INDIAN JOURNAL
OF
METEOROLOGY AND GEOPHYSICS

VOL. 11 | JULY 1960 | NO. 3

551·579 "1959"

Rainfall and floods during 1959 southwest monsoon period*

1. Introduction

Though the southwest monsoon in India is generally credited with a characteristic rainfall regime, it is the variability of the rainfall associated with it, both in space and in time, which are more important as they determine the incidence of floods and droughts during the season. In a paper presented at the symposium on the 'Monsoons of the World' held during February 1958, K. Parthasarathy has illustrated in detail this feature of the monsoon rainfall. The important part played by the migratory movement of the axis of the monsoon trough, north and south of its normal position, in determining the areas of rainfall, and the chief synoptic situations responsible for heavy rainfall and floods in the rivers in India have been described by S. Basu in a paper presented at a symposium on 'Floods and Flood Control' organised by the Central Board of Irrigation and Power, India, in 1954. The synoptic situation associated with heavy rainfall as given by him are—

(*i*) *Due to orographic ascent during a spell of strong monsoon*—Heavy rainfall along the West Coast of the Peninsula and on the southern slopes of the Khasi hills occur due to this cause.

(*ii*) *Monsoon depressions*—Heavy rains associated with monsoon depressions are the main contributories to floods in the central Indian rivers, such as the Narbada, Tapti, Mahanadi and Sabarmati and also the rivers of the Deccan like, Godavari and Krishna.

(*iii*) *'Breaks' in the monsoon*—Heavy rainfall over the eastern Himalayas during 'breaks' are mainly responsible for the major floods in the rivers of Uttar Pradesh, Bihar, north Bengal and Assam.

The rainfall during the 1959 monsoon and the associated floods have been reviewed in this note in the light of these observations.

2. Chief features of the rainfall

Table 1 gives the rainfall week by week during June to September 1959 in the 26 meteorological sub-divisions of India. The figures given are the percentage departures of the week's rainfall from normal. Periods and areas of excess (departures plus 25 per cent and more) and defective rainfall (departures minus 25 per cent and less) have been shaded in the table. The striking features of the table may be seen as follows:

* It is proposed to publish in future similar review article on rainfall and floods in the monsoon of each year. This first article was prepared in the Hydrology Section of the Headquarters Office of the India Meteorological Department, by K. Parthasarathy, Meteorologist-in-charge of the Section, with the assistance of J. Narayanan, S. Vatsal, B. C. Jain, Hem Raj, M. D. Kundra, P. A. Kamble and P. K. Datta Roy.

