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## Rainfall and floods in India during the 1971 southwest monsoon period

P. S. HARIHARA AYYAR, S. D. S. ABBI and HEM RAJ

*Meteorological Office, New Delhi*

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### 1. Introduction

The monsoon set in over south Kerala on 27 May 1971. Advancing rapidly northwards, it extended upto Gujarat State, Vidarbha and south Madhya Pradesh in the west and Assam and West Bengal in the east by 2 June. It set in over Orissa, Bihar State, north Madhya Pradesh, east Uttar Pradesh and southeast Rajasthan by 9 June. Thus the date of onset of the monsoon was about a week to ten days earlier than the normal date of its onset in most of these regions. Its activity weakened thereafter for about a fortnight. Then it revived and advanced into west Uttar Pradesh, Haryana and adjoining Himachal Pradesh on 23 June. By 26 June the monsoon had established itself over the entire country outside Jammu & Kashmir where also it set in on 2 July 1971.

The withdrawal of the monsoon from northwest India, Uttar Pradesh northwest Madhya Pradesh and north Gujarat State took place during the week ending on 15 September. It further withdrew from west Madhya Pradesh and Gujarat State by 20 September. The withdrawal of monsoon, like its onset, was also a week to ten days ahead of its

normal date.

During the season, 7 depressions and 8 low pressure systems traversed inland in quick succession from the head Bay of Bengal or neighbourhood. In association with these disturbances, concentrated spells of heavy to very heavy rainfall in the States of Uttar Pradesh, Bihar, Orissa and West Bengal and floods in the *Ganga* and many of its tributaries were experienced. According to official estimates, 1023 human lives were lost and property worth Rs. 5,270 million was damaged in floods in 1971. The total population affected was 55 million and altogether an area of 12.1 million hectares including a cropped area of 5.65 million hectares was affected in the country. 98 per cent of the total damage in the country occurred in Bihar, Orissa, Uttar Pradesh and West Bengal.

Taking the monsoon season 1971 as a whole, the rainfall over the country was normal except over Gangetic West Bengal, Bihar Plateau, east Uttar Pradesh, Haryana and Himachal Pradesh where it was above normal and Jammu & Kashmir, west Rajasthan, Marathwada, Vidarbha, Telangana and Rayalaseema where it was in deficit. Drought conditions were experienced in

## SOUTHWEST MONSOON 1971

PERCENTAGE DEPARTURES FROM NORMAL FOR WEEK ENDING

METEOROLOGICAL SUB-DIVISIONS	JUNE					JULY				AUGUST				SEPTEMBER				1 JUNE TO 30 SEPT		
	2	9	16	23	30	7	14	21	28	4	11	18	25	1	8	15	22		29	
NORTH ASSAM (INCLUDING N.E.F.A.)	-67	-31	-20	-59	-51	-13	2	-2	-48	30	-9	61	-5	-67	-40	-40	-66	45	-12	
SOUTH ASSAM (INCLUDING NAGALAND MANIPUR & TRIPURA)	-51	-60	-45	-55	17	10	-75	-15	-35	33	-37	-12	5	-36	15	-44	-59	-49	-19	
SUB HIMALAYAN WEST BENGAL	49	-15	71	-43	9	-25	1	-67	-63	-10	-52	44	5	-72	-57	-37	-78	67	-3	
GANGETIC WEST BENGAL	-27	60	-85	-50	64	64	-14	84	11	-13	7	19	31	232	27	-62	-70	-73	34	
ORISSA	-70	118	-86	101	-55	-48	-53	-9	-24	-4	87	-46	-46	31	-5	-93	-61	-52	-4	
BIHAR PLATEAU	-19	455	-76	-51	73	40	5	65	-5	-36	1	28	-30	121	36	-68	-86	-55	36	
BIHAR PLAINS	-2	33	40	-37	39	9	-18	-28	-2	-7	0	48	-6	-9	3	-67	-95	-54	7	
UTTAR PRADESH, EAST	145	268	-19	-27	81	102	59	-53	-55	-3	54	4	-36	15	96	-40	-100	-15	29	
PLAINS OF WEST U.P.		776		42	-52	148	-67	-26	-4	+31	26	71	-72	-18	147	-50	-100	-40	20	
HILLS OF WEST U.P.	357	267	179		35	41	103	-37	-49	-9	-18	22	24	23	10	94	-13	-95	-91	24
HARYANA (INCLUDING DELHI & CHANDIGARH)	498	-2	-58	110	-2	103	-58	-45	-33	221	145	89	-80	239	170	-44	-100	-88	41	
PUNJAB	39	-93	-97	-27	321	261	-98	-58	-70	83	-79	-56	-99	314	-39	-81	-100	-100	11	
HIMACHAL PRADESH	258	554	510	35	116	122	-27	-81	-45	9	139	-71	58	-10	-4	-61	-100	-100	25	
JAMMU AND KASHMIR	-51	-90	39	-37	69	-28	-52	-87	-99	59	-99	-97	-96	108	-72	-91	-100	-97	-49	
RAJASTHAN WEST	6	43	-100	-15	268	-65	-99	-5	-84	-25	-98	-35	-99	0	-1	-13	-100	-100	-31	
RAJASTHAN EAST	-65	271	-99	-58	352	-69	-94	6	81	-5	-56	41	-66	-29	127	8	-100	20	20	
MADHYA PRADESH WEST	114	392	-87	-1	41	-62	-61	63	25	-12	-82	9	-41	55	59	-64	-99	103	7	
MADHYA PRADESH EAST	48	855	-42	92	-35	6	-28	63	16	-18	-36	-52	-65	121	13	-72	-91	-71	8	
GUJARAT REGION (INCLUDING DAMAN, DADRA AND NAGAR HAVELI)	-33	451	-93	-47	108	-99	-76	119	-47	-14	-42	-60	-90	189	2	-84	-99	119	-10	
SAURASHTRA & KUTCH (INCLUDING DIU)	387	1363	-93	-86	92	-100	-86	186	-86	-45	-62	-93	-99	533	-24	-90	-100	80	5	
* KONKAN (INCLUDING GOA)	459	133	-93	101	-18	-87	-75	47	-62	-70	-72	33	-21	157	-41	-89	-91	139	-4	
MADHYA MAHARASHTRA	118	91	-93	-9	-36	-95	-94	-25	-76	-82	-40	-65	190	83	-64	-98	-61	172	-20	
MARATHWADA	578	-99	-34	-57	-7	-94	-99	-89	-89	-86	-86	41	75	168	-49	-99	-100	215	-31	
VIDARBHA	214	289	-80	59	-65	-76	-76	-63	-76	-72	-67	-48	-46	173	12	-97	-97	15	-33	
COASTAL ANDHRA PRADESH	208	-17	-22	-39	-88	-6	-95	-19	-76	-73	-24	-46	64	-19	18	-55	-40	97	-19	
TELANGANA	169	122	-60	1	-84	-25	-92	-56	-76	-79	-73	-35	6	-27	-66	-71	-60	7	-41	
RAYALASEEMA	107	-90	-79	-18	-68	15	-81	-75	-17	-77	-99	-61	61	-32	-93	-5	-90	-17	-35	
TAMIL NADU (INCLUDING PONDICHERRY)	54	-47	1	-77	-15	63	101	-41	-26	79	-77	158	33	-93	-38	-6	54	17	7	
COASTAL MYSORE	348	47	-66	82	-55	2	-42	-4	63	-35	-78	142	-27	-38	10	-90	-41	40	2	
INTERIOR MYSORE NORTH	191	82	-72	54	-46	-26	-81	-13	-73	-79	-69	-72	100	-14	-66	-99	-39	121	-16	
INTERIOR MYSORE SOUTH	114	77	-72	19	-53	-82	-56	-32	-48	-71	-13	-36	315	-28	-73	-4	188	37	16	
KERALA*	175	25	-41	-1	110	-39	-82	24	166	-17	-39	50	93	-32	-87	-67	67	259	23	

