

# Weather

## MONSOON SEASON (JUNE-SEPTEMBER 1988)\*

### 1. Introduction

For classification of rainfall distribution two norms have been used, one for describing the seasonal rainfall and the other for describing the monthly rainfall. The two norms are used because the limits for describing normal rainfall are generally decided on the basis of the variability or the standard deviation of rainfall. As the period increases the standard deviation decreases. Thus, in the case of seasonal rainfall, where the period is large, the limit of  $\pm 10\%$  departure from normal has been adopted for defining the normal rainfall, whereas for the monthly rainfall  $\pm 19\%$  departure from the normal rainfall has been adopted for defining the normal rainfall.

The summer monsoon rainfall of 1988 was either excess or normal in all the meteorological sub-divisions of the country except east Uttar Pradesh, hills of west Uttar Pradesh and east Madhya Pradesh where it was slightly deficient ( $-11\%$  to  $-25\%$ ). Area-wise, about 88 per cent of the country received normal or excess rainfall and the remaining 12 per cent received slightly deficient rainfall. Seasonal rainfall departures analysed on the basis of individual station rainfall data are shown in Fig. 5.

### 2. Chief features of the season

#### 2.1. Advance of monsoon

Southwest monsoon set in over Kerala on 26 May. Thereafter, the monsoon steadily advanced northwards along the west coast and reached south Gujarat by 14 June. The Bay branch of monsoon, advanced into Assam and adjacent States on 30 May and stagnated there up to 8 June. Further westward progress commenced from 9 June and the monsoon covered the eastern parts of east Uttar Pradesh by 13 June. Thereafter its further westward advance commenced only on 22 June and it covered the entire country by 1 July. The advance of monsoon over the Peninsular India was rather steady up to 13 June and it covered the entire Peninsula by that time except north coastal Andhra Pradesh, Telangana and Vidarbha.

In the first phase of its advance, commencing on 26 May and ending on 14 June, monsoon covered north-east India, south Gujarat and the entire Peninsula outside north Andhra Pradesh and Vidarbha. In the second phase, it advanced over the remaining parts of the

Peninsula and south Madhya Pradesh on 17 June. In the third phase which began on 22 June and ended on 1 July, monsoon covered the remaining parts of the Indian sub-continent. Daily progress of southwest monsoon over the country is shown in Fig. 1 and week by week progress is shown in Fig. 4.

This year the southwest monsoon set in over Kerala about 4 days earlier than the normal. It advanced about 4 to 7 days earlier than the normal dates over Assam and adjacent States, Bihar and Himachal Pradesh and within  $\pm 3$  days of the normal dates over the remaining parts of the country outside north coastal Andhra Pradesh, Telangana, Vidarbha, Madhya Pradesh and east Rajasthan, where its arrival was delayed by 5 to 7 days. In various parts of west Rajasthan the monsoon period about 7 to 15 days earlier than the normal date.

#### 2.2. Activity of monsoon

Though monsoon advanced in time over Arunachal Pradesh, Sub-Himalayan West Bengal & Sikkim, south Gujarat, Konkan & Goa, coastal Andhra Pradesh, Rayalaseema and interior Karnataka, its activity over these regions was quite weak. June rainfall was scanty ( $-60\%$  or less) in Arunachal Pradesh, Saurashtra & Kutch and Rayalaseema and it was deficient ( $-20\%$  to  $-59\%$ ) in Sub-Himalayan West Bengal & Sikkim, Gujarat region, Konkan & Goa, coastal Andhra Pradesh and interior Karnataka. In the remaining parts of India it was rather active giving excess ( $+20\%$  and above) or normal ( $\pm 19\%$ ) rainfall during the month.

Monsoon activity during July was normal or above normal over the entire country outside Orissa, west Uttar Pradesh and east Madhya Pradesh, where it was below normal. Increased rainfall in July made up the rainfall deficiency in Sub-Himalayan West Bengal & Sikkim, Gujarat, Konkan & Goa, coastal Andhra Pradesh, Rayalaseema and interior Karnataka and lowered the percentage of deficiency in Arunachal Pradesh. However, subdued activity over west Uttar Pradesh during the month caused deficiency in the cumulative rainfall up to 31 July in hills of west Uttar Pradesh.

Monsoon rainfall during August was either normal or excess over the entire country except in the meteorological sub-divisions of Orissa, hills of west Uttar Pradesh and Jammu & Kashmir, where it was deficient. The subdued monsoon activity over hills of west Uttar Pradesh during the month, did not, however, aggravate the

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TABLE 1

Sub-divisionwise rainfall summary for each month (June-September) and for the monsoon season (June-September 1988)

Sub-divisions	June		July		August		September		June-September			
	Actual (mm)	% dep. from normal	Actual (mm)	% dep. from normal	Actual (mm)	% dep. from normal	Actual (mm)	% dep. from normal	Actual (mm)	Normal (mm)	Dep. from normal	% dep. from normal
1. Andaman & Nicobar Islands	295	-34	420	10	298	-23	586	35	1599	1652	-53	-3
2. Arunachal Pradesh	256	-62	889	5	1745	179	590	57	3480	2522	958	38
3. Assam & Meghalaya	453	9	556	45	513	38	287	15	1808	1420	388	27
4. Nagaland, Manipur, Mizoram & Tripura	387	-4	351	2	285	-9	190	-12	1213	1276	-63	-5
5. Sub-Himalayan West Bengal & Sikkim	377	-37	761	17	906	66	458	0	2503	2255	247	11
6. Gangetic West Bengal	599	143	356	18	343	14	241	1	1539	1089	450	41
7. Orissa	270	31	246	-28	249	-24	263	1	1028	1131	-103	-9
8. Bihar Plateau	322	71	275	-19	277	-17	159	-29	1033	1084	-51	-5
9. Bihar Plains	171	-10	351	9	300	-4	137	-39	960	1049	-88	-8
10. East Uttar Pradesh	143	35	278	-7	302	-5	59	-69	783	918	-136	-15
11. Plains of West Uttar Pradesh	144	70	213	-24	294	3	93	-44	744	817	-73	-9
12. Hills of West Uttar Pradesh	293	27	249	-53	416	-20	ND	ND				
13. Haryana, Chandigarh & Delhi	70	34	355	98	313	74	248	101	986	535	451	84
14. Punjab	39	-17	455	139	266	42	343	183	1103	546	557	102
15. Himachal Pradesh	102	-14	647	29	443	-7	361	74	1554	1307	247	19
16. Jammu & Kashmir	67	18	282	103	83	-33	209	148	639	403	236	58
17. West Rajasthan	36	36	118	18	104	-5	49	-10	307	290	17	6
18. East Rajasthan	88	48	234	-1	211	-10	99	568	632	545	87	16
19. West Madhya Pradesh	166	48	310	-7	266	-13	109	-43	850	940	-90	-10
20. East Madhya Pradesh	232	41	301	-26	340	-13	133	-39	1006	1181	-174	-15
21. Gujarat Region, Daman, Dadra & Nagar Haveli	57	-44	574	86	220	6	154	1	1005	771	234	30
22. Saurashtra, Kutch & Diu	13	-82	569	143	113	-9	159	107	853	508	345	68
23. Konkan & Goa	483	-29	1248	25	627	4	597	200	2955	2613	342	13
24. Madhya Maharashtra	94	-8	229	30	123	2	325	136	770	537	234	44
25. Marathwada	221	63	348	74	307	69	457	153	1333	698	635	91
26. Vidarbha	152	-7	473	42	293	6	268	31	1185	975	210	22
27. Coastal Andhra Pradesh	48	-51	302	87	225	56	222	45	797	558	240	43
28. Telangana	137	-1	517	100	249	20	271	36	1174	805	369	46
29. Rayalaseema	28	-62	192	81	246	124	170	15	636	437	199	46
30. Tamil Nadu & Pondicherry	38	-11	81	33	137	52	140	55	396	284	113	40
31. Coastal Karnataka	1242	27	1079	-8	887	32	563	63	3771	3164	607	19
32. North Interior Karnataka	80	-26	188	4	217	59	242	59	727	577	149	26
33. South Interior Karnataka	34	-51	174	75	185	98	217	82	610	381	228	60
34. Kerala	519	-13	496	-16	388	18	501	110	1904	1754	150	9
35. Lakshadweep	242	-21	294	5	205	7	241	48	981	942	39	4