TABLE 1

Southwest Monsoon 1959

Percentage departures from normal of rainfall for week ending

METEOROLOGICAL SUB-DIVISIONS	JUNE			JULY					AUGUST				SEPTEMBER					OCT
	10	17	24	1	8	15	22	29	5	12	19	26	2	9	16	23	30	7
Assam	-67	+73	-47	-51	-11	-56	-7	+8	-32	-39	-41	-45	-92	+10	-5	+52	-100	+77
Sub-Himalayan West Bengal	-44	+20	-11	-38	-12	+24	-56	-18	-59	-58	-1	-77	-79	-13	-78	-10	-100	+294
Gangetic West Bengal	-13	-7	-48	-59	-51	+1	-42	-9	-34	-55	-45	-62	-13	-15	+274	-38	-6	+675
Orissa	-34	-40	-1	-39	-25	-22	-23	-3	-31	-36	-58	+5	-5	-9	-13	-75	-36	+236
Bihar Plateau	-29	+228	-99	-45	-41	+36	-19	-14	-38	-24	+18	-59	-1	+41	+18	-62	+41	+167
Bihar Plains	+91	-38	-69	-58	-56	+30	-31	-73	-31	+12	+39	-64	-28	-69	-79	+81	-89	+614
Uttar Pradesh East	-31	-78	-100	-98	-51	-13	+6	-76	-18	+2	+44	-79	-89	-28	-96	-93	-68	+216
Uttar Pradesh West	-77	-75	-100	-29	-28	-44	-18	+16	+10	-1	+86	-19	-51	+99	-21	+13	-10	+354
Punjab (India)	-100	-96	-100	+24	+120	-71	-75	+26	+19	-41	+113	-15	+10	+218	-79	+54	-3	+207
Jammu and Kashmir	-100	-33	-85	-93	+1220	-99	-77	+4	-63	-89	+42	-44	-10	+234	-79	-68	-39	-4
Rajasthan West	-100	-20	-93	+48	+4	-81	-84	+111	-81	-61	+4	-27	+51	+454	+577	-85	-55	-16
Rajasthan East	-90	-100	-59	-49	+27	+2	+21	+95	-81	-39	0	+34	+22	+70	+19	-94	+101	+170
Madhya Pradesh West	+13	-88	-74	-3	+15	+94	-22	-13	+9	+34	-48	+2	+128	+66	+44	-93	-43	+24
Madhya Pradesh East	+41	-69	-78	+7	-29	-38	+40	+11	+72	+9	-47	-10	-37	+47	+147	-93	+4	+13
Gujarat	+106	-98	-86	+81	+190	+18	+39	+48	+50	-80	-90	+76	+187	+82	+176	-57	+74	+513
Saurashtra and Kutch	+63	-100	-90	+252	+275	+39	+129	+228	+60	-81	-68	+6	+41	+495	+168	-32	+31	+805
Konkan	+30	-85	-41	+149	-11	-46	-41	+34	-16	-69	-94	+195	+158	+55	+26	-95	+131	+75
Maharashtra	-15	-75	+79	-1	+40	-65	+16	+47	-42	-60	-21	+180	-42	-36	-29	-98	+155	+82
Vidarbha	+139	-74	-81	+182	+40	-87	-3	+97	-14	-22	-48	+64	+57	+54	+667	-100	+87	-15
Coastal Andhra Pradesh	+63	-64	+118	+196	+51	-52	+173	+64	-31	+29	+39	+9	-45	-26	+5	-14	-26	+82
Telangana	+163	-77	+44	+71	+100	-84	+158	+41	+24	-46	-43	+315	+66	+48	-63	-100	+37	+33
Rayalaseema	-21	+122	+257	+40	+73	-82	+162	+65	-85	-73	+83	+33	-52	-99	-99	-51	+186	+6
Madras	-31	-15	+276	+58	+10	-45	-44	-50	-69	+10	+43	-89	-74	+11	-77	-15	-42	-51
Coastal Mysore	+54	-69	-7	+52	+23	-10	+112	+67	-68	-53	-34	+154	-16	+36	+32	-88	+134	-32
Interior Mysore North	-31	-78	+219	+110	[illegible]	-24	+69	-31	-26	-29	-80	+28	+94	-62	-83	+18	+135	+44
Interior Mysore South	-24	+50	+275	+576	+152	-25	+50	+33	-85	-69	+167	-17	-46	-84	-70	+252	+38	-77

Less than -50 | -50 to -25 | -24 to +24 | +25 to +50 | More than +50

(*a*) Northwest and north India in general had deficit rainfall during most of the weeks, this being very pronounced in Uttar Pradesh and Bihar.

(*b*) The southern half of the country had generally excess of rainfall during the season.

(*c*) Gujarat and Saurashtra and Kutch had large excess of rain during two spells of consecutive six and three weeks.

(*d*) Vidarbha and Andhra Pradesh also experienced large excess of rainfall during a number of weeks in succession.

From these features of the rainfall distribution it will be clear that during the 1959 monsoon season, the monsoon trough should have been most of the time in its normal position or south of it, rarely shifting to the north. This is reflected in the continued excess rainfall in the central parts of the country, north Deccan, Gujarat and Saurashtra and Kutch. Also the continued deficiency of rainfall in the northern sub-divisions, *viz.*, Uttar Pradesh, Bihar Plains, sub-Himalayan West Bengal, Assam and the Himalayas indicates that there should have been no well marked 'break' during the season.

A study of the synoptic charts of the monsoon season confirms these inferences. There was no 'break' during the monsoon of 1959. The axis of the trough stayed south most of the time. A large number of depressions formed and moved more westnorthwest or westwards than usual across Madhya Pradesh to Saurashtra and Kutch with the result, the regions to the south of the axis, *viz.*, Madhya Pradesh, Gujarat, Saurashtra and Kutch and Andhra experienced prolonged spells of excess rainfall. The rivers of these regions, the lower Godavari fed by Indravati, Penganga and Wainganga, and the Narbada and Tapti experienced serious floods; Saurashtra and Kutch and Gujarat also suffered much from these heavy rain spells which continued week after week.