Fig. 1

Andhra Pradesh and the district of Ongole was the worst affected.

## 2. Weekly and cumulative rainfall

The percentage departures of the monsoon rainfall week by week and for the season (June to September) as a whole in the 32 meteorological sub-divisions of India is shown in Fig. 1. The progress of monsoon from 1 June depicting the percentage departures from normal of the cumulative rainfall for the successive weeks is given in Fig. 2. The salient features of the rainfall distribution as seen from Figs. 1 and 2 are described below.

*June*—The southwest monsoon which established itself almost over the entire country outside northwest India by 9 June, was active to vigorous over most of the sub-divisions resulting in heavy to very heavy rainfall. During the week ending

on 9 June, the rainfall was in excess by 1363 per cent in Saurashtra & Kutch, 855 per cent in east Madhya Pradesh, 455 per cent in Bihar Plateau, 451 per cent in Gujarat Region, 392 per cent in west Madhya Pradesh, 289 per cent in Vidarbha, 271 per cent in east Rajasthan and 268 per cent in east Uttar Pradesh. Weak monsoon conditions prevailed over the country during the rest of the month except in Punjab, Himachal Pradesh and Rajasthan where it revived during the week ending on 30 June.

At the end of the month the cumulative rainfall was deficient over Assam, Marathwada, coastal Andhra Pradesh and Tamil Nadu, normal over West Bengal, Bihar Plains, Madhya Maharashtra, Vidarbha, Telangana, Rayalaseema and Mysore State and in excess over the rest of the country. The marked excesses were 102 per cent in the

SOUTHWEST MONSOON 1971

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

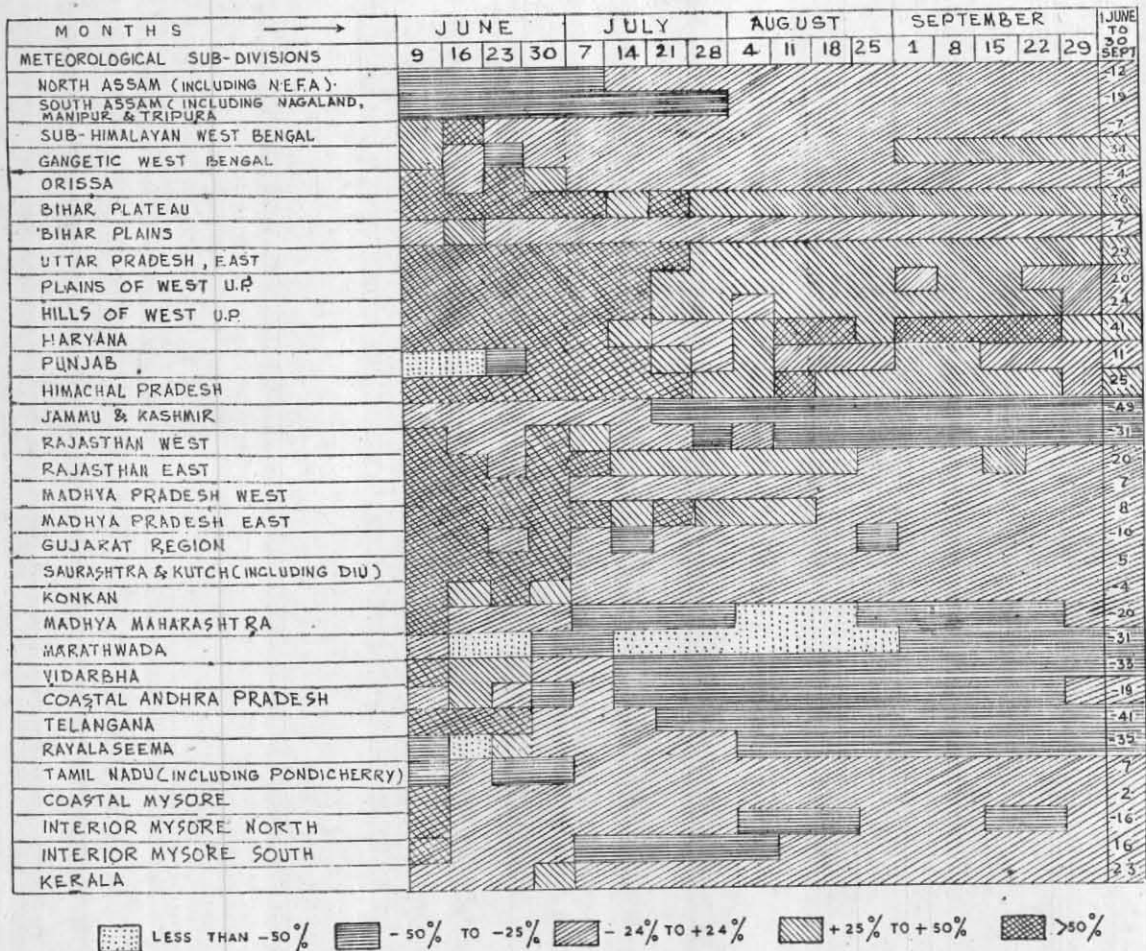


Fig. 2

Departures from normal of the cumulative rainfall

plains of west Uttar Pradesh, 135 per cent in the hills of west Uttar Pradesh, 274 per cent in Himachal Pradesh and 130 per cent in east Rajasthan.