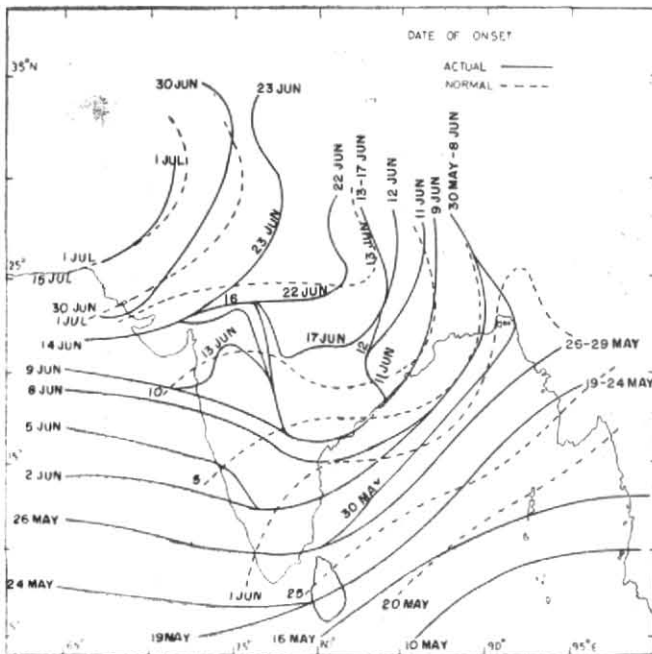


Fig. 1. Advance of southwest monsoon 1988

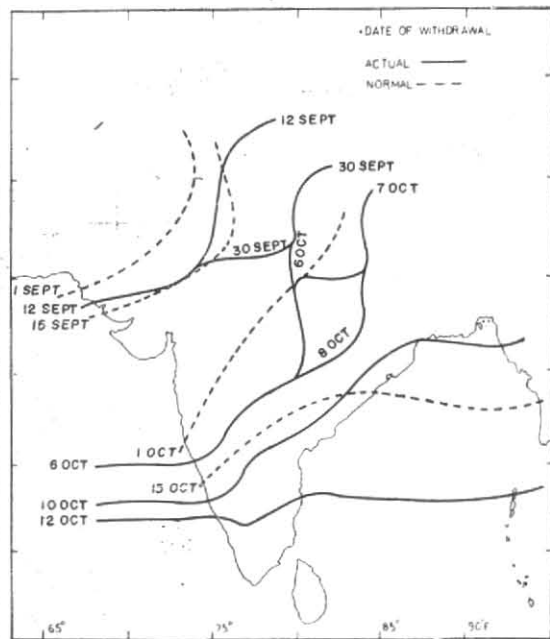


Fig. 2. Withdrawal of southwest monsoon 1988

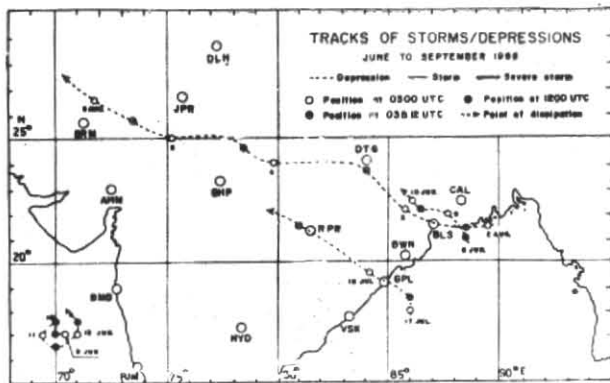


Fig. 3. Tracks of depressions, June-Sep 1988

the country began in the middle of September. On 12 September it withdrew from Jammu & Kashmir, west Rajasthan and from some parts of Himachal Pradesh and Punjab. It withdrew further on 30 September from west Uttar Pradesh, northeast Rajasthan and the remaining parts of Himachal Pradesh and Punjab. During October the withdrawal process was rather steady. Between 6 and 12 October, it withdrew from the remaining parts of the sub-continent outside Tamil Nadu and Kerala. Datewise withdrawal from the country is shown in Fig. 2.

2.4. Storms and depressions

At the very beginning of the season two depressions developed, one over the Arabian Sea and other over the Bay of Bengal. The depression over east central Arabian Sea on 9 June made a big loop there and dissipated over the sea. The other depression over north-west Bay on 8 June moved in a westnorthwesterly direction and dissipated over Bihar plateau and neighbourhood. The third depression of the season formed at a somewhat lower latitude over west central Bay in the middle of July and reached central India. The last depression of the season developed over north Bay on 2 August and had a long travel across the country up to west Rajasthan. The tracks of these depressions are shown in Fig. 3.

3. Significant monthly features

3.1. June

In association with the Arabian Sea depression monsoon progressed along west coast up to Konkan & Goa. The Bay depression brought in the onset of monsoon rainfall over West Bengal & Sikkim, Orissa and Bihar. The seasonal trough in the lower levels (up to 0.9 km a.s.l.) was not well delineated in the first fortnight of June. However, it was well established in the last week of June.

cumulative rainfall deficiency from 1 June to 31 August in the sub-division. During the month largely excess rainfall occurred over Arunachal Pradesh (+179%), Sub-Himalayan West Bengal & Sikkim (+66%), Haryana (+74%), Marathwada (+69%), Rayalaseema (+124%) and south interior Karnataka (+98%). September rainfall was either scanty or deficient over Bihar, Uttar Pradesh and Madhya Pradesh and was excess or normal over the rest of the country. The meteorological sub-divisions, which received excess rainfall by more than 100% during September were Haryana (+101%), Punjab (+183%), Jammu & Kashmir (+148%), east Rajasthan (+568%), Saurashtra & Kutch (+107%), Konkan & Goa (+200%), Madhya Maharashtra (+136%), Marathwada (+153%) and Kerala (+110%). At the end of the season no meteorological sub-division had largely deficient rainfall. Monthly and seasonal rainfall summary (Met. sub-divisionwise) are given in Table 1.

2.3. Withdrawal of monsoon

The withdrawal phase of southwest monsoon from

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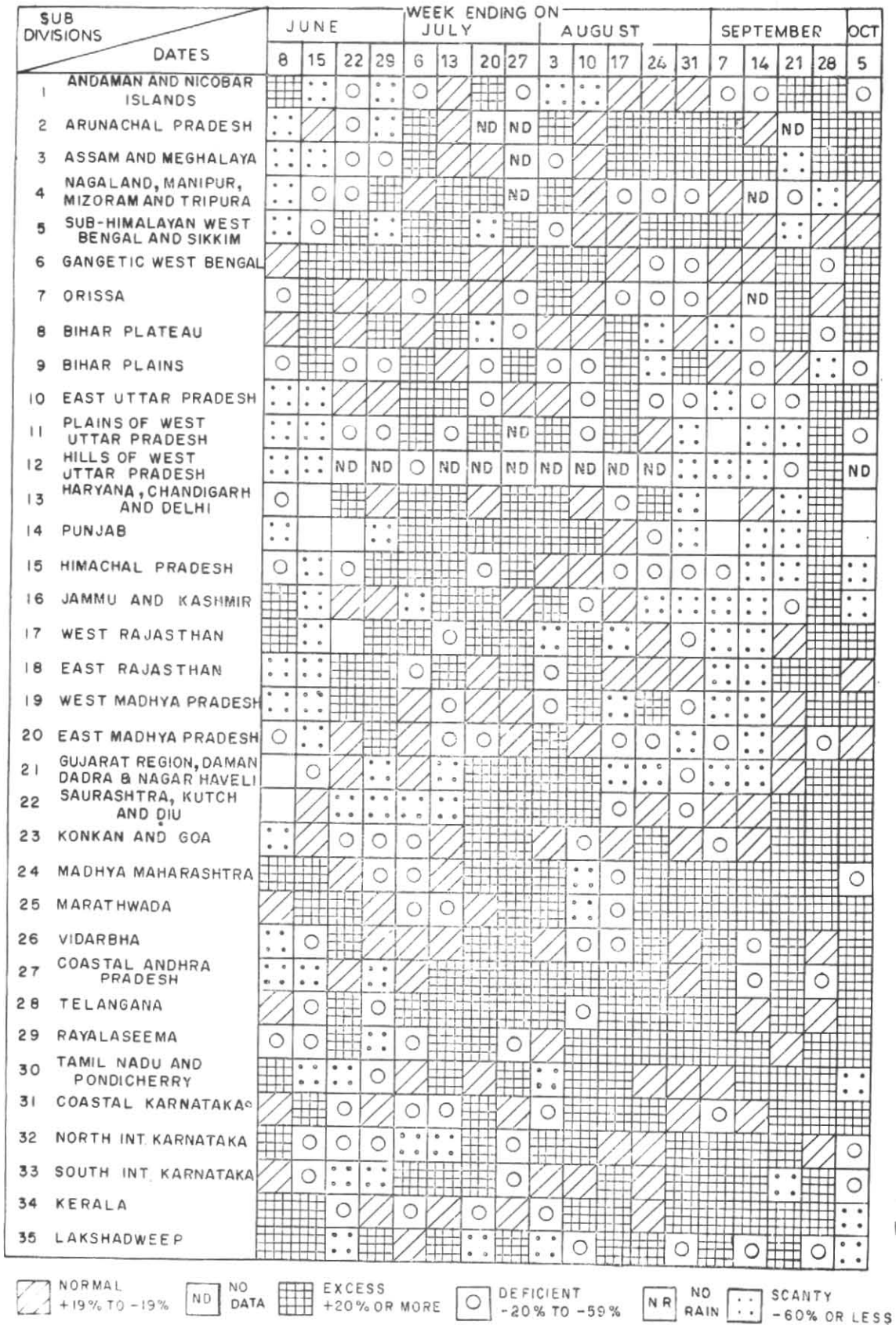


