



**INDIA METEOROLOGICAL DEPARTMENT
(MINISTRY OF EARTH SCIENCES)**

**SOUTHWEST MONSOON -2017
END OF SEASON REPORT
RAJASTHAN**

HIGHLIGHTS

- The rainfall over the country as a whole during the monsoon season (June – September) was 95% of its long period average (LPA).
- Seasonal rainfall over Northwest India and Rajasthan were 90% and 109% of their respective LPA.
- Seasonal rainfall was 92% of its LPA over East Rajasthan and 139% of its LPA over West Rajasthan.
- Monthly rainfall over the state was 192% of LPA in June, 161% of LPA in July, 66% of LPA in August and 48% of LPA in September.
- Out of 33 districts, 4 districts received largely excess rainfall; 6 districts received excess rainfall; 9 districts received normal rainfall and 14 district received deficient rainfall during the season.
- On a micro level, out of 245 tehsils, 32 tehsils received largely excess rainfall; 23 tehsils received excess rainfall; 73 tehsils received normal rainfall; 104 tehsils received deficient rainfall and 11 tehsils received largely deficient rainfall during the season.
- Southwest monsoon reached parts of southeast Bay of Bengal, south Andaman Sea and Nicobar Islands on 14th May (6 days ahead of its normal date). It advanced over Kerala on 30th May (2 days ahead of the normal schedule) and covered the entire country by 19th July (4 days later than the normal date).
- Monsoon withdrawal commenced from West Rajasthan on 15th September with a delay of nearly 3 weeks. It completely withdrew from Rajasthan on 11th October, 2017.

1. Onset and Advance of southwest Monsoon

With the formation of a cyclonic circulation over Andaman Sea, southwesterlies crossing the equator strengthened and deepened leading to persistent cloudiness and rainfall over the region. This resulted into advance of Southwest monsoon (SWM) into some parts of southeast Bay of Bengal, Nicobar Islands, entire south Andaman Sea and parts of north Andaman Sea on 14th May. The SWM advanced over Kerala on 30th May.

The formation of first intense low pressure system as a Deep Depression over North Bay of Bengal and its northward movement during 11th – 12th June accelerated the monsoon westerlies. This led to advancement of monsoon which almost covered most parts of Peninsular India and entire northeast India by 14th June. During the third week of June, the stronger than normal cross equatorial flow over the Bay of Bengal, increase in north-south pressure gradient and establishment of Tibetan High in its normal position, led to the increased rainfall over the core monsoon zone. This led to further advance of SWM over most parts of central and western India by 27th June. It covered remaining parts of north Arabian Sea, Saurashtra & Kutch, Gujarat region, some more parts of Madhya Pradesh and some parts of south Rajasthan by 27th June. A well-marked low pressure area formed over Indo-Gangetic plains, SWM advanced into remaining parts of Himachal Pradesh and Jammu & Kashmir and some more parts of east Rajasthan, Haryana and some parts of Punjab on 12th July. Further, with the subsequent advance on 14th, 17th and 18th, it advanced into remaining parts of west Rajasthan, Haryana and Punjab on 19th and thus covering the entire country on 19th July 2017. Isochrones of advance of monsoon 2017 is shown in Fig. 1.

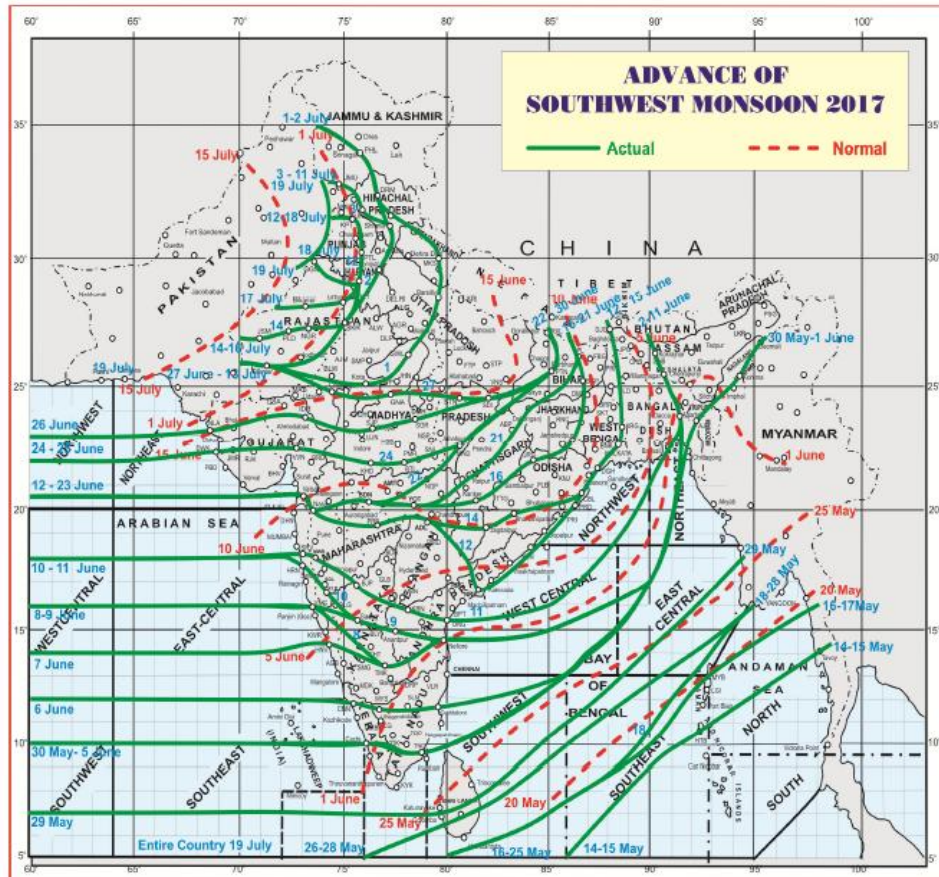


Fig.1: Progress of Southwest Monsoon – 2017

2. Chief Synoptic Features

The rainfall activity over Indian main land during this season was mainly decided by the intra-seasonal activity of the synoptic systems over Indian monsoon region. In the intra-seasonal scale, the rainfall activity over monsoon trough zone including central India and neighboring northwest India has a positive (negative) relationship with the number of low pressure systems (LPS) (lows, depressions, cyclones etc.) and LPS days over the Indian monsoon region (northwest Pacific).

During the season, 14 low pressure systems formed over the Indian subcontinent. Their month-wise frequency are given in the table below.

Systems / Month	Deep Depression	Depression	Well marked low pressure area	Low pressure area
June	1	0	2	2
July	0	2	1	3
August	0	0	2	0
Sept.	0	0	1	0

Table : Frequency of low pressure systems over Indian region during monsoon season, 2017

During the season, 4-6 depressions form over the Indian monsoon region. This year, 11 low pressure areas formed in the first half of the season with 3 of them intensifying into depressions. On the other hand, during the second half of the season, only 3 low pressure systems formed in the Indian monsoon region with none of them intensified into depression. The number of LPS days, had been 11 in June, 12 in July, 10 in August and 6 in September against a normal of 11, 14, 17 & 16 during the respective months. The total number of LPS days during the season had been only 39 as against the normal of 58.

