

**INDIA METEOROLOGICAL DEPARTMENT
METEOROLOGICAL CENTRE, JAIPUR**



**RAJASTHAN
MONSOON REPORT-2018**

Prepared by:

**METEOROLOGICAL CENTRE JAIPUR
PRABHUDAYAL MARG, SANGANER
JAIPUR, RAJASTHAN**

SOUTHWEST MONSOON -2018 END OF SEASON REPORT

HIGHLIGHTS

- The rainfall over the country as a whole during the monsoon season (June – September) was 91% of its long period average (LPA).
- Seasonal rainfall over Northwest India and Rajasthan were 98% and 94% of their respective LPA.
- Seasonal rainfall was 103% of its LPA over East Rajasthan and 77% of its LPA over West Rajasthan.
- Monthly rainfall over the state was 168% of LPA in June, 97% of LPA in July, 61% of LPA in August and 111% of LPA in September.
- Out of 33 districts, 4 districts received excess rainfall, 23 districts received normal rainfall, 05 district received deficient rainfall and 01 district received large deficient rainfall during the season.
- Southwest monsoon current reached south Andaman Sea and Nicobar Islands on 25th May (5 days later of its normal date), but further advance was relatively faster. It set in over Kerala on 29th May, 3 days ahead of its normal date, thereafter progressed rapidly and covered the entire country in one month (on 29th June) well ahead of its normal schedule. Monsoon withdrawal commenced from West Rajasthan on 29th September (with a long delay of almost one month). It completely withdrew from Rajasthan on 21st October, 2018.
- During the season, 10 monsoon low pressure systems (1 cyclone, 1 Deep Depression, 4 Depressions, 2 well marked low pressure areas & 2 low pressure areas) formed against an average of 6 Depressions & 8 low pressure areas.

1. Onset and Advance of southwest Monsoon :-

This year, the latter half of May remained cyclogenetically active over the north Indian Ocean. After the dissipation of the Cyclonic Storms 'SAGAR' and 'MEKUNU' which formed over the Arabian Sea, southerly to southwesterly winds prevailed over southeast Bay of Bengal and south Andaman Sea from 24th May. In view of the strengthening and deepening of Cross Equatorial Flow (CEF) and enhanced cloudiness and rainfall, southwest monsoon advanced into South Andaman Sea, some parts of South Bay of Bengal and Nicobar Islands on 25th May. It further advanced into some parts of South Arabian Sea and Maldives-Comorin area, some more parts of South Bay of Bengal, Andaman & Nicobar Islands and Andaman Sea on 27th May. Some more parts of southeast Arabian Sea, Maldives-Comorin area and Bay of Bengal, remaining parts of Andaman Sea, Andaman & Nicobar Islands were covered on 28th May.

In association with the genesis of a well-marked low pressure area over southeast Arabian Sea off Kerala – Karnataka coasts and another low pressure area over east central Bay of Bengal and neighborhood on 28th May, the CEF along the Indian longitudes further strengthened and deepened. Consequently the low pressure area over the Bay of Bengal became well marked and concentrated into a Depression on 29th May. The resultant enhanced convection and rainfall caused further advance of southwest monsoon into remaining parts of southeast Arabian Sea, Comorin - Maldives area, entire Lakshadweep, most parts of Kerala, some parts of Tamil Nadu and some more parts of Bay of Bengal on 29th. Thus the southwest monsoon set in over Kerala on 29th May 2018, three days ahead of its normal date of onset.

Thereafter, monsoon flow pattern weakened in general and this resulted in a 'hiatus' in the advance of southwest monsoon during 13th – 22nd June. This period was characterized by the shifting of the active convection zone over to the Pacific Ocean, which in-turn led to enhanced cyclogenesis and channeling of cross equatorial flow towards that region.

After the hiatus, monsoon gradually progressed into more parts of Maharashtra, Gujarat, Madhya Pradesh and West Bengal on 23rd & 24th June. It further advanced into some more parts of Odisha, most parts of West Bengal and some parts of Bihar and Jharkhand on 25th June. It further advanced into: more parts of Odisha, remaining parts of West Bengal and most parts of Bihar and Jharkhand on 26th June and into some more parts of Gujarat region, some parts of East Rajasthan, remaining parts of Maharashtra, Chhattisgarh, Odisha, Bihar and Jharkhand, entire Madhya Pradesh & East Uttar Pradesh, most parts of West Uttar Pradesh, Uttarakhand & Himachal Pradesh, entire Jammu & Kashmir and some parts of Punjab on 27th June. It then advanced into some more parts of Gujarat Region, most parts of East Rajasthan, some parts of West Rajasthan, entire Haryana, Chandigarh & Delhi and remaining parts of West Uttar Pradesh, Uttarakhand, Himachal Pradesh and Punjab on 28th June. It further advanced into remaining parts of Gujarat State, Rajasthan and North Arabian

Sea and thus the Southwest Monsoon covered the entire country on 29th June 2018, two weeks earlier than the normal date of 15th July.

In the recent past, the years 2015 & 2013 had also witnessed rapid advance of southwest monsoon when it covered the entire country on 26th June & 16th June respectively.