Fig. 4. Progress of the monsoon week by week from 1 June to 5 October 1988

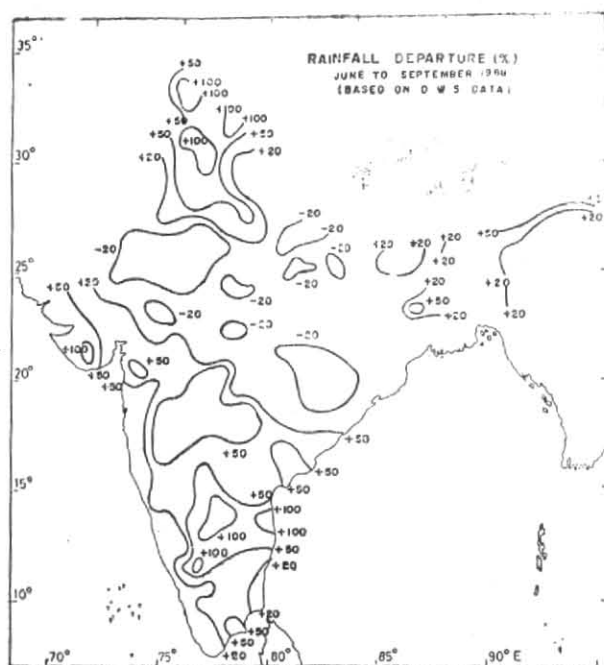


Fig. 5. Rainfall departure (per cent) June-September 1988

### 3.1.1. Features heralding the advance of southwest monsoon during June

Two depressions, one in the Arabian Sea and other in the Bay of Bengal developed during the first fortnight of the month helping in advance of monsoon over the country. The synoptic features, which were responsible for the advance of southwest monsoon over the country during June are given in Table 2.

### 3.1.2. Other synoptic features

The trough on sea level chart off west coast was noticed on several days from the second week of this month. The other synoptic features of the month are given in Table 3.

During this month rainfall was excess (+20% or above) or normal (+19% to -19%) in 23 meteorological sub-divisions. Monsoon was vigorous on 5 days in Gangetic West Bengal and on 1 to 3 days in Nagaland, Manipur, Mizoram & Tripura, Bihar, Haryana, east Madhya Pradesh, Marathwada and Kerala. It was active on 5 to 9 days in east Madhya Pradesh, Telangana, coastal Karnataka and Kerala and on 1 to 4 days in Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Orissa, Bihar, Uttar Pradesh, Himachal Pradesh, west Madhya Pradesh, Konkan & Goa, Marathwada, Vidarbha and north interior Karnataka. Though monsoon advanced over Bihar plains, Madhya Maharashtra, coastal Andhra Pradesh, Rayalaseema and south interior Karnataka by mid-June, yet the monsoon activity over those regions was quite weak. The rainfall during the month over Saurashtra & Kutch, coastal Andhra Pradesh, Tamil Nadu and south interior Karnataka was mainly of isolated nature.

Generally widespread rain or thundershowers occurred on 18 to 20 days over Konkan & Goa, coastal Karnataka

and Kerala and on 5 to 13 days in Andaman & Nicobar Islands, northeast India, hills of west Uttar Pradesh, Haryana, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Madhya Maharashtra, Marathwada, Telangana and north interior Karnataka.

### 3.1.3. Rainfall during June

Rainfall was excess (+20% or more) in Gangetic West Bengal, Orissa, Bihar plateau, Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Marathwada and coastal Karnataka; normal ( $\pm 19\%$ ) in Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Bihar plains, Punjab, Himachal Pradesh, Jammu & Kashmir, Madhya Maharashtra, Vidarbha, Telangana, Tamil Nadu, Kerala and Lakshadweep; deficient (-20% to -59%) in Andaman & Nicobar Islands, Sub-Himalayan West Bengal & Sikkim, Gujarat region, Konkan & Goa, coastal Andhra Pradesh and interior Karnataka and was scanty (-60% or less) in Arunachal Pradesh, Saurashtra & Kutch and Rayalaseema.

The significant amounts (cm) of rainfall were :

- 1st : Honavar & Trichirapalli 6 each, Madurai & Shirali 5 each, DehraDun & Salem 4 each
- 2nd : Trivandrum 12, Ramanathapuram 9, Kayamkulam 8, Chamrajnagar 7
- 3rd : Cannanore 18, Mannarghat 10, Long Island 6
- 4th : Quilon 11, Nedumanged 8, Port Blair & Trivandrum 6 each
- 5th : Long Island 10, Kozhikode & Shirol 8 each, Amini Divi & Cochin AP 6 each
- 6th : Long Island 19, Karwar 14, Maya Bandar 10, Mangalore 9, Mizamsagar 8, Belgaum AP, Kasargode & Sangli 7 each
- 7th : Kunnankulam 9, Navalgund 8, Amini Divi & Hospet 6 each, Karad & Kailashahar 5 each
- 8th : Cannanore 22, Kozhikode 17, Sandheads 16, Bantwal 14, Amini Divi 10, Mangalore AP 7
- 9th : Sandheads 40, Digha 33, Pallahara 23, Balasore & Panambur 16 each, Peermade 12, Cochin AP 10, Karwar 8, Mahabubnagar 6
- 10th : Thakurmunda 33, Balasore 18, Mancompu 10, Panjim & Shirali 8 each, Digha 7
- 11th : Sandheads 44, Diamond Harbour 11, Karwar 10, Phulbani & Shirali 9 each, Calcutta 7
- 12th : Sandheads 45, Calcutta AP 15, Jamshedpur AP & Midnapore 10 each, Bantwal 9, Chaibasa 8, Chandbali & Paradip 7 each
- 13th : Honavar 47, Sriniketan 22, Bhatkal 21, Shirali 19, Berhampore 18, Jamshedpur 16, Calcutta 11, Daltonganj 9, Purulia 8, Malda 6
- 14th : Sandheads & Patna AP 12 each, Ratnagiri 11, Chapra 8, Kundapur & Shegaon 7 each
- 15th : Sandheads 29, Bombay 10, Akola, Darbangha & Rupsi 6 each, Calcutta AP & Purnea 5 each
- 16th : Sandheads 22, Barobli 18, Alibag 10, Bombay 8, Krishnagar & Kokrajhar 6 each

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TABLE 2  
Details of weather systems responsible for advance of southwest monsoon

S. No.	Weather systems	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
<b>May</b>						
<i>(A) cyclonic Circulation</i>						
1	Lower and mid. trop. levels	24th-29th	Lakshadweep area	Westerly	Southeast Arabian Sea west of Lakshadweep area	
<b>June</b>						
<i>(B) Low/Depression etc</i>						
1	Deep depression	8th evening-10th	Northwest Bay	Northwesterly/west-northwesterly	Bihar Plateau and adjoining Gangetic West Bengal and north Orissa. The remnant became less marked over Bihar plateau by 18th	Appeared as a cyclonic circulation in the lower and mid-trop. levels over north Bay & neighbourhood on 1st
2	Deep depression	9th-13th	East central Arabian Sea off Maharashtra coast	Made an anticlockwise loop	East central Arabian Sea off Maharashtra coast. The remnant became unimportant off south Gujarat-north Maharashtra coast	Seen as a low-pressure area off Goa-north Karnataka coast on 8th
3	Low pressure area	21st-25th	Northwest Bay and adjoining land areas	Northerly/northeasterly	Became unimportant over the hills of Sub-Himalayan West Bengal & Sikkim and neighbourhood	Seen as a cyclonic circulation between 3.1 and 4.5 km a.s.l. over north coastal Andhra Pradesh and adjoining Bay on 17th
4	Low pressure area	27 Jun-1 Jul	Gangetic West Bengal and adjoining Bihar plateau	Westnorthwesterly	Haryana and adjoining north Rajasthan	
<i>(C) Cyclonic circulation</i>						
1	Middle and upper tropospheric levels	4th-8th	Lakshadweep area and neighbourhood	Northerly	Merged with the circulation of the low pressure area over east central Arabian Sea off Goa-north Karnataka coast	
2	Lower and mid-trop. levels	14th-20th	South Gujarat region and neighbourhood	Quasi-stationary	Gujarat and adjoining northeast Arabian Sea	

TABLE 3  
Details of weather systems during June 1988

S. No.	Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
<i>(A) Cyclonic circulations</i>						
1	Lower levels	29 May even.-1 Jun even.	Northeast Madhya Pradesh and neighbourhood	Westerly	Northeast Madhya Pradesh & neighbourhood	Developed over Bihar plateau and neighbourhood in the evening of 29 May
2	Lower trop. levels	3rd even. -7th	North Pakistan and neighbourhood	Easterly	Himachal Pradesh and neighbourhood	
3	Mid-trop. levels	24 Jun-1 Jul	South Gujarat, north Konkan & adjoining sea areas	Quasi-stationary	North Gujarat	
<i>(B) Western disturbances</i>						
1	Upper air system	31 May-3 Jun	North Pakistan and adjoining Jammu & Kashmir	Easterly	Moved away across Western Himalayas	
2	Do.	23rd-27th	North Pakistan and adjoining Punjab	Do.	Do.	

