Mausam, (1995), **46**, 3, 343-366

Weather

MONSOON SEASON (JUNE-SEPTEMBER 1994)*

1. Introduction

The summer monsoon rainfall (June to September 1994) over the country was 110% of the seasonal normal. 25 meteorological sub-divisions received normal or excess rainfall and 10 meteorological sub-divisions had deficient rainfall. No meteorological sub-division received scanty rainfall during the season. During this year, there was only one monsoon depression in August. However, a severe cyclonic storm formed in June in the Arabian Sea which moved away westwards. The seasonal rainfall departures stationwise and meteorological subdivisionwise are given in Figs. 1 & 2.

2. Features of the monsoon

2.1. *Advance of southwest monsoon*

The onset of southwest monsoon over south Kerala on 28 May was 4 days earlier than the normal date. It further advanced along the west coast upto Bombay by 6 June which was also about 4 days earlier. It's advance over northeast India was on 5 June which was close to the normal date. It advanced to Gujarat, Madhya Pradesh, Orissa and east Uttar Pradesh by 12 June which was 2 to 3 days earlier than the normal. It's advance upto east Rajasthan by 27 June was 5 days earlier than normal. Subsequently, it advanced over west Rajasthan and covered the entire country by 30 June, which was 2 weeks earlier than the normal. Isochrones of advance of southwest monsoon 1994 are shown in Fig. 3.

2.2. *Week-by-week performance of monsoon rains*

Meteorological sub-divisionwise weekly rainfall departures (percentge departure from normal) during the period 2 June 1994 to 5 October 1994 are given in Fig. 4. Rainfall figures given in this table are computed from real time data. Week-by-week rainfall distribution from the 2nd week of June to the 1st week of September except 3rd week of June and 2nd week of August 1994, when about 50% or more of met sub-divisions received normal or excess rainfall. Rainfall activity was subdued (when less than 35% of met sub-divisions received normal or excess rainfall) during the 3rd week of June and the 3rd and the 4th week of September.

Out of a total of 18 weeks (from 1 June to 5 October 1994) weekly rainfall was excess of normal in 10 weeks or more in Andaman and Nicobar Islands, Arunachal Pradesh, Gangetic West Bengal, Orissa, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh, Jammu & Kashmir, Rajasthan, Madhya Pradesh, Gujarat region, Konkan & Goa, Madhya Maharashtra, coastal Andhra Pradesh, Karnataka and Kerala. It was excess or normal in five weeks or less in Nagaland, Manipur, Mizoram and Tripura, Sub-Himalayan West Bengal, Bihar and hills of west Uttar Pradesh.

2.3. *Month-by-month performance of monsoon rain*

During June (Fig. 5) rainfall was excess in 16, normal in 8 and deficient in 11 meteorological subdivisions over India.

During July (Fig. 6) rainfall was excess in 17, normal in 11, deficient in 7 meteorological subdivisions over India.

During August (Fig. 7) it was excess in 11, normal in 20 and deficient in 4 meteorological subdivisions over India.

During September (Fig. 8), there was subdued rainfall activity over India. Rainfall was excess in 5, normal in 10, deficient in 13 and scanty in 7 meteorological sub-divisions over India.

2.4. *Seasonal performance of monsoon rainfall*

Seasonal rainfall distribution meteorological sub-divisionwise is given in Fig. 2 and Table 8. The

* *Compiled by*: U. S. De, D. S. Desai and S. G. Bhandari, Meteorological Office, Pune.

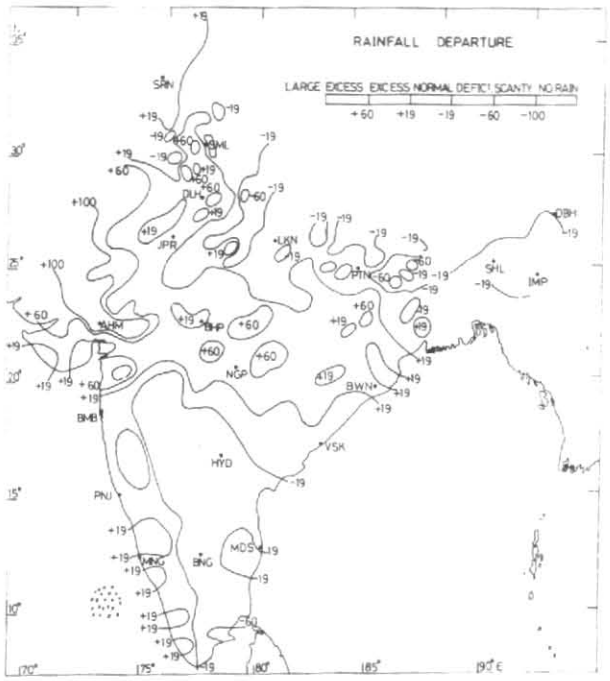

Fig. 1. Stationwise seasonal rainfall departure (%) for the period June-September 1994

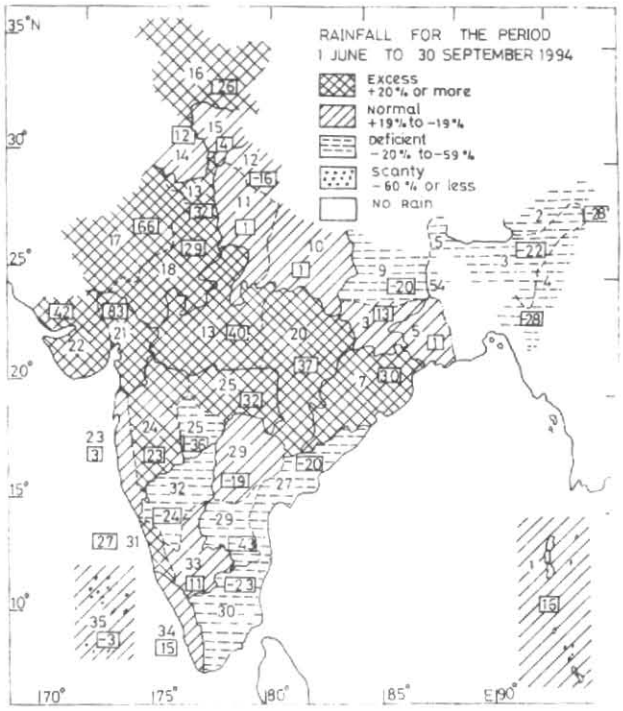

Fig. 2. Sub-divisionwise seasonal rainfall departure (%) for th period June-September 1994

seasonal rainfall was excess in 12, normal in 13 and deficient in 10 meteorological sub-divisions. Seasonal rainfall was deficient marginally in Assam and Meghalaya (−22), Bihar plains (−20), coastal Andhra Pradesh (−20), Tamil Nadu (−23) and north interior Karnataka (−24). Seasonal total rainfall for the country as a whole was 110% of long period average value.

2.5. *Districtwise distribution of rainfall*

Districtwise distribution of rainfall for each state, in terms of number of districts with excess, normal, deficient or scanty rainfall for the period from 1 June to 30 September 1994 is given in Table 1. Out of 398 participating meteorological districts, 147 (37%) districts received excess rainfall and 156 (39%) received normal rainfall.

2.6. *Withdrawal of southwest monsoon*

Southwest monsoon withdrew from west Rajasthan on 19 September as against the normal date of 15 September. However, monsoon withdrew from west Uttar Pradesh, west Madhya Pradesh and Gujarat on 23 September, which was one week earlier than the normal date. Further withdrawal of monsoon was rather slow. It withdrew upto Lat. 20°N by 15 October 1994. It then, withdrew rapidly

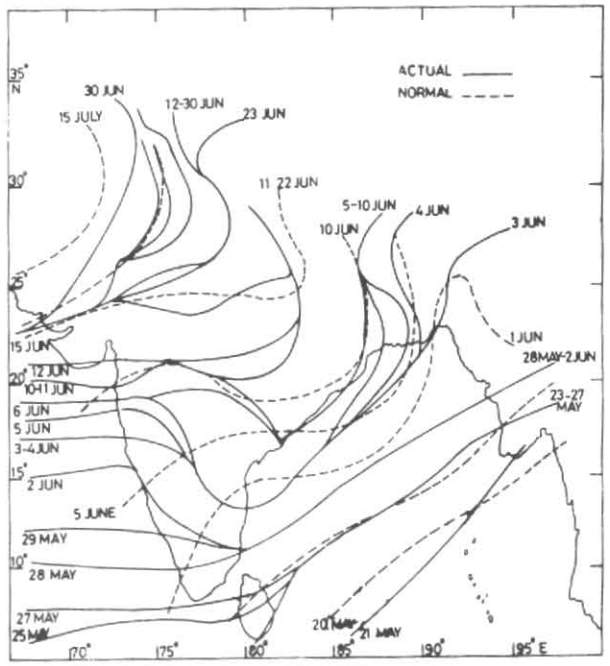

Fig. 3. Advance of southwest monsoon 1994

from rest peninsula and from the entire country by 17 October. Northeast monsoon rains commenced

over Tamil Nadu and adjoining states of Kerala, Karnataka and Andhra Pradesh by 18 October 1994. Withdrawal dates of southwest monsoon are shown in Fig. 9.

3. Chief synoptic features during the monsoon

The synoptic disturbances which affected the Indian monsoon region in June, July, August and September are given in Tables 2, 3, 4 & 5 respectively.

The summary of these disturbances is also given below :

Disturbances	June	July	August	September	Total
(*i*) Cyclonic storm/ Depression	1 (CS)	—	1 (D)	—	2
(*ii*) Well marked low/low pressure area	3	5	4	2	14
(*iii*) Cyclonic circulations	5	6	3	6	20
(*iv*) Off-shore trough	On most of the days from June to September				
(*v*) Lower level troughs	—	—	—	2	2
(*vi*) Trough (mid and upper tropospheric westerlies)	—	—	—	3	3
(*vii*) Eastward moving cyclonic circulations	3	—	—	1	4

3.1. *Cyclonic storm/depression*

3.1.1. *Severe cyclonic storm (SCS) over the Arabian Sea (5th June to 9th June 1994)*

A depression formed off south Maharashtra coast and adjoining Arabian Sea at 051800 UTC. It moved in a northwesterly direction initially and intensified into a cyclonic storm on 6 evening over the east central Arabian Sea. Then, it moved in a westnorthwesterly direction upto 7 morning. Later moving in a westerly direction it further intensified into a severe cyclonic storm on 7 evening. Moving further westwards it weakened into a depression on 9 morning and became unimportant off the Oman coast by the same evening.

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In association with the system the southwest monsoon advanced into Konkan and strengthened over west coast of India.

3.1.2. *Deep depression over the Bay of Bengal from 17th to 20th August 1994*

A depression formed over the northwest Bay off north Orissa-west Bengal coast on 17 morning. Moving in a westnorthwesterly direction it intensified into a deep depression on 17 evening and crossed north Orissa coast near Paradip on the 17 night. It lay as a deep depression on 18 morning near 21.0° N/85.0° E. It moved thereafter in a northwesterly direction and weakened into a depression on 18 evening. It weakened into a low pressure area over southeast Pakistan on 21 morning. Under its influence, southwest monsoon strengthened over central parts of the country.

