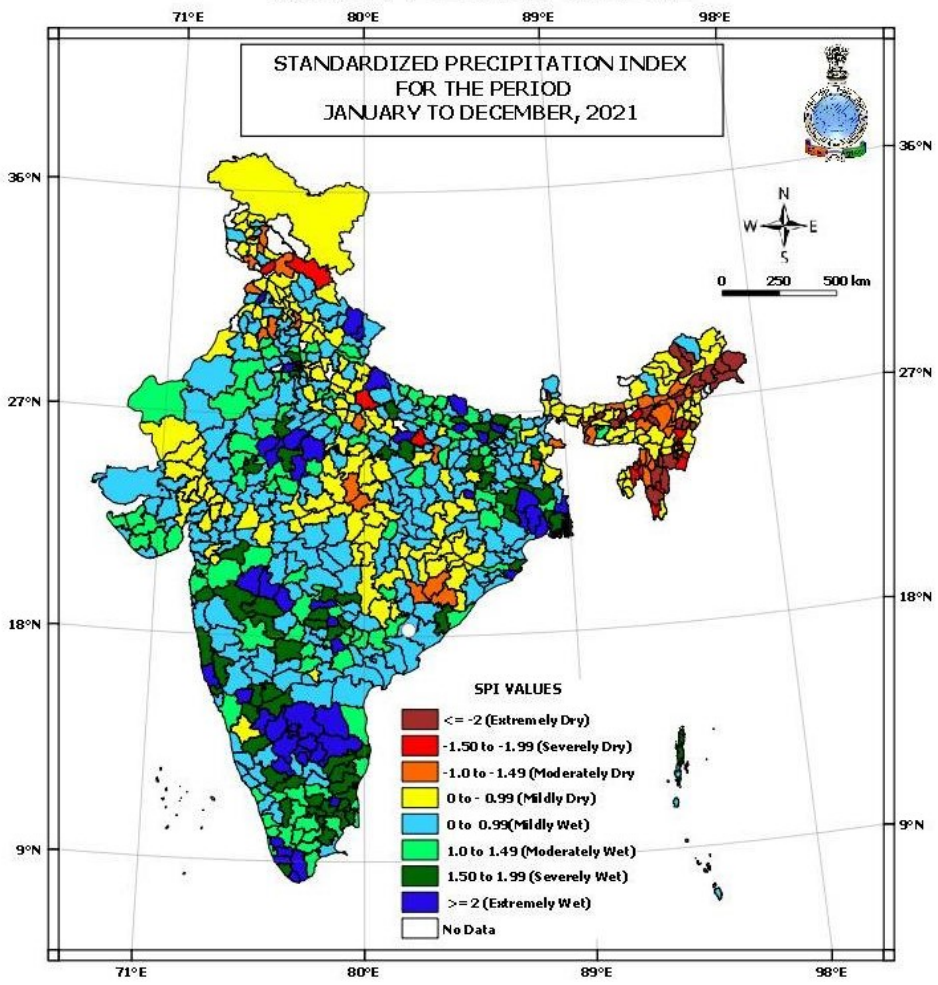

Fig.3: Standardized Precipitation Index (SPI) for January toDecember 2021

TRACKS of CYCLONES FORMED DURING 2021