17th : Songadh 22, Chikhali 19, Ahwa 12, Sandheads 10, Mangalore AP 8, Baghdogra AP & Durgachak 7 each

18th : Cooch Behar 26, Buldhana & Dharampur 16 each, Kokrajhar 14, Bombay AP 10, Jalpaiguri 9, Hardoi 7

19th : Chauldaghat 8, Ambadola 7

20th : Cooch Behar 20, Betul 12, Mahabubabad 11, Tiruvur 9, Kokrajhar 8, Akola, Bhatkal & Raigarh 7 each

21st : Pendra & Purnea 10 each, Sangola 8, Bhagalpur & Zirka 7 each, Asifabad 6

22nd : Dungarwadi & Rajapur 13 each, Paradip 12, Gudur, Kangra & Naharkatia 8 each, Bhubaneswar AP, Gopalpur & Nandyal 7 each

23rd : Kharior 15, Seoni 11, Ahmedpur 9, Chalisgaon, Chipulaun & Pusad 8 each, Gondia, Jabalpur & Kandaghat 7 each

24th : Cherrapunji 39, Shillong 21, Bansgaon 15, Churu & Sawai Madhopur 8 each, Gondia & Sirpur 7 each

25th : Shillong 27, Panambur 23, Agartala AP & Hosdurg 16 each, Rajapur 15, Karimganj 13, Alleppey & Kozhikode 12 each, Minicoy 11, Seoni 9

26th : Kailashahar & Karimganj 25 each, Agartala AP 18, Hosdurg & Kundapur 17 each, Panambur & Rajapur 12 each, Badaun 10, Sultanpur 9

- 27th : Calcutta AP 22, Bhatkal 13, Panambur & Pendra 12 each, Peermade 11, Honavar 10, Kalaikunda & Jamshedpur AP 9 each, Nagpur AP & Rajapur 7 each
- 28th : Ranchi AP 17, Jabalpur & Rajapur 13 each, Pendra 12, Jharsuguda AP, Baijnath, Demoh, Karwar & Vengurla 8 each, Purulia 7
- 29th : Jogindernagar 21, Jalandhar & Jenapur 8 each, Allahabad AP, Dharamsala, Jhansi & Nanded 7 each
- 30th : Chandigarh AP 20, Kasuali 11, Mangrol 10, Anandpur Sahib & Jalaun 9 each, Hansol & Karauli 8 each, Dehradun 7

#### 3.1.4. Temperature

Moderate heat wave conditions ( $+6^{\circ}\text{C}$  to  $+7^{\circ}\text{C}$ ) prevailed in Sub-Himalayan West Bengal & Sikkim on 4th and 5th, in Marathwada on 4th and in west Rajasthan on 13th. During the first fortnight of the month day temperatures were appreciably above normal ( $+4^{\circ}\text{C}$  to  $+5^{\circ}\text{C}$ ) on a number of days in Rajasthan, west Madhya Pradesh, Gujarat region, Vidarbha and Telangana. They were  $6^{\circ}\text{C}$  to  $10^{\circ}\text{C}$  below normal on 5 days in Jammu between 3rd and 9th and on 1 to 4 days in Orissa and Bihar between 11th and 15th.

#### 3.1.5. Disastrous weather events and damages

During June river *Brahmaputra* and its tributaries were in floods. It took a toll of 6 human lives and affected a large number of population. As per reports two persons died and several others injured due to severe duststorm in New Delhi and three persons were killed near Pune due to severe thunderstorms during the first week of June. 21 persons were reported to have lost their lives in interior Orissa due to oppressive heat during the first week of June.

### 3.2. July.

#### 3.2.1. Advance of monsoon

During the month of June, southwest monsoon covered the entire country outside the extreme western parts of Rajasthan. It covered that part on 1 July (Fig. 1).

#### 3.2.2. Monsoon activity and associated synoptic features

During July, the monsoon activity over the country was quite adequate. Most of the meteorological subdivisions received normal or excess rainfall during the month.

The monsoon trough in the lower levels was well delineated across the country from the middle of the month. However, it was mostly situated  $2^{\circ}$  to  $5^{\circ}$  to the south of its normal position. One depression and four low pressure areas developed in the trough region. But all of them first appeared as an upper air circulation and then descended on to sea level. Details of the synoptic features of the month are given in Table 4.

Outside Orissa, hills of west Uttar Pradesh and east Madhya Pradesh, monsoon activity over the country was well distributed during the month. It was vigorous on 4 to 7 days in Punjab, Himachal Pradesh, Gujarat and Andhra Pradesh and on 1 to 3 days in Arunachal Pradesh, Assam & Meghalaya, West Bengal & Sikkim, Bihar Plains, Haryana, Jammu & Kashmir, Maharashtra and interior Karnataka. It was active on 8 to 11

days in Arunachal Pradesh, West Bengal & Sikkim, Himachal Pradesh, Gujarat region, Konkan & Goa, Madhya Maharashtra, Marathwada, Telangana and north interior Karnataka, on 4 to 7 days in Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Orissa, Bihar, plains of Uttar Pradesh, Haryana, Punjab, Jammu & Kashmir, east Rajasthan, west Madhya Pradesh, coastal Andhra Pradesh, coastal and south interior Karnataka and on 1 to 3 days over the rest of the country. Rain or thundershowers were generally widespread on 25 days in hills of west Uttar Pradesh and on 9 to 14 days in Andaman & Nicobar Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub-Himalayan West Bengal & Sikkim, Orissa, Bihar, east Uttar Pradesh, Madhya Pradesh, Gujarat Vidarbha and Lakshadweep. Over Tamil Nadu the rainfall was mainly of scattered or isolated nature.

#### 3.2.3. Rainfall during July

Rainfall was excess in Assam & Meghalaya, Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, Gujarat, Marathwada, Andhra Pradesh, Tamil Nadu and south interior Karnataka; normal in Andaman & Nicobar Islands, Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Bihar, east Uttar Pradesh, Rajasthan, west Madhya Pradesh, coastal and north interior Karnataka, Kerala and Lakshadweep and deficient in Orissa, west Uttar Pradesh and east Madhya Pradesh.

The significant amounts (cm) of rainfall were :

- 1st : Mancompu 14, Alleppey & Katghora 13 each, Cooch Behar 12, Raipur 10, Pasighat 8
- 2nd : Bankura 22, Karkala, Sundernagar & Talkoi 11 each, Panjim 10, Cochin AP & Nurgpur 9 each, Cunnalore & Ratnagiri 8 each, Calcutta AP, Machilipatnam & Tezpur 7 each
- 3rd : Karnal 16, Kapurthala & Ratnagiri 15 each, Patiala, Hoshiarpur & Panposh 10 each, Turtipur 9, Ambikapur & Pasighat 8 each, Nagpur & Sarsawa AP 7 each
- 4th : Cherrapunji 42, Khurai 25, Kangra 20, Pasighat 14, Goalpara 12, Bombay AP & Shillong 11 each, Patiala & Sabour 9 each, Koderi 8
- 5th : Cherrapunji 67, Pantnagar 20, Roorkee 17, Shillong 15, Jalpaiguri 14, Jogindernager 13, Bansaon 12, Bhira & Pasighat 10 each, Kathua & Satna 9 each, Dholpur & Gorakhpur 7 each
- 6th : Kasauli 25, Jalpaiguri 17, Nahan 16, Chaparmukh 14, Banbasa & Dharampur 13 each, Shillong 12, Bangalore 10, Navsari & Satna 9 each
- 7th : Haldwani 24, Belonia 19, Agra 18, Narsipur 15, Shillong 14, Durgachak 11, Cooch Behar 10, Alleppey & Patiala 9 each
- 8th : Jalpaiguri 20, Chauldaghat 16, Pasighat & Tumkur 9 each, Nidadavole 8
- 9th : Harnai 15, Chauldaghat 14, Panjim 13 Patan & Vijayawada 9 each, Jalna & Mandla 8 each, Ahwa, Imphal AP, Kailashahar & Krishnanagar 7 each