Tracks of storms/depressions from 1 June to 30 September are given in Fig. 10.

3.2. *Low pressure area/well marked low pressure area (LPA/WMLPA)*

During the season there were fourteen LPA/WMLPA which were the main synoptic systems giving well distributed rainfall over the country. Monthwise breakup of these LPA/WMLPA is as follows :

3 in June, 5 in July, 4 in August and 2 in September.

In June, the first WMLPA (14 to 16) formed over the east central Arabian Sea off south Gujarat-north Maharashtra coast and remained quasi-stationary there. This helped in the advance of southwest monsoon over Gujarat and north Madhya Maharashtra. A second low pressure area (14-20) formed over Bihar plateau and neighbourhood. It remained quasi-stationary upto 17 and became less marked over west Uttar Pradesh and neighbourhood on 20. The associated cyclonic circulation which extended upto mid-tropospheric levels with this system persisted upto 22. Third WMLPA (25 June to 4 July) formed over the northwest Bay and adjoining Gangetic West Bengal. It moved in a northwesterly direction and lay over Rajasthan and neighbourhood by 2 July and moved away westwards by 4 July. In association with these two systems the southwest monsoon advanced further over central and north India and covered the whole country by 30 June.

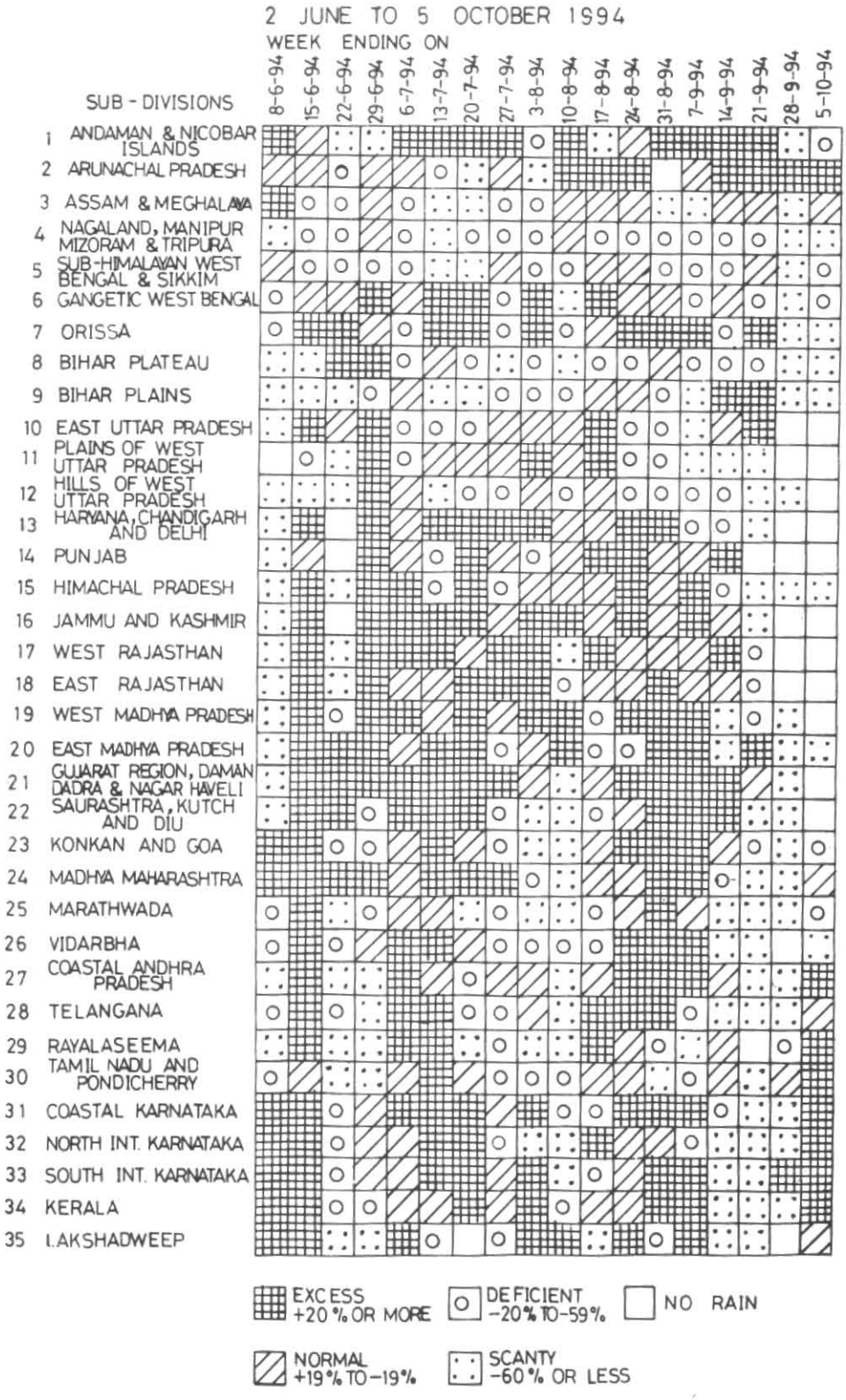


Fig. 4. Progress of southwest monsoon week by week (2 June to 5 October 1994)

TABLE 1

Statewise distribution of a number of districts with Excess (E), Normal (N), Deficient (D) and Scanty (S) rainfall for the period from 1 June 1994 to 30 September 1994

State/UT	Number of districts with rainfall				Data not available	Total
	E	N	D	S		
A & N Islands (UT)	0	1	0	0	0	1
Arunachal Pradesh	0	2	2	0	1	5
Assam	0	7	8	0	1	16
Meghalaya	0	1	0	0	1	2
Nagaland	0	0	0	0	1	1
Manipur	0	1	0	0	0	1
Mizoram	0	0	0	1	0	1
Tripura	0	0	1	0	0	1
Sikkim	0	0	1	0	0	1
West Bengal	2	9	5	0	0	16
Orissa	10	3	0	0	0	13
Bihar	3	21	11	0	4	39
Uttar Pradesh	13	31	11	0	1	56
Haryana	12	4	0	0	0	16
Chandigarh (UT)	1	0	0	0	0	1
Delhi (UT)	1	0	0	0	0	1
Punjab	4	5	3	0	0	12
Himachal Pradesh	4	5	3	0	0	12
Jammu & Kashmir	3	2	0	0	7	12
Rajasthan	19	9	1	0	1	30
Madhya Pradesh	33	11	1	0	0	45
Gujarat	16	3	0	0	0	19
Dadra & Daman (UTs)	1	0	0	0	0	1
Diu (UT)	1	0	0	0	0	1
Goa	0	1	0	0	0	1
Maharashtra	12	9	9	0	0	30
Andhra Pradesh	0	10	11	2	0	23
Tamil Nadu	1	7	12	2	0	22
Pondicherry (UT)	0	0	1	0	0	1
Karnataka	5	5	10	0	0	20
Kerala	6	8	0	0	0	14
Lakshadweep (UT)	0	1	0	0	0	1
Total	147	156	90	5	17	415
Distribution of Districts (Out of 398 received)	37%	39%	23%	1%	0%	

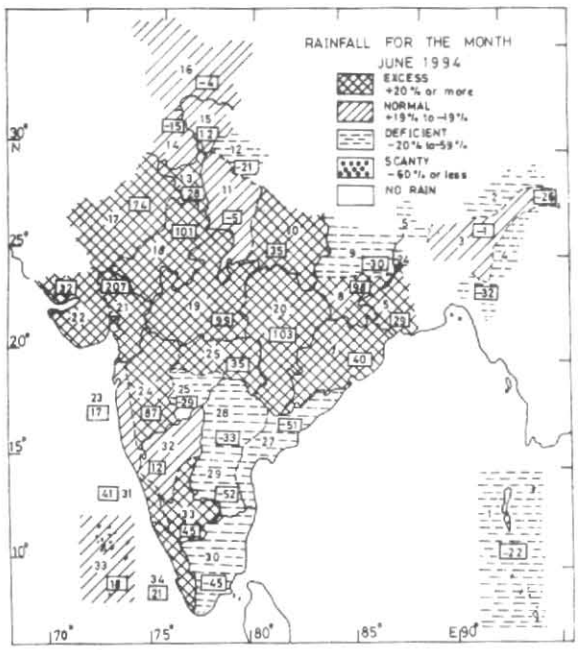


Fig. 5. Rainfall for the month of June 1994 (figures in box indicate rainfall percentage departure from normal)

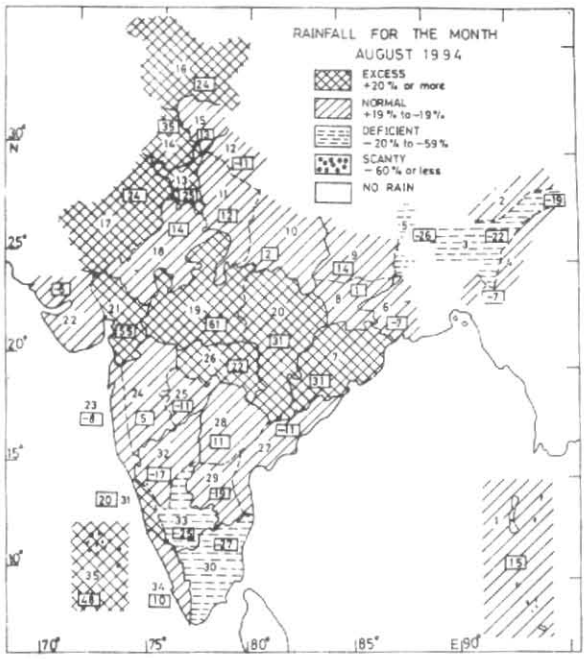


Fig. 7. Rainfall for the month of August 1994 (figures in box indicate rainfall percentage departure from normal)

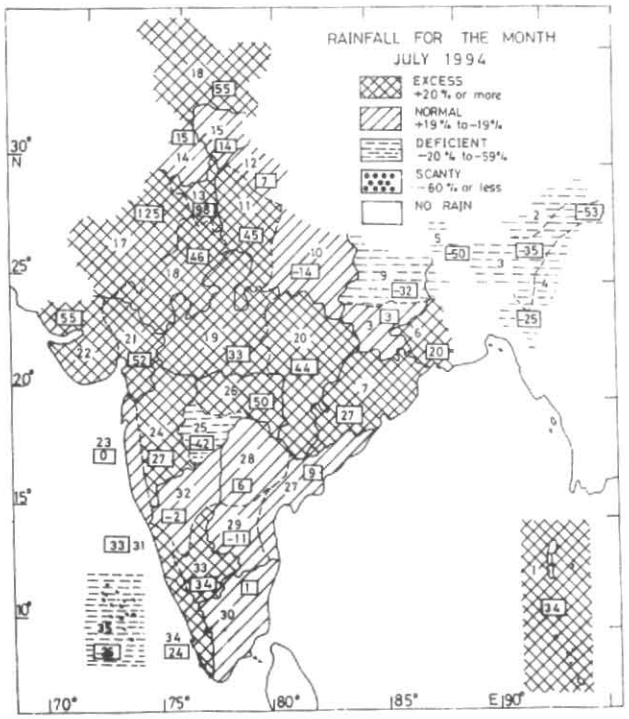


Fig. 6. Rainfall for the month of July 1994 (figures in box indicate rainfall percentage departure from normal)