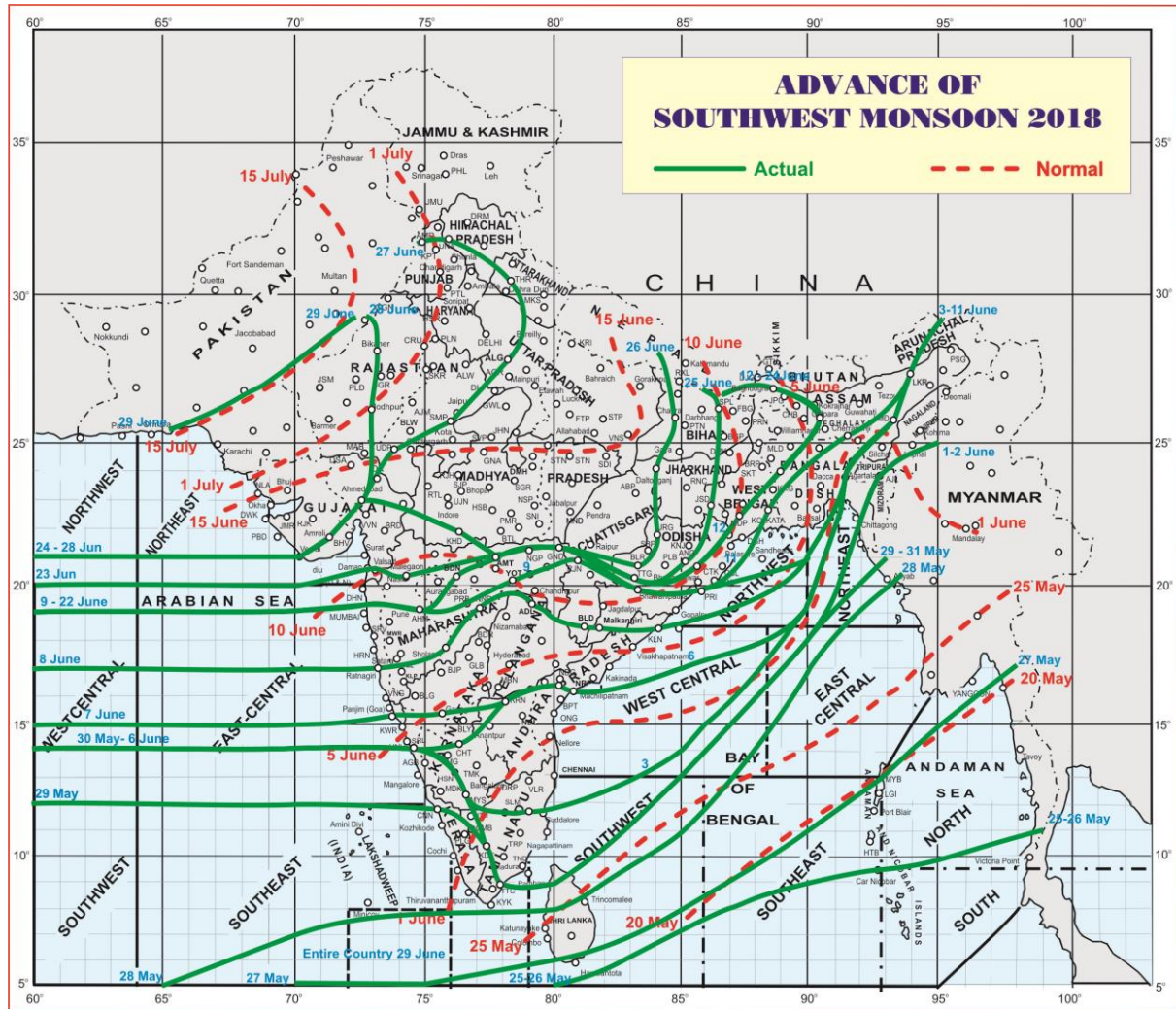


Fig.1: Isochrones of monsoon progress during 2018.

2. Chief Synoptic Features:-

During the season, 10 monsoon low pressure systems formed over the Indian region. Out of these, one system intensified into a Cyclonic Storm, one into a Deep Depression and 4 into Depressions. Their month-wise frequency and intensity are given in the table below. The season normally witnesses 6 Depressions and 8 low pressure areas.

Table 1: Number of Low-pressure System (LPS) including Low (L), Well Marked Low (WML), Depression (D), Deep Depression (DD), Cyclonic Storm (CS) and number of LPS days in monsoon 2024.

Systems/ Month	CS	DD	D	WML	L	Total Systems
June	0	0	1	0	0	1
July	0	0	1	1	1	3
August	0	0	2	1	1	4
September	1	1	0	0	0	2

The first low pressure system of the current monsoon season formed over northeast Bay of Bengal and adjoining Bangladesh coast on 10th June. It crossed Bangladesh coast and weakened over the land during the same night. Also, this had been the only intense low pressure system during June. Though short lived, it caused further strengthening of the CEF and enhanced rainfall along the west coast. The first system in July formed as a low pressure area over northwest Bay of Bengal & neighbourhood on 7th. This too had been short lived and became less marked on 8th. However, the remnant cyclonic circulation moved westwards up to northeast Madhya Pradesh and neighbourhood, providing well distributed rainfall along its track and thereby causing the southwest monsoon to advance over these regions upto 12th June.

The second system of July had been a well-marked low pressure area, during 13th – 19th July. Under the influence of a cyclonic circulation, a low pressure area formed over northwest Bay of Bengal & neighbourhood on 13th. It became a well-marked low pressure area over the same region 14th night. It gradually moved westwards up to central parts of north Madhya Pradesh and neighbourhood as a low pressure area and became less marked on 19th July.

The third system of July formed as a low pressure area over northwest Bay of Bengal and adjoining Gangetic West Bengal and Odisha on 19th July which concentrated into a Depression on 21st July morning. It crossed the coast in the evening of 21st July between Balasore and Digha and moved west northwest-wards across the central parts of the country. While moving west northwest-wards it weakened and its remnant lay over northwest Uttar Pradesh and neighbourhood as a low pressure area on 28th July. Under the influence of the system, widespread and intense rainfall activity occurred over Odisha, Gangetic West Bengal, Chattisgarh, Jharkhand and Madhya Pradesh.

Its persistence over West Uttar Pradesh and neighbourhood for nearly three days caused fairly widespread to widespread rainfall activity with heavy to very heavy and extremely heavy falls over Western Himalayan Region and adjoining plains of northwest India during 26th– 28th July.

The convective phase of Madden Julian Oscillation (MJO) remained nearly stationary over the tropical Pacific Ocean with moderate to high amplitude during the second week of August. The first system of August formed as a Low pressure area over Northwest Bay of Bengal and neighbourhood on 6th August. It subsequently concentrated into a Depression and crossed north Odisha –West Bengal coasts and moved west northwest-wards and weakened into Well Marked Low Pressure Area over Chattisgarh & neighbourhood and finally lay as a low pressure area over north Madhya Pradesh and neighbourhood on 9th August. It caused fairly widespread to widespread rainfall activity with heavy to very heavy and extremely heavy falls over eastern parts of Central India.

Moreover, genesis of this Depression resulted in the strengthening of low level westerlies causing widespread rainfall activity along the west coast. During its westward movement, convergence of easterlies along the foot hills caused fairly widespread to widespread rainfall with isolated heavy to very heavy falls over Western Himalayan Region and adjoining plains of Northwest India.

The second system in August formed as a low pressure area over North West Bay of Bengal and adjoining Coastal areas of West Bengal & Odisha on 13th August. It subsequently concentrated into a Depression and lay over Coastal Odisha and neighborhood on 15th August, moving west-northwestwards, it weakened gradually and lay as a low pressure area over southwest Madhya Pradesh and neighborhood on 17th August. Under its influence, fairly widespread to widespread rainfall activity with heavy to very heavy falls had been reported from parts of east and adjoining central India. Strengthening of the monsoon flow due to the formation of the low pressure system has caused widespread intense rainfall activity over south peninsular India.

Western part of the monsoon trough remained north of its normal position for about three days during 12th, 13th & 14th August. This resulted in fairly widespread to widespread rainfall activity with heavy to very heavy falls over Western Himalayan Region and adjoining plains of northwest India.

During the above mentioned active phase, vigorous monsoon conditions occurred on 5-6 days over Kerala and southern parts of Karnataka. There had been a few instances of extremely heavy rainfall events over these regions as well as over the Ghat sections of Tamil Nadu. From the 3rd week of August, the rainfall over south Peninsula reduced substantially due to the weakening of the CEF.

The third system in August was a Low Pressure area which formed over northwest Bay of Bengal and neighbourhood on 19th August. It subsequently moved west northwestwards before it became less marked over northwest Madhya Pradesh and neighbourhood on 22nd August. Under its influence, widespread very intense rainfall activity had been reported from parts of central India and adjoining peninsular

India. The remnants of the above system also caused fairly widespread to widespread rainfall activity over parts northwest India also.