TABLE 4

Details of weather systems during July 1988

S. No.	Weather systems	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
<i>(A) Low pressure area/depression etc</i>						
1	Low pressure area	1st evening-4th	Gangetic West Bengal and neighbourhood	Westnorth-westerly	Southeast Uttar Pradesh and adjoining Bihar plateau and north east Madhya Pradesh	Seen as a cyclonic circulation in mid-trop. levels over northwest Bay and adjoining land areas in the morning of 1st
2	Low pressure area	17th-19th	South Rajasthan and adjoining north Gujarat	Westerly	Saurashtra & Kutch	Appeared as a cyclonic circulation in the lower tropospheric levels over north Bay and adjoining Gangetic West Bengal and Bangla Desh on 12th
3	Depression	17th-21st	West central and adjoining northwest Bay off north Andhra-south Orissa coast	Westnorth-westerly	Northwest Madhya Pradesh and adjoining southeast Rajasthan	First observed as a cyclonic circulation upto mid-trop. levels over west central and adjoining northwest Bay on 15th
4	Low pressure area	21st-23rd	North coastal Andhra Pradesh, south coastal Orissa and adjoining Bay	Northwesterly	East Madhya Pradesh	Appeared as a lower and mid-trop. levels cyclonic circulation over northwest Bay and neighbourhood on 27th evening
5	Low pressure area*	23th	North Bay where persisted till last day of the month	—	—	First observed as a cyclonic circulation in mid-trop. levels over north Bay on 26th
<i>(B) Cyclonic circulation</i>						
1	Lower trop. levels	5th-9th	North Pakistan and neighbourhood	Quasi-stationary	Haryana and Punjab	
2	Lower and mid. trop. levels	6th evening-11th	Southwest Bay and neighbourhood	Westerly	Tamil Nadu and adjoining Kerala	
3	Lower trop. levels	9th-12th	Gangetic West Bengal and neighbourhood	Westerly	Central parts of Bihar	
4	Mid-trop. levels	11th-13th	Gulf of Cambay and adjoining south Gujarat and north Maharashtra coasts	—	<i>In situ</i>	
5	Lower trop. levels	13th-14th	Northwest Madhya Pradesh and neighbourhood	—	—	Merged on 14th with the circulation that travelled from the east and formed the low pressure area over south Rajasthan and neighbourhood on 17th
6	Lower trop. levels	22nd-24th	Southeast Rajasthan and neighbourhood	Northnorth-westerly	North Rajasthan and neighbourhood	
7	Lower and mid-trop. levels	25th-31st	East Madhya Pradesh and adjoining Orissa	Northwesterly	North Rajasthan and neighbourhood	
8	Lower trop. levels	24th evening-26th	Haryana and neighbourhood	Quasi-stationary	West Uttar Pradesh & neighbourhood	
9	Lower and mid-trop. levels	28th-31st	Gujarat	Quasi-stationary	Gujarat and adjoining south Rajasthan	
<i>(C) Western disturbances</i>						
1	Cyclonic circulation in lower trop. levels	1st-3rd evening	North Pakistan and neighbourhood	Easterly	Moved away across Western Himalayas	
2	Do.	9th evening-12th	Central Pakistan	Easterly	Northwest Rajasthan and neighbourhood	
3	Do.	13th-14th	North Pakistan	Easterly	Moved away across Jammu & Kashmir	
4	Do.	14th evening-17th	Northwest Rajasthan and neighbourhood	Eastnorth-easterly	Moved away across Himachal Pradesh	
5	Do.	25th-26th evening	Jammu & Kashmir and adjoining north Pakistan	Do.	Moved away across Jammu & Kashmir	

\*Concentrated into a depression on 1 August.

10th : Sandheads 24, Mayiladuthurai 12, Dharamsala &amp; Minicoy 9 each, Jamkhed 8, Navsari 7

11th : Dharamsala 16, Udupi 14, Jalpaiguri 13, Berhampore &amp; Thakurganj 12 each, Malegaon

9, Chauldaghat 8, Akhnoor, Turtipur &amp; Udaipur 7 each

12th : Puri 13, Sulurpeta 11, Okhimath 9, Chittorgarh &amp; Vidisha 8 each, Bhubaneswar AP, Cannanore &amp; Pendra 7 each



- 13th : Bhira 19, Kathua 18, Turtipur 17, Pathankot 15, Jammu 14, Nurpur 13, Sandheads 11, Khammam & Mangalore AP 10 each, Dhanbad 9, Alwar, Chandigarh AP, Jabalpur & Sikar 8 each
- 14th : Kannod 24, Bhira 19, Port Blair 18, Sherthala 15, Honavar 14, Nandurbar 13, Aligarh 11, Tibri 10, Sabour 9, Bhopal & Verinag 8 each, Indore & V.V. Nagar 7 each
- 15th : Navsari 28, Kalyan 25, Surat 21, Dahanu 19, Amreli 14, Lucknow AP 12, Sultanpur 11, Verinag 10, Agartala AP, Jhansi, Panna & Talguppa 7 each
- 16th : Rajkot AP 28, Khopoli 26, Kalyan 25, Surendernagar 17, Sirsi 13, Zahenabad 10, Katra & Khanapur 9 each, Batote, Jodhpur AP & Port Blair 7 each
- 17th : Tamini 33, Chandgad 28, Bhira 24, Rajkot 23, Talguppa 20, Dwarka 16, Huzurabad 15, Sirsi 13, Palghat 10, Tibri 7
- 18th : Tamini 38, Venkatapuram 33, Chandgad 32, Bhira 27, Talguppa 22, Navsari 19, Khanapur & Mannar 15 each, Mahuva 13, Visakhapatnam AP 8
- 19th : Bhira 29, Yeotmal 17, Bhagmandala 15, Siddapur 14, Katra 13, Indore & Khanapur 10 each, Dohad & Khargaon 8 each, Bankura, Barmer & Katihar 7 each
- 20th : Bhagamandala 33, Tamini 26, Bhira 19, Jalpaiguri 15, Bombay 11, Belthangady 10, Betul, Katra & Mannarghat 9 each, Deesa & Paradip 7 each
- 21st : Taibpur 22, Thakurganj 14, Jogindernagar & Murtijapur 13 each, Car Nicobar 11, Belthangady, Koderu & Mandi 10 each, Dibrugarh AP 7
- 22nd : Dharamsala 27, Cannanore 24, Uttoor 23, Akola 20, Cooch Behar 19, Jogindernagar & Katra 17 each, Udhampur AP 14, Nanded 13, Koderu 12, Belthangady & Bhagamandala 11 each, Bhavnagar AP 11
- 23rd : Cooch Behar 32, Tibri 24, Hosdurg 18, Pasighat 17, Nurpur 16, Dholpur & Kumta 12 each, Dharamsala & Muzaffarnagar 11 each, Bombay AP 10, Kathua, Sawai Madhopur & New Kandla 8 each, Jabalpur 7
- 24th : Cooch Behar 23, Rajapur 16, Honavar & Panjim 14 each, Pasighat 13, Chandigarh AP, Patiala & Nahan 12 each, Bombay AP & Sidhi 11 each, Hissar 9, Sapaul & V.V. Nagar 7 each
- 25th : Rajapur 20, Ratnagiri 18, Navsari 15, Bansaon 11, Pantnagar 8
- 26th : Baghdogra AP 14, Wardha 13, Uttoor 12, Bagati (Magra) & Billoli 9 each, Rupsi 8, Bhatkal, Cuttack, Jhansi & Parbhani 7 each
- 27th : Kangra 29, Surat 27, Mahuva 23, Tamini 21, Bramhapuri, Jamshedpur AP & Parbhani 10 each, Koderu & Supaul 8 each, Chittorgarh & Mandla 7 each
- 28th : Surat 33, Neemsar 13, Amreli 12, Bhira 10, Diu & Sidhi 8 each, Chamoli 7

- 29th : Vyara 22, Preur 21, Tamini 18, Deogarh 17, Bardoli 14, Polavaram 13, Bhubaneswar AP 12, Naliya 11, Puri & Raisen 10 each, Varanasi 8, Jogindernagar 7
- 30th : Perur 33, Nizamabad 23, Billoli 16, Satna 11, Tezu 10, Belthangady & Cooch Behar 9 each, Bankura 8, Pasighat 7
- 31st : Kinwat 19, Nahan & Lalitpur 18 each, Anandpur Sahib 17, Kasauli & Nanded 16 each, Jammu 10, DehraDun 9, Kathua & Udhampur AP 8 each, Muzaffarpur 7

#### 3.2.4. Disastrous weather events and damages

During the month there were widespread floods in northern India which caused considerable loss of lives as well as damage to crops and properties. In Assam *Brahmaputra* and its tributaries were in floods throughout the month affecting all the 15 districts of the State. Road communication in lower and upper Assam remained snapped for several days during the first fortnight. The entire Raha township was under knee deep water. National Highway No. 37 was submerged at different points between Raha and Nellie. Bihar experienced floods in the rivers *Adhwara* group, *Ghaghra*, *Kamala*, *Balan*, *kosi* and *Mahananda* and Uttar Pradesh in the rivers *Ghaghra* and *Rapti* from the second week of the month. In West Bengal river *Tista* was in floods. Heavy rain caused floods in Patiala, Ludhiana and Ropar districts of Punjab. Traffic was stopped on the Jammu-Srinagar National Highway following landslides during the first fortnight. Balon nullah at Pathankot-Srinagar National Highway had flash floods. In the third week of the month floods in river *Jhelum* washed away some bridges. Heavy rains in the third week of the month in Gujarat, caused over flowing of several dams in Saurashtra & Kutch causing widespread floods in those areas. About 1,50,000 people were marooned for several days in the Ghed area of Junagadh district. A breach in the embankment of river *Ghaghra* at Hanumannagar in Ganganagar district (Rajasthan) submerged 300 houses. Incessant rain in western Maharashtra caused floods in *Ulhas* river and in all its connected nullahs bringing havoc to thousands of residents.

As per reports the death toll during the month due to floods/heavy rain was 21 in Assam, 107 in Gujarat, 15 in Jammu & Kashmir, 30 in Maharashtra, 24 in Punjab and 76 in Uttar Pradesh. It also damaged crops and properties worth about rupees 8.60 crores in Bihar, 18.80 crores in Jammu & Kashmir and 13.00 crores in Punjab.