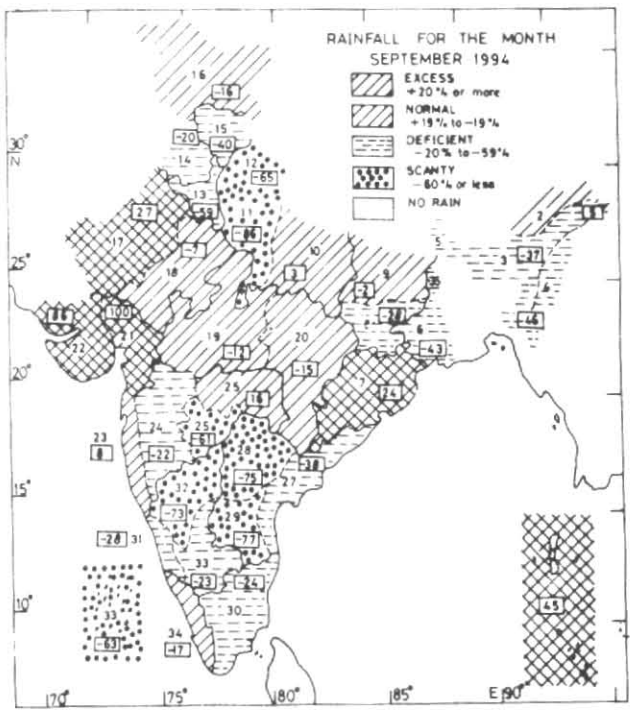


Fig. 8. Rainfall for the month of September 1994 (figures in box indicate rainfall percentage departure from normal)

In July, the first LPA (30 June to 2 July) formed over the Gulf of Martaban and neighbourhood and merged with the monsoon trough over north Andaman Sea. Then four more LPAs (3 to 6, 8 to 15, 14 to 17 and 15 to 25) formed and the monsoon trough was active. It remained south of its normal position on most of the days.

In August, 5 LPAs formed (2 to 7, 9 to 14, 21 to 24, 25 to 29, 26 August to 6 September) over northwest

TABLE 2

Details of weather systems during June 1994

S. No	Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A)	*Severe cyclonic storm*	6-9	East central Arabian sea	Initially northwards, then west-north-westwards and finally westwards	West-central Arabian Sea near Oman coast	It was first observed as a trough on sea level chart off Kerala coast on 26th May 5th - Well marked low formed over eastcentral Arabian sea off south Maharashtra coast 6th - Deep depression 17.5°N/71.5°E in evening cyclonic storm 18.0°N/70.5°E (about 300 km west-southwest of Bombay) 7th - Evening severe cyclonic storm 19.5°N/64.0°E (about 650 km westsouthwest of Porbandar) 8th - Cyclonic storm 19.5°N/61.0°E evening, deep depression over the same area 9th - Depression 19.5°N/59.5°E evening, low pressure area
(B)	*Low pressure area*					
1.	Well marked low pressure area	14-16	East-central Arabian sea off south Gujarat-north Maharashtra coast	Quasi-stationary	North Madhya Maharashtra and south Gujarat region	
2.	Low pressure area	14-20	Bihar plateau	Do.	Gangetic West Bengal adjoining Bihar	However, associated cyclonic circulation extending upto tropospheric levels was observed over northeast Madhya Pradesh. It became less marked on 22nd over west Uttar Pradesh
3.	Well marked low pressure area	25 Jun-4 Jul	Northwest Bay and adjoining Gangetic West Bengal	Northwesterly	Over Rajasthan and neighbourhood on 1 and 2. Moved away westwards on 4	
(C)	*Cyclonic circulations*					
1.	Lower tropospheric levels	9-12	Punjab and neighbourhood	Northeastwards	West Uttar Pradesh and adjoining parts of Haryana	A trough from this system running in lower levels to northwest Bay across north Madhya Pradesh from 9 to 13th

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Mid tropospheric levels	9-10	North Bay and neighbourhood	Stationary	*In situ*	
3.	Do.	20-24	Punjab and neighbourhood	Eastnortheasterly	Merged with the well-marked low (No. 3)	
4	Do.	20-26	Northwest Bay and adjoining Gangetic West Bengal	Stationary		Under its influence, a low pressure area formed over northwest Bay and adjoining south Orissa coast on 26th June
(D)	*Off-shore trough*					
1.	Off-shore trough	Most of the days in June to Sept	South Konkan to Kerala coast	Quasi-stationary	Gujarat coast to south Maharashtra coast	
(E)	*Eastward moving circulations*					
1.	Upper air system	31 May-2 Jun	North Pakistan and adjoining Jammu & Kashmir	Northeastwards	Moved away across western Himalayas	
2.	Do.	3-5 Jun	North Pakistan and adjoining Jammu & Kashmir	Do.	Moved away across Jammu & Kashmir	
3.	Do.	6-9	North Pakistan	Do.	Moved away	

Bay and neighbourhood and moved in a westnorthwesterly direction along the monsoon trough accentuating the monsoon trough/rainfall.

In September, two LPAs (1 to 11 and 15 to 19) formed over northwest Bay and neighbourhood and moved in a westnorthwesterly direction along the axis of the monsoon trough.

3.3. *Cyclonic circulations (CYCIR)*

In all 20 cyclonic circulations (lower levels and upper levels) formed during this season causing well distributed rainfall over the country. The monthwise breakup of cyclonic circulation is as follows :

5 in June, 6 in July, 3 in August and 6 in September.

In June, two cyclonic circulations formed over the north Bay and neighbourhood and remained stationary and two cyclonic circulations formed over Punjab and neighbourhood and moved northeastwards.

In July, two cyclonic circulations formed *in situ* over Kutch and neighbourhood and remained stationary. Three more cyclonic circulations formed over northwest India and two of them moved in a northeasterly direction and the third remained stationary. The next cyclonic circulation formed over west central Bay off Andhra coast.

In August, two cyclonic circulations formed over north Gujarat and neighbourhood and the third formed over west Rajasthan and neighbourhood.

In September, two cyclonic circulations formed, one over Gujarat region and the other over Pakistan and neighbourhood. Four more cyclonic circulations were also formed. The details of these are given in Table 5.

TABLE 3

Details of weather systems during July 1994

S. No.	Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A)	*Low pressure area*					
1.	Low pressure area	30 Jun-2 Jul	Gulf of Martaban and neighbourhood	Quasi-stationary	Merged with the monsoon trough over north Andaman Sea	
2.	Do.	3-6	Northwest Bay and adjoining south Orissa coast	Westwards	Merged with the monsoon trough over north Vidarbha and adjoining Madhya Pradesh	It was first observed as a cyclonic circulation on 1st in mid-tropospheric levels over northwest Bay and neighbourhood persisted there upto 5th
3.	Well marked low pressure area	8-15	Northwest Bay & neighbourhood	Northwesterly	Merged with the monsoon trough over north Orissa and adjoining Gangetic West Bengal	
4.	Low pressure area	14-17	North Gujarat region and neighbourhood	Do.	Merged with the seasonal trough over southwest Rajasthan and adjoining parts of Kutch	It was first observed as a cyclonic circulation on 13th over the same area
5.	Do.	15-25	Northwest Bay & neighbourhood	Do.	Merged with the monsoon trough over west Uttar Pradesh and adjoining parts of Haryana	
(B)	*Cyclonic circulation*					
1.	Mid-tropospheric levels	1-3	Kutch and adjoining regions	Stationary	*In situ*	
2.	Do.	6-7	Kutch and neighbourhood	Do.	Do.	
3.	Lower levels	17-22	North Pakistan & adjoining Punjab & west Rajasthan	North-north-westerly	North Pakistan & adjoining Jammu & Kashmir	
4.	Lower tropospheric levels	22-26	Pakistan and adjoining west Rajasthan	Northeasterly	Jammu & Kashmir and adjoining Punjab	
5.	Do.	24-25	South Rajasthan & adjoining west Rajasthan	Stationary	*In situ*	
6.	Upper tropospheric levels	25-29	West central Bay off Andhra coast	West-north-westerly	Northwest Bay	Under its influence a well marked low pressure area has formed over northwest Bay on 29th. (Details are given in Table 5)

TABLE 4

Details of weather systems during August 1994

S. No. (1)	Weather system (2)	Period (3)	Place of first location (4)	Direction of movement (5)	Place of dissipation (6)	Remarks (7)
(A)	*Depression*					
1.	Deep depression	17-21	Northwest Bay off west Bengal-north Orissa coasts	Westnorth-westerly	Southeast Pakistan and neighbourhood	It was first observed as a cyclonic circulation over north Bay and neighbourhood on 15th with associated cyclonic circulation extending upto mid-tropospheric levels, under its influence a well marked low pressure area formed over northwest Bay off north Orissa-West Bengal coast on 16th and depression formed over the same area (centre 20.5°N/88.5°E. about 180 km southeast of Balasore at 0300 UTC of 17th). It further intensified into a deep depression over northwest Bay (20.5°N/87.5°E about 60 kms southeast of Chandbali at 1200 UTC of 17th) crossed Orissa coast near Paradip. It weakened into a depression on 18th (21°N/85°E), when it was 80 kms northwest of Bhubaneshwar, further it got weakened in well marked low pressure area over southeast Pakistan and neighbourhood on 21st
(B)	*Low pressure area*					
1.	Low pressure area	2-7	North Bay and neighbourhood	Northwesterly	Northeast Uttar Pradesh and neighbourhood	
2.	Do.	9-14	Northwest Bay off north Orissa-West Bengal coasts	West-north-westerly	Central parts of Rajasthan	Associated cyclonic circulation became less marked on 15th
3.	Do.	21-24	Northwest Bay & neighbourhood	Do.	Merged with the seasonal trough over north Orissa and neighbourhood	It was first observed as a cyclonic circulation extending upto mid-tropospheric levels over the same area on 15th
4.	Do.	25-29	Gangetic West Bengal and neighbourhood	Do.	South Pakistan and adjoining Kutch	

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Well marked low pressure area	26 Aug-6 Sep	Northwest and adjoining westcentral Bay off north Andhra-south Orissa coasts	Do.	Northeast Arabian Sea	
(C)	*Cyclonic circulations*					
1.	Mid-tropospheric levels	10-12	West Rajasthan and adjoining Pakistan	Northwesterly	Northeast Pakistan and neighbourhood	
2.	Do.	22-30	North Gujarat and westerly neighbourhood	Merged with the lowpressure area over south Pakistan and adjoining Kutch		
3.	Do.	30 Aug-1 Sep	North Gujarat region & neighbourhood	Merged with the lowpressure area over south Pakistan		

3.4. *Off-shore trough*

On most of the days, during June to September, the off-shore trough along west coast (surface and in low levels) persisted and this is one of the characteristic features of southwest monsoon 1994.