August witnessed the development of a fourth system, which formed as a Low pressure area over coastal areas of West Bengal, north Odisha and adjoining North West Bay of Bengal on 25th which further developed into a well-marked Low Pressure Area within subsequent 48 hours and lay over Northwest Bay of Bengal and adjoining West Bengal and Odisha coast. Under its influence, Odisha experienced widespread intense rainfall activity during 25th to 27th August. Remnants of this system also caused widespread intense rainfall activity over Chattisgarh and East Madhya Pradesh during 27th to 29th August.

The eastern part of the monsoon trough passed through northeast India on 23rd August and caused fairly widespread to widespread intense rainfall activity over northeastern states for a couple of days. Apart from the above systems, an east– west shear zone in the mid-tropospheric levels across central India and an active monsoon trough with cyclonic circulations in the lower tropospheric levels embedded in that also caused fairly widespread to widespread rainfall activity with isolated heavy falls over parts of central and northwest India during 23rd– 29th August.

In the last few days of August and initial days of September, the monsoon trough remained slightly north of its normal position but remained active with two to three cyclonic circulations in the lower tropospheric levels embedded in it. This situation caused fairly widespread to widespread rainfall with isolated intense rainfall activity over parts of northwest India (including Western Himalayan Region), east and northeast India and adjoining central India during 30th August to 5th September. However during this period, monsoon activity remained subdued over south peninsular India and over Maharashtra and Gujarat states.

The first system during September formed as a Low pressure area over northwest Bay of Bengal & neighbourhood in the morning of 5th September and became a well-Marked Low pressure area by the evening of the same day. It concentrated into a Depression and further intensified into a Deep Depression on 6th September. It crossed West Bengal coast and moved north-westwards and weakened gradually. Under the influence of the system, widespread and very intense rainfall activity occurred over Odisha. The system also caused widespread and intense rainfall activity over Chhattisgarh, Madhya Pradesh and East Rajasthan.

During 6th – 12th September, the monsoon trough lay to the north of its normal position and its eastern end extended across northeastern states on 10th & 11th. Also a north-south trough in the lower tropospheric levels lay extending from eastern parts of Bihar to West Central Bay of Bengal, causing moisture incursion into northeast and adjoining east India. Widespread intense rainfall activity occurred over northeastern states and Sub-Himalayan West Bengal & Sikkim during this period.

The monsoon trough ran close to the foot hills of the Himalayas during 12th – 14th September. The western part of it continued to run close to the foot hills whereas its eastern part shifted southwards and extended to Northeast Bay of Bengal on 15th & 16th September. It got filled up and thus became less marked from 17th September.

Northeastern states and Sub-Himalayan West Bengal had experienced fairly widespread to widespread and intense rainfall activity during 12th–14th September due to the downstream convergence of westerly winds and presence of the trough across the region. Under the influence of a western disturbance, Western Himalayan Region experienced scattered to fairly widespread rainfall with isolated intense activity during 13th–15th September. Subdued rainfall activity prevailed over parts of central, northwest and peninsular India during 13th – 19th September.

The last low pressure system formed as a low pressure area over East Central Bay of Bengal and adjoining Myanmar coast on 18th September, evening. It concentrated into a Depression over east central Bay of Bengal and neighbourhood during the night of 19th. It then intensified further into **Cyclonic Storm ‘DAYE’** over northwest Bay of Bengal on 20th September and crossed south Odisha and adjoining north Andhra Pradesh coasts close to Gopalpur during mid-night of 21st September, gradually weakened into a Depression and moved across central India upto western parts of Madhya Pradesh on 21st & 22nd September. During the traverse, it started interacting with a Western Disturbance and thus the system, after weakening into a well- marked low pressure area, started re-curving northwards. This constructive interaction between the monsoon low pressure system and the Western Disturbance caused a revival of the active to vigorous monsoon conditions over central and northwest India during 21st–25th September. Subsequent to the dissipation of the remnant low pressure area over Haryana and neighborhood on 25th September, a drastic reduction in rainfall activity occurred over northwest and adjoining central India.

Cyclonic Storms affecting the Indian coast during September is not very common. Past such occurrence was in 2005, when Cyclonic Storm ‘PYARR’ crossed Andhra Pradesh coast on 21st September. Cyclonic vorticity advection from the remnants of Typhoon ‘Manghkut’ and Tropical Cyclone ‘Barijat’ formed over west Pacific had contributed to the formation of Cyclonic Storm ‘DAYE’.

This year, a few of the monsoon lows had a lengthy track and traversed upto northwest India. The number of Low Pressure System (LPS) [low pressure areas and Depressions combined] days had been 4 in June, 19 in July, 15 in August and 12 in September, against a normal of 11, 14, 17 & 16 during the respective months. The total number of LPS days had been 50 as against the normal of 57.

strong cross equatorial flow often caused flood situations over various areas during different parts of the season. Kerala experienced one of the worst flood situations of the Century, due to frequent heavy rain spells and several extremely heavy rain events, especially during the first half of August.

Ahead of the monsoon current, severe thunder squalls affected parts of northwest India, including Delhi on 9th June. Parts of Uttar Pradesh and Bihar were also affected by Severe Thunderstorms and Lightning during the second week of June.

