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Rainfall and Floods during 1966 Southwest Monsoon period*

1. Introduction

The monsoon rainfall has been characteristic of drought conditions over most of the northern parts of the country. This has happened for the second year in succession, the worst affected areas are Bihar and east Uttar Pradesh. While some parts of Bihar received deficit rainfall, the other parts were affected by floods. Although 6 depressions from the Bay of Bengal crossed inland during the period, only two of them penetrated deep into the country—one as far as west Uttar Pradesh and the other into the Punjab and Himachal Pradesh. These, however, did not improve the overall rainfall situation over most parts of the country.

2. Onset and Withdrawal of Monsoon

The monsoon advanced simultaneously into the Arabian Sea, south of 8°N and south Bay of Bengal by 26 May. It further advanced into Kerala between 1 to 3 June and into Assam by about 5 June. The northward movement of the Arabian Sea branch continued, to cover the entire Peninsula by 12 June. The monsoon was very active over upper Assam from 9 to 15 June as a result of which the tributaries of the Brahmaputra went in spate causing inundation in the low lying areas. The activity of the monsoon shifted to lower Assam by about 15 June due to a deep depression which formed in the north Bay. Moving north-northeast, this depression crossed the East Pakistan coast on the morning of 17 June. Fairly well distributed rainfall also occurred over northeast India outside Bihar State; Orissa received heavy rains. The flood situation improved in the Brahmaputra valley but worsened in south Assam due to floods in the river Barak. Further advance of the monsoon over rest of the country outside west Rajasthan and western parts of Punjab (India) and Jammu and Kashmir occurred between 15 and 22 June. However, under the influence of a depression which formed about 200 km south of Calcutta on 28 June and moved northwards, active monsoon conditions prevailed over Gangetic West Bengal, Orissa,

Bihar Plateau and east Madhya Pradesh between the end of June and the beginning of July. It was feeble over Peninsula during the period.

Break monsoon conditions existed from 2 to 5 July when Assam and sub-Himalayan West Bengal got the third spell of renewed monsoon activity, throwing the entire plains of Assam in the grip of a second wave of devastating floods.

A depression formed in the Bay on the morning of 17 July with centre about 300 km east of Puri. Moving westwards, it crossed coast on the 18th and then weakened. In association with these developments, there was a general strengthening of the monsoon over the country and the monsoon was active in Maharashtra and Gujarat States, and west Madhya Pradesh during the latter half of July. A serious water supply position in Bombay that arose out of very weak monsoon activity over Konkan till 2nd week of July, eased considerably later.

A depression formed in the Bay on 28 July with centre about 300 km southeast of Calcutta. Moving west-northwest it weakened and lay as a low pressure area over the northern parts of Madhya Pradesh by 1 August. Under these developments, monsoon activity was well sustained throughout the country especially over northern parts of the country and in west Uttar Pradesh, east Rajasthan and the Punjab and Jammu and Kashmir during this period. This ameliorated the water scarcity conditions in Rajasthan.

Break conditions of monsoon again occurred from 21 to 31 August and the monsoon activity was confined to north and central India. There was heavy rainfall over the Himalayas and adjoining plains.

A depression formed on 2 September with centre about 200 km east of Puri. It moved westward till 5 September. Later it took a northwesterly course and was centered near Neemuch on 7 September. It recurved and broke up over the western Himalayas by 9th. Under its influence there was

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NOTE—Flood accounts and damage reports given in the article are as obtained from the *Flood News Letters* issued by the Central Water and Power Commission, New Delhi