3.5. *Low level trough*

Two low level troughs in the monsoon westerlies in September affected the country.

3.6. *Upper level trough*

Upper level westerly troughs in mid and upper troposphere which moved eastwards across north India are discussed here. Three such troughs moved across north India during September. The first trough in September (13 to 14) remained practically stationary, while the other two (16 to 19 and 22 to 29) moved rather slowly only upto the Long. 72°E.

3.7. *Eastward moving circulations*

Three eastward moving circulations as upper air systems moved across northwest India in June and one in September.

4. Extra-Indian systems

4.1. *Cross-equatorial flow*

Cross-equatorial flow (15 to 25 kts) was stronger in the Arabian Sea than in the Bay of Bengal (10 to

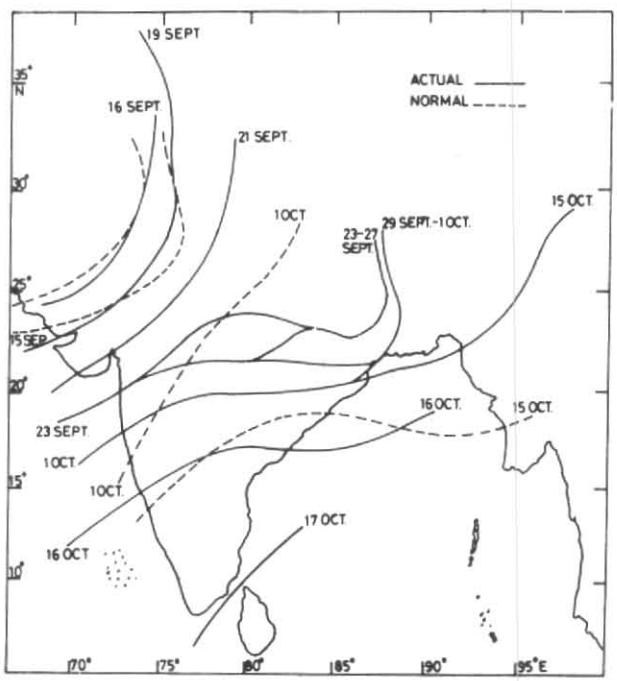


Fig. 9. Withdrawal of southwest monsoon 1994

15 kts) during June, July and August 1994. In June and July, the strength of the cross, equatorial flow reached to 40-45 kt over the Arabian Sea while over the Bay of Bengal it was between 25 and 30 kt.

4.2. *Mid-latitude troughs*

Mid and upper tropospheric westerly troughs which moved along Lat. 30° north and south are

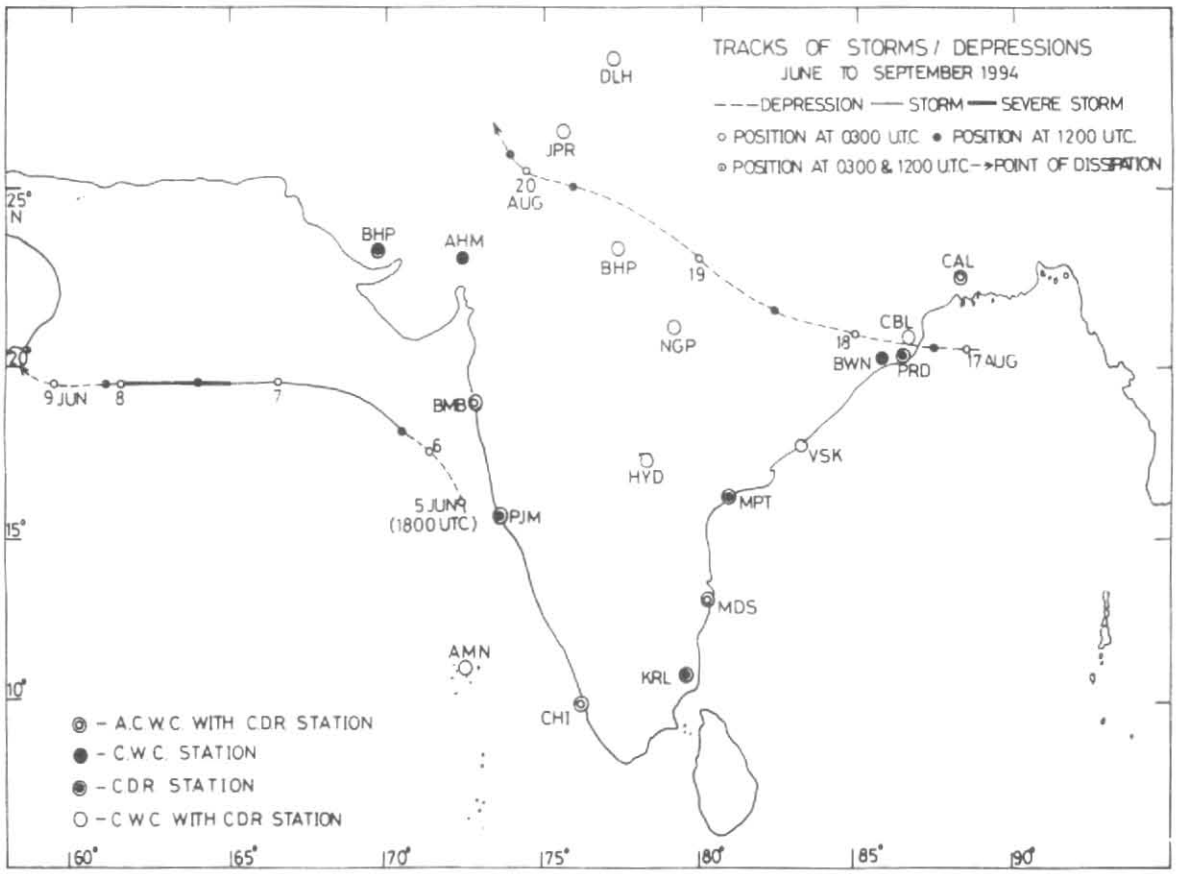


Fig. 10. Tracks of storms/depressions (June-September 1994)

given below. In all 16 troughs moved across north India and 23 troughs moved across south Indian Ocean.

	Jun	Jul	Aug	Sep	Remarks
North India	6	4	3	3	Occasionally, troughs were seen extending equatorwards as far as 25° N.
South Indian Ocean	5	6	6	6	Occasionally, troughs were seen extending equatorwards as far as 20°S.

4.3. *Systems in south China Sea/west Pacific Ocean*

During the four monsoon months of 1994 there were 11 typhoons (including 2 super typhoons), 11 tropical storms and two tropical depressions, making a total of 24 systems as against 21 in the last year. 17 of these 24 systems formed in the western north Pacific Ocean and the other seven systems formed over south China Sea. None of these systems emerged into the Bay of Bengal. Ten systems recurved northeastwards. The monthwise breakup of these systems is as follows :

2 in June, 8 in July, 6 in August and 8 in September. Table 6 gives the account of tropical storms in west Pacific in June, July, August and September.

4.4. *Systems in the Southern Hemisphere*

(a) No tropical cyclone formed in south Indian Ocean during the season.

(b) The intensity of Mascarene High was 1-2 hPa above normal in June and September, 3-4 hPa in July and 4-5 hPa in August (normal intensity being 1024 hPa). The Mascarene High was east of normal position (Lat. 30° S/Long. 60° E) by 4° to 5° in longitude in July. Mascarene High was south of normal position by 2° to 3° Lat. in

TABLE 5

Details of the weather systems during September 1994

S. No. (1)	Weather system (2)	Period (3)	Place of first location (4)	Direction of movement (5)	Place of dissipation (6)	Remarks (7)
(A)	*Low pressure area*					
1.	Well marked low pressure area	1-11	Northwest Bay	Westnorthwesterly	Merged with the seasonal low over south Pakistan	
2.	Do.	15-19	West Bengal-north Orissa coast	Northwesterly	Western parts of Bihar and east Uttar Pradesh	It was first observed as a cyclonic circulation over Bangladesh on 9th
(B)	*Cyclonic circulations*					
1.	Mid tropospheric levels	14-22	Gujarat Region & neighbourhood	Do.	Southeast Pakistan & neighbourhood	
2.	Do.	14-15	Thailand and neighbourhood	Westerly	Merged with the monsoon trough over north Andaman Sea	
3.	Lower tropospheric level	17-18	Pakistan and adjoining parts of Punjab	Northeasterly	Moved away across Himachal Pradesh	
4.	Do.	20-23	North Bangladesh & neighbourhood	Northeasterly	Meghalaya and neighbourhood	
5.	Mid tropospheric levels	22-25	North coastal Andhra Pradesh	Do.	*In situ*	
6.	Lower tropospheric levels	27-30	Gulf of Martban and adjoining parts of Thailand	Westerly	North Andaman Sea	
(C)	*Troughs in the upper tropospheric westerlies*					
1.	Upper tropospheric westerlies	13-14	Long. 74°E, north of Lat. 25°N	Stationary	*In situ*	
2.	Mid and upper tropospheric	16-19	Long. 65°E, north of Lat. 25°N	Easterlies	Long. 72°E, north of Lat. 20°N	
3.	Upper tropospheric westerlies	22-29	Long. 64°E, north of Lat. 20°N	Northeasterly	Long. 72°N, north of Lat. 25°E	
(D)	*Other troughs*					
1.	Lower Levels	22-29	Telangana to south Tamil Nadu	Westerly	North interior Karnataka to south Tamil Nadu	
2.	Lower tropospheric levels	23-27	North Assam to northeast Bay	Stationary	*In situ*	
(E)	*Eastward moving circulations*					
1.	Upper air system	11-13	Jammu and Kashmir and adjoining Punjab	Quasi-stationary	Punjab and neighbourhood	

TABLE 6

Tropical storms in west Pacific 1994

	Jun	Jul	Aug	Sep
Depression	—	2	—	—
T. S.	1	3	3	4
TY	1	3	3	4
Total	2	8	6	8
Mean (1959-1994) 35 years	2.1	4.6	6.2	5.8

T.S. — Tropical storm. TY — Typhon

August and north of normal position by 1° to 2° Lat. in September.

(c) The intensity of the Australian High was above normal by 3 to 4 hPa in June, 4 to 5 hPa in July and 5 to 6 hPa in August, while it was normal in September (normal intensity being 1020 hPa). The Australian High was in the normal position throughout the season except in June when it was more north of its position by 1° to 2° in latitude.

5. Semi-permanent systems

5.1. *Heat low*

Heat low over west Rajasthan and adjoining parts of Pakistan appeared on 5 June and persisted there almost in the same position upto 3 July. The lowest isobaric value of the heat low was 990 hPa on 26 June.

The heat low again was seen from 10 to 16 July and from 24 to 31 July over Pakistan and adjoining west Rajasthan. The lowest isobaric value was 992 hPa on 15, 30 and 31 July.