3. Chief floods of 1959

The *Daily Flood Newsletters* issued by the Central Water and Power Commission show that apart from the usual minor and medium floods, the important floods of 1959 were the following—

(1) Assam floods	15-20 June
(2) Floods in Kashmir	1st week of July
(3) Floods in Saurashtra and Kutch	16-17 July
(4) Godavari in high floods	4-6 August
(5) West Bengal rivers in spate	21-24 August
(6) Godavari in high flood	7-8 and 11-18 September
(7) Narbada	7-8 September
(8) Tapti	15-17 September
(9) Damodar and West Bengal rivers	30 September to 2 October

It will be seen that during 1959, the rivers of central India, western India and the north Deccan had the maximum number of floods while north and northwest and northeast India escaped with very few floods. The incidence of floods thus corresponds closely to the incidence of rainfall.

4. Analysis of the more important floods of the season

The major floods of the year that were responsible for large human suffering and damage to property were (*i*) the Assam flood of the middle of June, (*ii*) the Kashmir floods of July, (*iii*) the Godavari floods of 11-18 September, (*iv*) the Tapti floods 13-15 September and (*v*) the floods in West Bengal rivers and Damodar early in October. The meteorological situations associated with each

of these floods and the interesting features of the floods are described below—

(*i*) *Assam and north Bengal floods of 15-25 June*—The monsoon advanced into Assam and sub-Himalayan Bengal between 11 and 12 June (about the normal date) and continued to be active to strong over these areas during the next fortnight. During this period under the combined influence of westerly waves moving across the eastern Himalayas and favourable pressure distribution over the north Bay of Bengal, the activity of the monsoon became accentuated during two spells, on the 14th and 15th and from 22nd to 25th, when some locally very heavy falls were recorded in the Jalpaiguri and Kalimpong districts of West Bengal and in north Assam and the Manipur State. The catchments of the northern tributaries of Brahmaputra and the West Bengal rivers, Teesta and Mahananda had a prolonged period of moderate to heavy rain which resulted in severe floods in these rivers. However neither the magnitudes of the associated rainfall, nor that of the flood were as high as those of the high floods in Assam in 1952 and 1954.

(*ii*) *Kashmir floods of the 1st week of July*—The flood in the Kashmir Valley in the first week of July 1959 has been reported as one of the worst floods experienced there. The river Jhelum rose to a level of 31 ft at Sangam on the night of 4-5 July, which was only 3 inches below the record flood level in 1957. All the tributaries of Jhelum were also reported to have reached their peak levels almost simultaneously with the result that the entire valley right from Wular Lake to Sangam was in floods. The Wular Lake itself reached a level of 5185·8 ft above mean sea level which is 2·4 ft higher than the previous record.

The synoptic situation associated with this flood was as follows. A monsoon depression which formed in the north Bay of Bengal on 27 June crossed the Orissa coast between Puri and Chandbali and moved westnorthwestwards across the central parts of the country and Gujarat and emerged into the Arabian Sea off Kathiawar coast by the morning of 2 July, when its centre was located between Dwarka and Karachi. During its movement across the country, it gave widespread rain with locally heavy falls in Orissa, Madhya Pradesh, north Hyderabad and southeast Rajasthan. After 2 July, the depression curved towards north under the influence of a western disturbance moving in the latitude of Kashmir, and moved into lower Sind by 3rd. It then moved rapidly northeastwards and merging with the western disturbance lay as a well marked trough of low pressure extending from Sind and Rajasthan to Kashmir, with its axis oriented north-south. Under the influence of this trough the Arabian Sea monsoon which was vigorous, started flowing as a deep southerly current into the Punjab and Kashmir from 3 July. The Bay branch of the monsoon was also simultaneously coursing upto the Punjab and Kashmir. The latter flow was maintained by another depression which formed over the north Bay of Bengal on 3 July and moved upto Gwalior as a low pressure area and finally broke over the west Uttar Pradesh hills. The vigorous inflow of the monsoon air from the Arabian Sea combined with the influx of the Bay monsoon current resulted in widespread and heavy rainfall in Kashmir between 4 and 6 July and in the Punjab, Himachal Pradesh and the hills of west Uttar Pradesh from 5th to 8th. These heavy falls of rain over a period of three days were responsible for the floods in Kashmir.

A point of interest with regard to the 1959 Kashmir flood, is that though the floods were very high, the actual rainfall amounts, as far as data are available, do not indicate any abnormally heavy rain to account for the severity of the flood. This fact leads to various speculations about the cause of the high magnitude of the flood. Normally, major floods in the Kashmir Valley occur in the second half of August or in September. This year's flood came early in July. Also, heavy snowfalls continued in Kashmir Valley as late as the end of April. Taking these two facts together, it is suggested that snowmelt might have contributed considerably towards this year's floods.