RAINFALL AND FLOODS DURING 1966 SW MONSOON

TABLE 1

SOUTHWEST MONSOON 1966

PERCENTAGE DEPARTURES FROM NORMAL RAINFALL FOR WEEK ENDING

METEOROLOGICAL SUB-DIVISIONS	JUNE					JULY					AUGUST					SEPTEMBER					OCT
	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5		
NORTH ASSAM INCLUDING N.E.P.	+ 8	+135	- 61	- 82	-35	+23	-17	-48	-35	-13	+	-46	-18	-24	-17	-31	-61	-62	-6		
ASSAM (INCLUDING NAGALAND MANIPUR AND TRIPURA)	-25	-5	-12	+ 6	-46	+10	-60	-5	-19	-5	-12	-40	-24	+3	+6	-40	+75	-90	-72		
SUB-HIMALAYAN WEST BENGAL	-42	+61	-52	-95	-60	-37	+08	-25	-36	-40	-61	-28	+205	+150	-64	-21	+9	-90	-72		
GANGETIC WEST BENGAL	-56	-30	-40	-18	-44	-10	-59	-42	-62	-28	-27	+5	-43	-70	+9	-22	-47	-85	-45		
ORISSA	-42	-70	-20	-37	-74	-53	-79	+12	-18	-31	-60	-35	-44	-82	-35	-66	-89	-60	-72		
BIHAR PLATEAU	-30	-80	-70	-13	-84	-56	-38	-30	-87	-12	+9	-23	-34	-89	-29	-63	-88	-89	-85		
BIHAR PLAINS	-54	-84	-71	-80	-32	+14	-80	-41	-87	-80	-37	-36	-28	-83	-65	-38	-81	-80	-82		
U.P. EAST	-99	-100	-71	-36	-112	+6	-95	-90	-30	-68	-3	+19	-20	-68	-80	-84	-100	-60	-63		
U.P. WEST	+ 7	-99	-71	-68	-132	+9	-99	-81	-78	-38	+61	+83	-3	-77	-38	-10	-81	-93	-64		
PUNJAB (INCLUDING DELHI)	-16	-100	+131	+117	+211	-24	-96	-87	-71	+21	+86	-200	-38	-94	-54	+80	-84	-99	-34		
HIMACHAL PRADESH	-84	-100	-359	-377	-625	-9	-85	-72	-19	-17	-17	+22	-38	-46	-64	+128	0	-100	-31		
JAMMU & KASHMIR	-135	-98	-99	-171	-60	+20	-88	-75	-28	-12	+104	-30	0	-85	-90	-464	-70	-87	-31		
RAJASTHAN WEST	-58	-32	-100	+140	+3	-9	-81	-48	-9	+23	+141	-79	-69	-100	-37	+70	-29	-80	-99		
RAJASTHAN EAST	-93	-88	-9	-333	-715	-97	-98	-13	-92	-37	-37	-57	-57	-96	-30	-11	-73	-99	-100		
MADHYA PRADESH WEST	-84	-77	+9	-41	-49	-74	-88	0	-30	+60	-13	-10	-12	-95	+18	-89	-75	-91	-96		
MADHYA PRADESH EAST	-91	-80	-5	-40	-87	-87	-83	-32	-22	+11	-20	+3	-27	-87	-3	-96	-96	-70	-92		
GUJARAT REGION (INCLUDING Saurashtra & Nagar Havelli)	-100	-100	-48	-168	-57	-99	-90	-84	-4	-5	-61	-91	-96	-86	-23	-65	-82	-97	-100		
SAURASHTRA & KUTCH	-100	-100	-48	-4	-57	-96	-74	-74	-3	-85	-98	-88	-100	-96	+3	-37	-52	-90	-100		
KONKAN (INCLUDING GOA)	-90	-82	-7	-30	-82	-97	-76	-118	-42	-33	-76	-65	-62	-69	-130	-59	-96	-68	-81		
MADHYA MAHARASHTRA	-100	-100	-68	-40	-88	-95	-60	-64	-27	-125	-49	-71	-94	-27	-164	-92	-51	-8	-64		
MARATHWADA	-57	-72	-34	-74	-98	-99	-17	-108	-38	-208	-42	-28	-82	-42	-245	-100	-96	-40	-94		
VIDARBHA	-95	-95	-45	-89	-82	-90	-81	-118	-87	-66	-38	-54	-25	-84	-162	-97	-90	-57	-94		
COASTAL ANDHRA PRADESH	-89	-104	-27	-68	-81	-92	-23	-1	-203	-30	+6	-45	-6	-43	+12	-74	-83	-57	-94		
TELANGANA	-100	-87	-68	-59	-87	-99	-46	-73	-57	-30	-13	-88	-19	+60	+94	+12	-73	-23	+10		
RAJALASEEMA	-100	-21	-24	-80	-88	-97	-127	-57	-30	-13	-88	-19	+60	+94	+12	-73	-23	+10	-3		
MADRAS STATE (INCLUDING PONDICHERY)	-99	-80	-108	0	-10	-46	-27	-17	-92	-40	-51	-166	+30	-62	-23	-30	-191	-23	-23		
COASTAL MYSORE	-91	-86	-36	+8	-51	-25	-38	+19	-60	+6	-51	-74	-77	-20	+57	-38	-90	-53	+62		
INTERIOR MYSORE NORTH	-100	-23	-19	-63	-90	-95	-5	-54	+2	-73	-98	-30	-89	+105	-234	-75	-29	-88	-47		
INTERIOR MYSORE SOUTH	-100	+21	-46	-47	-92	-95	-26	-23	-17	-76	-90	-44	-3	-30	-46	-197	-181	+66	+66		
KERALA	-66	-8	-64	+21	-5	-8	-8	-40	-30	-20	-22	-54	-86	-50	+10	-8	-93	-178	-103		

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revival of monsoon activity generally over the country, the activity being more marked over northwest and central parts of India. Heavy rains occurred over northwest India and Gujarat State. After the depression moved off, the monsoon weakened generally over the country.