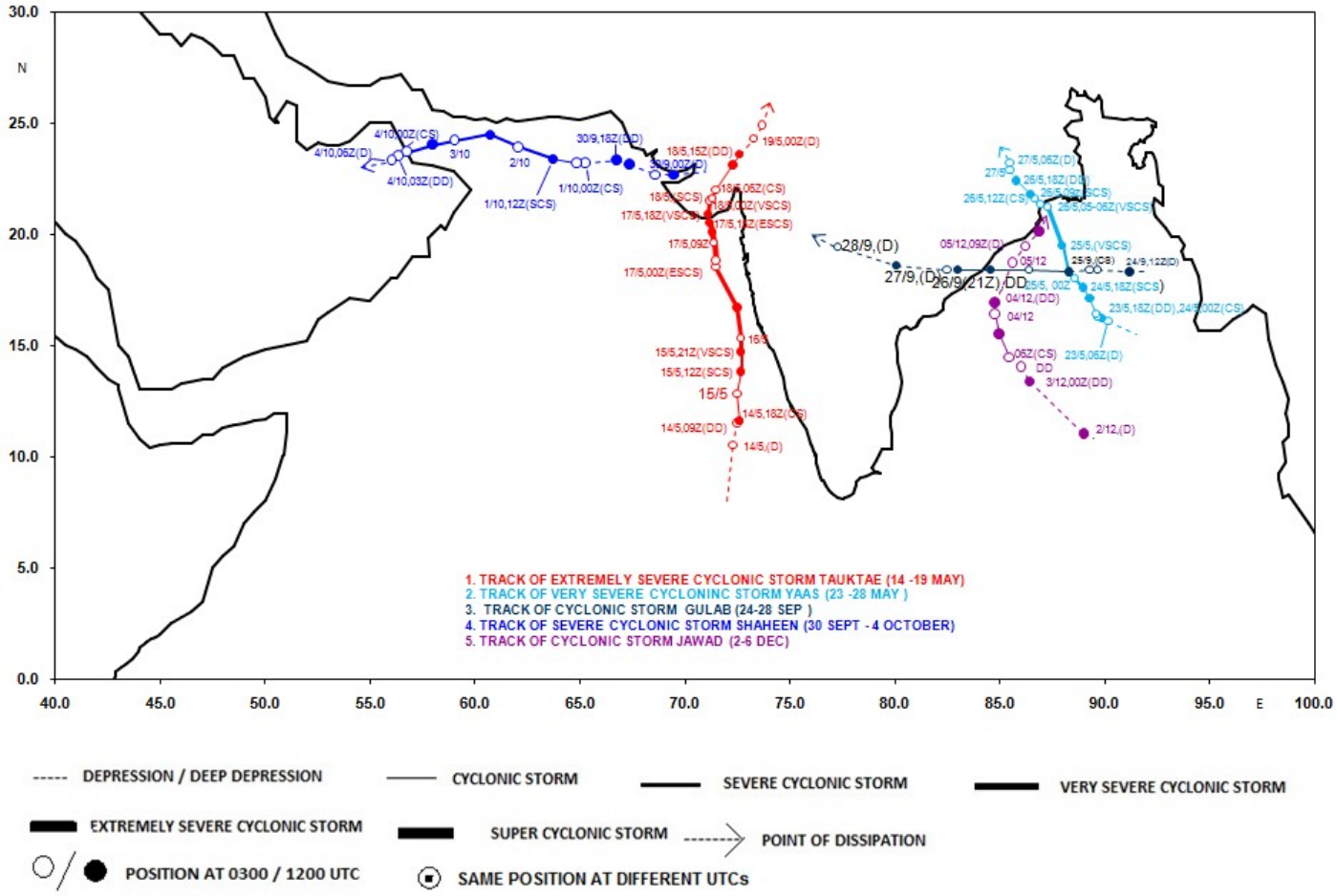

Fig. 4: Tracks of the Cyclones formed over North Indian Ocean during 2021

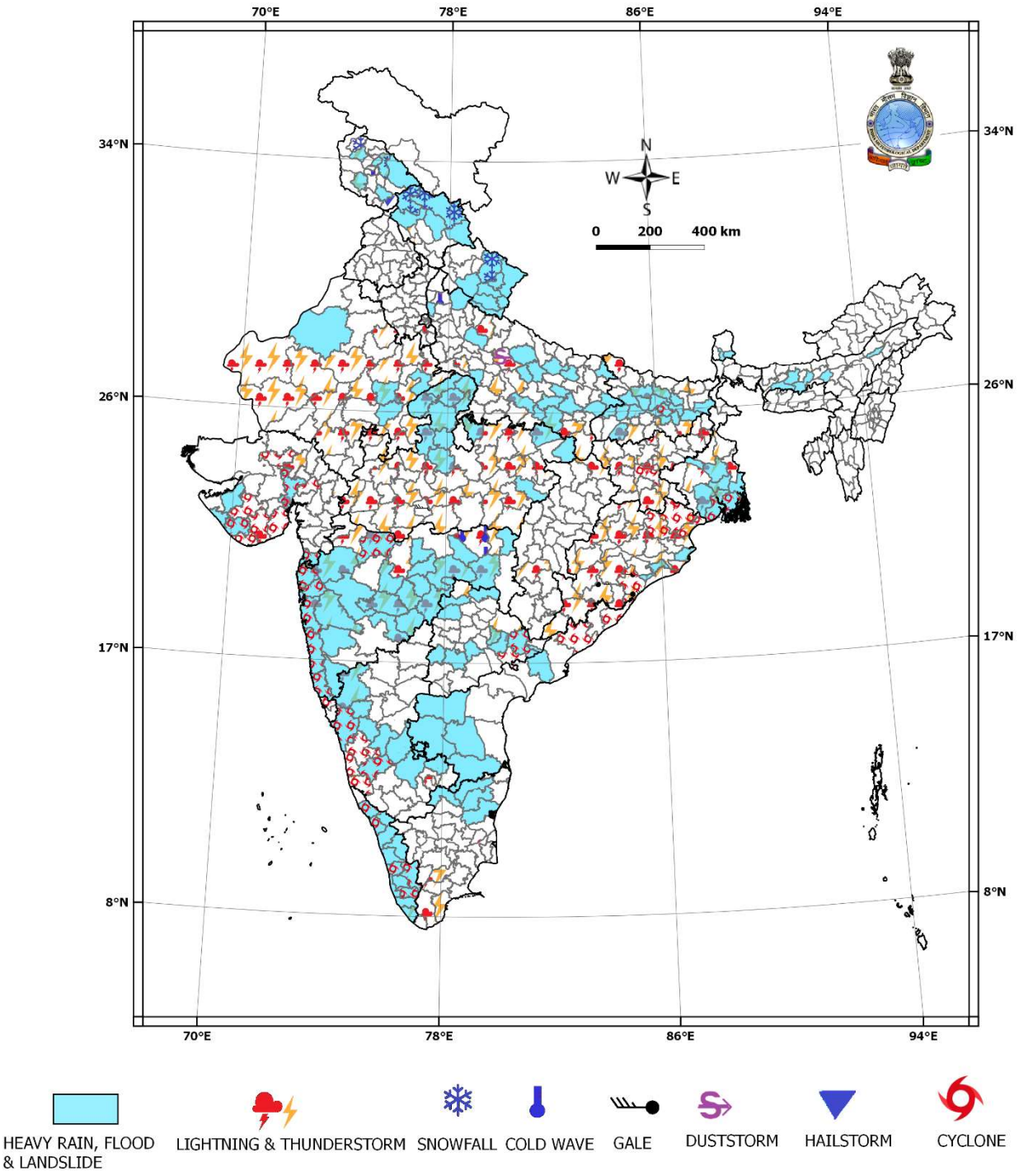

Fig.5:Major Extreme Weather Events during 2021 causing loss of life (details provided in the Table 1).

Table 1: Extreme Weather Events during 2021 along with associated loss of humanLives