### 3.3. August

#### 3.3.1. Monsoon activity and associated synoptic features

Monsoon activity during the month was rather good over the Peninsular India and in Arunachal Pradesh, Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, Haryana and Punjab. One depression and three low pressure areas formed during the month and these systems appeared first as upper air cyclonic circulations and then descended on the surface level. During the month the seasonal monsoon trough in the lower levels was as well organised as in the month of July. It was well delineated across the country only for a few

TABLE 5  
Details of weather systems during August 1988

S. No.	Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
<i>(A) Low pressure area/depression etc</i>						
1	Deep depression*	2nd-7th	Northwest and adjoining northeast Bay	Westnorth-westerly	Merged with the seasonal low over south Pakistan	*It was a low pressure area over north Bay on 28 Sep
2	Low pressure area	7th-11th	North Bay and adjoining west Bengal and Bangla Desh	Do.	Central parts of Bihar	Appeared as a cyclonic circulation in the mid-trop. levels over north Bay and neighbourhood on 6th
3	Low pressure area	17th-21st	Northwest Bay and adjoining land areas of West Bengal and Orissa	Do.	Central parts of Madhya Pradesh and adjoining Vidarbha. However the cyclonic circulation upto mid-trop. levels became less marked there on 25th	Observed on 15th as cyclonic circulation in the lower and mid-trop. levels over Tripura and neighbourhood
4	Low pressure area**	30th evening-31st	Central parts of coastal Andhra Pradesh and adjoining west central Bay. On 31st lay over central coastal Andhra Pradesh and adjoining Telangana	—	—	Observed as a cyclonic circulation between 3.1 and 5.8 km a.s.l. over south coastal Andhra Pradesh north Tamil Nadu and adjoining Bay areas on 27th
<i>(B) Cyclonic circulations</i>						
1	Lower trop. levels	1st-4th	Haryana and neighbourhood	Quasistationary	<i>In situ</i>	
2	Lower and mid-trop. levels	11th-12th	Bihar and adjoining east Uttar Pradesh and north-east Madhya Pradesh	Westnorth-westerly	West Uttar Pradesh	
3	Lower trop. levels	11th-13th	Punjab and neighbourhood	Quasi-stationary	<i>In situ</i>	
4	Lower and mid. trop. levels	12th-15th	Southwest Bay and adjoining Tamil Nadu	Westerly	Moved away across Lakshadweep	
5	Do.	15th evening-22nd	Saurashtra & Kutch	Quasi-stationary	Northeast Arabian Sea and adjoining Saurashtra	
6	Lower trop. levels	19th-26th	Haryana and neighbourhood	Easterly	Moved away across Himachal Pradesh	Persisted over Haryana till 24th
7	Mid-trop. levels	25th-27th	Kerala	Westerly	Southeast Arabian Sea	
<i>(C) Western disturbance</i>						
1	Cyclonic circulation in lower trop. levels	9th-11th	Punjab and neighbourhood	Easterly	Moved away across Himachal Pradesh	
2	Do.	26th-28th	North Pakistan and adjoining Punjab	Eastnorth-easterly	Moved away across Jammu & Kashmir	

\*\*Carried over in September

days during the first and third week of the month and was mostly to the south of its normal position. On other days it was mostly prominent to the east of Long. 85°E.

Details of the synoptic features of the month are given in Table 5.

The monsoon activity was well distributed throughout the month in Assam & adjacent States, Sub-Himalayan West Bengal & Sikkim, Haryana, Himachal Pradesh, Andhra Pradesh and Karnataka. It was active to vigorous on 9 to 14 days in Arunachal Pradesh, Assam & Maghalaya, Sub-Himalayan West Bengal & Sikkim, Bihar plains, Marathwada, Andhra Pradesh and Karnataka; on 6 to 8 days in Nagaland, Manipur, Mizoram & Tripura, plains of west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Vidarbha and Kerala and on 1 to 4 days over the rest of the country outside Jammu & Kashmir and west Rajasthan, where the number of active days were none. West Rajasthan mainly experienced rainfall of scattered or isolated nature, while Jammu & Kashmir received generally widespread rainfall on 6 days during the month. Generally widespread rain or thundershowers also occurred on 14 to 16

days over Andaman & Nicobar Islands and Lakshadweep and on 5 days in Tamil Nadu.

### 3.3.2. Rainfall during August

Rainfall was excess in Arunachal Pradesh, Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, Haryana, Punjab Marathwada, Andhra Pradesh, Tamil Nadu and Karnataka; normal in Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Bihar, plains of Uttar Pradesh, Himachal Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Konkan & Goa, Madhya Maharashtra, Vidarbha, Kerala and Lakshadweep and was deficient in Andaman & Nicobar Islands, Orissa, hills of west Uttar Pradesh and Jammu & Kashmir.

The significant amounts (in cm) of rainfall were :

1st: Nawashahar 25, Jagadhari 23, Rewa 22, Patiala 20, Ambala & Mandi 14 each, Khajuraho & Sarsawa AP 13 each, Chandigarh AP & Satna 12 each, Gondia 11, Jamshedpur AP 9, Joginder-nagar 8

- 2nd: Sandheads 35, Dungarwadi 26, Bhira 20, Dharamsala 19, Kangra 13, Malikpur 11, Dalhousie & Palwal 10 each, Nowgong 9, Bahraich 8, Satna 7
- 3rd: Koyna 35, Talkoi 32, Sandheads 21, Chandbali & Kolhapur 13 each, Yellapur 12, Jogindernagar & Khanapur 11 each, Baijnath & Sambalpur 10 each, Dharamsala & Raigarh 9 each, Gurudaspur & Shivpuri 7 each
- 4th: Sirsi 20, Nilambur 19, Chandgad & Katangi 18 each, Singdega 17, Jashpurnagar & Talguppa 13 each, Bagamandala 10, Jabalpur & Panposh 9 each, Narsinghpur 8, Madras 7
- 5th: Banswara 23, Rajgarh 16, Belthangady & Shajapur 15 each, Idar 14, Dohad 13, Ujjain 12, Karwar 9, Udaypur 8, Bagati (Magra) 7
- 6th: Tenali 15, Cooch Behar 11, Idar, Okha & Pasighat 10 each, Kasargode 9, Dehradun 8, Deesa & North Lakhimpur 7 each
- 7th: Nurpur 18, Katra 17, Cooch Behar 13, Tirupattur 11, Jalpaiguri & Tirupati AP 9 each, Jaisalmer & Purnea 8 each, Kangra & Udhampur AP 7 each
- 8th: Kasauli 29, Jagadhari 24, Dharampur 21, Dholai 19, Chandpur 17, Nawarangpur & Ropar 13 each, Jagdalpur, Katra & Sandheads 9 each, Chandigarh AP, Tezpur & Uluberia 7 each
- 9th: Nurpur 18, Jogindernagar 15, Malikpur 13, Kumta 11, Patiala & Rajkot AP 9 each, Bapatla, Belthangady, Durgachak & Panjim 7 each
- 10th: North Lakhimpur 12, Hiraikund 9, Banbasa & Berhampore 8 each, Baijnath, Pasighat & Visakhapatnam AP 7 each
- 11th: Jashpurnagar 22, Gorakhpur 21, Orai 13, Gaya AP & Lucknow AP 12 each, Tamini 11, Bhira & Bramhapuri 9 each, Chidambaram, Lumding & Patna AP 7 each, Pondicherry 7
- 12th: Amlah & Thakurganj 14 each, Badaun, Ropar & Tirupattur 10 each, Morena 9, Alwar, Pasighat & Sikar 8 each, Chouldaghat & Jashpurnagar 7 each
- 13th: Narora 17, Pasighat 12, Badaun & Belthangady 10 each, Supaul 9, Cooch Behar, Shimla & Tezu 7 each
- 14th: Lucknow AP, Mainpuri, New Delhi AP & Pasighat 11 each, Kailashahar, Kolar Gold Fields & Mathura 7 each
- 15th: Narayangarh 15, Bhatkal & Hardwar 11 each, Chapra & Kangra 10 each, Banihal & Calcutta AP & Gorakhpur 8 each, Dehradun, Kailashahar & Panjim 7 each
- 16th: Trivani 16, Koderu 15, Long Island 11, Karwar 9, Nidadavole, Sangareddy & Tambaram 8 each
- 17th: Honavar 17, Karwar 15, Kasargode 11, Bhagamandala 10, Cochin AP 9, Tezpur & Udgir 8 each, Chouldaghat, Panjim & Ratnagiri 7 each
- 18th: Kumta 20, Karwar 15, Aizwal & Hosdurg 12 each, Karimganj 11, Nanded 9, Asifabad, Lumding & Pusad 8 each, Vengurla 7
- 19th: Kumta 14, Panjim & Shirali 11 each, Asifabad & Ratnagiri 9 each, Dibrugarh AP, Honavar & Talguppa 8 each, Tadong 7
- 20th: New Delhi (SFD) 16, Sikandrabad 13, Kama-reddy & Rangiya 11 each, Amravati 10, Bombay 9, Belthangady, Asifabad & Talguppa 7 each
- 21st: Rajapur 16, Amravati 15, Pasighat 13, Akola & Jalpaiguri 11 each, Dibrugarh AP & Sirhind 9 each, Aurangabad AP & Jogipet 8 each
- 22nd: Pasighat 48, Tezu 22, Simdega 19, Jalpaiguri 14, Tamini, Jogindernagar, Pathan & Perur 8 each, Cooch Behar, Gorakhpur, Parbhani & Rajkot 7 each
- 23rd: Pasighat 32, Dungarwadi 24, Tezu 21, Karimganj 13, Billoli 11, Banbasa & Cooch Behar 10 each, Varanasi AP 9, Nagpur AP 8, Khargaon, Pantnagar & Satna 7 each
- 24th: Cherrapunji 40, Pasighat 22, Cooch Behar 19, Beki Road Bridge 14, Tezu 11, Mancompu 10, Satna 9, Betul, Coimbatore AP & Shillong 8 each, Malikpur 7
- 25th: Cherrapunji 50, Pasighat 27, Purnea 26, Cooch Behar 25, Nandyal 14, Cuddapah & Shillong 12 each, Dharamshala 10, Rajnandgaon 9, Katra 8
- 26th: Cherrapunji 64, Kursela 35, Beki Road Bridge & Parkal 20 each, Pasighat 15, Goalpara 11, Jalpaiguri & Malda 10 each, Tezu 9, Purnea & Taran Taran 7 each
- 27th: Cherrapunji 46, Goalpara 16, Jaipur AP 12, Shillong 10, Tezu 9, Jogipet, Meajbat & Tangla 7 each
- 28th: Sira 14, Hospet & Kumta 13 each, Cooch Behar 12, Balurghat & Chauldaght 10 each, Parkal 9, Chitradurga, Kursela, Pasighat & Peermade 7 each
- 29th: Cooch Behar 15, Nirmal 13, Anantpur, Hasepet & Hyderabad AP 9 each, Agartala AP 8, Adriampattinam, Goalpara & Parkal 7 each
- 30th: Peermade 16, Kavali 13, Billoli 12, Calcutta AP 10, Parbhani & Cochin AP 7 each
- 31st: Hanamkonda & Jamkhed 10 each Aurangabad AP & Khammam 7 each.