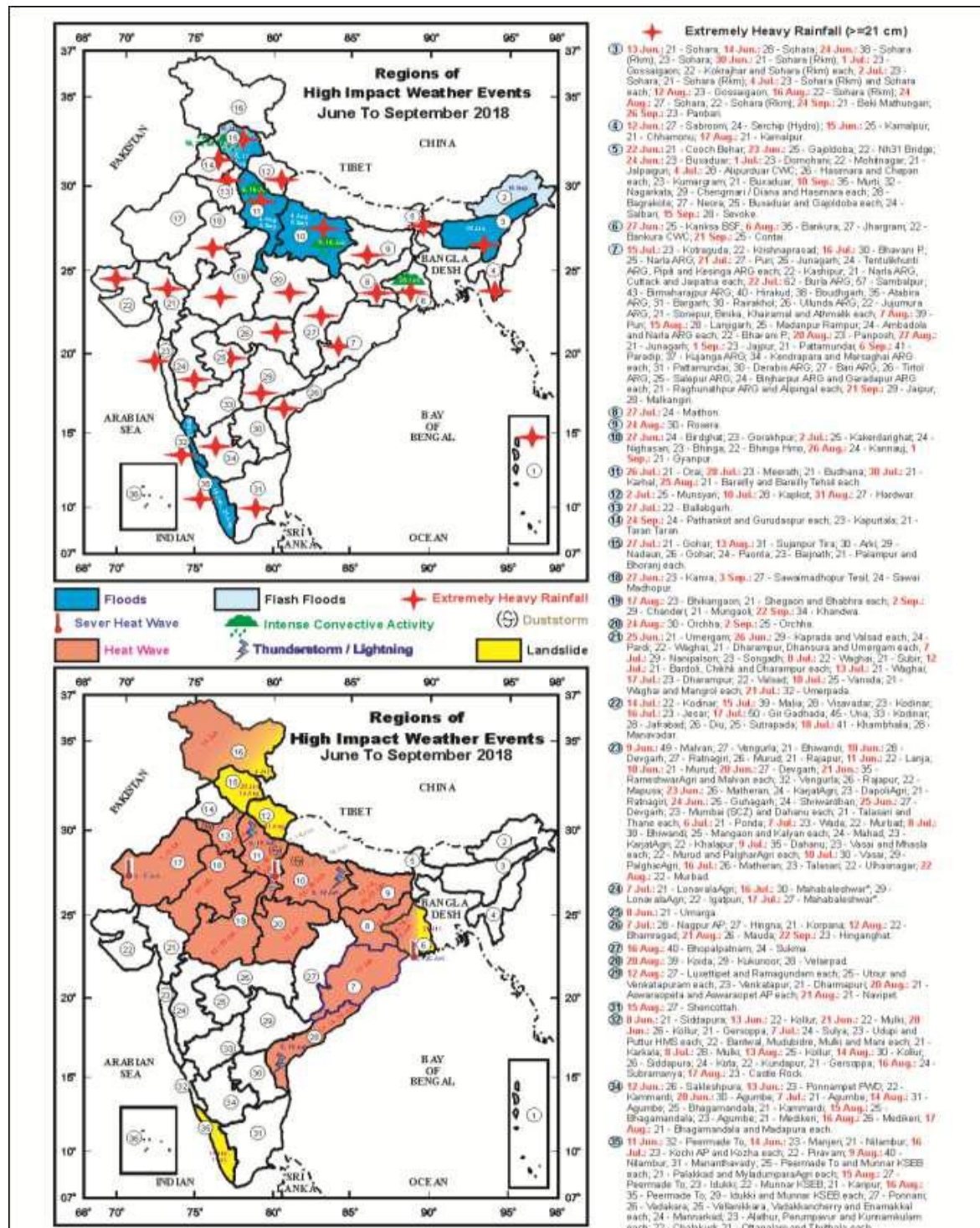


Fig. 3: Regions of High Impact Weather events during Monsoon 2018

4. Withdrawal of Southwest Monsoon :-

Reduction in moisture associated with the monsoon flow and a changeover in the lower tropospheric circulation pattern from 'cyclonic' to 'anti-cyclonic' over Rajasthan and neighbouring areas occurred from 28th September. Thus the southwest monsoon withdrew from parts of west Rajasthan and Kutch on 29th September, with a delay of almost a month as the normal date of commencement of withdrawal from extreme western parts of Rajasthan is 1st September. However, further withdrawal took place rapidly, as the flow pattern change took place in an abrupt manner, when the southward shift of the Inter Tropical Convergence Zone occurred in the beginning of October itself.

The monsoon withdrew from most parts of northwest India and adjoining central India by 1st October and by 6th October, the withdrawal has been completed from major parts of India, outside southern parts of Peninsula, where rainfall activity continued due to the presence of an active Inter Tropical Convergence Zone (ITCZ) with embedded easterly wave perturbations. Subsequent to the equator ward shifting of the ITCZ and reduction in rainfall, the southwest monsoon withdrew from the entire country, Bay of Bengal and the Arabian Sea on 21st October 2018, with a delay of 6 days.

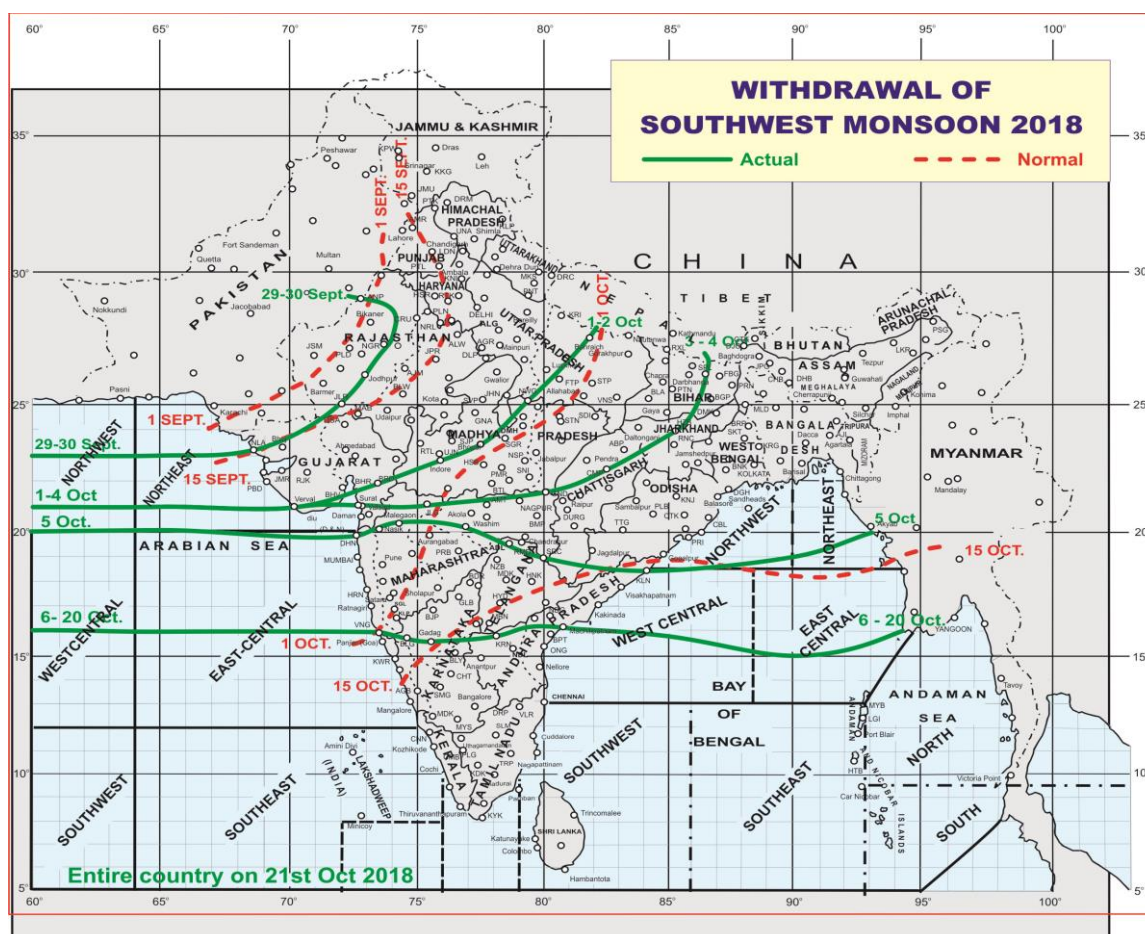


Fig.4: Isochrones of withdrawal of southwest monsoon – 2018

5. Rainfall Distribution:-

The 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 2: Rainfall during southwest monsoon 2018 over Rajasthan and its subdivisions

Monsoon Season (June to September) Rainfall			
Region / Area	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
Rajasthan	393.7	419	-6
East Rajasthan	635.3	615.8	3
West Rajasthan	201.8	263.2	-23

The seasonal rainfall over Rajasthan was 94% of its LPA, East Rajasthan 103% of its LPA and West Rajasthan 77% of its LPA. The rainfall distribution was not uniform over the State. Out of 33 districts, 4 districts received excess rainfall, 23 districts received normal rainfall, 05 districts received deficient rainfall and 01 district received large deficient rainfall during the season. The district wise seasonal distribution of rainfall is shown in **Fig. 5**.