*July* — The monsoon was more or less active throughout the month only in Gangetic West Bengal and Bihar Plateau. It was active to vigorous over east Uttar Pradesh and Tamil Nadu during the first fortnight of the month and over Kerala during the second fortnight. During the week ending on 7 July, the monsoon was active to vigorous over west Uttar Pradesh, Haryana, Punjab and Himachal Pradesh, and during the week ending on 21st over Madhya Pradesh, Gujarat State and Konkan. But for this, the monsoon was weak over the country during the month.

The cumulative rainfall during the season upto the week ending on 28 July was normal over the country except in Bihar Plateau, Uttar Pradesh, Himachal Pradesh, east Rajasthan and east Madhya Pradesh where it was above normal and in south Assam, Jammu & Kashmir, Maharashtra State (excluding Konkan), coastal Andhra Pradesh, Telangana and south Interior Mysore where it was below normal.

*August* — During August, the monsoon rainfall was fairly well distributed over northeast India, Uttar Pradesh, Haryana and Himachal Pradesh. It, however, continued to be weak over the rest of the country outside the Peninsula where the monsoon revived during the week ending on 25



TABLE 1

Percentage departures of rainfall for the period 1 June to 30 September for the years 1961—1971

Sub-division	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
North Assam (including NEFA)	-14	-20	-1	+6	-21	-15	-13	-8	-4	+3	-12
South Assam (including Nagaland, Manipur and Tripura)					-7	-13	-20	+2	-3	-7	-19
Sub-Himalayan West Bengal	-29	-14	-6	+18	+11	-4	-10	-5	-7	+2	-7
Gangetic West Bengal	-3	-17	-8	-13	-9	-29	+5	+16	-2	+13	+34
Orissa	+32	-14	+2	-1	-35	-30	0	-16	-5	-5	-4
Bihar Plateau	+9	-13	-7	-7	-31	-39	+5	-1	-6	-5	+36
Bihar Plains	-19	-32	-4	-1	-17	-49	-14	-9	+11	-8	+7
Uttar Pradesh East	-1	+6	+3	-3	-41	-41	+2	-18	+8	+12	+29
Uttar Pradesh West	+27	-3	+29	+15	-32	+4	+33	-20	+4	-2	+20
Haryana (including Chandigarh and Delhi)								+8	+15	+5	+41
Punjab (including Delhi)	+6	+30	+4	+50	-46	+6	+21	-6	-4	+15	+11
Himachal Pradesh				-15	-61	-7	+18	-26	+7	+1	+25
Jammu & Kashmir	-16	-10	-45	+4	-64	+4	-14	-8	-24	+20	-49
Rajasthan West	+45	-13	-40	+30	-42	-22	0	-56	-58	+18	-31
Rajasthan East	+25	-6	+3	+1	-39	-38	+10	-26	-5	+17	+29
Madhya Pradesh West	+30	0	-1	-6	-46	-30	-12	-8	+5	+13	+7
Madhya Pradesh East	+27	-23	-19	+7	-37	-30	+1	-26	-8	+9	+8
Gujarat Region (including Daman, Dadra and Nagar Haveli).	+27	-28	+8	+8	-45	-32	+6	-28	-25	+40	-10
Saurashtra & Kutch (including Diu)	+118	+13	-19	+13	-33	-43	+22	-30	-35	+51	+5
Konkan (including Goa)	+15	+4	+18	0	-20	-31	-3	-24	+11	+21	-4
Madhya Maharashtra	+9	-3	+7	+22	-8	-14	+2	-14	+32	+3	-20
Marathwada	+26	+4	+46	-7	-5	-6	-9	-12	+11	+37	-31
Vidarbha	+20	+5	-17	+2	-32	-10	-16	-17	-8	+20	-33
Coastal Andhra Pradesh	+25	+26	-7	+37	-10	-3	+3	-40	-32	+11	-19
Telangana	-3	+26	+12	+10	-7	-3	+9	-28	+9	+27	-41
Rayalaseema	-3	-14	+10	+71	-4	+20	-1	-24	-4	+38	-35
Tamil Nadu (including Pondichery)	+30	+25	+7	+30	-1	+45	+13	-17	-32	+6	+7
Coastal Mysore	+62	+3	-7	-3	-19	-23	+3	0	-2	+35	+2
Interior Mysore North	+9	+9	-4	+52	+9	-1	+12	-11	+18	+26	-16
Interior Mysore South	0	-13	-1	+45	-18	+10	-12	+10	-17	-21	+16
Kerala	+68	+4	+2	+5	-24	-10	+15	+39	-10	-3	+23

August. The marked excesses during the month were 221 per cent in Haryana during the week ending on 4th, 145 per cent in Haryana and 139 per cent in Himachal Pradesh during the week ending on 11th, 158 per cent in Tamil Nadu and 142 per cent in coastal Mysore during the week ending on 18th and 190 per cent in Madhya Maharashtra, 100 per cent in north Interior Mysore and 315 per cent in south Interior Mysore during the week ending on 25 August.

The cumulative rainfall at the end of August continued to be normal over the country except in Uttar Pradesh, Haryana and Himachal Pradesh where it was above normal and in Jammu & Kashmir, west Rajasthan, Gujarat Region, Maharashtra State (excluding Konkan), coastal Andhra Pradesh and Telangana where it remained below normal.