5.2. *Axis of the monsoon trough*

Axis of the monsoon trough (surface and at 0.9 km asl) got established from Ganganagar to east central Bay across the plains of north India by the end of June 1994.

On 5 and 6 July the eastern end of the axis was passing through Assam and Meghalaya. On 7 July it moved northwards and lay close to the foot hills of the Himalayas. It shifted southwards on 8 July and extended upto the north Bay till the end of July. The western end of the monsoon trough was generally over central Rajasthan during the same period.

In August, the eastern end of the monsoon trough was in its normal position over north Bay. However, the western end was in its normal position (*i.e.*, 27° N and 71° E) upto 13 August and was north of the normal position from 14 to 18 August. Then it shifted to its normal position from 15 to 25 August and shifted south of its normal position from 25 to 31 August.

In September, the eastern end of monsoon trough continued to pass through the north Bay. The western end of the monsoon trough was along normal position over northwest India from 1st to 15th September.

5.3. *Tibetan anticyclone/high*

Tibetan anticyclone/high got established and was well defined by the 3rd week of June both at 500 hPa as well as 300 hPa levels. Its position at 300 hPa was near 28°N and 90°E.

It was well defined again from 9 July to 29 July near 32°N and 95°E at 500 hPa level near 30°N and 90°E at 300 hPa level. In August, it was seen near 30°N and 94°E at 500 hPa level and near 30°N and 92°E at 300 hPa level throughout the month.

In September, it was seen in its normal position (28°N and 92°E) at 500 hPa level and from 1 to 16 September at 300 hPa level near 29° N and 90° E.

5.4. *Westerly jet*

Winds at 200 hPa level over Ambala and Patiala were more than 60 kt from 9 June to 15 June. Maximum westerly winds of 75 kt were reported over Patiala on 13 June at 200 hPa. Winds were otherwise less than 60 kt at 200 hPa level over Jodhpur, Delhi, Srinagar, Gwalior, Luckow, Calcutta and Guwahati throughout the season suggesting the shift of westerly jet further north.

5.5. *Tropical easterly jet (TEJ)*

Tropical easterly jet (TEJ) was observed over Port Blair, Madras, Thiruvananthapuram and Minicoy from 1 to 28 June. Some significant high

TABLE 7

Wind anomalies June-September 1994

W/E Date	June				July				August					September			
	7	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27
Lower tropospheric westerly — Weekly wind anomalies*																	
TRV																	
850 hPa	24017	30611	31507	00106	33904	02101	24409	33005	29810	01506	06509	07501	27604	27106	04009	23504	11010
700 hPa	26024	28612	27208	00908	32003	29303	30807	07305	32309	09503	11514	14803	25613	26704	09709	23611	09714
BMB																	
850 hPa	11912	19514	26309	25409	23206	28512	26216	27607	27809	20203	25404	29203	26911	24512	23510	19501	12006
700 hPa	09419	17807	26909	23403	23708	29112	26513	26609	32709	32610	30605	28604	26612	25414	24815	34003	16504
NGP																	
850 hPa	17805	14908	22013	25609	20711	29915	25513	24908	27307	28511	24406	28205	29511	26313	21312	28804	31704
700 hPa	16903	10604	29006	28006	21313	34513	25509	23408	21206	29605	22805	25501	30403	28807	20410	22705	21710
Tropical easterly jet — Weekly wind anomalies*																	
MDS																	
200 hPa	34205	04614	03417	03409	00206	31710	27305	34106	25417	06405	33807	31808	30217	33911	17902	14805	19015
TRV																	
200 hPa	33711	07412	06016	09121	22404	06708	14213	10507	13611	18312	01204	03304	08410	01301	22613	18715	22416

* Easterly anomalies at 850 and 700 hPa mean westerlies are weaker than normal.
Westerly anomalies at 200 hPa means easterlies are weaker than normal.

speed occurred : Port Blair reported easterly winds of 80 kt at 132 hPa level on 16 June and Madras reported easterly winds of 100 kt at 104 hPa level on 20 June. Thiruvananthapuram reported easterly winds of 110 kt at 100 hPa level on 28 June. Minicoy reported easterly winds of 100 kt at 145 hPa on 17 June. TEJ was again seen from 1 July to 10 July over Port Blair. Madras. Thiruvananthapuram. Bombay and Minicoy. In the second fortnight of July. Port Blair reported easterly winds of 70 kt. on 5 July at 108 hPa level and Bombay reported easterly winds of 110 kt at 108 hPa on 1st July. Madras reported easterly winds of 90 kt at 104 hPa level on 2nd July.

Thiruvananthapuram reported easterly winds of 90 kt at 150 hPa on 8 July and Minicoy reported easterly winds 115 kt at 144 hPa on 22 July.

TEJ was observed in August and 1st fortnight of September over Thiruvananthapuram. Minicoy. Madras and Bombay. Minicoy and Bombay reported easterly winds of speed more than 80 kt on many days in August.

6. Sea surface temperature

Sea surface temperature (SST) over Arabian sea and Bay of Bengal — Monthly mean SST over Arabian Sea and Bay of Bengal, isopleths of normal values and the anomalies of SST for the months of June, July, August and September are given in Fig. 11 (a-d).

In June, SSTs were nearly normal over the south Bay and above normal by about 1°C over south Andaman Sea and nearly normal over the central and south Arabian Sea.

In July, SSTs were nearly normal over the south Bay and south Andaman Sea. Over the east central Arabian Sea they were nearly normal and over the west central and the south Arabian Sea they were above normal by about 1°C.

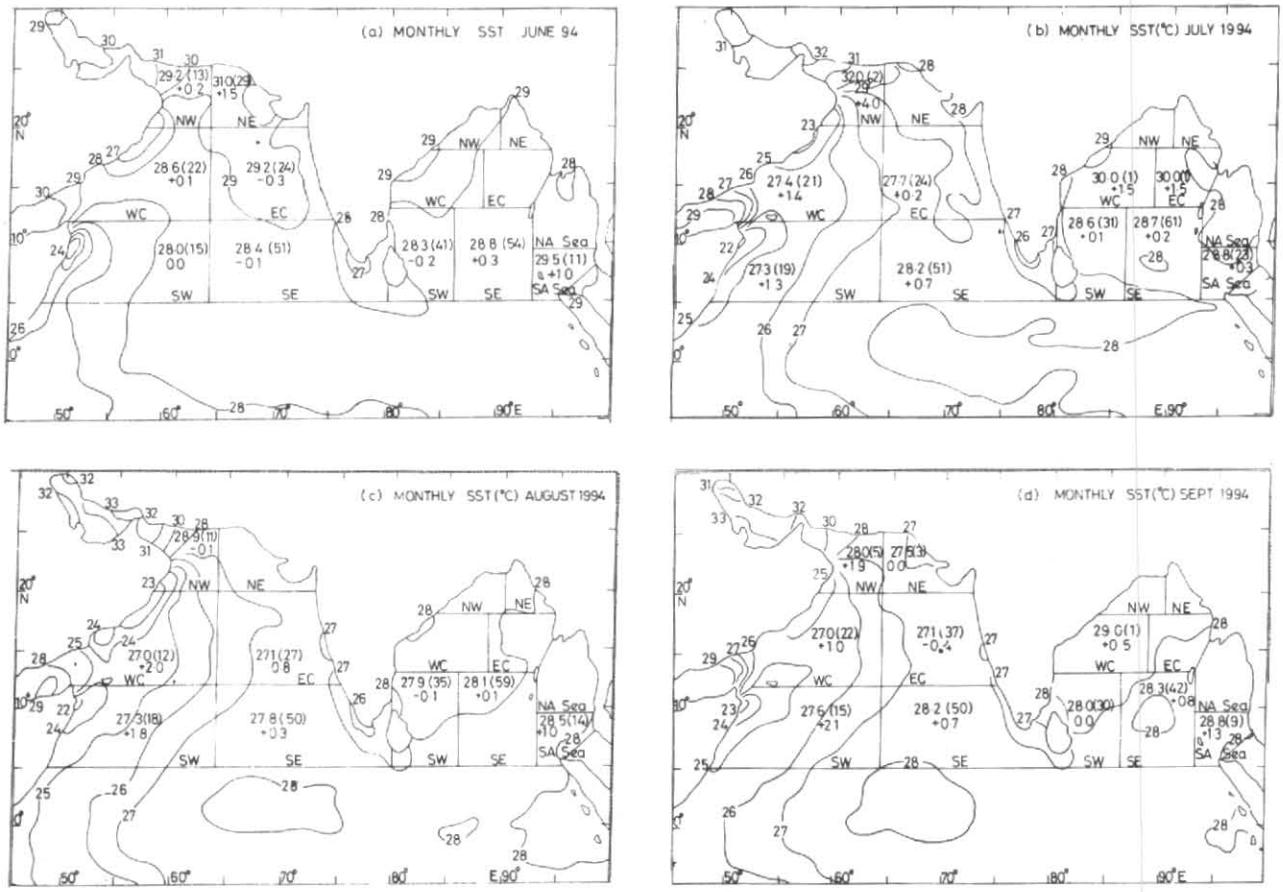
In August, SSTs were nearly normal over south Bay and above normal by about 1°C over south Andaman Sea. Over the east central and southeast Arabian Sea they were nearly normal and over the west central and southwest Arabian Sea they were above normal by about 2°C.

In September, SSTs were nearly normal over southwest Bay and about 1°C above normal over southeast Bay and south Andaman Sea. Over east central Arabian Sea they were nearly normal and over west central and southeast Arabian Sea they were about 1°C above normal and over southwest Arabian Sea about 2°C above normal.