It can be seen that most of the districts in West Rajasthan received deficient rainfall, whereas most of the districts in North, South and East Rajasthan received normal rainfall.

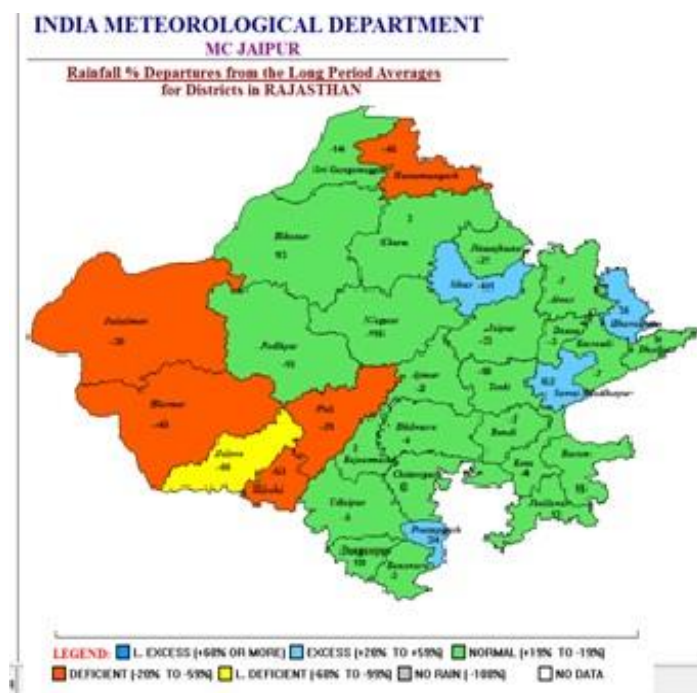


Fig.5: District wise rainfall distribution over Rajasthan during southwest monsoon season (June to September) – 2018.

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 3-5** below with respective LPA values.

Table 3: Rainfall during southwest monsoon 2018 over Rajasthan

Month	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
June	74.8	44.5	68
July	152.8	156.8	-3
August	92	150.8	-39
September	74	66.9	11

Table 4: Rainfall during southwest monsoon 2018 over East Rajasthan

Month	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
June	102.4	62.5	64
July	233.3	225.2	4
August	157	228.4	-31
September	142.7	99.7	43

Table 5: Rainfall during southwest monsoon 2018 over West Rajasthan

Month	Actual (in mm)	Long period average LPA (in mm)	Departure from normal %
June	52.9	29.9	77
July	88.9	102.7	-13
August	40.4	89.3	-55
September	19.5	41.3	-53

From the above tables it is observed that Rajasthan received highest rainfall during the month of June, which was 168% of LPA (i.e. large excess category). Both East Rajasthan and West Rajasthan received their highest 164% of LPA (large excess) and 177% of LPA (large excess) respectively during month of June. The rainfall trend was not uniform during the season. Only first month of the season Rajasthan's rainfall was in large excess category but in the month of August very less rainfall occurred, due to which Rajasthan fell in normal category.

The cumulative seasonal rainfall for the State as a whole was 94% of its LPA and it was 103% and 77% of LPA over East and West Rajasthan, respectively. Out of 33 districts, the seasonal rainfall was excess in 4 districts, normal in 23 districts, deficient in 5 districts and large deficient in 1 district. Sirohi district received least rainfall (47% of LPA) and Sawai Madhopur district received highest rainfall (152% of LPA). The seasonal rainfall for various districts of Rajasthan is given in **Table 6**.