*September* — The monsoon activity revived over many parts of the country except Assam, Sub-Himalayan West Bengal and southern parts of the Peninsula during the week ending on 1 September when heavy to very heavy rainfall was experienced over most of the sub-divisions resulting in devastating floods particularly over the Ganga Basin. The monsoon continued to be active to vigorous over Bihar State, Uttar Pradesh, Haryana, east Rajasthan and west Madhya Pradesh during the week ending on 8th. Thereafter, the withdrawal of the monsoon from northwest India, Uttar Pradesh, Madhya Pradesh and Gujarat State commenced. It continued to be weak over the rest of the country also till the week ending on 22nd. Its activity over Peninsular India, however, increased during the last week of September. The marked excesses of rainfall during September were 232 per cent in Gangetic West Bengal, 121 per cent in Bihar Plateau, 239 per cent in Haryana, 314 per cent in Punjab, 108 per cent in Jammu & Kashmir, 121 per cent in east Madhya Pradesh, 189 per cent in Gujarat Region, 533 per cent in Saurashtra & Kutch, 157 per cent in Konkan, 168 per cent in Marathwada and 173 per cent in Vidarbha during the week ending on 1 September, 147 per cent in the plains of west Uttar Pradesh, 170 per cent in Haryana and 127 per cent in east Rajasthan during the week ending on 8th, 188 per cent in south Interior Mysore during the week ending on 22nd and 119 per cent in Gujarat Region, 139 per cent in Konkan, 172 per cent in Madhya Maharashtra, 215 per cent in Marathwada, 121 per cent in north Interior Mysore and 259 per cent in Kerala during the week ending on 29th.

The sub-divisionwise percentage departures of rainfall for the season as a whole (1 June to 30

September) are given in the last column of Figs. 1 and 2. As can be seen that the monsoon rainfall was normal ( $\pm 24$  per cent) over most of the sub-divisions of the country. It was in excess by 34 per cent in Gangetic West Bengal, 36 per cent in Bihar Plateau, 29 per cent in east Uttar Pradesh, 41 per cent in Haryana and 25 per cent in Himachal Pradesh. The rainfall was, however, deficit by 49 per cent in Jammu & Kashmir, 31 per cent in west Rajasthan, 31 per cent in Marathwada, 33 per cent in Vidarbha, 41 per cent in Telangana and 35 per cent in Rayalseema.

Table 1 gives the percentage departures of the monsoon rainfall over the various sub-divisions of India for the years 1961 to 1971. The years 1965 and 1966 stood out as drought years for many parts of the country. 1971 stands out as an year of droughts in Andhra Pradesh, Vidarbha, Marathwada, west Rajasthan and Jammu & Kashmir but of excessive rainfall in Gangetic West Bengal, Bihar Plateau, Uttar Pradesh and Haryana.

### 3. Major flood producing rainfalls during southwest monsoon season

Most of the States in the country were generally free from floods during 1971 except Uttar Pradesh, Bihar and West Bengal where disastrous floods were caused in several rivers due to heavy and widespread rain in association with low pressure systems/depressions which moved inland in quick succession. The States of Haryana, Madhya Pradesh and Rajasthan also experienced some heavy spells of rain resulting in serious inundation of low lying areas.

The major spells of heavy rainfall and floods that affected various parts of the country during the southwest monsoon season are listed below —

- (i) Floods in river *Alaknanda* during the second week of June.
- (ii) Floods in *Brahmaputra* and its tributaries during the second week of June.
- (iii) Floods in Kerala during the last week of June.
- (iv) Heavy rainfall and floods in Rajasthan and Madhya Pradesh from 21 to 24 July.
- (v) Heavy rainfall and floods in Gangetic West Bengal and Bihar State during the last week of July.
- (vi) Heavy rainfall and floods over the Ganga Basin during the first fortnight of August.

(vii) Heavy rainfall and floods over the eastern Ganga Basin during the second fortnight of August.

(viii) High floods in river *Gomti* during the first fortnight of September.

An account of these heavy rainfall and flood situations is given below.

### 3.1. Floods in river *Alaknanda* during second week of June

A depression formed in the Bay of Bengal on the morning of 3 June which intensified into a cyclonic storm on the 4th and crossed the coast near Sagar Island on the morning of 5th. Moving westnorthwest it weakened into a low pressure area over northwest Bihar on the morning of 9th. Moving further northwards it broke up over Nepal-Himalayas on the 10th. Also two western disturbances moved across the Western Himalayas between 7 and 12 June, causing fairly widespread rain with isolated heavy falls over the Western Himalayas. The district of Chamoli was the worst affected when heavy to very heavy rainfall occurred on 10 and 11 June 1971, resulting in floods in *Alaknanda* river.

According to press reports and the *Flood Newsletters* issued by the Central Water and Power Commission, there were a number of landslides in the region. The Rishikesh-Joshimath road was badly damaged between Sonli and Joshimath. Nearly five thousand pilgrims were stranded between Nand Prayag and Badrinath. Loss of human lives and of hundreds of cattle was reported.

The chief amounts of rainfall recorded during the period were :

Dehra Dun 13 cm and Roorkee 7 cm on 8th; Dehra Dun 8 cm on 9th and 7 cm on 11th; Dharchula 9 cm, Askote 7 cm and Joshimath 8 cm on 12th.

### 3.2. Floods in *Brahmaputra* and its tributaries during the second week of June

Associated with the movement of the low pressure mentioned in 3.1, the monsoon trough over central and northeast India moved to the foot of Himalayas and remained there till the 12 June causing fairly widespread rain with isolated heavy falls in Assam and Sub-Himalayan West Bengal from 10 to 13 June. According to press reports the flooded *Brahmaputra* inundated low lying areas in Dibrugarh and North Lakhimpur sub-divisions. The *Kosi*, the *Teesta* and the *Bagmati* rivers also rose in floods. On 14th, the *Brahmaputra* was flowing above the danger mark along a 144 km

stretch from Dibrugarh in North Lakhimpur to Neamati in Sibsagar district in upper Assam.

The chief amounts of rainfall recorded during the period were :

Pasighat 8 cm on 10th; Baghdogra 11 cm on 11th; Agartala 9 cm, Pasighat 8 cm and Baghdogra 7 cm on 12th; Tongla 7 cm on 13th.