The activity of low pressure systems (with intensity of depression and above) over the northwest Pacific was normal during the first half and above normal during the second half of the season. This resulted in above normal convective activity over the northwest Pacific and below normal convective activity across the entire Intertropical convergence zone including the monsoon trough zone over India during the second half of the season. The below normal rainfall over the central and northwest India during the second half of the season was also caused by the above normal convective activity over southern hemispheric equatorial trough (SHET) during the period. **Tracks of Depressions & Deep Depressions are given in Fig.2.**

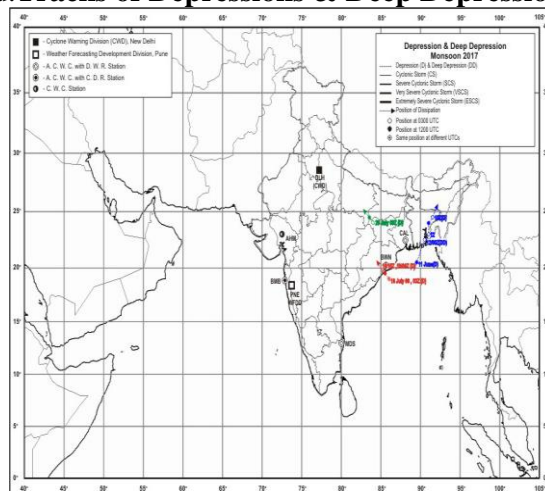


Fig.2: Track of the monsoon Depressions and Cyclonic Storms

3. High Impact Weather Events

Fig. 3 depicts the met. Sub-divisions or parts thereof, which experienced high impact weather events like, floods, landslides, lightning associated with thunderstorm sand Heat waves during the southwest monsoon season (June- September). It also indicates areas that experienced isolated extremely heavy rainfall (Rainfall amount ≥ 21 cm reported during the 24 hours ending at 0830 hrs IST) events during the season. Apart from the flood situations experienced in association with the advance phase of SWM over northeast India and southern most peninsular India, there had been flood situations over various other parts including Odisha, Bihar, Gujarat, Konkan (Mumbai city also experienced extremely heavy rainfall twice during the season viz., 29th August & 19th September), Karnataka, Madhya Pradesh, East Rajasthan (Mount Abu received exceptionally heavy rainfall of 77 cm on 24th July), parts of Haryana etc. High temporal and spatial variability of rainfall caused such floods and flash floods and at the same time, intense convection during the weak phases of monsoon led to events of severe thunderstorms and lightning over major parts of the country.

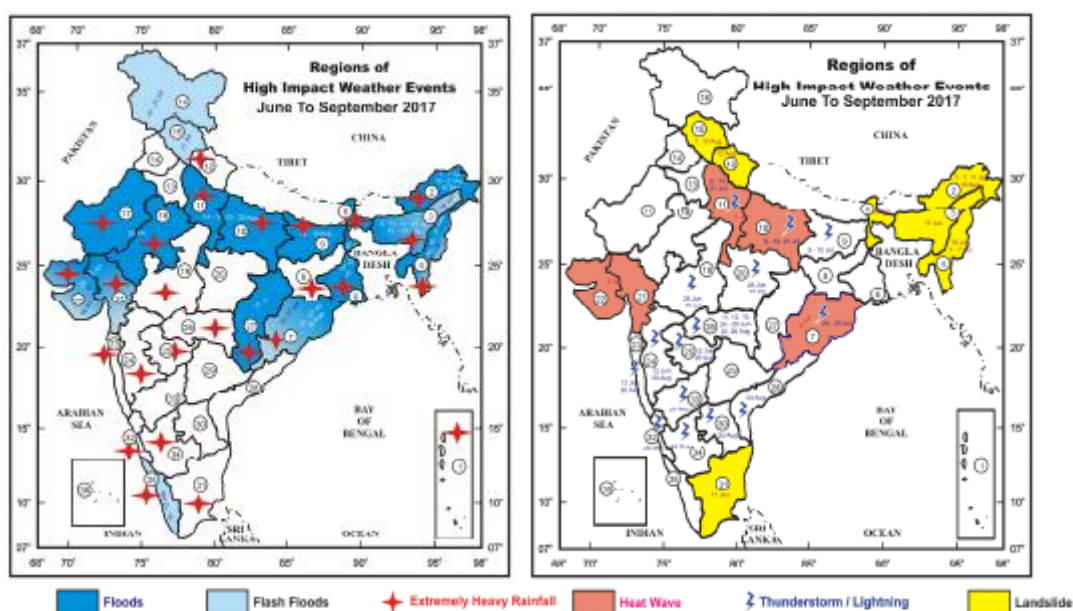


Fig.3: Areas of high impact weather events during the 2017 southwest Monsoon.

Table: List of stations which reported extremely heavy rainfall (> 21 cm in 24 hours) during monsoon season.

Date	Station	District	Rainfall in cm
14/07/2017	Ghatol	Banswara	24
14/07/2017	Pipalkhunt	Pratapgarh	24
24/07/2017	Jawai Dam	Pali	23
24/07/2017	Sumerpur	Pali	23
24/07/2017	Bhinmal	Jalore	26
24/07/2017	Raniwada	Jalore	39
24/07/2017	Mt. Abu	Sirohi	77
24/07/2017	Pindwara	Sirohi	30
24/07/2017	Sirohi	Sirohi	38
24/07/2017	Abu Road	Sirohi	27
24/07/2017	Reodar	Sirohi	40

25/07/2017	Sanchore	Jalore	39
25/07/2017	Gudamalani	Barmer	23
25/07/2017	Mt. Abu	Sirohi	73
25/07/2017	Sirohi	Sirohi	30
25/07/2017	Abu Road	Sirohi	27
25/07/2017	Reodar	Sirohi	45
26/07/2017	Mt. Abu	Sirohi	32
29/07/2017	Pratapgarh	Pratapgarh	24
20/08/2017	Pipalkhunt	Pratapgarh	22

Table: Broken rainfall records in Rajasthan during monsoon season 2017

S.No.	District	Station	Previous Record	New Record
1	Sirohi	Mt. Abu	700.0mm/08 Sep 1992	773.0mm/24 July
2	Sirohi	Reodar	317.0mm/08 Sep 1992	451.0mm/25 July
3	Sirohi	Sirohi	362.7mm/14 Aug 1941	380.0mm/24 July

4. Withdrawal of southwest Monsoon

Dry weather prevailed over western parts of Rajasthan since 18th September. However, the changeover of atmospheric circulation was delayed. Establishment of an anti-cyclone in the lower tropospheric levels, substantial reduction in moisture content and prevalence of dry weather indicated the withdrawal of southwest monsoon from some parts of Punjab, Haryana, most parts of west Rajasthan, some parts of Kutch and north Arabian Sea on 27th September. It further withdrew from remaining parts of Punjab, Haryana, Chandigarh & Delhi, west Rajasthan, Kutch, entire Jammu & Kashmir, Himachal Pradesh, some parts of Uttarakhand, west Uttar Pradesh, most parts of east Rajasthan, some parts of west Madhya Pradesh, north Gujarat region, Saurashtra and some more parts of north Arabian Sea on 30th September. It further withdrew from remaining parts of Uttarakhand, West Uttar Pradesh and East Rajasthan, some parts of East Uttar Pradesh and some more parts of north Madhya Pradesh and Gujarat on 11th October. **Isochrones of withdrawal of monsoon 2017 are shown in Fig. 4.**