Stationwise Total Seasonal Rainfall

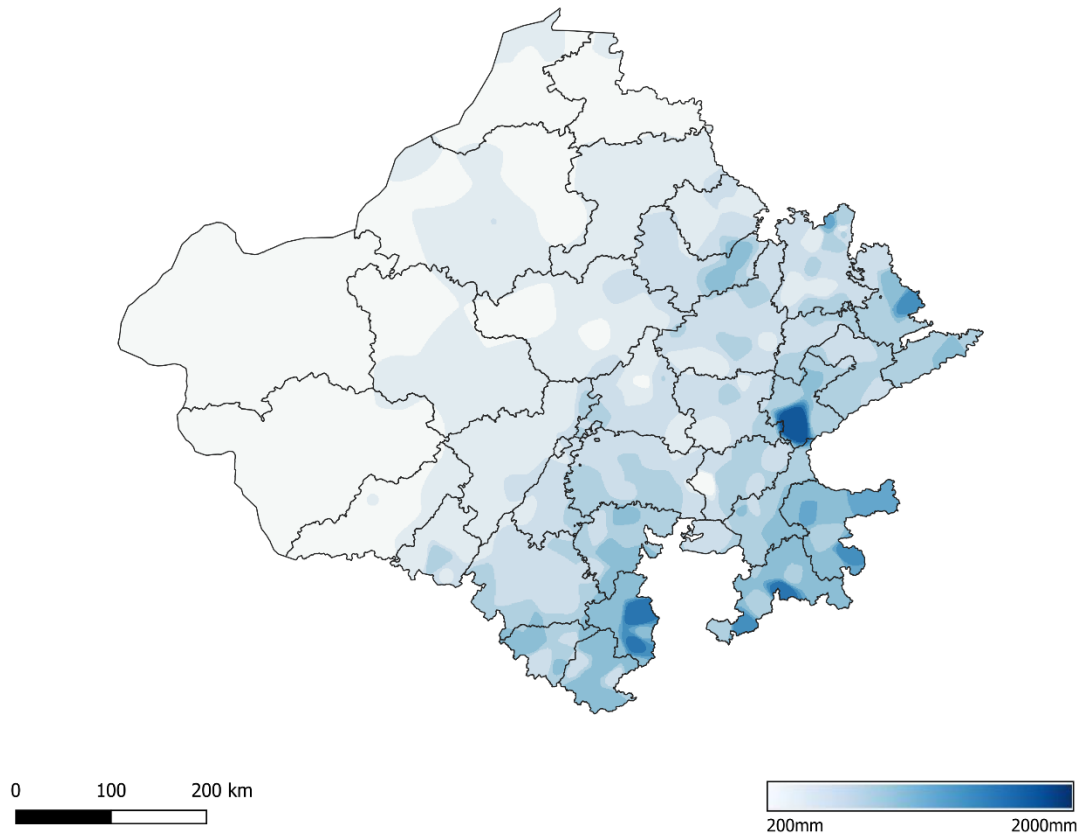


Fig 6.: Station wise Total Seasonal Rainfall

Table 6: District-wise seasonal rainfall distribution monsoon 2018

Sr. No.	State/Districts	Monsoon rainfall in mm (June - September 2018)		
		Actual (in mm)	Normal (in mm)	%Dep
	RAJASTHAN	393.7	419	-6
EAST RAJASTHAN				
1	AJMER	421	429.6	-2
2	ALWAR	518.1	555.3	-7
3	BANSWARA	808.3	831.8	-3
4	BARAN	946.6	792.2	19
5	BHARATPUR	755.4	557.6	35
6	BHILWARA	606.7	580.9	4
7	BUNDI	608.4	655.9	-7
8	CHITTORGARH	706.8	709.7	0
9	DAUSA	592.8	612.1	-3
10	DHOLPUR	708.2	650	9
11	DUNGARPUR	761.8	637.8	19
12	JAIPUR	508.6	524.6	-3
13	JHALAWAR	958.5	855.1	12
14	JHUNJHUNU	402.1	410	-2
15	KARAULI	591.8	637.4	-7
16	KOTA	719.4	746.3	-4
17	PRATAPGARH	1135	845.8	34
18	RAJSAMAND	514.4	506	2
19	SAWAI MADHOPUR	1008.7	664	52
20	SIKAR	565.6	402.5	41
21	SIROHI	409	868.6	-53
22	TONK	512.3	566	-9
23	UDAIPUR	562.3	591.3	-5
	EAST RAJASTHAN	635.3	615.8	3
WEST RAJASTHAN				
24	BARMER	123.2	243.4	-49
25	BIKANER	259.1	228.7	13
26	CHURU	324.4	313.7	3
27	HANUMANGARH	138.1	252.5	-45
28	JAISALMER	110.5	158.4	-30
29	JALORE	155.9	394.2	-60
30	JODHPUR	232	274.5	-15
31	NAGAU	287.1	348.5	-18
32	PALI	316.9	446.7	-29
33	SRI GANGANAGAR	173.5	201.4	-14
	WEST RAJASTHAN	201.8	263.2	-23