(*iii*) *Godavari floods of the second and third week of September*—Following heavy rains in the upper reaches of the catchment, there was a minor flood in the river Godavari at Dowleshwaram between 4 and 7 September. The river started rising again on 11 September and the level of water over the anicut at Dowleshwaram went up by 4·5 ft in 24 hours from 11th to 12th. The river crossed the danger mark of 16·0 ft on 13 September. The rising trend continued during the next three days, and the maximum level of 18·8 ft was reached at 4 P.M. on the 17th. This level was only 0·7 ft below the record flood level of 19·50 ft reached in 1953. The flood water breached the bunds at a number of places. Many towns like Dummagudum, Bhadrachalam, Polavaram etc were isolated from the outside world. Many localities of Rajamundry town were under 2 to 3 ft of water. The northern tributaries of the Godavari, *viz.*, the Wardha, Pranita etc were also in spate. The synoptic situation responsible for these floods is described below—

With a fresh strengthening of the Bay monsoon a low pressure area formed on 2 September extending from northwest Madhya Pradesh to the northwest Bay of Bengal. Moving slowly westnorthwestwards, the 'low' lay over south Rajasthan and Gujarat on 5th and over lower Sind and Kutch on 7th. It merged with the seasonal low on the 8th. The heavy rainfall which occurred in Vidarbha and Madhya Pradesh in asociation with this low was responsible for the floods in Godavari between the 4th and 7th. As this flood was subsiding, conditions became favourable for a fresh spell of heavy rain in the catchments of the Penganga, Pranita, Wardha and Indravati, the northern tributaries of the Godavari. A 'low' pressure area which appeared over Orissa, Chota Nagpur and Gangetic West Bengal on 7 September and persisted till the 10th intensified into a depression over Orissa on the latter day. Moving slowly westwards it was centred near Nagpur on the morning of 14 September. Thereafter it took a northwesterly course and merged with the seasonal low over Rajasthan by the 16th. In its association widespread and locally very heavy rain occurred in Vidarbha, Chota Nagpur and Madhya Pradesh between the 12th and 16th and in Saurashtra and Kutch on 15th and 16th. The heavy rains in the Baster district of Orissa and over the whole of Vidarbha swelled all the northern tributaries of Godavari and were responsible for the near record flood in lower Godavari between the 15th and 17th. Isohyetal analysis of the flood period shows that the heavy rainfall responsible for the flood was confined to Penganga, Wainganga and Indravati subcatchments, the rest of the Godavari catchment getting little rain. The storm rainfall in these three sub-basins are given in Table 2.

TABLE 2

Name of Sub-basin	Period of heavy rain	Total rain (cm)
R. Indravati	10-13 Sep	16·3
R. Wainganga	13-14 Sep	10·4
R. Penganga	14-15 Sep	19·2*

*15·8 cm on 14 Sep 1959

(*iv*) *Tapti floods of 15-17 September*—The same depression which was responsible for the flood in Godavari gave very heavy rain from 13th to 15th in the upper reaches of the Tapti river in the Yeotmal, Buldhana and Akola districts and adjoining area. Akola recorded 55 cm of rain in 48 hours. This resulted in an unprecedented flood in the lower reaches of the Tapti and at Surat. The Tapti river is reported to have reached a record height of 103 ft R.L. at Surat on 17 September. The dykes protecting the town gave way and most areas of Surat town were flooded to a depth of 4 ft of water. A number of human lives were lost and a large amount of property was damaged or destroyed by the flood.

An interesting feature about the flood at Surat was that during the period of flood and the preceding few days, Surat and neighbourhood experienced very little rain. The flood was purely an upstream flood resulting from

TABLE 3

Tapti catchment	Basin rainfall (cm) on 14 Sep 1959	Basin rainfall (cm) on 15 Sep 1959	Total storm rainfall (cm)
Upper	12·5	15·7	28·2
Middle	1·8	5·6	7·4
Lower	0·3	3·3	3·6

the very heavy downpour in the upper catchment of the river. As the depression which caused the rainfall took a northwesterly course from Nagpur, the middle and lower catchments of the Tapti escaped the influence of the depression and, therefore, the heavy rain. Figs. 1 and 2 giving the isohyetals for this rainstorm clearly brings out this feature. The average rainfall in the upper, middle and lower Tapti catchments during the storm are set out in Table 3.