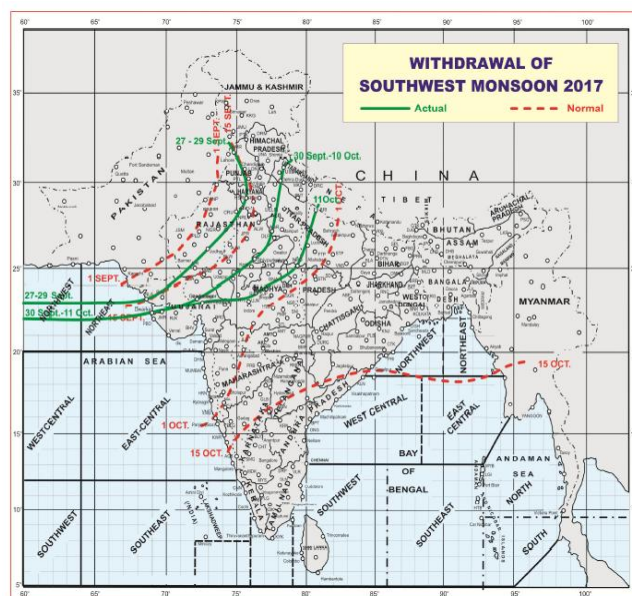


Fig.4: Isochrones of withdrawal of southwest monsoon – 2017

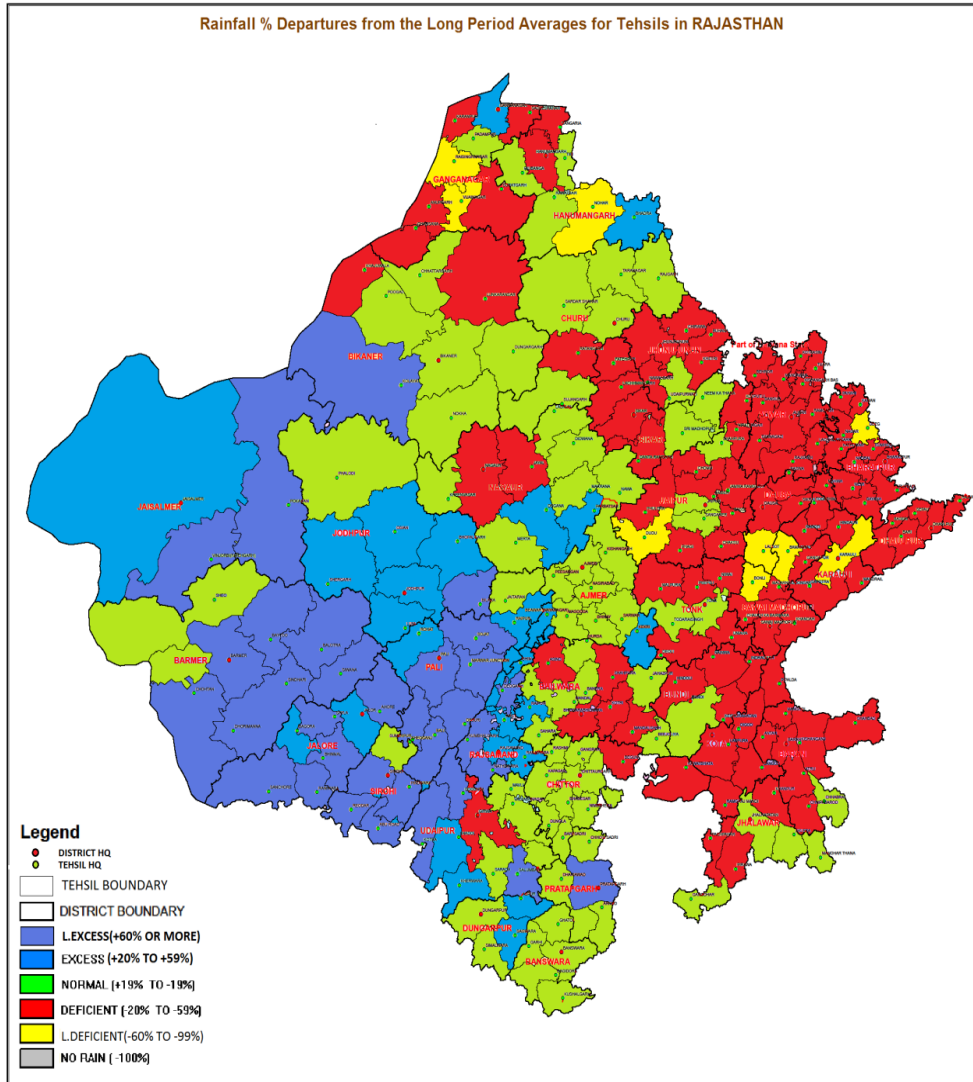


Fig.6: Tehsilwise rainfall distribution over Rajasthan during southwest monsoon season (June to September) – 2017.

The monthly rainfall during monsoon season (June to September) for the State as a whole and its two meteorological sub divisions is given in the table below with respective LPA values.

Table: Rainfall during southwest monsoon 2017 over Rajasthan

Month	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
June	85	44.1	+92
July	252.3	156.8	+61
August	84.8	150.8	-44
September	32.3	66.9	-52

Table: Rainfall during southwest monsoon 2017 over East Rajasthan

Month	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
June	89.1	62.2	+43
July	293.3	225.2	+30
August	137.2	228.4	-40
September	46.4	99.7	-53

Table: Rainfall during southwest monsoon 2017 over West Rajasthan

Month	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
June	81.6	29.8	+174
July	219.7	102.7	+114
August	43.1	89.3	-52
September	21.2	41.1	-49

From the above tables it is observed that Rajasthan received highest rainfall during the month of July, which was 161% of LPA (i.e. excess category). Both East Rajasthan and West Rajasthan received their highest 130% of LPA (excess) and 214% of LPA (excess) respectively during month of July. The rainfall trend was not uniform during the season. During first two months of the season Rajasthan's rainfall was in excess category but in the month of August & September very less rainfall occurred, due to which Rajasthan fell in Deficient category. West Rajasthan received 274% of LPA rainfall and East Rajasthan received 143% of LPA rainfall in the month of June. Trends followed during July, West Rajasthan received 214% of LPA rainfall and East Rajasthan received 130% of LPA rainfall. Several stations received extremely heavy rainfall during this period, creating flood like situation in many areas. Both East and West Rajasthan received deficient rainfall during August & September.

The cumulative seasonal rainfall for the State as a whole was 109% of its LPA and it was 92% and 139% of LPA over East and West Rajasthan respectively. Out of 33 districts, the seasonal rainfall was largely excess in 4 districts, excess in 6 districts, normal in 9 districts and deficient in 14 districts. Karauli district received least rainfall (50% of LPA) and Jalore district received highest rainfall (226% of LPA). The seasonal rainfall for various districts of Rajasthan is given in table below.

Table: District-wise seasonal rainfall distribution monsoon 2017

Sr. No.	State/Districts	Monsoon rainfall in mm (June - September 2017)		
		Actual (in mm)	Normal (in mm)	%Dep
	RAJASTHAN	454.9	419	9
EAST RAJASTHAN				
1	AJMER	486.7	429.6	13
2	ALWAR	300.3	555.3	-46
3	BANSWARA	892.1	831.8	7
4	BARAN	531.8	792.2	-33
5	BHARATPUR	321.6	557.6	-42
6	BHILWARA	559.1	580.9	-4
7	BUNDI	451.8	655.9	-31
8	CHITTORGARH	688.2	709.7	-3
9	DAUSA	323.4	612.1	-47
10	DHOLPUR	344.5	650	-47
11	DUNGARPUR	825.1	637.8	29
12	JAIPUR	342.9	524.6	-35
13	JHALAWAR	799	855.1	-7
14	JHUNJHUNU	253.1	410	-38
15	KARALI	319.5	637.4	-50
16	KOTA	465.5	746.3	-38
17	PRATAPGARH	1090.8	845.8	29
18	RAJSAMAND	728.1	506	44
19	SAWAI MADHOPUR	394.2	664	-41
20	SIKAR	296.1	402.5	-26
21	SIROHI	1815.5	868.6	109
22	TONK	418	566	-26
23	UDAIPUR	810.6	591.3	37
	EAST RAJASTHAN	566.9	615.8	-8
WEST RAJASTHAN				
24	BARMER	465.9	243.4	91
25	BIKANER	212.5	228.7	-7
26	CHURU	280	313.7	-11
27	HANUMANGARH	210.6	252.5	-17
28	JAISALMER	226.1	158.4	43
29	JALORE	892.8	394.2	126
30	JODHPUR	400.5	274.5	46
31	NAGPUR	366.6	348.5	5
32	PALI	785.5	446.7	76
33	SRI GANGANAGAR	147.5	201.4	-27
	WEST RAJASTHAN	365.9	263.2	39

Weekly rainfall distribution over the two Meteorological sub divisions of the state is shown in the following charts (Figure 7 to 10).