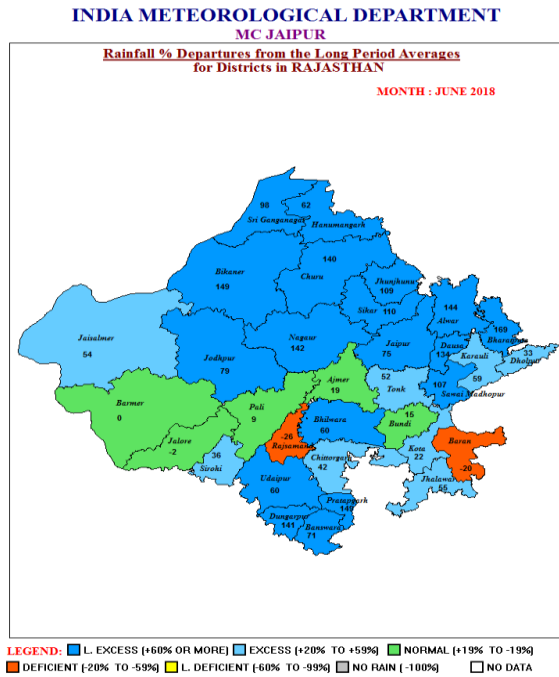


Fig.7 Districtwise Monthly Rainfall Distribution Over Rajasthan – June 2018

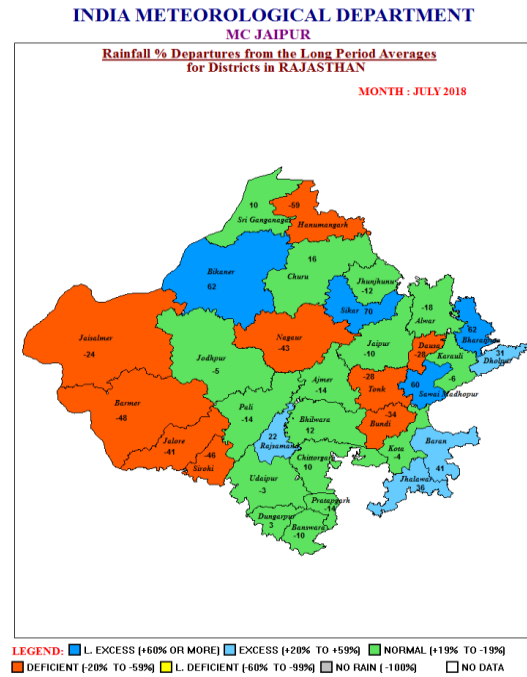


Fig. 8 Districtwise Monthly Rainfall Distribution Over Rajasthan – July 2018

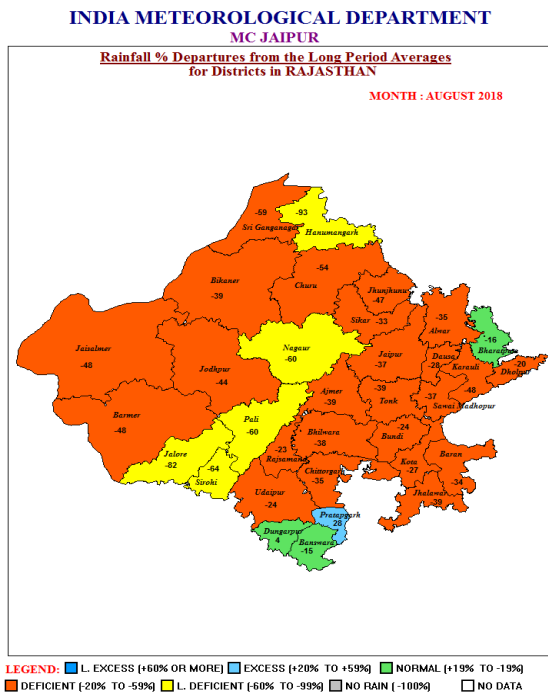


Fig. 9 Districtwise Monthly Rainfall Distribution Over Rajasthan – August 2018

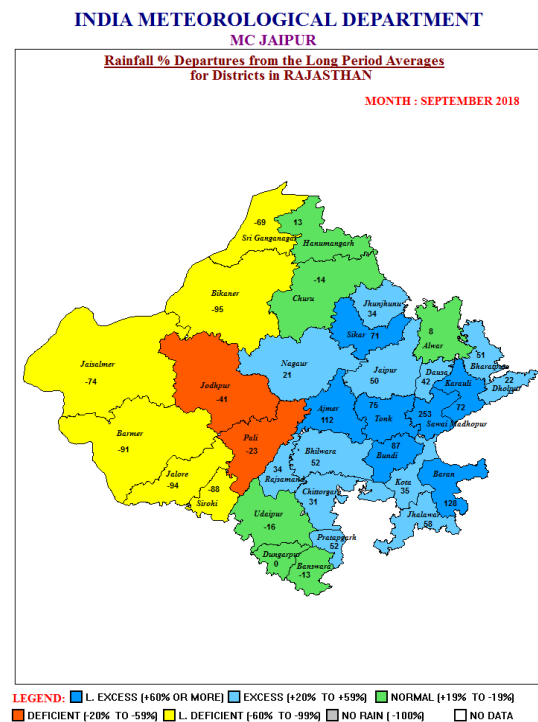


Fig. 10 Districtwise Monthly Rainfall Distribution Over Rajasthan–September 2018

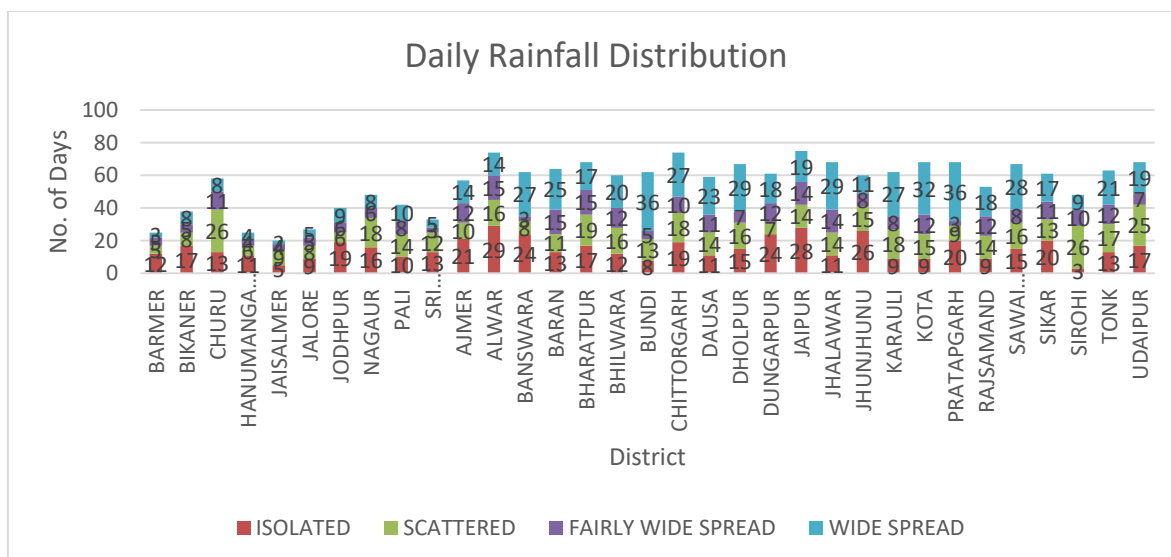


Fig.11 Districtwise Daily Spatial Rainfall Distribution

Fairly wide spread to wide spread rainfall occurred on 6 days (minimum) to 44 days (maximum) over different districts in Rajasthan during the whole monsoon season. Bundi and Pratapgarh district got wide spread rainfall on 36 days (highest) during the whole season.

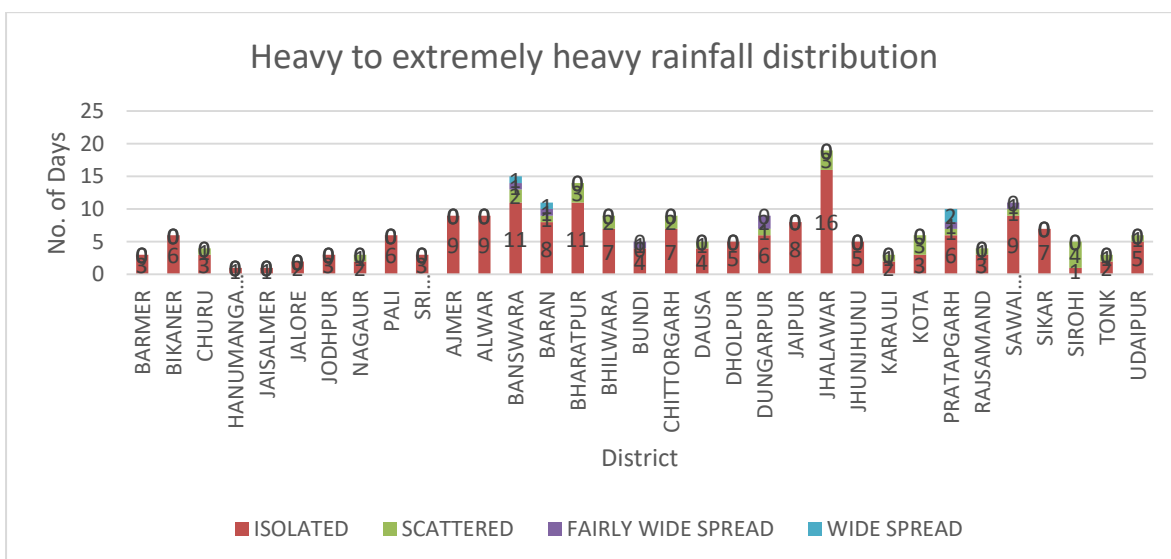


Fig.12 District wise Daily Heavy Rainfall Distribution

Heavy to very heavy rainfall occurred at isolated to most places in all districts of the state on a few days. Pratapgarh received heavy rainfall at most places on 2 days during the whole season followed by Banswara and Baran on 1 day each. Dungarpur, Pratapgarh, Banswara, Baran, Bundi and Sawai Madhopur districts experienced heavy rainfall at many places on 1 to 2 days during the season.

Table 7: Extremely Heavy Rainfall during Southwest Monsoon 2018

S.No.	Station	Date	Amount (in mm)	District
1	Sawai Madhopur Tehsil	3 September	265.0	Sawai Madhopur
2	Sawai Madhopur	3 September	240.0	Sawai Madhopur
3	Kanva	27 June	230.0	Dungarpur

Month wise very heavy and extremely heavy rainfall events are shown in **Fig.13** and **Fig. 14** respectively. Highest rainfall of 265mm occurred in Sawai Madhopur on 3rd September.

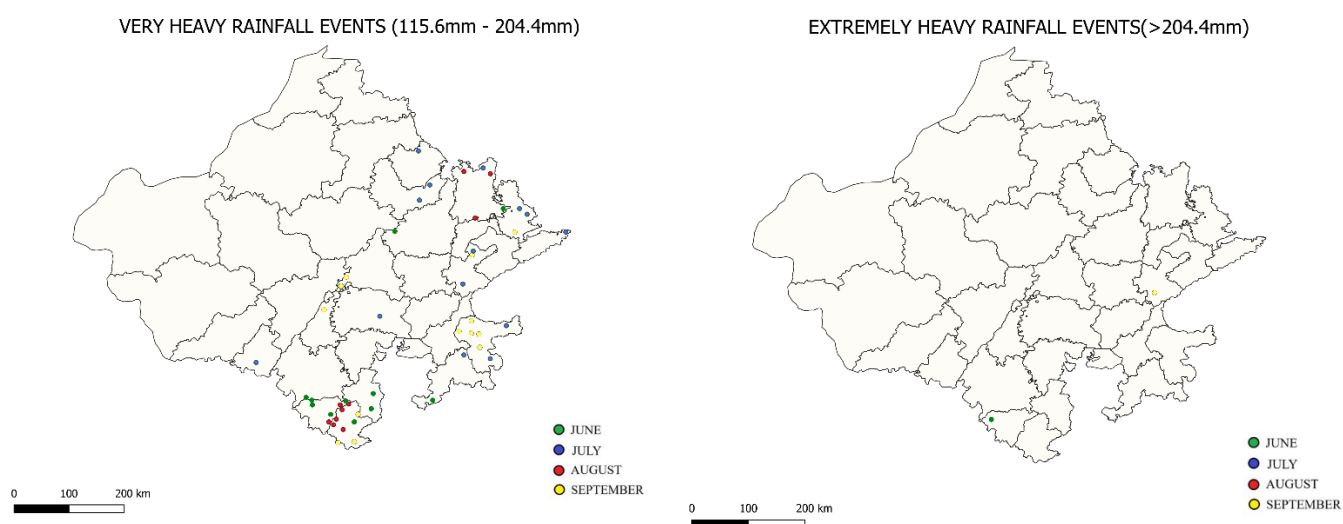


Fig. 13: The location of Very Heavy Rainfall (115.6 to 204.4 mm)