Sum of Deaths	Extreme Weather Events and loss of Lives				
State / UT	**Cyclones**	**FLOODS, HEAVY RAINS & Land Slides**	**LIGTNING & THUNDERSTORM**	**OTHER EVENTS**	**STATEWISE TOTAL**
Andhra Pradesh	4 (CS GULAB-24 to 28 Sep.)	46 (6 Sep.; 8 to 21 Nov.)			**50**
Assam		14			**14**
Bihar	1 (VSCS YAAS-23 to 28 May)	12	89 (12 May ; 23 to 28 Jun.; 30 Jul.; 7 Aug.; 2, 27 Sep.; 1, 2, 17, 19 Oct.)		**102**
Chhattisgarh			3		**3**
Goa	3 (ESCS TAUKTAE-14 to 19 May)				**3**
Gujarat	79 (ESCS TAUKTAE-14 to 19 May)	7	6		**92**
Haryana			1		**1**
Himachal Pradesh		55 (12, 25, 27 Jul.; 11 Aug.)		4	**59**
Jammu & Kashmir		21	4	7	**32**
Jharkhand	3 (VSCS YAAS-23 to 28 May)		54 (9, 20, 26, 31 May; 1, 2 Jun.; 2, 11, 19 Jul.; 2, 7, 29 Aug.)		**57**
Karnataka	8 (ESCS TAUKTAE-14 to 19 May)	33	4		**45**
Kerala	9 (ESCS TAUKTAE-14 to 19 May)	53 (23 to 25 May; 14 & 15 Jul.; 11 to 19 Oct.; 10 to 15 Nov.)	5		**67**
Madhya Pradesh		34	156 (2, 3 Jan.; 16, 18 Feb.; 12 to 23 Mar.;10, 11 Apr.; 2 to 30 May; 5, 6 Jun.; 11 to 13, 23, 24 Jul.;2, 17, 18, 22 to 31 Aug.; 4 to 29 Sep.; 1, 2, 3, 17, 18 Oct.)	1	**191**
Maharashtra	45 + 11 = 56 (ESCS TAUKTAE-14 to 19 May) (CS GULAB-24 to 28 Sep.)	215 (3, 9 Jun.; 9 to 31 Jul.; 29 to 31 Aug.; 1, 6, 7, 20, 21, 28 Sep., 6 & 9 Oct.)	76 (18 Feb.; 20 Mar.; 10, 11 Apr.;2 to 9, 18, 29, 30, 31 May;3 to 9, 28 Jun.; 7, 9. 11, 22 Jul.; 10, 20, 21, 27 Sep.; 1, 5, 6, 7, 9 Oct.)	3	**350**
Odisha	3 + 1 = 4 (VSCS YAAS-23 to 28 May) (CS GULAB-24 to 28 Sep.)	3	213 (12 Jan.; 4 to 29 Apr.; 4 to 31 May; 1 to 30, Jun.; 1 to 25 Jul.; 2 to 31 Aug.; 1 to 29 Sep.)	3	**223**
Rajasthan		14	48 (12, 22, 23 Mar. ; 11, 13, 14 Jul.; 31 Aug.; 2, 6, 7, 21, 22, 28 Sep.; 18 Oct.)		**62**
Sikkim		2			**2**
Tamil Nadu		20	14		**34**
Telangana	3 (CS GULAB-24 to 28 Sep.)	15	7		**25**
New Delhi		4		3	**7**
Uttar Pradesh		42	49 (21 Apr.; 11 Jul.; 14 & 22 Sep.)	7	**98**
Uttarkhand		143 (7 Feb. 2021; 23 Apr.; 11 Jul.; 29 Aug.; 16 to 19 Oct.)		4	**147**
West Bengal	2 (VSCS YAAS-23 to 28 May)	26	58 (11, 25, 27 May; 5, 7, 8, 10, 13 Jun.; 2, 7 Aug.; 26 Sep.)		**86**
Total	**172**	**759**	**787**	**32**	**1750**

- **Other Events: COLD WAVE + DUST STORM + GALE + HAILSTORM + SNOWFALL**

- **CS:** Cyclonic Storm, SCS: Severe Cyclonic Storm, VSCS: Very Severe Cyclonic Storm, ESCS: Extremely Severe Cyclonic Storm