### 3.3. Floods in Kerala during the last week of June

Under the influence of a trough of low pressure off the West Coast of India, the monsoon was active to vigorous over Kerala during the last week when concentrated spells of heavy to very heavy rainfall occurred over many parts in the State causing floods in many of the rivers of the State. Landslides were reported to have occurred in the districts of Kozhikode, Cannanore and Trivandrum. Sea erosion was also reported to have occurred in the districts of Alleppey, Quilon and Trivandrum. Seven human lives were lost and about one thousand houses were damaged. Severe damage to the crops was also reported besides the disruption of communications in many of the districts in the State.

The chief amounts of rainfall recorded during the period were :

Palghat 9 cm, Agumbe and Mercara 15 cm each on 24th; Kottayam 13 cm, Agumbe 21 cm, Kozhikode and Mercara 11 cm each on 25th; Trivandrum 13 cm on 27th; Agumbe 14 cm, Trivandrum City 13 cm, Trivandrum 12 cm, Alleppey 10 cm on 28th and Palghat 9 cm on 29th.

### 3.4. Heavy rainfall and floods in east Rajasthan and west Madhya Pradesh during 22-24 July

A depression formed in the northwest Bay of Bengal on the morning of 14th about 250 km south of Calcutta, moved northwest, crossed the coast near Contai and was centred near Gaya on the morning of 17th. Thereafter, moving slowly westnorthwest it was centred near Banda in east Uttar Pradesh on the morning of 21st. It then weakened into a low pressure area over south Uttar Pradesh and adjoining north Madhya Pradesh by the evening of 22nd. It persisted there till 24th and subsequently moved northward to the central parts of Uttar Pradesh and merged with the monsoon trough on the evening of 25th.

Under its influence, the monsoon was active in west Madhya Pradesh and adjoining east Rajasthan, from 22nd to 24th when heavy and widespread rain occurred there. According to the reports, the rivers *Parwati*, *Parwan* and *Kalisindh* with their tributaries were in spate. The Shaha-



bad and Khatoli towns in Kota district and Haldoi village in Jhalawar district were marooned by flood waters resulting in collapse of *kutch* houses. The communications on the Jhansi-Gwalior road were badly affected. A number of irrigation tanks in Bundi, Jhalawar and Sawai Madhopur districts of Rajasthan were overflowing as a result of the heavy rains.

The principal amounts of rainfall recorded during the period were :

Bhopal 8 cm, Pachmarhi 7 cm, Ujjain 7 cm, Guna 8 cm and Shiv Puri 16 cm on 22nd; Guna 10 cm, Kota 19 cm, Jhalawar 13 cm and Sawai Madhopur 8 cm on 23rd; Guna 7 cm, Shiv Puri 10cm and Ratlam 7 cm on 24th.

### 3.5. Heavy rainfall and floods in Gangetic West Bengal and Bihar State during the last week of July

A depression formed over the northwest Bay of Bengal and adjoining land areas with its centre about 150 km southeast of Calcutta on the morning of 26 July. It moved westnorthwest and lay over northeast Madhya Pradesh and adjoining Uttar Pradesh and Bihar with centre about 130 km west of Daltonganj on the morning of 28th. Moving further westnorthwestwards it weakened and lay over east Rajasthan on 30th and subsequently merged with the seasonal low by 31 July.

Under its influence the monsoon was active in Gangetic West Bengal and Bihar State from 26th to 28th during which widespread rain with scattered heavy falls occurred over there resulting in floods. According to the press and the *Flood Newsletter*, the rivers *Kosi*, *Dubrachiti*, *Dwarka*, *Bhagirathi*, *Jalangi*, *Rupnarain*, *Ajoy*, *Bhairab*, *Damodar* and *Ganga* in Gangetic West Bengal were in floods in the third week of July. A number of villages in the districts of Hooghly, Murshidabad, Birbhum and Bankura were affected. Several breaches were reported in different river embankments. The rivers *Ganga*, *Sone* and *Pun Pun* in Bihar which were in medium floods during the third week continued to be so during the last week of July. Due to a serious breach in the embankment near Kharagala, the waters of *Ganga* entered the country-side affecting over 700 villages and disrupting rail and road communications.

The chief amounts of rainfall recorded during the period were :

Kalimpong 22 cm and Darjeeling 11 cm on 22nd; Calcutta 10 cm on 23rd; Asansol 6 cm, Jamshedpur 23 cm, Patna 7 cm on 26th and Calcutta 8 cm on 27th.

### 3.6. Heavy rainfall and floods over the Ganga Basin during the first fortnight of August

Three low pressure systems moving westnorthwestwards through the basin during the first fortnight of August in quick succession resulted in severe floods almost in the entire basin.

The first low pressure system developed over the Gangetic West Bengal on 3 August. It moved westnorthwestwards and lay over southwest Bihar and adjoining east Uttar Pradesh on the 4th. It then moved northwards to Bihar Plains and adjoining east Uttar Pradesh on the 5th and broke up over the Nepal-Himalayas the next day.

Simultaneously another low pressure area developed over Bangla Desh and adjoining Gangetic West Bengal on the 6th. It extended into the north Bay of Bengal on the morning of 7th. A depression formed over the northwest Bay of Bengal with its centre about 150 km south of Calcutta on the evening of 7th. It deepened on the morning of 8th and moving northwestwards, it crossed West Bengal coast near Contai the same evening. Continuing to move northwestwards, it weakened into a low pressure area over Bihar and adjoining east Uttar Pradesh on 10th and merged with the monsoon trough on the 11th.

Yet another low pressure area developed and lay over southwest Uttar Pradesh and the adjoining parts of Rajasthan and Haryana upto 15th. Later, it moved slowly northwards and broke up over the hills of west Uttar Pradesh on 17th. With its northward movement, the monsoon trough also moved north and lay close to the foot of the Western Himalayas on 17th and 18th.

In association with these systems monsoon was active to vigorous over the Gangetic West Bengal, Bihar Plains, east Madhya Pradesh and Uttar Pradesh during the period 1st to 15th causing widespread rain with scattered heavy falls in many parts of northeast India and east Uttar Pradesh leading to floods in north Bengal, Bihar and Uttar Pradesh. Heavy rains in the Western Himalayas also caused breaches and landslides in Badrinath-Kedarnath sectors.