TABLE 8

Rainfall figures (mm) for each month and season as a whole (June-September 1994)

Meteorological sub-division	June			July			August			September			Season		
	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep (%)
1. A. & N. Islands	366	470	−22	486	361	34	414	360	15	591	407	45	1856	1599	16
2. Arunachal Pradesh	393	527	−26	281	598	−53	346	425	−19	285	273	5	1304	1823	−28
3. Assam and Meghalaya	554	558	−1	344	533	−35	321	414	−22	208	328	−37	1427	1833	−22
4. Nag., Mani., Miz. & Tri.	266	388	−32	237	332	−29	270	291	−7	125	232	−46	898	1242	−28
5. SHWB & Sikkim	419	553	−24	307	616	−50	374	509	−26	275	420	−35	1375	2097	−34
6. Gangetic West Bengal	321	249	29	367	305	20	282	303	−7	135	239	−43	1106	1096	1
7. Orissa	317	227	40	462	363	27	464	354	31	310	249	24	1553	1193	30
8. Bihar Plateau	379	191	98	346	336	3	335	331	1	161	223	−28	1222	1081	13
9. Bihar Plains	119	171	−30	217	318	−32	267	313	−14	222	226	−2	826	1028	−20
10. East U.P.	142	105	35	262	306	−14	306	299	2	197	191	3	906	901	1
11. Plains of west U.P.	76	80	−5	386	267	45	301	268	12	23	162	−86	785	778	1
12. Hills of west U.P.	134	169	−21	481	449	7	397	448	−11	81	229	−65	1092	1295	−16
13. Haryana, Chandigarh & Delhi	66	52	28	346	175	98	223	179	25	44	108	−59	679	513	32
14. Punjab	36	43	−15	218	190	15	230	169	35	80	100	−20	564	502	12
15. Himachal Pradesh	108	97	12	397	349	14	365	323	13	96	159	−40	966	927	4
16. Jammu & Kashmir	55	58	−4	294	189	55	235	190	24	73	87	−16	656	523	26
17. West Rajasthan	49	28	74	233	103	125	133	108	24	62	49	27	477	288	66
18. East Rajasthan	114	57	101	329	226	46	265	233	14	112	121	−7	820	636	29
19. West Madhya Pradesh	229	115	99	428	329	33	451	280	61	172	196	−12	1291	920	40
20. East Madhya Pradesh	337	166	103	584	407	44	513	392	31	183	215	−15	1617	1179	37
21. Gujarat Region	445	145	207	651	428	52	457	295	55	361	181	100	1914	1048	83
22. Sau. & Kutch	118	89	32	371	239	55	120	126	−5	156	84	86	765	539	42
23. Konkan & Goa	798	685	17	1107	1106	0	611	663	−8	376	347	8	2891	2801	3
24. Madhya Maharashtra	262	140	87	344	271	27	188	179	5	121	155	−22	914	745	23
25. Marathwada	104	146	−29	119	206	−42	166	187	−11	70	179	−61	459	717	−36
26. Vidarbha	225	167	35	502	355	50	336	277	22	233	201	16	1297	980	32
27. Cot. Andhra Pradesh	55	111	−51	183	168	9	141	160	−11	106	170	−38	486	609	−20
28. Telangana	91	135	−33	254	240	6	234	210	11	48	192	−75	627	777	−19
29. Rayalaseema	29	61	−52	78	87	−11	79	98	−19	30	132	−77	217	378	−43
30. Tamil Nadu	29	53	−45	74	73	1	71	98	−27	78	103	−24	252	326	−23
31. Coastal Karnataka	1225	866	41	1553	1164	33	818	681	20	218	303	−28	3814	3014	27
32. N.I. Karnataka	109	97	12	143	147	−2	102	122	−17	40	150	−73	394	517	−24
33. S.I. Karnataka	214	147	45	371	278	34	139	185	−25	105	138	−23	829	748	11
34. Kerala	836	692	21	941	759	24	479	435	10	206	247	−17	2462	2133	15
35. Lakshadweep	361	307	18	210	283	−26	283	192	48	60	161	−63	915	943	−3



Figs. 11 (a-d). Mean monthly (June-September) SST anomalies (°C) of Indian seas during SW monsoon 1994

The values of normal SSTs for calculating anomalies are estimated from the isopleths of normal values.

The statements are based on the real time data which were some times not adequate in number.

7. Other features

7.1. *Weekly anomalies in monsoon circulation 1994*

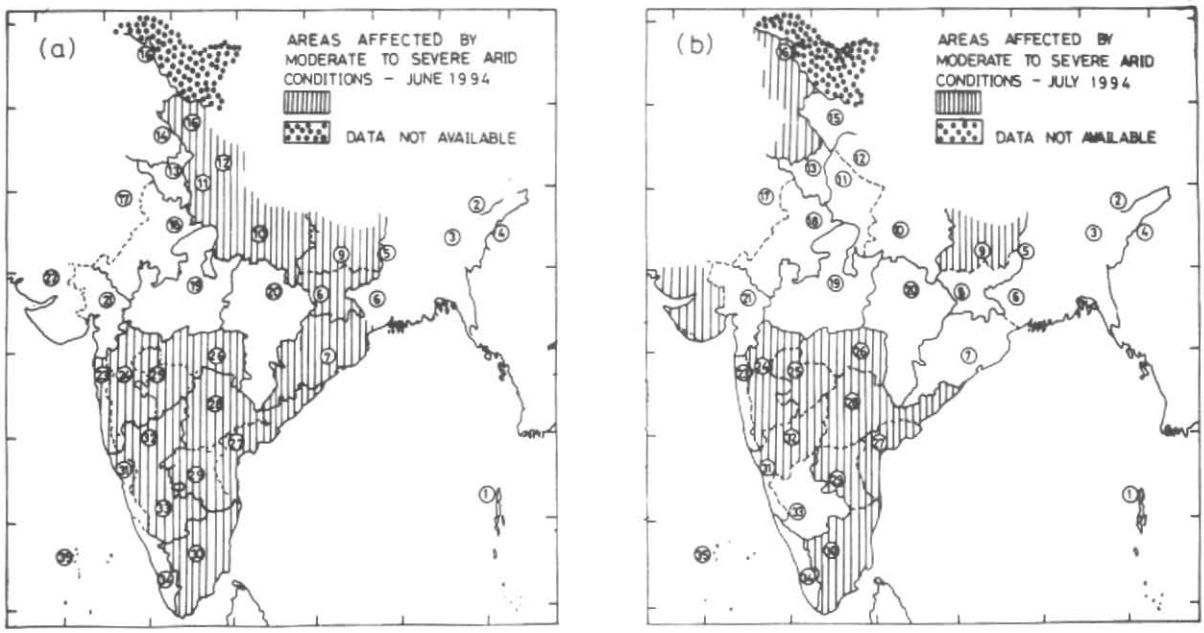
Weekly wind anomaly charts for 850, 700 and 200 hPa levels and the corresponding anomaly circulation patterns have been studied. Anomaly winds week-by-week are given in Table 7.

June-July — Almost on all the weeks of June and July, anomaly trough was present in the lower levels (850 and 700 hPa). The first anomaly trough was along Lat. 13° N on 7 June which moved to about 20° N on 14 June and 23° N to 24° N on 21 June and also on 26 June. On 5 July, only the western end of trough was seen along 24° N and it became less marked later on. The second anomaly trough was seen along 20° N on 12 July which moved to 22° N on 19 July and to 25° N on 26 July, when only the western end was seen. In the week ending on 2 August the trough was seen along 21° to 22° N.

At 200 hPa mostly easterly anomaly winds were present over peninsula in June except the first week and on 12 and 26 July. During the remaining weeks the anomaly winds were of the mixed type.

August-September — Anomaly trough in the lower levels in northwest-southeast orientation was seen from north Rajasthan to north Bay on 23 and 30 August and on 6 and 20 September. A ridge was along 14° to 15° N and in the lower levels on 9 and 16 August and along 11° to 12° N on 23 August. In September also ridge was seen along 14° N on 13 September and along 20° to 22° N on 27 September.

At 200 hPa mostly mixed anomaly winds were present over peninsula during the month of August.



Figs. 12 (a & b). Meteorological sub-divisions affected by moderate to severe aridity conditions during (a) June and (b) July 1994

During September, the anomaly winds over peninsula were mostly southerlies, southwesterlies or westerlies.

7.2. *Stratospheric features*

The available rocket wind data over Balasore have been plotted and analysed for the period June to August 1994. The following features of circulation have been noticed :

Wind regime in the vicinity of 10 hPa level is mainly dominated by easterly flow during monsoon season. Strong easterly winds of about 60 kt were noticed from middle June till end of August. Meridional components of wind were 2.5 kt only.

Data from Thumba and Sriharikota is not being received since September 1993.

7.3. *Aridity conditions during monsoon 1994*

Aridity index (AI) is computed based on Thornthwaite's formula :

$$AI = \frac{PE-AE}{PE} \times 100$$

where *PE* denotes water need of the plants which is called potential evapotranspiration. *AE* denotes the actual evapotranspiration (*PE*−*AE*) denotes the water deficiency. *PE* is computed by Penman's modified equation and *AE* obtained from the water balance procedure which takes into account the water holding capacity of the soil.

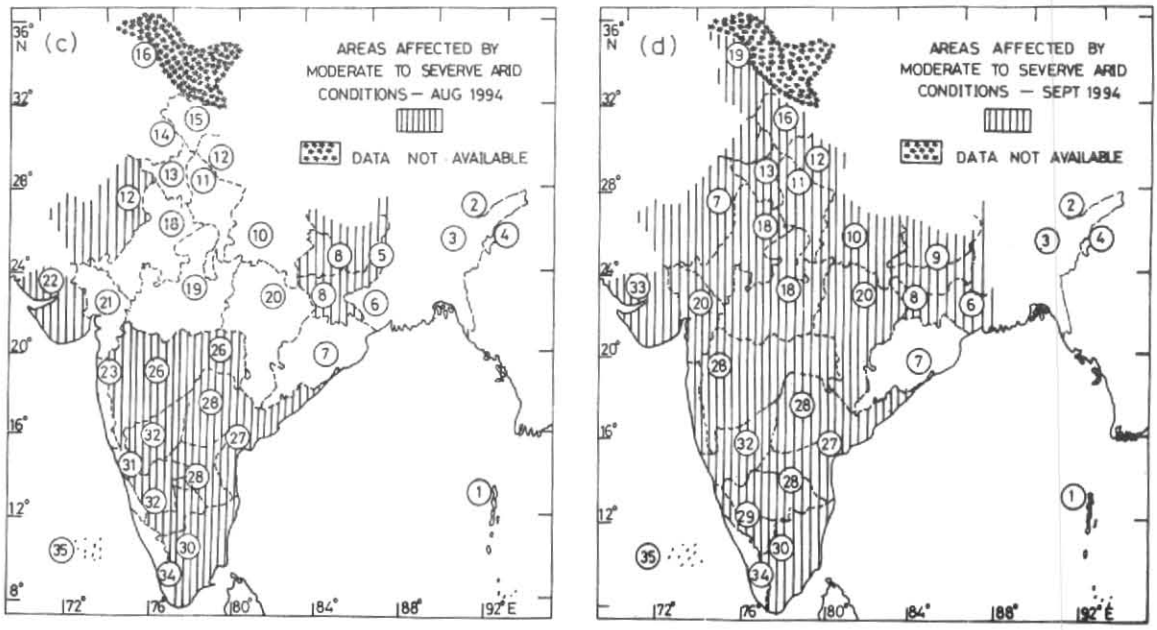
The difference between actual aridity for the week and normal aridity, *i.e.*, the aridity anomaly is worked out. The aridity anomaly have been classified into the following classes :

Aridity Anomaly	*Class*
Zero or less	non-arid
1 to 25	mild arid
26-50	moderate arid
more than 50	severe arid

Aridity anomaly maps for June and July are given in Figs. 12 (a & b) and for August and September are given in Figs. 12 (c & d). Names of meteorological sub-divisions where moderate to severe arid conditions prevailed in June, July, August and September, are given below :

June

Meteorological sub-divisions affected-16 :



Figs. 12 (c & d). Meteorological sub-divisions affected by moderte to severe aridity conditions during (c) August and (d) September

(1) Orissa. (2) Bihar Plateau. (3) Bihar plains. (4) East Uttar Pradesh. (5) Plains of west Uttar Pradesh. (6) Hills of west Uttar Pradesh. (7) Himachal Pradesh. (8) Madhya Maharashtra. (9) Marathwada. (10) Vidarbha. (11) Coastal Andhra Pradesh. (12) Telangana. (13) Rayalaseema. (14) Tamil Nadu and Pondicherry. (15) North Interior Karnataka and (16) South Interior Karnataka.