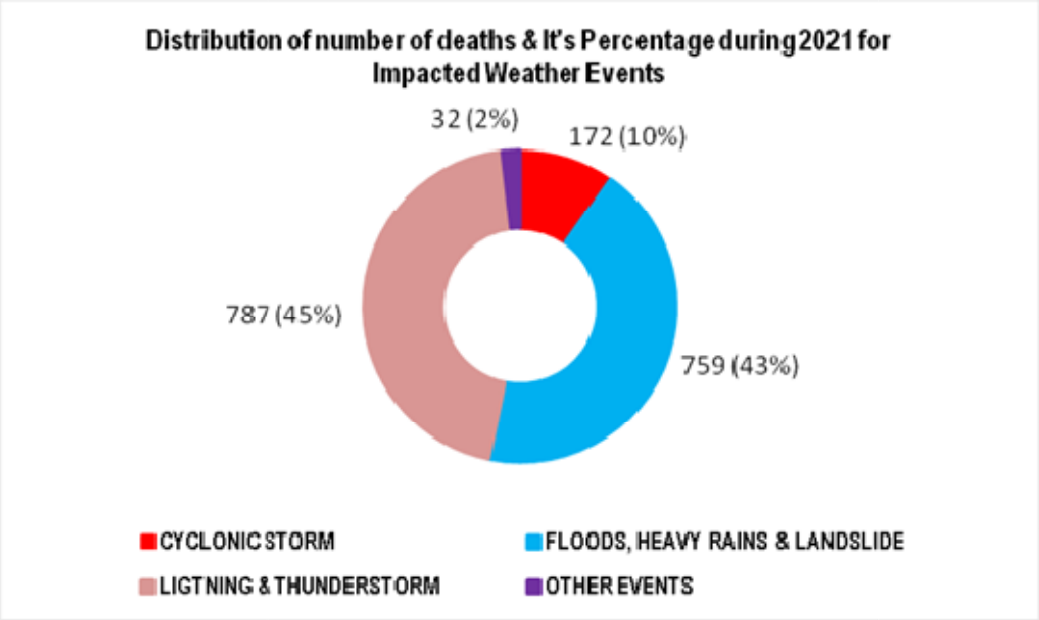

Fig.6:Distribution of the number of deaths & its percentage during 2021 due to extreme Weather Events