According to the press reports and the *Flood Newsletters* the rivers *Ganga*, *Yamuna*, *Sarda*, *Ghaghra* and *Rapti* in Uttar Pradesh rose in floods in the first week of August. The river *Ganga* recorded levels of 85.05 and 72.37m as against the warning stages of 84.73 and 71.26 m at Allahabad and Varanasi respectively on 3 August. The river was again above the warning stage during

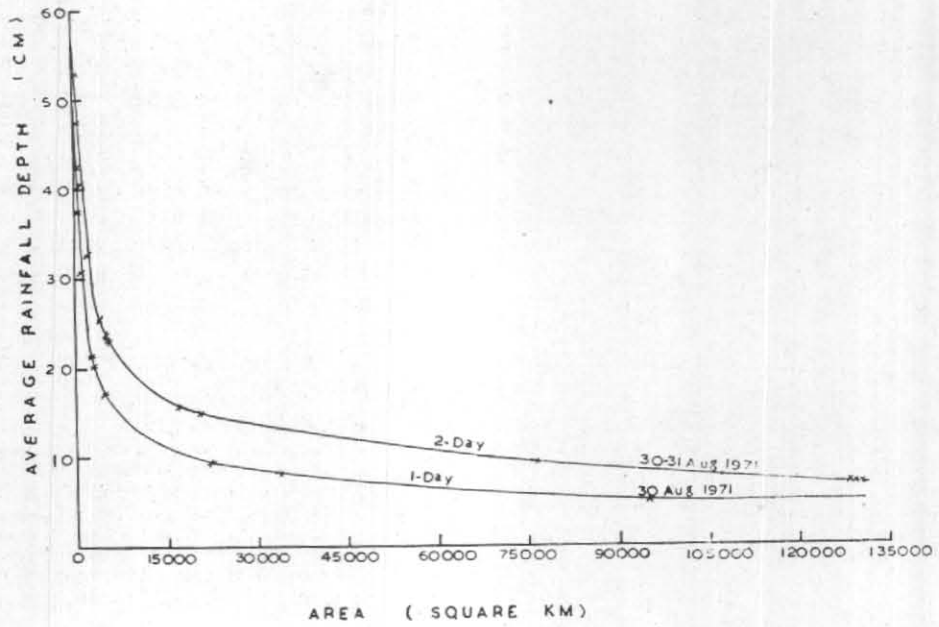


Fig. 3

Depth-Area-Duration curves for the rainstorm (30-31 Aug 1971) over Bihar

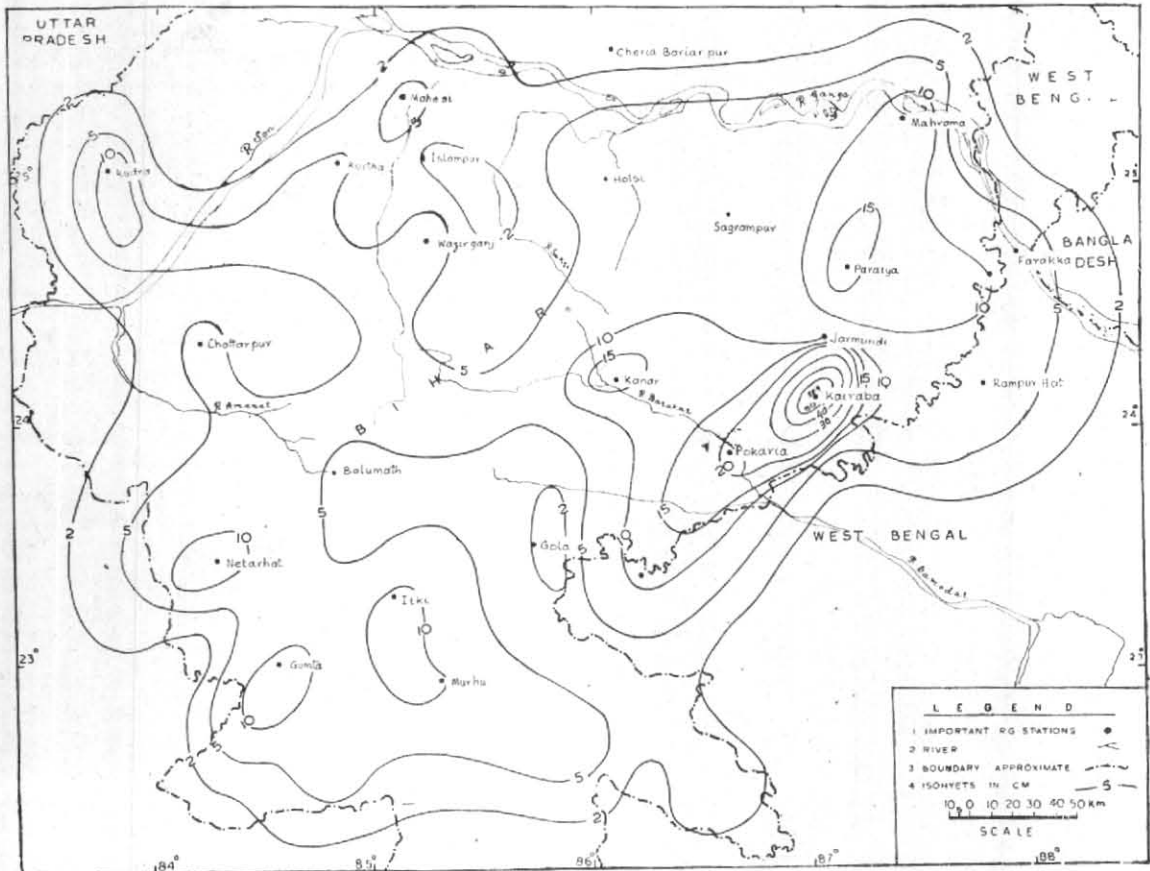


Fig. 4

Isohyetal pattern of 2-day rainstorm (30-31 Aug 1971) over Bihar



the later half of the second week. The rivers *Sone*, *Pun Pun* and *Ganga* in Bihar and *Dwarka*, *Bhagirathi*, *Jalangi*, *Kosi*, *Kapileshwari* and *Damodar* in south Bengal were also in floods. Malda town was completely cut off from the rest of the State by the flood waters. In West Bengal alone nine districts were affected by floods. Over 40 lakhs of people were affected and about 1.5 lakh houses were damaged by the floods. 26 human lives and several hundred cattle heads were lost.