The monsoon withdrew from northwest India and Gujarat by the end of third week of September. However, there was fairly well distributed rainfall in northeast India and Peninsula. Monsoon further withdrew from Uttar Pradesh and west Madhya Pradesh by the 28 September and from the country outside the Peninsula by about 9 October 1966.

3. Weekly and Seasonal Rainfall

Rainfall week by week, for the period 25 May to 5 October 1966, in each of the 30 meteorological sub-divisions* of the country is shown in Table 1 as percentage departure from the normal rainfall. The main inferences from this table are as follows.

During the period June–September 1966, the rainfall was in deficit by over 25 per cent for a continuous period of five weeks or more in Bihar, east Uttar Pradesh, Saurashtra and Kutch, Konkan and Vidarbha. Particular mention may be made of east Uttar Pradesh, Saurashtra and Kutch, Gujarat region, Rajasthan East, Bihar Plains where the deficit was maintained around 80 to 100 per cent in a number of individual weeks. Bihar plains were the worst affected by drought since out of the 19 weeks considered here, the rainfall was more than 25 per cent in deficit for 17 weeks.

Fig. 1 shows the departures from normal of the cumulative rainfall from 1 June till the end of each successive week of the period. Percentage departures of the total seasonal rainfall (1 June to 30 September) for all the sub-divisions are shown in the last column. The main features revealed by this figure are—

- (i) Almost throughout the season, north and south Assam, sub-Himalayan West Bengal

*Changes on account of the re-organisation of States from 1 November 1966 have not been incorporated in this note