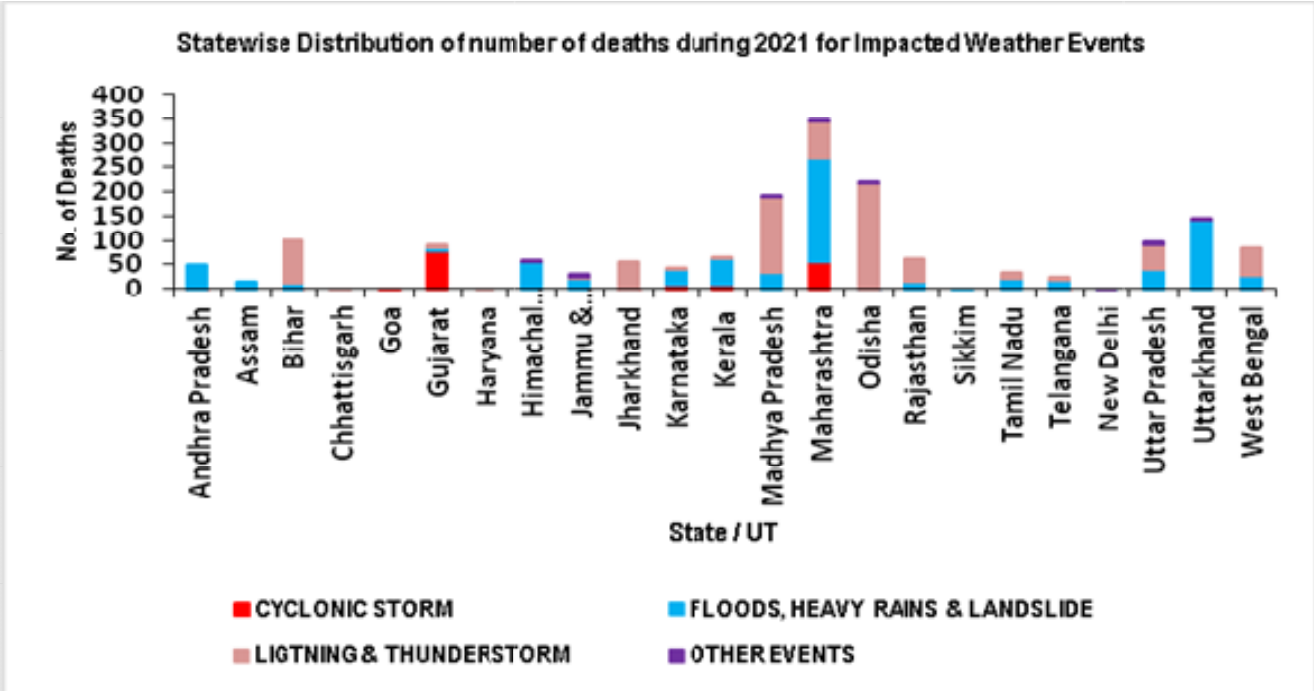

Fig.7:State-wise Distribution of the number of deaths during 2021 for High Impact Weather Events.

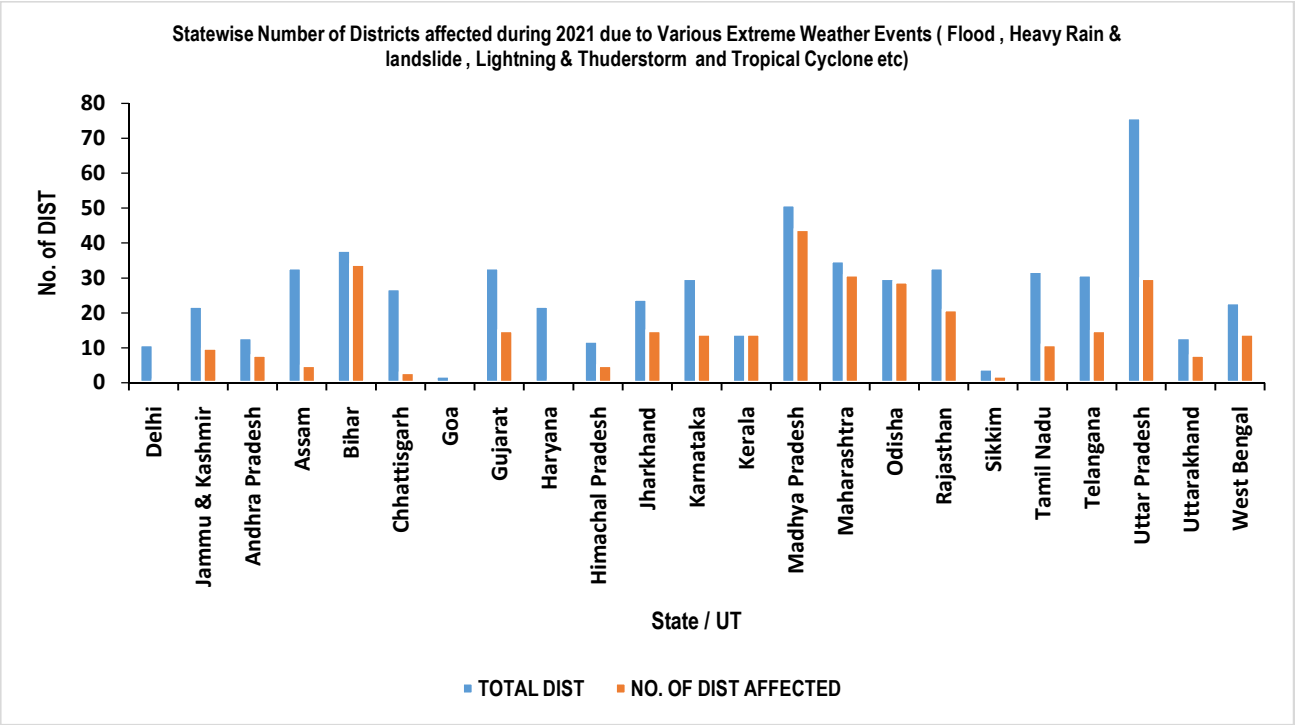

Fig.8:State-wise Number of Districts affected during 2021 due to various Extreme Weather Events