July

Meteorological sub-divisions affected-12 :

(1) Punjab. (2) Jammu & Kashmir. (3) Bihar Plains. (4) Saurashtra & Kutch. (5) Madhya Maharashtra. (6) Marathwada. (7) Vidarbha. (8) Coastal Andhra Pradesh. (9) Telangana. (10) Rayalaseema. (11) Tamil Nadu & Pondicherry and (12) North Interior Karnataka.

August

.Meteorological sub-divisions affected-14 :

(1) Sub-Himalayan West Bengal & Sikkim. (2) Bihar Plateau. (3) Bihar plains (4) West Rajasthan. (5) Saurashtra & Kutch. (6) Madhya Maharashtra. (7) Marathwada. (8) Vidarbha. (9) Telangana. (10) Coastal Andhra Pradesh. (11) Rayalaseema. (12) North Interior Karnataka. (13) South Interior Karnataka and (14) Tamil Nadu & Pondicherry.

September

All meteorological sub-divisions except (1) Andaman & Nicoar Islands. (2) Arunachal Pradesh. (3) Assam & Meghalaya, (4) Nagaland, Manipur. Mizoram & Tripura. (5) Orissa, (6) Kerala and (7) Lakshadweep, experienced moderate to severe arid conditions.

8. Characteristic features of southwest monsoon 1994

(*i*) Onset of southwest monsoon over south Kerala coast was on 28 May while normal date is 1 June. It was not associated with any onset vortex over the Arabian Sea. It further advanced along the west coast upto Bombay and over northeast India by 6 June. Its advance into Gujarat, Madhya Pradesh and Orissa and east Uttar pradesh was by 12 June which was 2-3 days earlier than the normal. It advanced over the rest of the country by 30 June. which was 2 weeks earlier than the normal.

(*ii*) Only two intense systems, a severe cyclonic storm over the Arabian Sea from 6 to 9 June and a monsoon depression over the northwest Bay from 17 to 20 August formed during the monsoon

season, as against normal occurrence of 5 to 6 depressions.

(*iii*) Low pressure areas (3 in June, 5 in July, 4 in August and 2 in September) and upper air cyclonic circulations (5 in June, 6 in July, 3 in August and 6 in September) were the principal synoptic systems during this monsoon season.

(*iv*) Seasonal rainfall and week-by-week rainfall activity over India was generally well distributed in space and time except for the northeast India in association with low pressure areas and cyclonic circulations (Fig. 4).

(*v*) The rainfall during monsoon season was excess in 12, normal in 13 and deficient in 10 meteorological sub-divisions. Deficient rainfall was marginal in Assam and Meghalaya (−22%), Bihar plains (−20%), coastal Andhra Pradesh (−20%), Tamil Nadu (−23%) and north interior Karnataka (−24%).

(*vi*) 24 or more meteorological sub-divisons out of 35 received normal or excess rainfall in June, July and August. However, rainfall in September decreased and only 15 meteorological sub-divisions received normal or excess rainfall in that month.

(*vii*) All the low pressure areas initially formed as an upper air cyclonic circulations and then descended to the surface as low pressure areas.

(*viii*) Barring the cyclonic storm over the Arabian Sea in June (which moved away westwards) only one monsoon depression formed in August during the previous year.

(*ix*) Axis of the monsoon trough was along the normal position or south of the normal position on most days of June, July, August and September. In particular the eastern end of the monsoon trough was south of the normal position over northwest Bay.

(*x*) Southwest monsoon withdrew from west Rajasthan on 19 September as against the normal date of 15 September. Monsoon further withdrew from west Uttar Pradesh, west Madhya Pradesh, Gujarat on 23 September which was one week earlier than the normal. It withdrew from the entire country by 17 October.

(*xi*) Northeast monsoon rains commenced over Tamil Nadu and adjoining states of Kerala, Karnataka and Andhra Pradesh by 18 October 1994.

(*xii*) Northeast monsoon withdrew from Tamil Nadu and adjoining states of Karnataka, Kerala and Andhra Pradesh by 14 December.

(*xiii*) Tibetan anticyclone/high got established by the third week of June both at 500 hPa and 300 hPa. It was intense and in its normal or south of normal position in July, August and first fortnight of September.

(*xiv*) Off-shore trough along the west coast on the surface or in the low levels persisted throughout the season.

9. Damage due to floods etc. during monsoon season

Heavy rains/floods caused varying amounts of damages in the states of Assam, Arunachal Pradesh, West Bengal and Orissa in eastern parts of India and Gujarat, Rajasthan, Himachal Pradesh, Maharashtra and Madhya Pradesh in western and central parts of India and in Karnataka. According to Press reports, millions of people were affected due to heavy rains/floods and landslide. About 1000 people were reported to have lost their lives due to flood in the states. Death toll was 231 in Gujarat, 107 in Madhya Pradesh, 76 in Maharashtra, 52 in Orissa and 120 in Himachal Pradesh. More than 2 million people were rendered homeless, a large number of villages being submerged by the flood waters.

9.1. *Significant spells of heavy rain*

During June, widespread rains with isolated heavy falls occurred over Assam and Meghalaya on a number of days, in coastal and south interior Karnataka and Kerala between 2 and 16 & 26 and 30, in Madhya Maharashtra, Konkan & Goa and Gujarat Region between 10 and 17 & 25 and 30. Widespread rains with isolated heavy rains also occurred on 5 to

7 days in Madhya Pradesh, Gangetic West Bengal, orissa and Bihar Plateau during 2nd and 3rd week of June.

In July, widespread rains with isolated heavy falls occurred over Konkan & Goa on almost all days and over Orissa on a number of days. Widespread rains with isolated heavy falls occurred in Gangetic West Bengal between 26 and 31, in Madhya Pradesh between 8 and 13, in Madhya Maharashtra between 10 and 22, in Vidarbha between 9 and 13 and in Kerala between 13 and 18 and 27 and 31.

In August, widespread rains with isolated heavy falls occurred over Madhya Pradesh between 1 and 7, over Konkan & Goa between 12 and 14 & 18 and 31 and over coastal Karnataka between 18 and 29. Widespread rains with isolated heavy falls also occurred on 3 to 5 days in West Bengal and Sikkim, Bihar Plain, Hills of west Uttar Pradesh and east Rajasthan during the first half of August and on 8 days in Orissa and on 3 to 5 days in Bihar Plains, Punjab, Himachal Pradesh, Gujarat Region and Madhya Maharashtra during 2nd half of August.

In September, widespread rains with isolated heavy falls occurred on 3 to 5 days in Andaman and Nicobar Islands, Orissa, Gujarat, Konkan & Goa and Madhya Maharashtra during 1st half of September.

10. Significant monthly features

10.1. *June*

Southwest monsoon set in over Kerala on 28 May without any onset vortex. Other details are given in para 2.1.

10.1.1. *Advance of monsoon*

Details are given in para 2.1 and Fig. 3.

10.1.2. *Synoptic systems*

Synoptic systems are given in Table 2.

10.1.3. *Monthly rainfall*

Monthly rainfall is given in para 2.3 and principal amounts of daily rainfall are given in Appendix I.

10.1.4. *Temperatures*

Heat wave conditions prevailed over Haryana, Punjab and Rajasthan and in some parts of Uttar Pradesh from 1 to 8 June. Highest day temperature was 50°C at Anupgarh on 8 June 1994.

10.1.5. *Disastrous weather events and damages during June*

In Assam, due to heavy rains more than 500 villages were submerged in the flood waters affecting more than 50 thousand people.

Very heavy rains caused loss of 10 human lives in Maharashtra and Goa and 8 in Kerala in 1st week of June. In Gujarat, heavy rains disrupted rail, road transport and the power supply in many areas. It took a toll of 51 people in 3rd week of June.

10.2. *July*

10.2.1. *Synoptic systems*

Details of synoptic systems are given in Table 3.

10.2.2. *Monthly rainfall*

Details of monthly rainfall are given in para 2.3 and the principal amounts of daily rainfall are given in Appendix I.

10.2.3. *Disastrous weather events and damages during July*

Vigorous monsoon rains caused floods in Himachal Pradesh, Punjab, Orissa, Kerala and parts of Rajasthan, Gujarat, Maharashtra, Madhya Pradesh and Karnataka affecting more than a million people causing damage to their houses and properties. Heavy to very heavy spells of rains caused damage to a number of dams, 27 lives were lost in Rajasthan and 30 lives were lost in Maharashtra during 2nd week of July. 60 persons were reported to be killed in a cloud burst in Kullu and Kangra districts in Himachal Pradesh on 11 July.

Total number of deaths in flood affected areas is reported to be around 450.

10.3. *August*

10.3.1. *Synoptic systems*

Details of the synoptic systems of August are given in Table 4.

APPENDIX I

Principal amounts of rainfall (cm)
(June to September 1994)