### 3.3.3. *Disastrous weather and damages*

Widespread floods were reported from north India during the month. River *Siang* in Arunachal Pradesh was in high spate in the fourth week, which heavily damaged Pasighat-Jonai and Pasighat-Lidimtene roads.

TABLE 6

Details of weather systems during September 1988

S. No.	Weather systems	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
<i>(A) Low pressure area/depression etc</i>						
1	Low pressure area**	1st-5th	Lay over southeast Madhya Pradesh and adjoining Telangana and coastal Andhra Pradesh on 1st	Westnorth-westerly	South Gujarat and adjoining north Maharashtra coast	**B/F from August
2	Low pressure area	10th evening-13th	South Vidarbha and neighbourhood	Westnorth-westerly	Coastal areas of north Maharashtra and south Gujarat	Seen as a cyclonic circulation in lower and mid-trop. levels over south east Madhya Pradesh and adjoining Telangana and Vidarbha on 9th
3	Well marked low press. area*	16th evening-22nd	Northwest and adjoining west central Bay off south Orissa-north Andhra coast	Westnorth-westerly	Merged with the low pressure area over north Maharashtra and neighbourhood	Observed as a cyclone circulation up to mid-trop. levels on 15th over north Bay and neighbourhood
4	Low pressure area	16th evening-19th	Vidarbha and neighbourhood	—	<i>In situ</i>	Observed as a cyclonic circulation in the lower trop. levels over northeast Madhya Pradesh and neighbourhood on 15th
5	Well marked low press. area*	18th-25th	East Central Arabian Sea and adjoining north Maharashtra coast	Easterly/north-northeasterly	Haryana and neighbourhood. However associated cyclonic circulation moved away eastwards across Himachal Pradesh on 29th	*Merged on 22nd with the system under S. No.3 & the resultant system moved.
6	Low pressure area	21st-24th	Northwest Bay and adjoining coastal areas of Orissa	Westerly	North Orissa and adjoining east Madhya Pradesh	Seen as a cyclonic circulation in the lower trop. level over north coastal Andhra Pradesh and adjoining south Orissa coast on 20th evening
7	Low pressure area**	29th	West central Bay and adjoining northwest Bay	—	—	Appeared over north Andaman Sea and neighbourhood on 15th where it persisted till 21st and then moved
<i>(B) Cyclonic circulation</i>						
1	Lower and mid-trop. levels	2nd-3rd	North Orissa and adjoining Gangetic West Bengal and Bihar plateau	—	<i>In situ</i>	
2	Lower levels	4th-5th	West Rajasthan and neighbourhood	—	<i>In situ</i>	
3	Lower and middle trop. levels	10th-13th	West central Bay off south Andhra coast	Quasi-stationary	North Tamil Nadu-south Andhra coast	
4	Lower and middle trop. levels	11th-13th	South Interior Karnataka and neighbourhood	Do.	Coastal Karnataka and neighbourhood	
5	Lower trop. levels	14th-16th	Haryana & neighbourhood	Northeasterly	Moved away across Himachal Pradesh and neighbourhood	
6	Lower and mid-trop. levels	27th-30th	East central Arabian Sea off north Maharashtra coast	Quasi-stationary	Konkan and adjoining Gujarat region and Sea areas	
<i>(C) Western disturbances</i>						
1	Cyclonic circulation in lower trop. levels	6th-7th even.	Jammu & Kashmir and adjoining north Pakistan	Easterly	Moved away across Western Himalayas	
2	Cyclonic circulation in lower trop. levels	8th-12th	Punjab and neighbourhood	Easterly	Moved away across Himachal Pradesh and neighbourhood	
3	Cyclonic circulation in lower levels	16th-19th	Northwest Rajasthan and adjoining Pakistan	Northeasterly	Became unimportant over Himachal Pradesh	
<i>(L) Upper air trough in westerlies</i>						
1	Mid. and upper trop. levels	1st-3rd	Jammu & Kashmir to Haryana	Quasi-stationary	<i>In situ</i>	
2	Do.	24th-26th	Russian Turkistan to north-east Bay	Do.	<i>In situ</i>	

\*\*Became a depression there on 1 October

Also river *Talon* and *Mayee* eroded Yegrung village and river *Sibiya* washed away range headquarters in the State. Brahmaputra valley remained under the grip of floods throughout the month and it took a severe turn in the last week. About 1200 UTC villages were sub-

merged by flood waters in the State. Rivers in Bihar and Uttar Pradesh and river *Ganga* at Farakka in West Bengal were also in spate throughout the month affecting a large number of population. Katihar town in Bihar was flooded in the last week of the month. During the

first fortnight breach in Dhusi bund along river *Ravi* inundated large areas in Amritsar and Gurdaspur districts of Punjab. A bridge near Sirajpur in Haryana on the river *Jhakra* collapsed due to flash floods in the first week. Delhi-Kalka road was also closed during this period following landslides at some places. A cloud burst in Chhatragul village in south Kashmir killed 6 members of a family on 15th. The flood situation in Kaira district of Gujarat was grim during the first week. Floods in river *Mahi* inundated seven villages in the district. Owing to heavy rain, river *Godavari* was in spate in the first week affecting eight districts in Andhra Pradesh. Heavy rain also inundated parts of Rajmundry town.

As per reports floods in Andhra Pradesh claimed about 100 human lives and about 4200 livestock. Paddy crops in about 2 lakh hectares was damaged.

Floods/heavy rains claimed about 100 human lives in Bihar, 35 in Gujarat, 7 in Punjab, 5 in Haryana and about 430 in Uttar Pradesh during the month. As per press reports the estimated damage to crops and properties was about Rs. 77 crores in Assam and Rs. 15 crores in Bihar.

### 3.4. September

#### 3.4.1. Withdrawal of southwest monsoon

The withdrawal phase of southwest monsoon commenced on 12 September when it withdrew from Jammu & Kashmir, west Rajasthan and parts of Himachal Pradesh and of Punjab. Thereafter, the withdrawal halted till the last day of the month. On 30 September it withdrew from hills of west Uttar Pradesh, Haryana, remaining areas of Himachal Pradesh and Punjab and from most parts of plains of west Uttar Pradesh and of east Rajasthan. It further withdrew from the entire country outside Tamil Nadu and Kerala on 12 October. Withdrawal of southwest monsoon in phased manner has been shown in Fig. 2.

#### 3.4.2. Monsoon activity and synoptic features

During the month on most occasions, the seasonal trough in the lower levels was running across the Peninsula or the central parts of the country. It was prominent in the first week and in the second fortnight of the month.

Six low pressure areas developed over the Indian sub-continent and the neighbouring sea areas during the month of which two became well marked. All these systems first appeared as upper air cyclonic circulations and then further developed into low pressure areas. A trough on sea level chart extending from Maharashtra coast to Kerala coast/Lakshadweep area was observed almost throughout the month. Details of the synoptic features are given in Table 6.