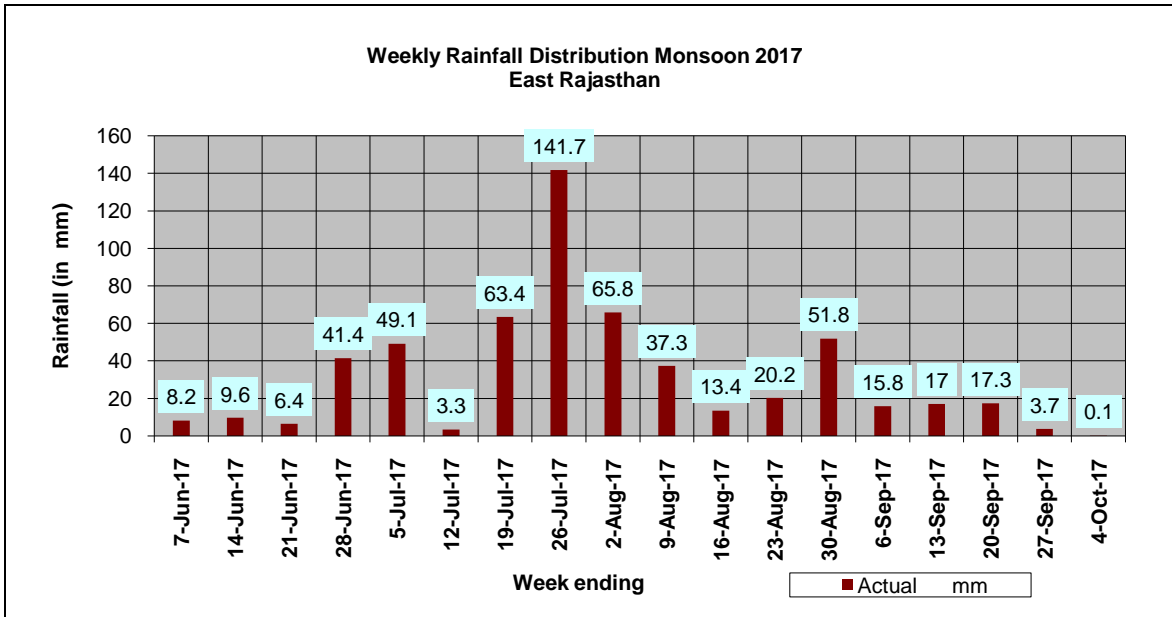


Fig.7 Weekly rainfall distribution over East Rajasthan Monsoon 2017

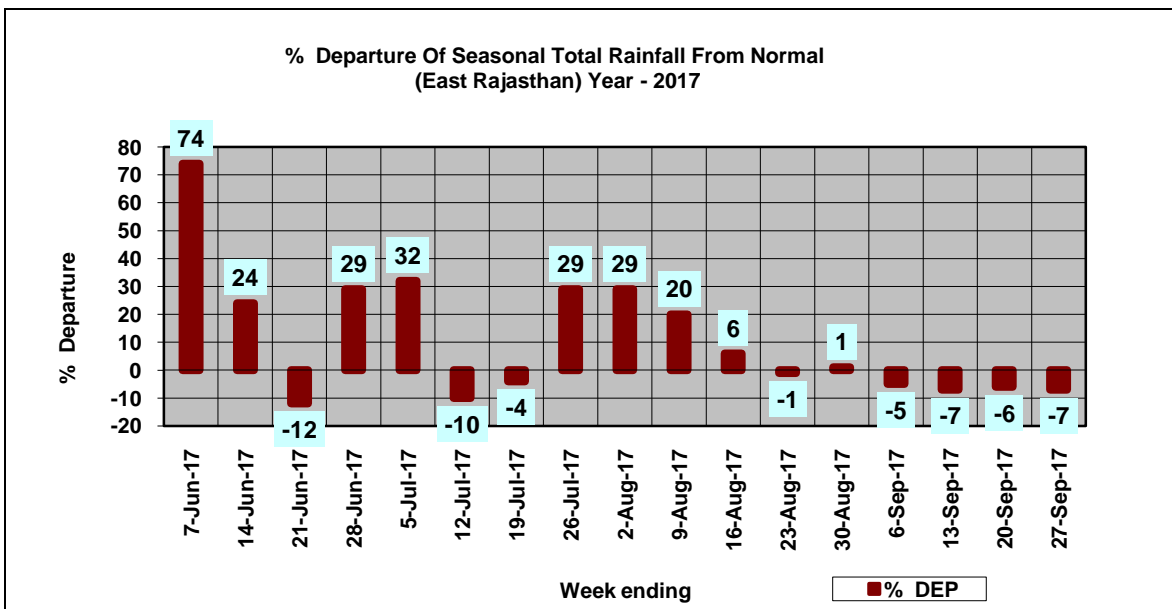


Fig. 8 Percentage departures of cumulative seasonal rainfall over East Rajasthan

The highest rainfall (141.7 mm) was received during the week ending 26th July 2017 over East Rajasthan.