PERCENTAGE DEPARTURES FROM NORMAL RAINFALL FOR THE PERIOD 1ST JUNE TO WEEK ENDING

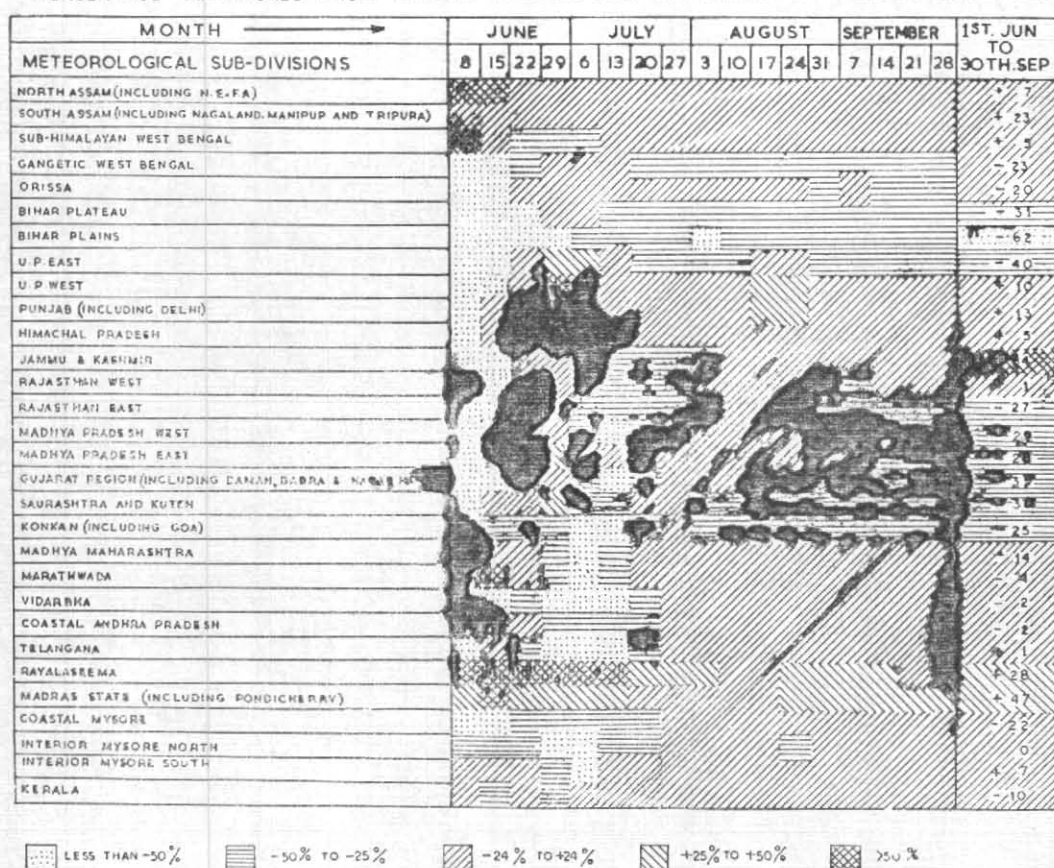


Fig. 1

Punjab, Himachal Pradesh and Kerala have shown normal conditions (-24 per cent to $+24$ per cent) of rainfall, whereas Rayalaseema and Madras States have shown rainfall excesses from normal throughout the season.

- (ii) From the middle of July, the following meteorological sub-divisions showed normal rainfall conditions:

Madhya Maharashtra, Marathwada, Vidarbha, Coastal Andhra Pradesh, Telangana, Coastal and Interior Mysore and west Uttar Pradesh.

- (iii) Gangetic West Bengal, Rajasthan East, Gujarat, Saurashtra and Kutch, Bihar Plateau, Bihar Plains and Uttar Pradesh East (except for a brief period from middle of June to mid-July) and Madhya Pradesh (West) and Konkan were characterised by moderate to severe drought conditions throughout the season.

- (iv) Rainfall at the end of the season was 25 to 50 per cent deficit in Saurashtra and Kutch, Uttar Pradesh (East), Bihar Plateau, Rajasthan (East), Gujarat region, Madhya Maharashtra, Madhya Pradesh (West), Madhya Pradesh (East) and Konkan. Bihar Plains recorded a rainfall deficit of 62 per cent.

4. Chief Floods of the Season

Brahmaputra and its tributaries were in flood during a major portion of the monsoon season. Although Bihar State experienced drought conditions and the seasonal rainfall was in great defect, it also experienced floods during the first week of July and again between 20 to 25 August, especially the catchment area of the river Bagmati. No major floods have occurred in the rivers in the Peninsula. The chief floods during the period are listed below—

- (i) Assam floods:

Two spells of floods—5 to 15 June and first week of July—in north Assam and

during third week of June in south Assam and Manipur.

- (ii) Floods in river Baghmata during first week of July.
- (iii) Yamuna floods in the first week of August.
- (iv) High floods in river Ghaggar from 18 to 24 August.
- (v) Floods in Bihar rivers 23 to 30 August.
- (vi) Punjab rivers in high floods: Second week of September.

Floods account and associated meteorological situation in regard to some of the significant floods listed above are detailed below.

4.1. Assam floods in June

Persistent heavy rains due to premonsoon thunderstorm activity over Assam followed by the heavy rains in the upper reaches of Brahmaputra after the onset of monsoon, caused a rise in the level of Brahmaputra and its tributaries by middle of June. The heavy rains over Assam that occurred in association with a deep depression over north Bay on 16 June and its movement towards south Assam caused further rise in Assam rivers and the flood situation worsened. At Dholia on Brahmaputra, the high flood level surpassed all previous records with a gauge reading of 424.78 ft on 7 June and Dibrugarh recorded a level of 343.5 ft against danger level of 342.0 ft. Communications between Assam and the other parts of the country were cut off. According to an All India Radio report of 15 June 1966 about 7 lakh people were affected by floods, 80 per cent of cultivated land was damaged and 12 people lost their lives. Several embankments and dykes in Nowgong, Sibsagar and Darrang districts were breached and roads were submerged. Noteworthy amounts of rainfall are—

Station	Rainfall (cm)	Date (June 1966)
Dhubri	18	2
Pasighat	23	3
	13	4
	11	5
	16	9
North Lakhimpur	13	9
Tezpur	11	12

Associated with the above meteorological situation, south Assam, Manipur and Tripura also experienced heavy rains. The level of river Barak at Silchar railway godown on 12 June was 21.02 m (danger level 19.87m). Heavy rains continued till 21 June, flooding vast areas in Silchar and Karimganj districts. It was reported that 80 per

cent of the crop had been damaged in Cachar district and there were as many as 61 cuts and breaches of embankments in Silchar district alone. Land and air routes linking Imphal with the rest of the country had been dislocated. It was reported that 3,38,000 people had been affected and 1,000 head of cattle had been lost in Manipur.

