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Rainfall and Floods during 1967 Southwest Monsoon period*

1. Introduction

Having experienced droughts during two consecutive years 1965 and 1966 due to weak monsoon activity, the country received good amount of rainfall during this monsoon season. The times of onset and withdrawal of the monsoon, were almost normal every where in the country. The country generally was free from any serious and disastrous floods which generally accompany with good monsoon activity.

2. Onset and withdrawal of the monsoon

A temporary advance of the southwest monsoon took place into Kerala and the Arabian Sea Islands by about 13 May in association with the movement of a low pressure area across the Comorin-Maldive areas. Kerala, Mysore and Madras States and Rayalaseema got a good spell of rain upto the 18th. The rainfall activity over Kerala continued to be good until 26th when the monsoon weakened considerably over the Kerala coast.

In association with a depression that formed on 15 May, centred about 150 km westsouthwest of Port Blair, the Bay branch of the monsoon advanced into the extreme southwest and southeast Bay and Andaman Sea Islands. Moving in a northerly direction the above depression intensified into a severe cyclonic storm by 17th when it was centred 350 km northnorthwest of Port Blair. After this the monsoon activity over the Bay remained weak for about 10 days and revived later. The Bay Islands received a good spell of rain during the last 3 days of May.

The monsoon activity over Kerala revived by 7 June. Under the influence of a trough of low pressure which developed over central parts of the Arabian Sea, the monsoon activity extended northwards up to Konkan as a feeble current and also covered Interior Mysore, Madhya Maharashtra and most parts of Andhra Pradesh by 14 June. The Bay branch of the monsoon current on the other hand advanced into Assam and West Bengal by about 10th.

The monsoon advanced into Gujarat State, the central parts of the country and also as feeble current into Bihar by 18 June. It further advanced into Uttar Pradesh, Himachal Pradesh and East Rajasthan by about 27 June and established over the entire country by 2 July.

The monsoon started to retreat in the third week of September and withdrew from northwest India, west Uttar Pradesh and northwest Madhya Pradesh by 24 September. It further withdrew from Gujarat State, southwest and northeast Madhya Pradesh, Vidarbha, east Uttar Pradesh and Bihar State by 1 October, from West Bengal by 7 October and from Orissa, southwest Madhya Pradesh and the remaining parts of Maharashtra by the 11th. The monsoon finally withdrew from the rest of the country outside south Peninsula by 15 October.

3. Weekly and Seasonal Rainfall

Fig. 1 shows the percentage departure of rainfall from normal, week by week, for the period 1 June to 4 October 1967 in each of the 30 meteorological sub-divisions of the country excluding Bay Islands and Arabian Sea Islands. Fig. 2 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 for the sub-divisions are shown in the last column. The salient features of the monsoon activity as revealed by these diagrams are given below.

June — In the first half of June rainfall was in deficit over the entire country outside north Assam, sub-Himalayan West Bengal and Madras State. At the end of the first week of June the rainfall was more than 50 per cent excess in Madras

*Prepared by the Meteorologist-in-charge, Hydrology Section of the Headquarters Office of the India Meteorological Department, New Delhi with the assistance of other officers and staff of the Section