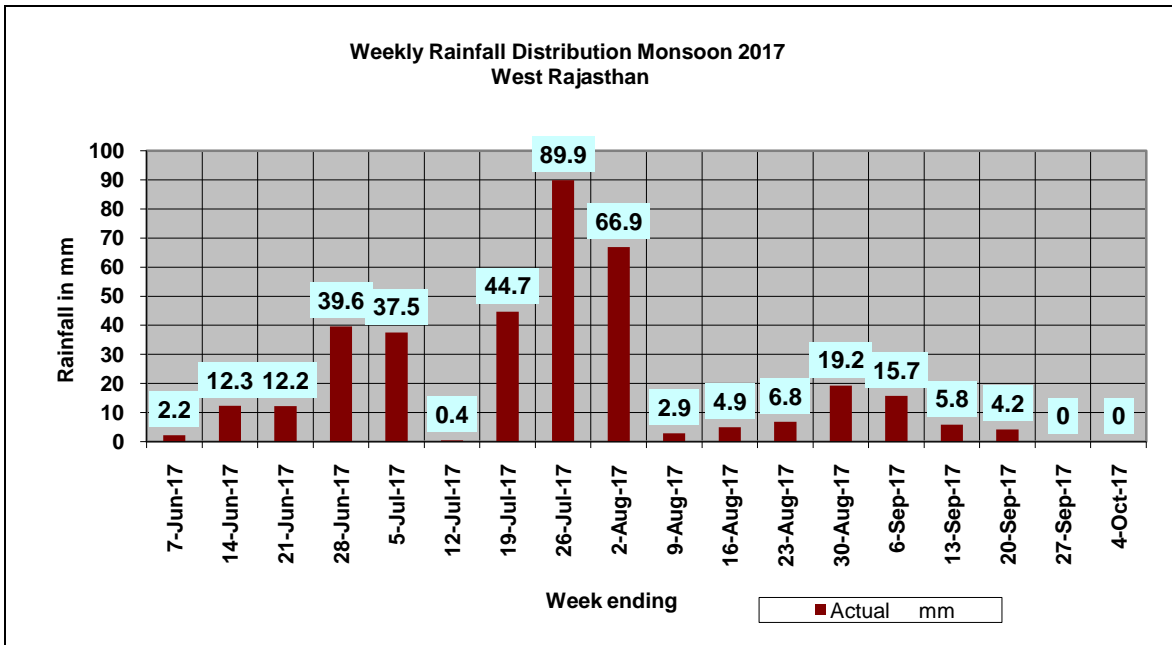


Fig.9 Weekly rainfall distribution over West Rajasthan Monsoon 2017

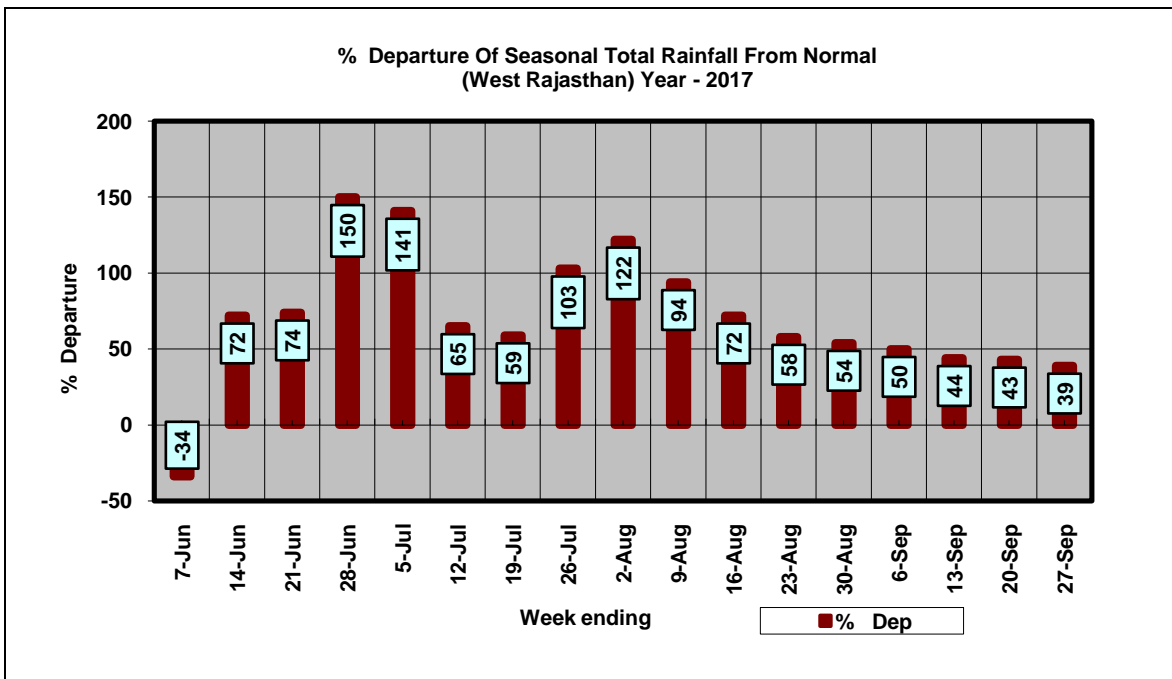


Fig. 10 Percentage departures of cumulative seasonal rainfall over West Rajasthan

Highest rainfall (89.9 mm) was received during the week ending 26th July in West Rajasthan.

The district wise weekly rainfall distribution over the state of Rajasthan during South West monsoon season 2017 is shown in the following table.

Table: Districtwise weekly rainfall distribution monsoon 2017

DISTRICTWISE WEEKLY RAINFALL IN MM MONSOON - 2017																			
S.NO.	DISTRICTS	7-Jun	14-Jun	21-Jun	28-Jun	5-Jul	12-Jul	19-Jul	26-Jul	2-Aug	9-Aug	16-Aug	23-Aug	30-Aug	6-Sep	13-Sep	20-Sep	27-Sep	4-Oct
EAST RAJASTHAN																			
1	AJMER	1.2	13.1	5.6	70.7	49.4	0	47	89	44.1	65.7	20.7	7.3	41.5	3.1	23.8	4.6	0	0
2	ALWAR	13.1	1.6	19.6	15.9	51.8	9.1	21.9	30.6	37.2	15.8	6.7	7.1	35.2	15.8	14.8	0	5.6	0
3	BANSWARA	0.6	38.6	0	56	43.2	1.7	164.1	214.5	48.1	5.4	18.1	103.8	84.7	22.7	33	57.5	0	0
4	BARAN	0.8	7.1	2.8	28.8	48	0	53.6	92.9	50.1	68.1	11.8	10.6	44.6	16.5	44	18.4	33.8	0
5	BHARATPUR	15.3	1.7	29.1	14.7	45.6	13.2	12.5	50.5	12.6	28	25.8	8.7	20.2	23	6.2	1.3	13.2	0
6	BHILWARA	2.7	11	1	73	22.6	0.4	66.8	118.5	67.3	61.8	28.8	5	47.8	10.1	16.8	23.9	0	0
7	BUNDI	0	7.7	0	67.2	21.5	4.7	25.7	84.8	28.3	101.2	17	23	41.3	3	18.3	6.8	0.2	0
8	CHITTORGARH	0	14.2	3.4	60.1	20.4	3.4	100.5	158.9	140.2	32	20.7	7.9	62.9	16.7	16.1	30.9	0	0
9	DAUSA	9.6	0.8	28	29.6	28.6	1	20.2	52.8	32.4	27	18.6	15	30	12.6	20.2	7.6	0	0
10	DHOLPUR	12.7	1.5	18.5	9.2	37.8	3.2	4.8	49.2	18.7	57.5	14.8	17.8	42.5	34.2	5.7	0.7	15.8	0
11	DUNGARPUR	0	19.2	2.1	45.6	54.8	6.9	93.5	234.9	59.8	15.8	16.1	89.9	95.2	28.4	26.3	35.1	0	1.5
12	JAIPUR	20.2	6.6	4.2	26.7	44.5	2	37.2	55.4	32.1	8.3	4.8	3.3	63	13.6	13.9	7.3	0	0
13	JHALAWAR	2	15.5	0.2	40.2	65	0	136.1	78.7	186.4	59.5	7.3	12.7	77.4	14.3	37.8	30.3	23.1	0
14	JHUNJHUNU	20.7	4.6	13.3	23.2	60.6	0	17	32.1	33.7	0	2.8	9.1	15.3	9	3.4	7.3	0	0
15	KARALI	10.7	0.2	9	17.7	59.7	0	24	47.7	21.5	51.6	5.3	16.3	25.7	5.5	11.5	12.3	0	0
16	KOTA	2.6	10	0.4	43.5	24.9	0	39.8	68.8	55.5	111.3	24.4	10.3	24.4	6.7	24.9	9.1	0.9	0
17	PRATAPGARH	0	20.6	14.8	58	26.8	6.4	175.8	274	155.4	9.8	25.4	101.2	145.6	27.6	15.2	33.6	0.4	0.2
18	RAJSAMAND	0	14.1	0	73.9	27.1	2.1	58.7	282.4	62.3	39	19.9	5	52.3	16.4	22.1	35.9	0	0
19	SAWAI MADHOPUR	10.3	6.1	0.3	21	60	13.4	33.5	71.9	23.5	69.8	3.8	3.9	39.6	6.5	4.8	25.9	0	0
20	SIKAR	18.5	11.5	13.9	29.9	57.6	0	19.2	25.5	45.6	1.4	4.3	13.9	27.4	18.7	6.9	3.3	0	0
21	SIROHI	6.2	5.9	2.1	32.5	144.3	1.5	171.4	1080.9	215.7	9.1	9.9	32.9	32.5	41.8	9.5	15.2	1	0
22	TONK	4	8.2	0.1	31.2	63.1	1.9	28.6	95	25.1	73	12.3	6.6	44.1	6.2	7.8	5.5	1	0
23	UDAIPUR	14.2	9.3	3.6	51.2	63.6	6.8	116.9	227.4	100	2.9	8.1	45	85.1	27.5	14.7	33.9	0	0.5
WEST RAJASTHAN																			
24	BARMER	0	5.6	3.5	32.2	51.8	0.1	43.2	162.4	116	0.2	1.6	7.3	17.3	18.1	0	6.8	0	0
25	BIKANER	5.3	15.5	19.6	42.1	15.7	0	16.7	5.2	15.1	0	9.4	0.1	23.9	26.8	11.2	2.6	0	0
26	CHURU	7	10.7	16	32.4	43.7	3.1	30.9	7.1	70.8	2.3	10.7	1.9	8.8	21.3	3.8	2.8	0	0
27	HANUMANGARH	0.7	11.1	34.4	17.1	31.3	1.6	30.3	6	19.7	0	0.6	0	16.4	36.1	5	0	0	0
28	JAISALMER	0	10.2	4.8	11.5	22.3	0	58	37.8	60.8	0	0	4.9	7.9	8	0.1	0.3	0	0
29	JALORE	0	10.9	4.1	53.1	78.5	0	81.3	464.1	148.7	0	3.5	15.5	14	11	0	8	0	0
30	JODHPUR	0	17.9	13.9	67.5	35.2	0	54.5	88.8	59.2	6.3	3.9	18.5	12.2	5.4	7.3	8.7	0	0
31	NAGOUR	7.8	15.1	8	69.4	78.3	0	33.9	36	23	2.9	3.9	4.9	45.5	6	25.9	4.3	0	0
32	PALI	0	19.4	18.4	78.2	32.7	0	76.3	266.1	171.5	25.9	20.5	17	52.3	3.3	1.7	7.4	0	0
33	SRI GANGANAGAR	2.9	7.6	22	7.1	7.4	1.5	30.8	0.5	15.3	0	0.4	0	0.8	43.9	2.5	3.2	0	0