The chief amounts of rainfall recorded during the period were :

Faizabad 21 cm, Jaunpur 17 cm and Kanpur 12 cm on 1st; Bulandshahr 14 cm on 2nd; Roorkee 11 cm on 6th; Roorkee and Sandheads 16 cm each, Dehra Dun 11 cm on 7th; Chandbali 22 cm, Baripada 16 cm, Balasore 13 cm, Sambalpur 12 cm, Balia 10 cm on 8th; Allahabad 12 cm on 9th; Dehri 16 cm, Varanasi 14 cm, Allahabad 12 cm on 10th.

3.7. *Heavy rainfall and floods over eastern Ganga Basin during the second fortnight of August*

During the third week of August a cyclonic circulation extending to the middle troposphere developed over Gangetic West Bengal and adjoining Bangla Desh on the 19th. It moved westwards across Bihar, east Uttar Pradesh and adjoining north Madhya Pradesh by 21st. A low pressure area also developed on that day over the same area. This system moved further westwards to northwest Madhya Pradesh and adjoining south Uttar Pradesh by 23rd and became unimportant on the next day. In association with this system, widespread rain occurred in northeast India and east Uttar Pradesh from 19th to 21st. The flood situation in West Bengal was reported to have worsened, while in Bihar it continued to be grave.

Another well-marked low pressure area developed over the central parts of Madhya Pradesh on the 28th, which concentrated into a depression on the morning of 30th, with its centre between Umaria and Pendra.

In association with this, monsoon was active to vigorous in Gangetic West Bengal, Bihar Plateau and Orissa causing widespread heavy rainfall. This further worsened the flood situation in south Bengal. Midnapore district was the worst affected area in West Bengal. The flood situations in Bihar continued to be grave. Barauni was virtually a floating township and its Thermal Power Station had to be closed down on 21 August as water from the swollen *Ganga* entered the power generation chamber.

According to the *Flood Newsletter* and the press reports, 80 per cent of Malda town was under water on 27 August. Rail and road communications in the district were completely paralysed. In West Bengal alone 10 districts were affected by the floods. An area of 12.2 lakh hectares including a cropped area of 6.6 lakh hectares was affected. About 61 human lives and 1061 cattle heads were lost; 61 lakhs of people were reported to have been affected by the floods.

The chief amounts of rainfall recorded during the period were :

Dhubri 12 cm, Cooch Behar 11 cm, Jalpaiguri 10 cm on 16th; Burdwan 9 cm on 17th; Monghyr and Balurghat 11 cm each, Muzaffarpur, Nautanwa and Askote 9 cm each on 19th; Calcutta (Dum Dum) 9 cm, Burdwan 10 cm on 20th; Baghdogra 12 cm, Cooch Behar 11 cm on 25th; Calcutta (Dum Dum) 8 cm on 26th; Balasore 9 cm on 28th; Naya Dumka 12 cm on 29th; Dhanbad and Monghyr 11 cm each and Sabour 10 cm on 31 August.

A detailed study of this heavy rainspell over Bihar State and its neighbourhood has been carried out by Depth-Area-Duration analysis. The daily rainfall data from the observatory stations of the India Meteorological Department and State raingauge stations located in this area were examined and it was found that a heavy rainstorm of 2-day duration occurred on 30-31 August 1971 over Bihar. The rainstorm was subjected to isohyetal analysis for obtaining the average maximum rainfall depths for 1-day and 2-day durations occurring on 30th and 30-31 August 1971 respectively. The Depth-Area-Duration curves of rainfall for 1-day and 2-day are shown in Fig. 3 and the isohyetal pattern of the 2-day rainstorm (30-31 August 1971) is given in Fig. 4. The corresponding depth values for standard areas are given as under —

Depth-Area-Duration Statistics

Area (Sq. km)	Average maximum depth of precipitation (cm)	
	1-day	2-day
2,000	24.8	34.0
5,000	17.0	23.8
10,000	13.0	18.8
20,000	9.8	15.0
50,000	7.0	11.5
75,000	5.8	9.5
100,000	5.0	8.1