The total damage caused by floods in the State were estimated at Rs. 33 crores.

4.2. Yamuna floods in the first week of August

A deep depression formed over the Bay on 28 July near Lat. 21°N and Long. 88°E. Moving west-northwestwards, it crossed coast near Balasore the next morning and then weakened into a low pressure area on 1 August over north Madhya Pradesh and finally moving northwards it merged with the seasonal trough. In the wake of the depression, widespread rains occurred over Himachal Pradesh and the hills of the Punjab, west Uttar Pradesh and caused floods in the river Yamuna.

The noteworthy rainfall amounts were, Roorkee 12 and Dharmasala 7.5 cm on 31 July, Dharmasala 9 cm on 2 August and Delhi 12 cm on 3 August 1966.

Yamuna at Delhi Railway Bridge crossed danger level of 672.00 ft on 2 August. It was reported that 45 villages were inundated affecting more than 15,000 people.

4.3. Bihar rivers in spate during 23 to 30 August

The axis of the seasonal trough lay close to the foot of Himalayas from 23 to 27 August 1966, indicating a break in monsoon. Active monsoon conditions prevailed during the week prior to this break period and caused widespread rain in the catchment areas of the Bihar rivers.

The level of Baghmata at Dheng Bridge had risen to 232.95 ft (danger level 230.00 ft) on 25 August and that of Gandak at Bhainsalotan on 24th was 365.10 ft (danger level 359.80 ft). Rail communication between Dheng and Baigamia had been suspended from 24 August due to severe floods in the rivers Baghmata, Marha and Hardi in Muza-farpur district. No loss of human life or cattle was reported. A crop area of 15.5 lakh acres had been affected and the estimated value of damage to crops was put at Rupees 25 crores. A population of 36 lakhs had been affected and about 24,000 houses had been damaged.

4.4. Heavy rainfall situations over Punjab and Uttar Pradesh

Widespread rains occurred over Punjab and northwest Uttar Pradesh in association with a wel