LESS 10 10-20 20-50 50-100 GREATER THAN 100

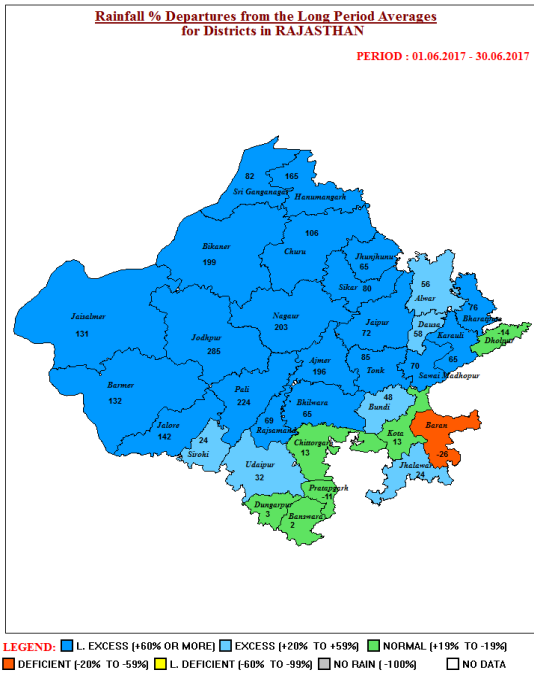


Fig.11 Districtwise Monthly Rainfall Distribution Over Rajasthan – June

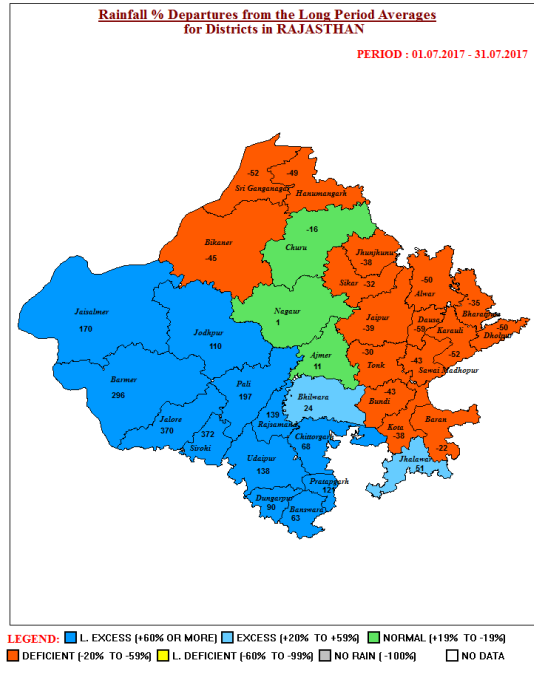


Fig. 12 Districtwise Monthly Rainfall Distribution Over Rajasthan - July

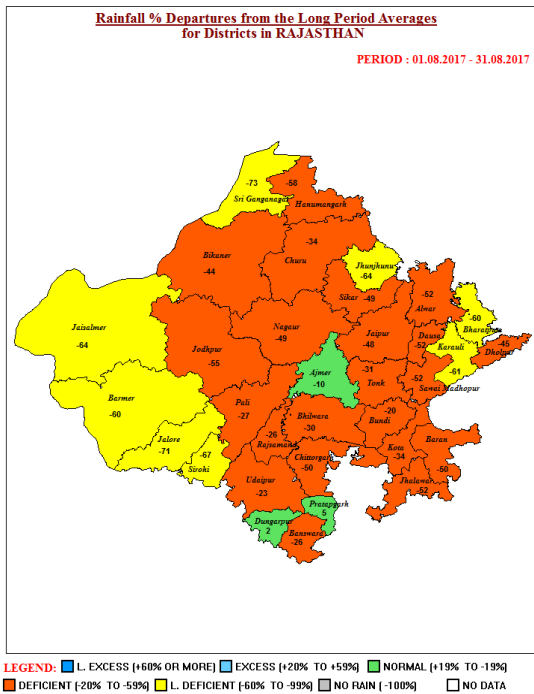


Fig. 13 Districtwise Monthly Rainfall Distribution Over Rajasthan - August

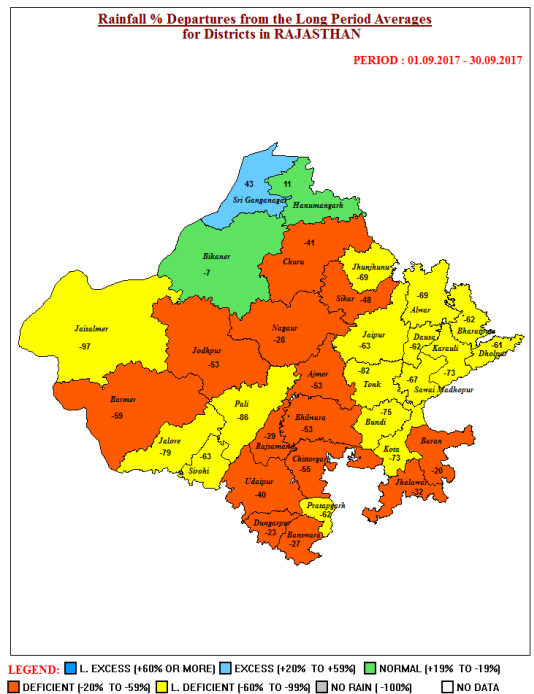


Fig. 14 Districtwise Monthly Rainfall Distribution Over Rajasthan - September

During June 2017 out of 33 districts, 20 districts received largely excess , 6 districts excess, 6 districts normal and 1 district deficient rainfall. During July 12 districts received largely excess, 2 districts excess, 3 districts normal and 16 districts deficient rainfall. During August 3 districts received normal, 22 districts deficient and 8 districts largely deficient rainfall. During September 1 district received excess, 2 districts normal, 14 districts deficient and 16 districts largely deficient rainfall.

During the 2017 monsoon season West and East Rajasthan subdivisions received excess and normal rainfall as shown in **Figure 15**.