Comparing this flood with other major floods in Tapti in the past, it is found that all the floods were associated with monsoon depressions moving westwards across the country. The floods fall broadly under two categories. In the first, illustrated by the flood under discussion, heavy rainfall is mainly confined to the upper catchment. In the second, heavy rainfall occurs progressively over the whole catchment by the depression traversing the whole length of the catchment. In the later case, the flood wave is more prolonged in the lower reaches of the river and the flood hydrographs often show two peaks.

(v) *Floods in Damodar and other West Bengal rivers from 30 September to 2 October*—The river Damodar and the other rivers of the plains of West Bengal, *viz.*, Bhagirathi, Jalangi, Churni and Rupnarain experienced high floods during the first week of October, which caused considerable damage to property and suffering to people. The floods were the result of the incidence of heavy rainfall over the basins in association with a cyclonic storm from the Bay of Bengal.

After 12 September till the end of the month, practically dry weather prevailed over the whole of Bihar, West Bengal and the adjoining areas. This was broken on the 30th when rainfall started over Gangetic West Bengal and Chota Nagpur plateau under the influence of a severe cyclonic storm in the Bay of Bengal. The storm originated as a 'low pressure area' over the Andaman Sea on 26 September, moved northwest and intensifying at the same time became a severe cyclonic storm by the 30th morning when its centre was located about 250 km southsoutheast of Calcutta. The storm crossed the coast near Balasore on the morning of 1 October, weakened into a deep depression and moved northwestwards across Bihar Plateau between the 1 and 2 October. Thereafter it curved towards north and became unimportant. Heavy rainfall started in Gangetic West Bengal in the catchments of the rivers Mor, Ajoy, Bhagirathi and Brahmani and in the lower Damodar basin on 30 September to 1 October. With the westward movement of the depression, the region of heavy rainfall shifted to the upper Damodar basin on 2 October. Rainfall over the basin decreased considerably thereafter.

The average rainfall in the Damodar and its sub-catchments as also in the rivers of West Bengal during this spell are given in Table 4.

The heaviest rainfall in 24 hours at a station during this spell was 21·6 cm (8·5″) at Burdwan on 30 September and the heaviest 3-day rainfall was 25·2 cm at Naya Dumka. Within the Damodar basin, the heaviest station rainfall was 20·8 cm at Mandar on 2 October.

A comparison of the rainfall in the Damodar basin upto Rhondia during this flood with the rainfall on similar occasion in the past has shown that on as many as 17 occasions in the past (1891—1958) 3-day rainfall amounts equal to or higher than that during the 1959 storm have been recorded in the basin. The highest 3-day