Date (1)	June (2)	July (3)	August (4)	September (5)
1	Ponnani 17, Kimi Power Bridge 10, Kozhikode 9	Baran 24, Mudibidere 18, Guna 16, Okha 14, Rajkot 12, Dabolim 8	Idukki 16, Peermade 15, Jabalpur 14, Agumbe 12, Gharkota 10, Barmer 8	Mahabaleshwar 21, Bhainsdehi and Pen 20 each, Khargaon 19, Thrissur 15
2	Kasargode 15, Mulki 13, Kozhikode 11, Puthimori 10, Mangalore 9, Shillong 8	Sojat 30, Bhilwara 25, Sonbarsa 18, Pathankot 17, Numaligarh 12, Bhira 9	Sailana 32, Banswara and Ratlam 24 each, Kadana 23, Piravom 21, Mt. Abu 20	Tamini 28, Mahabaleshwar 26, Somwarpet 11, Panjim 10, Nagpur 7
3	Malvan 15, Kankavali 12, Gargoti 8, Panbari 7	Sirsilia 21, Nangal Dam 14, Kundapur, Muzzaffarpur and Una 12 each	Chitrasani 16, Kunnamkulam, Mount Abu, Sulya and Uluberia 13 each, Balasore 12	Koyna 23, Narsinghpur 10, Budhni, Chandipada and Gadchiroli 9 each
4	Kannur 16, Koddungalur 10, Hut Bay & Hasimara 9 each, N. Lakimpur 8	Rajura 32, Adilabad 21, Naharkatia 19, Bombay 12, Pendra 10	Kurwai 17, Katghora 15, Ambala and Kudulu 11 each, Chandigarh 10	Bangana and Gadchiroli 20 each, Tikarpara 11, Parvathipuram 10
5	Mangalore 22, Maya Bandar 21, Kasargode 13, Minicoy 11, Ratnagiri 9	Mathanguri 27, Janjira Murud 17, Akola 11, Bombay 9, Ahmedabad 8	Khurai 18, Siddapura 12, Hosdurg 9, Fazilka 8, Agumbe 7	Amgaon 20, Nagbhir 18, Dhamtari 15, Kalam Seoni 14, Raipur 11, Uttar Kashi 7
6	Malvan 24, Panjim 19, Kannur 17, Karwar 11, Kochi and Mangalore 9 each	Shahpurkandi 27, Nagrota and New Kandla 9, Bombay 8	Tikamgarh 16, Pachmarhi 12, Sawai Madhopur 10, Alipurdwar 8, Jaipur 7	Betul 30, Ashti 24, Mahabaleshwar 23, Malegaon 19, Nagpur 14, Khandwa 13
7	Sevoke 10, Mani and Vayithiri 9 each, Irinjalkuda 8, Kundapura 7	Krishnagiri 16, Bahadurgarh 15, Basholi 10, Karwar and Nurpur 7 each	Jagadhari 17, Balaghat 10, Amravati and Pachmarhi 9 each, Calcutta 8	Surgana 13, Piravom 7
8	Hosanagara 10	Hindegir 26, Suri 23, Una 12, Jammu 11, Bokajan, Kalpi and Raigarh 8 each	Sohagpur 13, Amgaon 10, Adampur and Gondia 8 each, Balaghat 7	Ahmedabad 18, Igatpuri 17, Tansa 13, Mount Abu 12, Shivpuri 7
9	Mulki 16, Kasargode 14, Mangalore 13, Kodungallur and Nancowry 8 each	Sandheads 27, Khairamal 15, Ranchi 14, Kondagaon 13, Panipat 10, Raipur 7	Basua 19, Gaya 13, Ranchi 11, Jeypore 10, Jamshedpur 7	Patan 20, Mount Abu 11, Naliya 9, Kalka and Manamadurai 7 each
10	Sinnar 19, Bombay 12, Rajampet 10, Baghdogra and Sevoke 8 each	Sandheads 38, Raigarh 18, Gaganbavda and Kargal 15 each, Mt. Abu 13	Pathankot 15, Regali 11, Kangra and Jenapur 10 each, New Delhi 9	Munger 14, Mt. Abu and Naliya 10 each, Darbhanga 9, Tamini 8, Jamtara 7
11	Bhira and Mulki 11 each, Margherita 10, Shirali and Thalaserry 7 each	Pauni 37, Jabalpur 20, Vayithiri 12, Bhira and Valsad 10 each, Nandurbar 8	Yellandu 19, Bareilly and Mahabubabad 14 each, Ludhiana 13	NIL
12	Gaganbavda 19, Pusad 15, Shillong 14, Ootnur 13, Matijuri 11, Panambur 8	Bhira 32, Nagpur 30, Dharamshala 24, Manjeri 15, Kozhikode 14, Bikaner 11	Titlagarh 16, Satna 15, Belthangady and Bhiwandi 13 each, Damoh 11	Parbhani 20, Adampur 15, Chapra 13, Varanasi and Venkatagirikota 8 each
13	Dhorai 20, Kasargode 16, Alibag 12, Panjim and Mahabaleshwar 10 each	Mahabaleshwar 31, Nanipalsan 30, Surat 18, Bombay 16, Nagpur 12	Uthangarai 14, Panjim 13, Pakala 11, Vellore 10, Jalpaiguri 9, Agumbe 8	Jhanjharpur and Varanasi 11 each, Guhla 9, Canning Town 8, Bhimavaram 7
14	Chauldhaghat 15, Itanagar 12, Champua Raipur 8, Surat 7	Mahabaleshwar 36, Rajkot 24, Bombay 11, Honavar 10, Jabalpur 9	Tamini 17, Tiruvuru 11, Jodhpur 10, Miryalaguda 9, Bhira 8	Gazhipur 12, Baghdogra 11, Majhian 10, Kheri 9, Ponnani 8, Vellore 7

APPENDIX I *(Contd.)*

(1)	(2)	(3)	(4)	(5)
15	Kottigehara 18, Sambalpur 17, Mahabaleshwar 13, Ratnagiri 11	Mudigere 25, Mahabaleshwar and Okha 20 each, Kozhikode 15	Sardhanagarh 19, Bhagalpur 18, Mohitnagar 15, Kishanganj 13	Bangana 26, Khadda 24, Ramnagar 17, Gorakhpur 13, Ambadola 12
16	Kakrapar and Mahabaleshwar 22 each, Ukai 20, Dahanu 14, Panposh 10	Radhanagari 19, Kargal 11, Honavar 9, Jharsuguda 8, Deesa 7	Hardoi 25, Patiala 15, Dhneta and Jagadhari 14 each, Gohar 13	Berhampur 24, Nimapada 18, Tribeni 14, Gopalpur 13, Ichhapuram 12, Mharajganj 11
17	Ahwa 32, Ukai 29, Lanja 13, Bhowrah 10, Asansol & Bokajan 8 each	Chengannur 14, Alapuzha 13, Mahabaleshwar 11, Raipur 10, Ambala 7	Chamba and Nimapada 8	Palahara 20, Bhubaneswar 10, Bombay, Kheroj and Maheshwar 8 each, Digha 7
18	Vada 12, Silvasa 11, Kimi 9, Vayithiri 8, Panbari and Sevoke 7 each	Anandpur Sahib 15, Balasore 14, Jabalpur 13, Bangana 10, Jammu 9	Balliguda 29, Mohana 25, Gariaband and Kamareddy 18 each	Mirzhapur 33, Meja 20, Sidhi 15, Panposh and Varanasi 10 each, Umaria 7
19	Dapoli 10, Sevoke 8, Galgalia 7	Jaipur (Ori.) 21, Bhira 14, Balasore and Lucknow 11 each	Lanji 29, Amarwara 24, Bodhan 18, Panambur 12, Taliparamba 9	Basti 44, Domohani 15, Agra 14, Jalpaiguri 9, Sidhi 7
20	Bhira 15, Chauldhaghat 12, North Lakhimpur 11, Mahabaleshwar 9	Bhira 20, Kahu and Jharsuguda 19 each, Udhampur 18, Chandigarh 16	Pachmarhi 19, Ahmedabad 16, Shirali 14, Mt. Abu 13, Hosdurg 10	Shahjina 23, Gorakhpur 18, Jalpaiguri 13, Darbhanga 8
21	Margherita 15, Khairamal 14, Bolangir 12, Matizuri 9	Agumba 13, Nadiad 11, Quiandy 10, Kozhikode 8, Hut Bay 7	Mt. Abu 14, Dharamsala 13, Gaya and Shirali 9, Dehra Dun 7	NIL
22	Bilaspur 11, Jamsolaghat 9, Pendra 8, Dholai 7	Surat 26, Agumbe 22, Hosdurg and Mt. Abu 9 each, Chandigarh 8, Bangalore, Guwahati and Port Blair 7 each	Shahapur 18, Berhampore 12, Dehra Dun 11, Baghdogra 10	Balurghat 8, Nirmali 7
23	Sagar 13, Silvasa 10, Bhopal and North Lakhimpur 8 each	Mahabaleshwar 17, Agumbe 15, Srinagar 11, Sawai Madhopur 10	Malikpur 19, Karnal 15, Una 13, Bombay and Karwar 9 each	Dharmapuri 7
24	Gonda 17, Amalapuram 8, Thaliparamba 7	Galgalia 15, Bhira 12, Barmer and Gorakhpur 7 each	Bhira 14, Agra 10, Berhampur, Honavar and Ludhiana 9 each	Balod and Vedasandur 9 each
25	Broach 15, Adoor 9, Ranchi 8, Krishnagar and Tezu 7 each	Hasimara 14, Agra 8, Hissar 7	Gazipur 14, Sagar island 11, Patna 10, Darjeeling 9, Agumbe 8	Mana 9, Gundlupet 7
26	Basti 28, Mudigere 20, Hanovar 10, Satna 9, Jamshedpur 10, Mt. Abu 9	Cooch Behar 29, Agumbe 13, Bhira 12	Narsinghpur 23, Amgaon 18, Gondia 14, Shirali 10	Turaiur 11
27	Narsinghpur 15, Mangalore 12, Baripada 9, Bhavnagar 7	Kodungallur 15, Cooch Behar 13, Raigarh 8, Calcutta 7	Amgaon 38, Ahwa 18, Khammam 8, Dhule and Nandyal 7 each	Arasikere 12, Chitradurga 9, Purushottampur 7
28	Hoshangabad 29, Bhira 25, Sandheads 23, Narsingpur 18, Bombay 13	Kannur, Sringeri 18, Kozhikode 13, Jammu 11, Gaganbavda 10	Koyna 17, Tandla 13, Mahabaleshwar 12, Petlabad 9, Karwar 8	Gopalpur 9, Denkanikottai 7
29	Mahabaleshwar 36, Ranchi 22, Mangalore 15, Ambikapur 14	Mangalore 21, Barota 20, Kozhikode 8, Kalimpong 7	Kandla 17, Agumbe 15, Sidhi 10, Hosdurg 8, Mana 7	Palani 9, Nidadavole 8

APPENDIX I (*Contd.*)

(1)	(2)	(3)	(4)	(5)
30	Mangalore 34, Sawantwadi 21, Barmer and Indore 9 each	Sakaleshpur 24, Mangalore 19, Kozhikode 12, Jamshedpur and Mysore 9 each	Nagbhir 36, Wardha 15, Dharamshala 13	NIL
31	—	Hosdurg 34, Faridabad 15, Jabalpur 12, Ganganagar 11, Jamshedpur 8	Mahabaleshwar and Dahanu 23 each, Silvasa 15, Seoni 11, Yeotmal 7	—

10.3.2. *Monthly rainfall*

Details of monthly rainfall are given in para 2.3 and the principal amounts of rainfall are given in Appendix I.

10.3.3. *Disastrous weather events and damages during August*

Heavy monsoon rains caused floods and damages in parts of Bihar, West Bengal, Uttar Pradesh, Gujarat, Karnataka and Maharashtra during 3rd and 4th weeks of August and beginning of September.

Due to heavy rains, 19 people lost their lives in Jammu & Kashmir and 70 in Uttar Pradesh and Bihar during the 2nd and 3rd week of August. In Himachal Pradesh, flash flood triggered by cloud burst took 15 lives on 23 August. In Maharashtra, 3 persons died in house collapse.

10.4. *September*

10.4.1. *Synoptic systems*

Details of the synoptic systems are given in Table 5.

10.4.2. *Withdrawal of southwest monsoon*

Details of the withdrawal of southwest monsoon are given in para 2.6 and Fig. 9 gives the map showing withdrawal dates of southwest monsoon 1994.

10.4.3. *Monthly rainfall*

Details of monthly rainfall are given in para 2.3 and the principal amounts of rainfall are given in Appendix I.

10.4.4. *Disastrous weather events and damages during September*

As stated above flood situation in a number of states remained grim during 1st week of September. Total loss of life in flood affected areas during August and early September is estimated to be around 450.

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