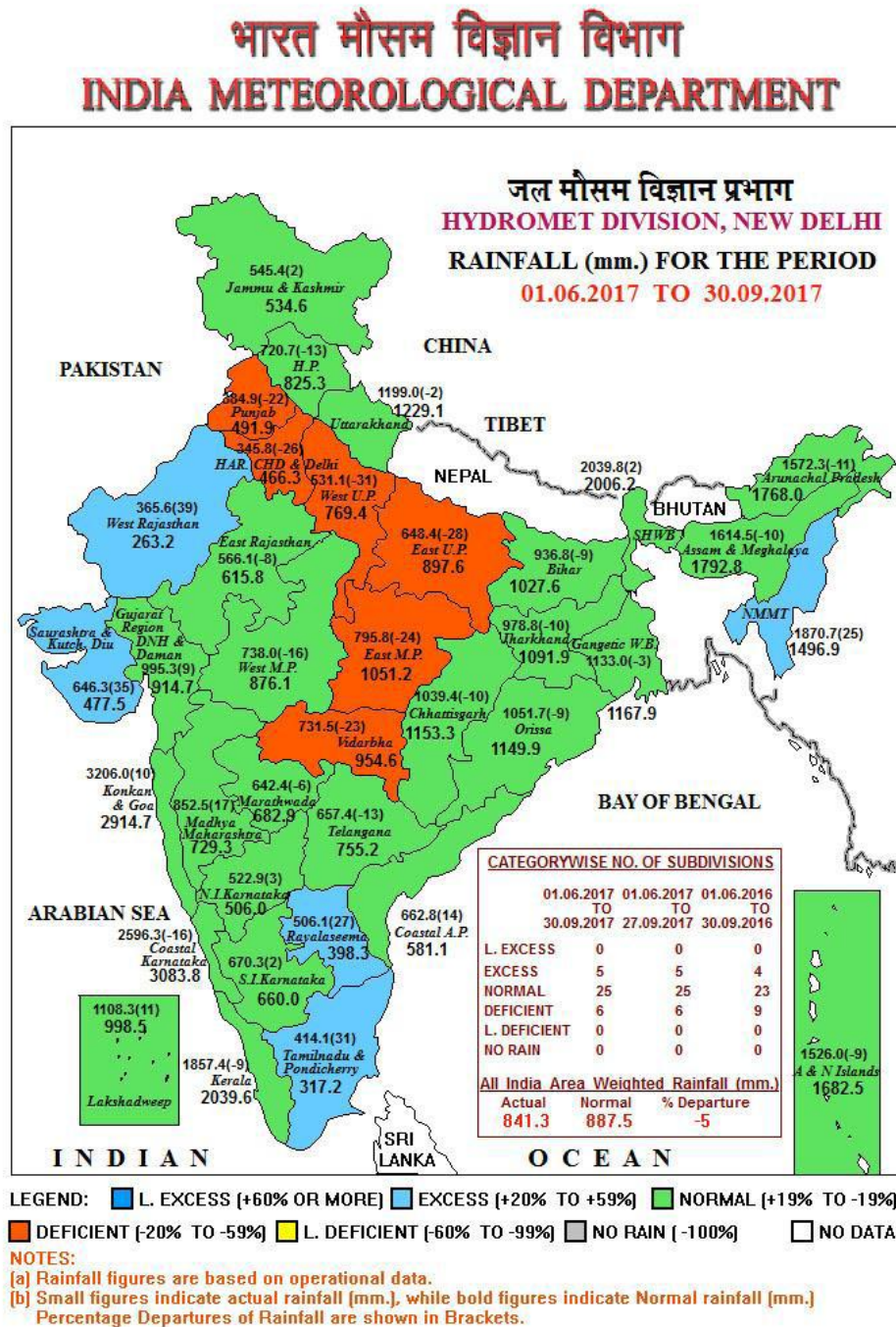


Fig.15 Subdivision Wise Seasonal Rainfall Distribution Over India (June-September 2017)

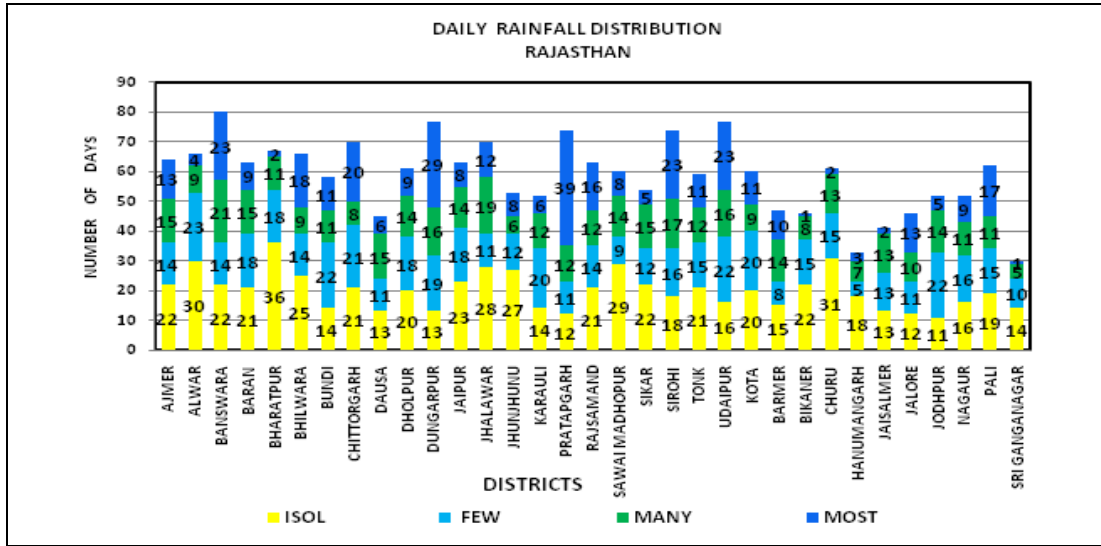


Fig.16 Districtwise Daily Spatial Rainfall Distribution

Fairly wide spread to wide spread rainfall occurred on 6 days (minimum) to 51 days (maximum) over different districts in Rajasthan during the whole monsoon season. Pratapgarh district got wide spread rainfall on 39 days (highest) during the whole season.

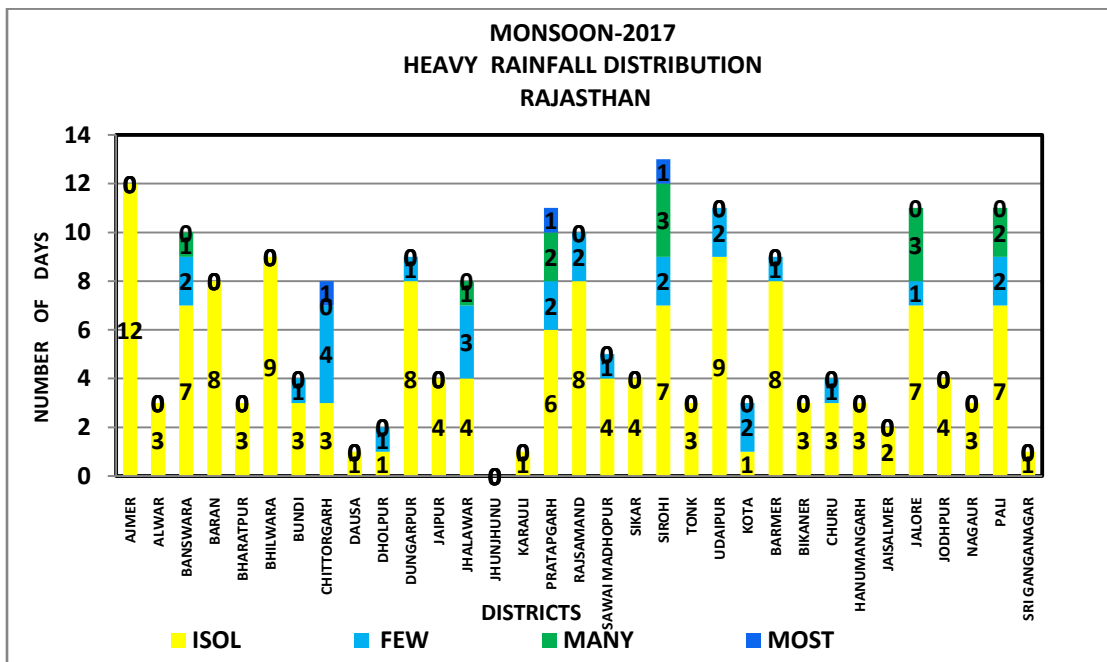


Fig.17 District wise Daily Heavy Rainfall Distribution

Heavy to very heavy rainfall occurred at isolated to most places in all districts of the state on a few days. The districts namely Chittorgarh, Pratapgarh and Sirohi received heavy rainfall at most places on 1 day each during the whole season. Banswara, Jhalawar, Pratapgarh, Sirohi, Jalore and Pali districts experienced heavy rainfall at many places on 1 to 3 days during the season.