Fig. 14: The location of Extremely Heavy Rainfall (more than 204.4 mm)

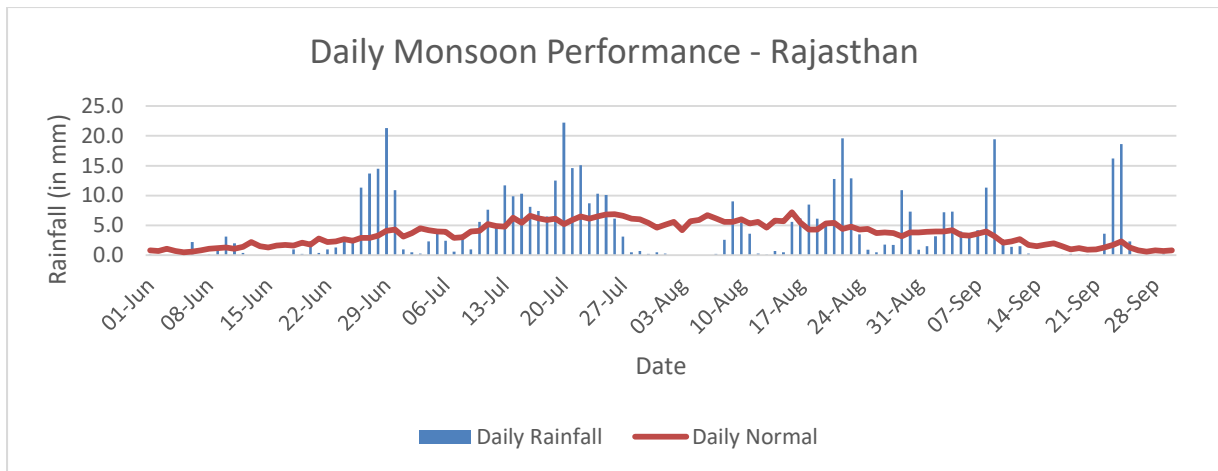


Fig. 15: Daily Rainfall - Rajasthan

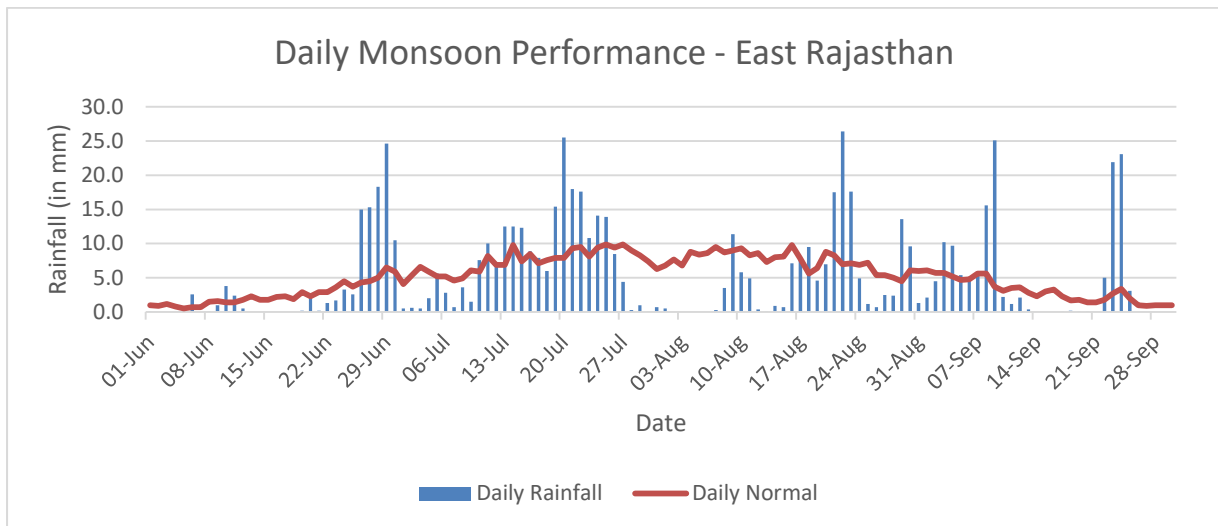


Fig. 16: Daily Rainfall – East Rajasthan

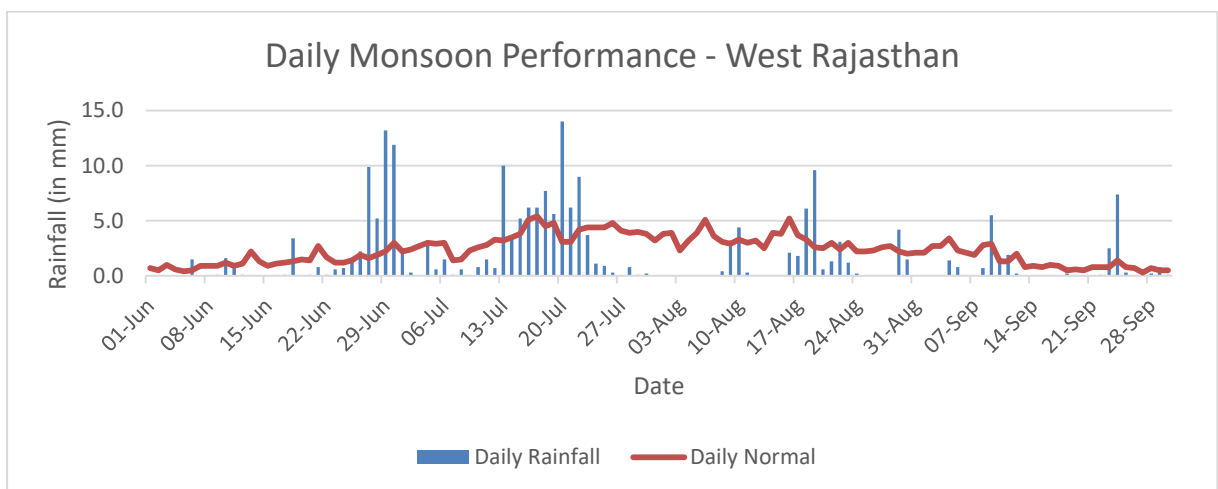


Fig. 17: Daily Rainfall – West Rajasthan

Report prepared by: Smt. Deepika Gupta, Met A

Sh. Pushkal Karamchandani, SA

Radheshyam Sharma
(Head, Meteorological Centre Jaipur)