During the month active to vigorous monsoon conditions prevailed on 19 to 20 days in Madhya Maharashtra and Marathwada; on 9 to 12 days in Arunachal Pradesh, Assam & Meghalaya, Konkan & Goa, Telangana, Rayalaseema, Karnataka and Kerala; on 5 to 6 days in West Bengal & Sikkim, Orissa, Bihar plains, Haryana, Vidarbha and coastal Andhra Pradesh and on 1 to 3 days in Nagaland, Manipur, Mizoram & Tripura, Bihar

plateau, plains of Uttar Pradesh, Punjab, east Rajasthan, west Madhya Pradesh and Gujarat. The active to vigorous monsoon activity occurred over plains of Uttar Pradesh, east Rajasthan, west Madhya Pradesh and Gujarat during 22nd to 25th. East Madhya Pradesh did not experience any active or vigorous monsoon on any day during the month. Andaman & Nicobar Islands experienced generally widespread rain or thundershowers on 20 days and Lakshadweep on 8 days. The rainfall during the month over east Madhya Pradesh was mainly of scattered or isolated nature. After the withdrawal of monsoon, Punjab, Himachal Pradesh and Jammu & Kashmir experienced heavy to very heavy spell of rainfall between 23rd and 27th in association with the passage of a low pressure area across northwest India, which caused devastating floods in those areas. Also heavy snowfall was reported from the upper reaches of Himachal Pradesh and Jammu & Kashmir during the 4th week of the month.

#### 3.4.3. Rainfall

Rainfall during the month was excess in Andaman & Nicobar Islands, Arunachal Pradesh, Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, east Rajasthan, Saurashtra & Kutch, Maharashtra, coastal Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Kerala and Lakshadweep; normal in Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Orissa, west Rajasthan, Gujarat region and Rayalaseema; deficient in Bihar, plains of west Uttar Pradesh and Madhya Pradesh and was scanty in east Uttar Pradesh. Data from hills of west Uttar Pradesh were not available.

The significant amounts (cm) of rainfall were :

- 1st : Udgir 14, Sangareddy 9, Ahwa & Gaganavda 8 each, Gokak & Nalgonda 7 each
- 2nd : Karimnagar 18, Hukkeri 12, Parenda 11, Akola & Telkoi 9 each, Nanded 8, Chintalapudi, Minicoy & Nizamabad 7 each
- 3rd : Sandheads 22, Chittur 15, Bhagamandala 10, Vita 9, Swampatna 8, Kolhapur & Thuckalay 7 each
- 4th : Shirota 12, Pasighat 10, Bagati (Magra), North Lakhimpur & Tezu 8 each
- 5th : Panbari 17, Udayagiri 10, Triveni 8, Beki Road Bridge & Pasighat 7 each
- 6th : Jalpaiguri 25, Cooch Behar 21, Muzaffarpur 11, Tiruchirapalli 10, Berhampore 9, Chalakudi & Mathanguri 7 each
- 7th : Nizamabad & Pasighat 13 each, Haskote 12, Yellapur 10, Nagpur & Purnea 9 each, Mandya 8, Cooch Behar & Yavatmal 7 each
- 8th : Ahwa 19, Cooch Behar 14, Kayamkulam 13, Alleppey 11, Dahanu, Jaypur, Purnea, Umerkhet & Uttoor 9 each, Sironcha 8, Bhubaneswar AP, Haldwani, Kokrajhar, Trivandrum & Valod 7 each
- 9th : Motihari 18, Kayamkulam 16, Sriniketan 14, Cooch Behar & Vaikom 12 each, Namakkal 10, Jalpaiguri 8, Billoli, Calcutta, Gaganavda & Nizamabad 7 each

- 10th : Pannagaram 21, Bombay 14, Bangalore 13, Kailashahar 11, Salem & Yelhanka AP 10 each, Muktesar 8, Gondia 7
- 11th : Dharampuri 10, Goa AP & Pakala 9 each, Kumta 8, Belgaum AP, Bombay & Tirup. tur 7 each
- 12th : Bangalore 18, Valsad 10, Tiruchirapalli 9, Tumkur 7
- 13th : Madurai AP 11, Pamban 8, Kankavali & Tezu 7 each
- 14th : Kunnamkulam 17, Chitradurga 10, Rahuri & Tuljapur 9 each, Deogarh 7
- 15th : Honavar 17, Amini Divi 13, Mannarghat 9, Holenarsipur, Purulia & Solapur 8 each, Chalisgaon, Jogipet & Raichur 7 each
- 16th : Nilanga 12, Jeur 11, Long Island & Osmanabad 10 each, Goa AP & Midnapore 9 each, Alleppey & Port Blair 8 each, Karwar & Punalur 7 each
- 17th : Paithan 11, Harnai, Malerkotla & Nahan 8 each, Madras & Utnoor 7 each
- 18th : Thodupuza 25, Althur 16, Jaypur 12, Car Nicobar 11, Bhubaneswar AP 9, Balasore 8, Pune AP 7
- 19th : Machilipatnam 19, Mohana 18, Sompeta 16, Kozhikode & Visakhapatnam 13 each, Vengurla 12, Ashti & Gopalpur 10 each, Billoli & Khammam 9 each, Kottayam & Puri 8 each
- 20th : Mancheril 19, Harnai 13, Alibag 12, Chalisgaon 11, Berhampore, Billoli, Buldhana & Chaibasa 9 each, Aurangabad, Bombay & Port Blair 7 each
- 21st : Rajapur 13, Nandyal & Shahad 10 each, Karwar 9, Ahwa, Bagamandala & Port Blair 8 each
- 22nd : Gwalior 22, Chandgad 17, Gaganbavda 15, Harobi 13, Car Nicobar & North Lakhimpur 9 each, Orai & Vengurla 8 each, Bhira, Jamshedpur & Kanpur 7 each
- 23rd : Gaganbavda & Surat 12 each, Katghora & Puranpur 11 each, Batala, Poladpur & Sadulpur 10 each, Katra AP & Kunnamkulam 9 each, Dharampur & Rajnandgaon 8 each, Bagati (Magra), Car Nicobar & Halwara 7 each
- 24th : Una 32, Kapurthala 28, Nurpur 21, Chandigarh AP & Kandaghat 19 each, Ajnala & Dharamsala 18 each, Hissar 17, Baderwah 16, Batote, Dalhousie & Patiala 15 each, Navsari 10, Bhavnagar AP 8, Jammu 7
- 25th : Hamirpur 40, Batote 32, Katra 29, Jammu 27, Kathua 25, Kandaghat 18, Raya 17, Ajmer 16, Amritsar AP 15, Malikpur 14, Chandigarh AP & Patiala 12 each, Bijnore & Najibabad 11 each, Una 10
- 26th : Nahan 27, Tibri 22, Bhatkal & Nurpur 21 each, Chamba & Kapurthala 16 each, Sompeta 15, Batote & Dharamsala 12 each, Amritsar AP 11, Bombay 8
- 27th : Una 26, Mathanguri 24, Harnai 18, Joginder-nagar 13, Cooch Behar & Tezu 11 each, Chandigarh AP 10, Car Nicobar, Karwar & Pune AP 8 each, Valsad 7
- 28th : Alibag 19, Bombay & Mathanguri 13 each, Tezu 12, Cooch Behar 11, Ahwa, Gulbarga & Pasighat 10 each, Parbhani & Ratnagiri 7 each
- 29th : Valsad 18, Port Blair 15, Bombay AP 14, Gangtok 13, Ahwa, Balurghat & Jalgaon 10 each, Latur, Dhanbad & Tadong 8 each, Porbandar AP 7
- 30th : Banswada 17, Billoli 13, Nizamabad 10, Bramhapuri, Koderu & Nagpur 7 each.

#### 3.4.4. *Disastrous weather events and damages*

Floods in Bramhaputra valley of Assam and in Bihar continued almost throughout September. Uttar Pradesh and West Bengal experienced floods during the first fortnight of the month. Following heavy rains in the 4th week of the month, rivers in Haryana, Punjab, Himachal Pradesh and Jammu & Kashmir were in high spate. The fury of the floods was so severe that it had been described as the century's worst flood in the northern States. In Haryana National Highway No. 10 was badly damaged and Sirsa-Bhatinda railway line was under water. High spate in rivers *Ravi*, *Sutlej* and *Beas* badly affected Ludiana, Hoshiarpur, Amritsar, Gurudaspur, Jalandhar and Kapurthala districts in Punjab. In Himachal Pradesh rivers *Ravi*, *Chenab* and *Beas* and in Jammu & Kashmir rivers *Jhelum*, *Tawi* and *Chenab* were in spate. Flash floods in river *Swan* in Una district of Himachal Pradesh caused heavy damages to life and property. Road networks in Una, Kangra, Chamba, Shimla and Kulu districts were disrupted due to landslides. Wireless and telecommunication systems had virtually collapsed in the State. In Jammu & Kashmir several parts of Anantnag town were inundated and Srinagar-Jammu National Highway was submerged at several points. Heavy snowfall in the upper reaches of Jammu and Kinnaur, Dhauladhar, Dodrakar, Lahaul, Spiti ranges in Himachal Pradesh paralysed life in those areas. Srinagar-Leh Road was closed due to heavy snowfall on 26th on both sides of Zozila Pass.

Floods/heavy rains claimed about 120 lives in Assam, 40 each in Bihar and west Bengal, 370 in Uttar Pradesh, 40 in Haryana, 760 in Punjab, 210 in Himachal Pradesh and 110 in Jammu & Kashmir during the month. The estimated damages to crops and properties were worth about Rupees 29.50 crores in Bihar, 359.30 crores in Haryana, 161.30 crores in Punjab, 305.70 crores in Himachal Pradesh and rupees 169.60 crores in Jammu & Kashmir.