MONSOON 2017 TEHSILWISE RAINFALL DISTRIBUTION

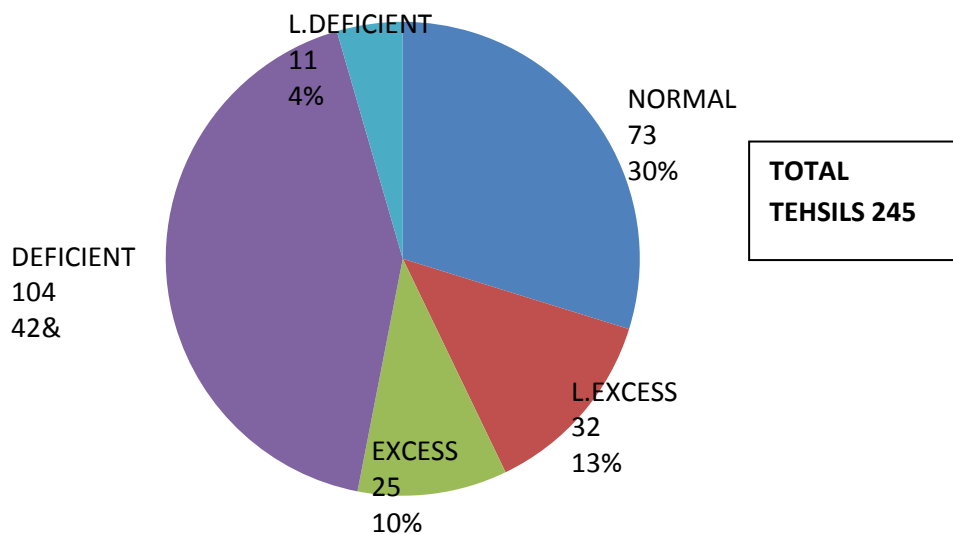


Fig.18 Tehsilwise Seasonal Rainfall Distribution

32 tehsils received largely excess, 25 tehsils received excess and 73 tehsils received normal rainfall during the season. The rainfall was deficient in 104 tehsils and it was largely deficient in 11 tehsils. The worst affected districts during this season were Sri Ganganagar in West Rajasthan and Karauli in East Rajasthan. Out of 9 tehsils in Sri Ganganagar district, 2 tehsils got largely deficient and 5 got deficient rainfall. Out of 6 tehsils in Karauli district, 1 tehsils got largely deficient and 5 got deficient rainfall. The daily rainfall timeseries is shown in **figure 19 to 21** for East Rajasthan, West Rajasthan and Rajasthan respectively. The intensity of distribution of rainfall (in terms of number of stations reported rainfall) for East and West Rajasthan is shown in **figure 22 and 23**.

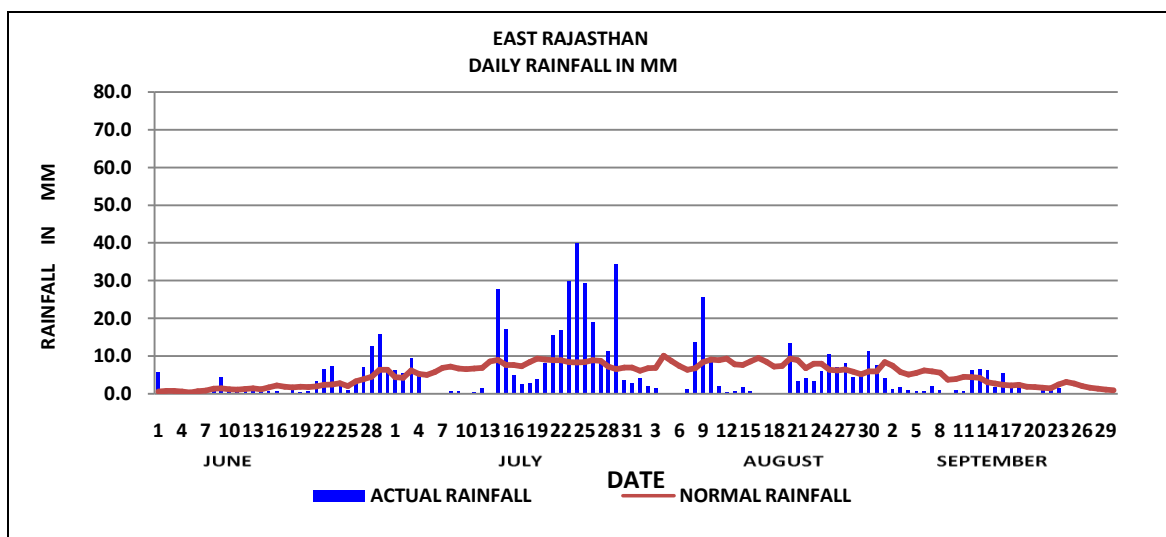


Fig.19 Daily Average Rainfall over East Rajasthan

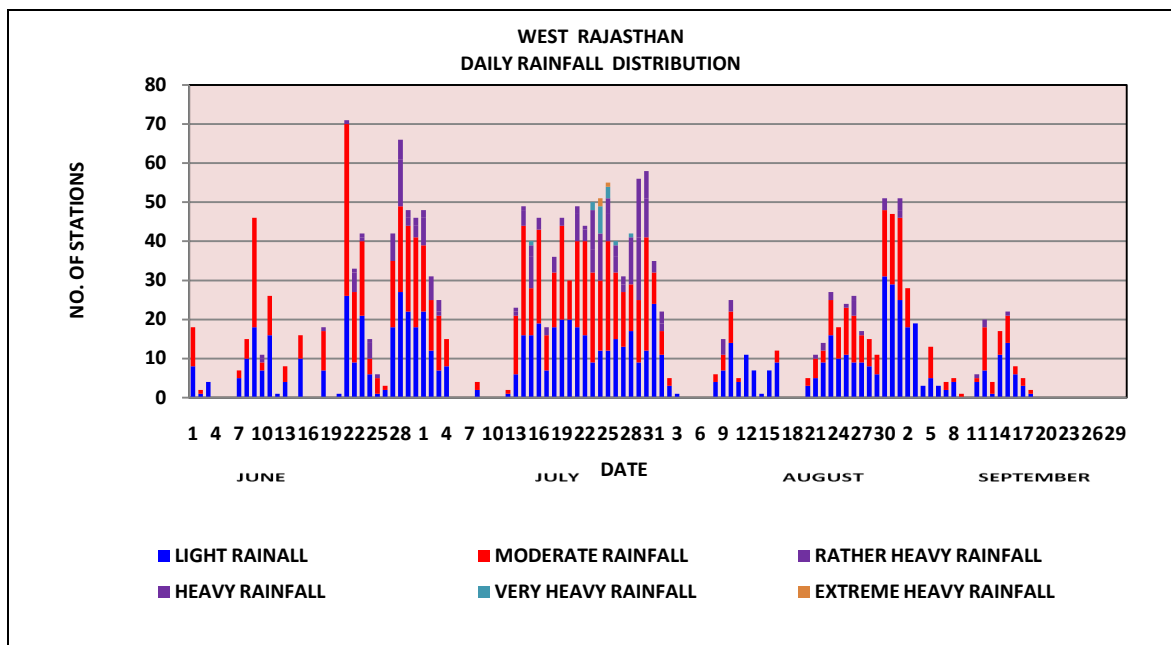


Fig.23 Daily Rainfall Intensity Distribution Over West Rajasthan (Monsoon Season 2017)

6. Verification of the Long Range Forecasts

The southwest monsoon rainfall for (June to September) over northwest India was predicted (96% of LPA) with a model error of $\pm 8\%$. The actual rainfall for this region and the State (part of NW India) were 90% of LPA (i.e 6% of LPA less than the forecast). Thus the forecast for the seasonal rainfall are realized to be within the stipulated forecast error ranges.

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