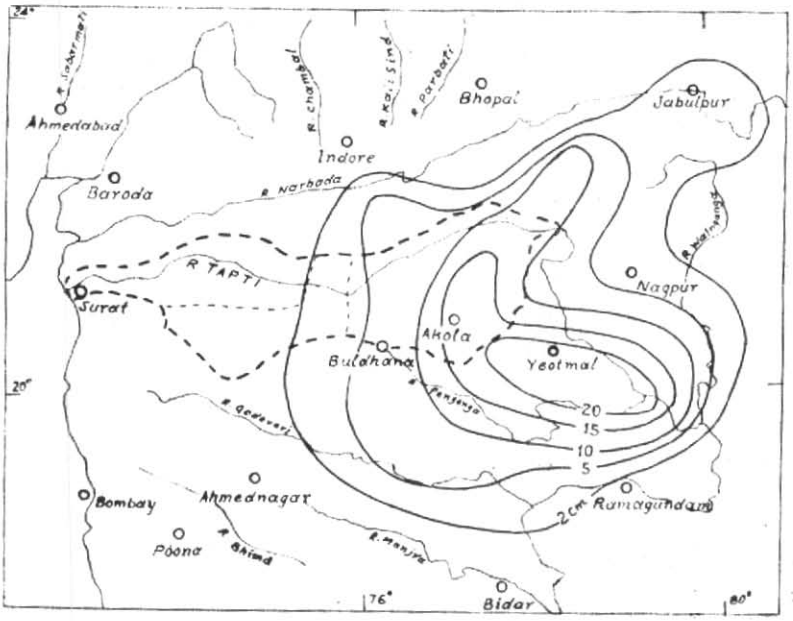

Fig. 1. Isohyets of Tapti Catchment for 14 September 1959

Raiufall in cm for 24 hours ending 0830 IST of 14 September 1959

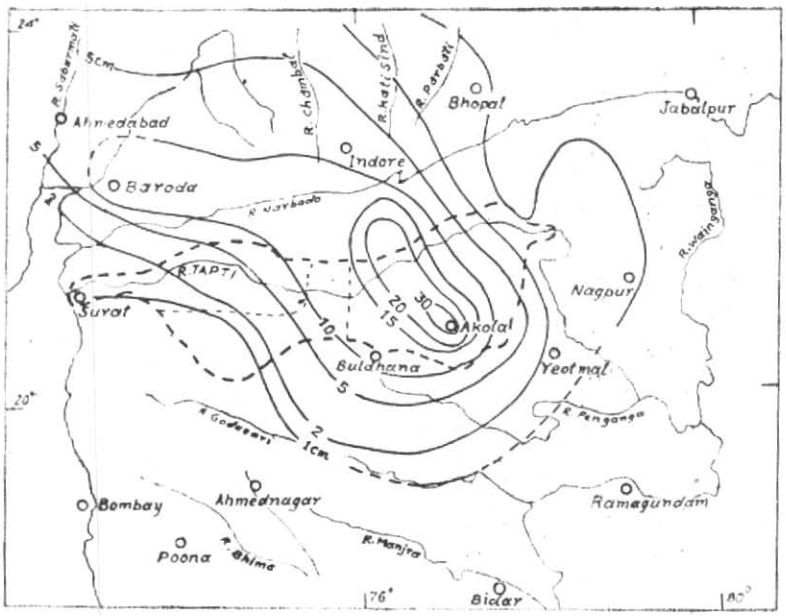

Fig. 2. Isohyets of Tapti Catchment for 15 September 1959

Rainfall in cm for 24 hours ending 0830 IST of 15 September 1959

TABLE 4

Name of the Catchment	Rainfall (cm) on 30 Sep 1959	1 Oct 1959	2 Oct 1959	Total storm rainfall (cm)
R. Damodar				
(*a*) Upper Damodar upto Raniganj	1·0	4·4	8·0	13·4
(*b*) Lower Damodar (below Raniganj)	2·0	12·6	5·0	19·6
(*c*) Barakar (upto Maithon)	0·8	4·3	9·4	13·5
R. Ajoy	0·3	7·2	11·4	18·9
R. Mor	0·02	7·0	11·6	18·6
R. Brahmani	0·2	6·1	12·0	19·3
R. Bhagirathi (including Jalangi)	0·3	9·9	5·6	15·8

TABLE 5

Storm rainfall of 24-26 September 1956

Name of River	Rainfall (cm)
R. Damodar	
(*a*) Upper Damodar	6·9
(*b*) Lower Damodar	25·6
(*c*) Barakar	4·8
R. Ajoy	15·7
R. Mor	20·3
R. Brahmani	25·3
R. Bhagirathi	27·7

rainfall in the basin has been 9·21″ recorded on two occasions (*i*) 7-9 August 1913 and (*ii*) 11-13 August 1935 which is very much higher than the rainfall of 5·27″ during the 1959 floods. Thus, the storm characteristics and the rainfall amounts associated with the 1959 Damodar flood cannot be regarded as exceptional or even rare.

This is found to be true of the floods in the other West Bengal rivers also. In Table 5 are given the rainfall in the basins of these rivers during the 3 days, 24-26 September 1956 associated with the high floods of September 1956. A comparison with Table 4 will show that the rainfall in the basins of these rivers was much heavier in the September 1956 storm than during the floods of 1959.

5. Conclusion

The following features of the rainfall distribution during the southwest monsoon of 1959 and the major floods of the season have been brought out—

(1) As a result of the persistence of the axis of the monsoon trough south of its normal position practically all through the season and the occurrence of a large number of monsoon depressions which moved more west than northwest, the central parts of the country, the Deccan and western India experienced heavy rainfall week after week and north and northwest India suffered from deficit rainfall over a large number of weeks.

(2) Spells of heavy rainfall over the southern slopes of the Himalayas associated with periods of 'breaks' in the monsoon were also absent during 1959.

(3) The consequence of (1) and (2) was the occurrence of serious floods in the rivers of central India and the Deccan and the non-occurrence of any major flood in the rivers of Uttar Pradesh and Bihar.

(4) The rainfall and associated floods in the rivers of West Bengal and Damodar in October 1959, though heavy, were not of such a magnitude as to be termed abnormal or even rare. The same holds good with regard to the Assam floods of June 1959.