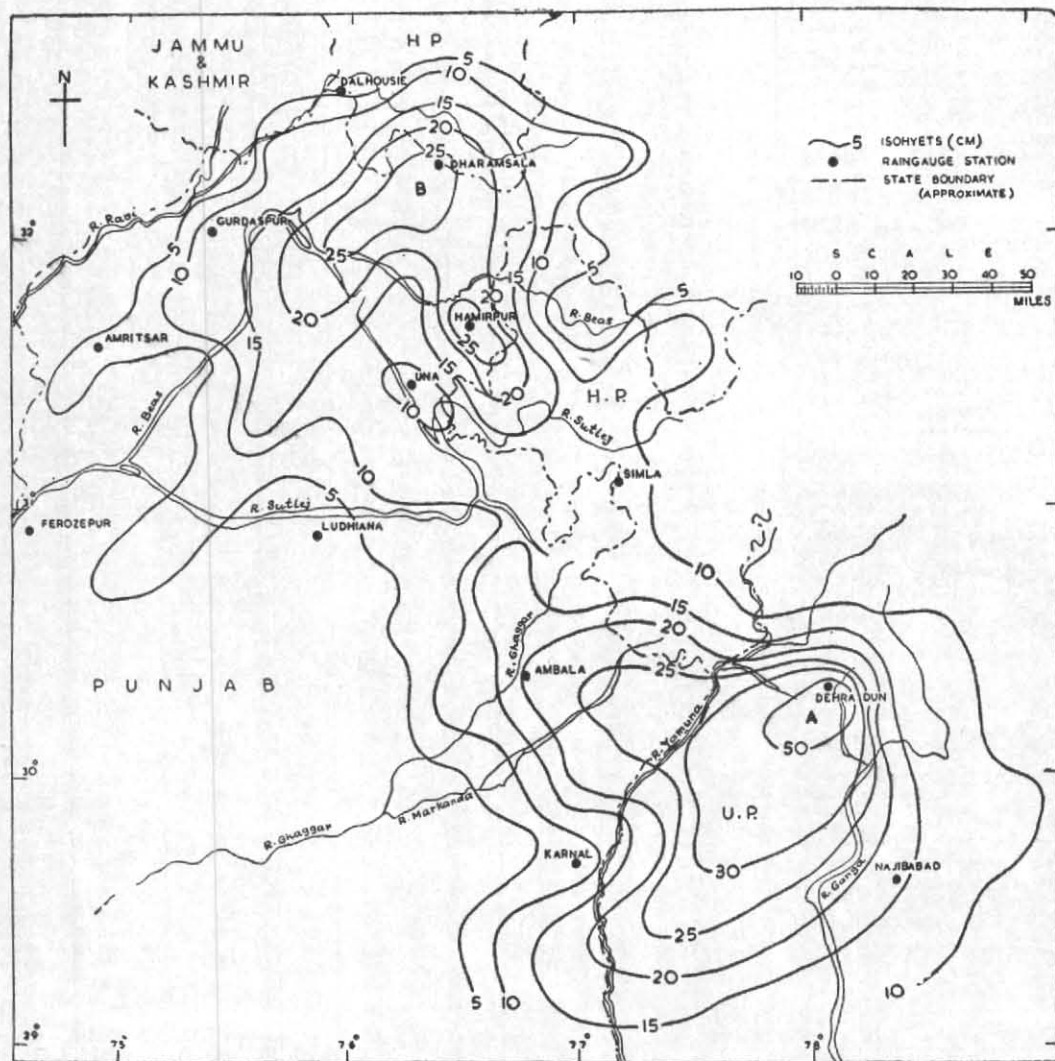


Fig. 2. Isohyetal map of Punjab and Uttar Pradesh region for the period 23-26 July 1966

A and B are storm centres

marked upper air cyclonic circulation over Punjab from 23 to 26 July. Dehra Dun received 48.5 cm on 25 July. Other noteworthy rainfall amounts during the above period are—

Station	Rainfall (cm)	Date (July 1966)	Station	Rainfall (cm)	Date (July 1966)
Dharamsala	10	24	Dadupur	15	25
(Lower)	15	25	Roorkee	24	25
Hamirpur	19	25	Mussoorie	15	25
Jagadhari	19	25	Dharamsala	18	26
Naraingarh	16	25	Kangra	16	26
			Palampur	17	26

The rivers in Punjab rose in spate and considerable damage was caused to various canals and flood protection works in the region. Damage to the irrigation works had been estimated to be about Rs. 3.80 lakhs.

The isohyetal map of Punjab—Uttar Pradesh region for the period 23 to 26 July is given at Fig. 2 and the depth area values for standard areas are as follows—

Storm centre A		Storm centre B	
Area (sq. km)	4-days depth (cm)	Area (sq. km)	4-days depth (cm)
2000	47.7	2000	27.0
5000	41.2	5000	24.0
10000	33.7	7000	21.3
15000	29.3	10000	20.9
20000	26.7	—	—

4.5. Punjab rivers in high floods during the 2nd week of September

A depression in the Bay was centered at Lat. 19°N and Long. 88°E on 2 September. Moving westward it crossed coast near Puri on 3rd, continued to move westwards till 5 September and then took a northwesterly course and was centered near Jabalpur on 7th. Later, it recurved north-north-eastward and broke up over the western Himalayas on the 9th. Under its influence there was general revival of monsoon activity over the country, the activity being more marked over central and north-west India. Vigorous monsoon conditions prevailed over Punjab and the State experienced floods once again during 7 to 9 September 1966. Noteworthy amounts of rainfall are—

Station	Rainfall (cm)	Date (September 1966)
Dalhousie	14	8
Amritsar	9.5	8
Qazigund	17	9
Jammu	17	9
Amritsar	9	9
Dalhousie	9	9

River Jhelum rose in floods in Srinagar valley where due to breaches in the embankment about 50 villages were inundated.

The Ravi was also in high floods at Dera Baba Nanak. In Ferozepur district, the floods had caused considerable damage to houses in Muktsar, Rupar and other places due to stagnation of water in some villages. River Sutlej also was in medium floods at Hussainwala Headworks. There had been widespread damage to standing *Kharif* crop due to stagnation of water.

5. Conclusions

The rainfall during southwest monsoon season was generally below normal for the second year in succession. The worst affected parts which suffered from lack of rainfall were Bihar, east Uttar Pradesh, Madhya Pradesh, Rajasthan, Saurashtra and Kutch. This year's rainfall situation was slightly better for the southern states of the country.

As expected from a deficient rainfall condition, there were no major floods over the central parts of the country, these occurred only in the regions of Assam and north India comprising of Punjab and west Uttar Pradesh.

During the first week of July and last week of August when break monsoon conditions prevailed, heavy rains occurred in the upper catchments of the rivers in Bihar, which sent their lower basins into spate, ironically enough when other parts of the State were experiencing drought conditions.