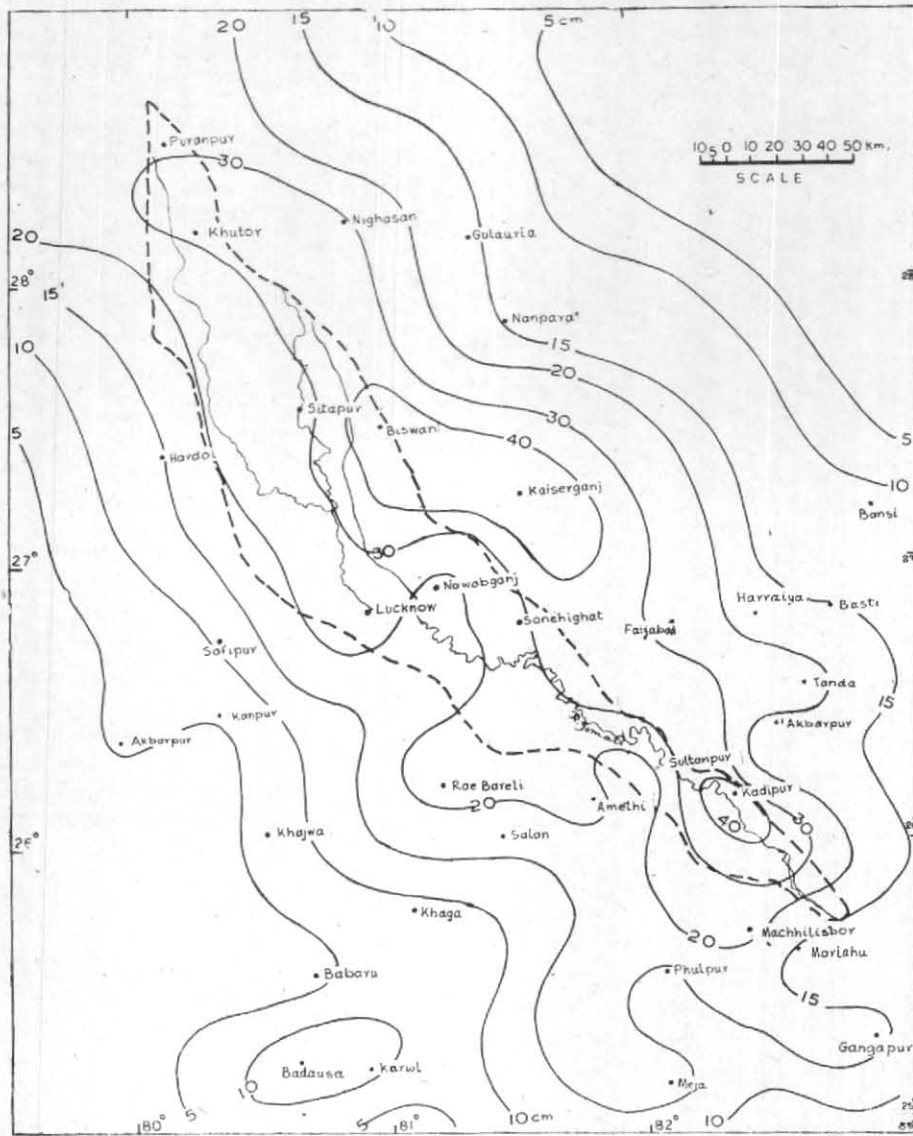


Fig. 5

Isohyetal pattern of 3-day rainstorm (1-3 Sep 1971) over Gomti Catchment

3.8. High floods in river Gomti during the first fortnight of September

The depression over Madhya Pradesh described in Sec. 3.7 moved slowly in a northwesterly direction and lay centred about 100 km west of Kanpur on the morning of 1 September. It then moved northwards and lay close to Mainpuri on the morning of 2nd. It then weakened and merged with the monsoon trough the next day.

Another low pressure area, with circulation extending upto the middle troposphere developed over north Orissa and adjoining north-west Bay on the 3rd. It moved westwards initially and later northwards to the central parts of Bihar by 7th morning. Yet another low pressure system developed over south Uttar Pradesh and adjoining north Madhya Pradesh on the evening of 6th and persisted there on the 7th. These two lows combined into an extended low over southwest Uttar Pradesh on the evening of 7th and moved to central Uttar Pradesh on the morning of 8th where it persisted till 9th. Subsequently, it moved northwards and broke up over the Himalayas on the 10th.

Under the influence of these systems active to vigorous monsoon conditions prevailed in Uttar Pradesh almost during the entire first fortnight of September and heavy to very heavy rainfall occurred over large areas of central and eastern Uttar Pradesh resulting in floods in all the rivers.

As per the *Flood Newsletter* and the press reports, the water level of the river Gomti at Lucknow recorded a steady rise at a rate of 3 cm per hour from 2 to 4 September 1971. It further rose and touched a steady level of 110.31 m on 7 September which was 1.5 m above danger level. The city of Lucknow was adversely affected by floods this year. The flooded Gomti submerged large areas of Lucknow City including the Hazarat Ganj area—the most fashionable shopping centre. With this continuous rise in the water levels of the Ganga, Gomti, and several other rivers of Uttar Pradesh, the districts of Jaunpur, Barabanki, Sultanpur, Lakhimpur Kheri, Deoria and Pratapgarh were badly affected. Rail and road communications were severely dislocated in the State. An area of about 52.6 lakh hectares including a cropped area of about 26.5 lakh hectares was affected. A population of over 200 lakhs was affected and about 7.3 lakhs houses damaged.

About 600 human lives and over 3,000 cattle heads were lost.

The chief amounts of rainfall recorded during the period were :

Bareilly, Lucknow City & Varanasi (Airport) 10 cm each on 1st; Lucknow (Airport) 12 cm, Sahajahanpur 24 cm, Bareilly 23 cm, Sitapur 22 cm, Kheri and Nainital 17 cm each, Bahraich 14 cm, Mukteshwar 13 cm on 2nd; Najibabad and Roorkee 10 cm each Nainital 17 cm, Kheri 15 cm, Pilibhit 14 cm on 3rd; Grakhpur 14 cm on 4th; Faizabad 10 cm on 8th; Pilibhit 26 cm on 10th.

A detailed study of the rainstorm which occurred over Gomti Catchment area and caused severe floods in the river was also carried out by isohyetal method. The rainstorm was of 3-day duration and its isohyetal pattern for the period 1-3 September 1971 is shown in Fig. 5. The maximum 1-day, 2-day and 3-day average depth of precipitation yielded by the rainstorm in the catchment area are as under:

Duration	Period	Maximum average depth of precipitation (cm)
1-day	2 September 1971	11.2
2-day	2-3 September 1971	21.3
3-day	1-3 September 1971	27.8

The sustained floods during September 1971 in river Gomti lasting for over a week were due to persistent rainfall causing the areal distribution of the rainstorm almost along the entire catchment area as can be seen in Fig. 5.

4. Summary

(i) The southwest monsoon set in over the country about a week to ten days earlier than the normal date of its onset. It withdrew from Rajasthan and Uttar Pradesh by the middle of September, about a week to ten days earlier and persisted in Bihar and West Bengal till the normal date.

(ii) A series of monsoon depressions or low pressure areas (7 depressions and 8 lows in number) formed in quick succession over the head Bay of Bengal or neighbourhood and most of them moved over the Ganga Basin causing heavy to very heavy rains along their tracks. This continuous movement of monsoon depressions throughout the monsoon period over the Gangetic Plains was responsible for the sustained heavy floods in the Ganga Basin.



(iii) Weekly rainfall pattern over the country during the southwest monsoon period was characterised by rather below normal rainfall in many parts of the country in June and July, above normal in August and again less than normal in September.

(iv) The accumulated monsoon rainfall was normal over most parts of the country. It was in excess over Gangetic West Bengal, Bihar Plateau,

east Uttar Pradesh, Haryana and Himachal Pradesh whereas the States of Jammu & Kashmir, west Rajasthan, Marathwada, Vidarbha, Telangana and Rayalaseema recorded deficient rainfall.

(v) As only one low pressure area passed over north Peninsula and that too late in September, there were drought conditions over Andhra Pradesh, Marathwada, Madhya Maharashtra and Vidarbha during the monsoon season.

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