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

Percentage departures from normal rainfall for week ending

MONTH →	JUNE				JULY				AUGUST					SEPTEMBER				OCT	1st JUNE TO 30th SEPT.
METEOROLOGICAL SUB DIVISIONS	7	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	4	
NORTH ASSAM INCLUDING NEFA	11	-35	-38	-47	-42	40	-11	-51	-29	-17	-47	-40	-55	-20	-18	-19	19	15	-13
SOUTH ASSAM INCLUDING NAGALAND, MANIPUR AND TRIPURA	-53	-5	-50	-63	-21	74	-7	-45	-66	+6	-56	-40	-51	-44	-20	-17	-8	44	-20
SUB-HIMALAYAN WEST BENGAL	19	-38	85	40	-61	103	66	-6	-91	-73	-51	-95	-15	-83	-10	45	-48	-58	-10
GANGETIC WEST BENGAL	-98	-48	-24	-68	-7	-20	-25	-72	-23	55	-13	47	1	56	22	109	-24	18	5
ORISSA	-100	-66	0	-29	-23	-51	-59	-27	91	-43	-24	33	-4	13	-23	-20	-27	-59	0
BIHAR PLATEAU	-96	-74	14	-71	-20	-66	20	-84	-1	-13	-27	-37	-27	-45	-39	-33	-64	-69	-5
BIHAR PLAINS	-64	-71	-47	-79	-46	-26	-27	-87	-71	-22	-58	-49	-68	-73	-47	-80	-31	-96	-14
U.P. EAST	-100	-73	-84	-32	-15	-29	51	-47	-58	114	-19	-23	65	-12	-62	-29	-81	-85	2
U.P. WEST	-100	-80	-63	-1	149	-11	-25	9	-24	74	57	59	161	140	-12	1	-96	-100	33
PUNJAB (INCLUDING DELHI)	-81	-99	-35	-67	159	-45	-80	-82	-56	144	128	-33	208	-40	-19	12	-100	-97	21
HIMACHAL PRADESH	-99	236	176	151	-40	31	127	-74	-46	62	-74	101	109	-76	148	-23	-100	-100	18
JAMMU AND KASHMIR	-74	-46	-32	-81	66	-39	-56	-51	-55	-79	-74	-91	0	-81	-23	7	0	-48	-14
RAJASTHAN, WEST	-100	-100	243	13	83	-84	-92	21	-28	-23	32	-1	58	-4	82	132	-100	-89	0
RAJASTHAN, EAST	-100	-81	84	91	98	-82	-94	6	-23	6	31	61	2	67	-25	-20	-100	-100	10
MADHYA PRADESH, WEST	-95	-85	-28	35	3	-92	-66	-31	11	-5	-12	-4	-11	146	-80	38	-96	-98	-12
MADHYA PRADESH, EAST	-99	-76	3	-25	79	-61	-44	-46	59	-38	-7	88	52	5	-45	70	-59	-73	1
GUJARAT REGION (INCLUDING DAMAN, DADRA & NAGAR HAVELI)	-100	-67	202	-6	-14	-89	-82	7	144	28	-44	-84	48	19	33	-79	-97	-99	6
SAURASHTRA & KUTCH (INCLUDING DIU)	-100	-51	373	6	156	-75	-67	157	204	-61	-92	-47	6	-95	-63	-84	-73	-97	22
KONKAN (INCLUDING GOA)	-99	-90	-28	89	-15	-59	16	76	71	-44	-82	-73	-14	-55	-85	-67	210	70	-3
MADHYA MAHARASTRA	-77	-79	48	-38	21	-88	-7	82	240	19	-80	-66	-19	-70	-91	-78	84	28	4
MARATHWADA	-100	-97	160	57	-69	-99	-21	54	223	31	-82	-61	11	-81	-100	-100	329	75	-9
VIDARBHA	-95	-57	-36	17	-63	-95	24	118	14	-23	-56	-31	-5	-67	-84	-60	26	-47	+16
COASTAL ANDHRA PRADESH	-85	16	59	-27	-27	-87	22	79	-27	-68	-10	-7	-27	-97	-63	3	-27	-42	3
TELANGANA	-100	13	-7	20	-49	-90	111	215	-29	-67	-73	-14	71	-87	-75	-60	125	17	9
RAYALASEEMA	-100	-66	75	-1	-69	-41	282	72	-100	-91	-89	-94	-18	-80	-95	-19	104	162	-1
MADRAS STATE (INCLUDING PONDICHERRY)	54	53	156	-45	-62	-29	145	5	-52	+13	67	-27	20	-12	-47	0	51	-3	13
COASTAL MYSORE	-94	-80	-6	-31	9	5	-29	96	18	59	-71	-31	8	-29	-100	-85	232	223	3
INTERIOR MYSORE NORTH	-96	-68	62	-12	21	-75	97	186	101	-2	-81	-59	-26	-84	-96	-49	77	205	12
INTERIOR MYSORE SOUTH	-97	-94	88	-11	4	-49	81	82	92	-8	-51	-86	-32	-78	-77	-77	-27	-19	-12
KERALA	-82	-50	-82	14	61	-3	-25	4	68	66	21	86	2	-54	-100	-69	63	14	15

LESS THAN -50% | -50% TO -25% | -24% TO +24% | +25% TO 450 % | >50%

Fig. 1. Southwest Monsoon 1967

State. Rainfall has been between 50 to 74 per cent deficit in south Assam, Bihar Plains and Jammu & Kashmir and more than 75 per cent deficit over most of the sub-divisions. Excess rainfall over majority of the sub-divisions during the 3rd and 4th weeks of June improved the overall rainfall position in the country (Fig. 1). The cumulative rainfall since 1 June till 28th was more than 50 per cent deficit over Gangetic West Bengal, Bihar and Punjab States and more than 50 per cent excess over Himachal Pradesh, Saurashtra & Kutch and Madras State.

July — Excess rainfall was recorded over west Uttar Pradesh, Punjab, Himachal Pradesh, Jammu and Kashmir, Rajasthan, Madhya Pradesh, Saurashtra & Kutch and Kerala in the first week of July, whereas the rainfall was either normal (±24 per cent) or deficit (—25 per cent to —50 per cent) over rest of the country (Fig. 1). At the end of the month the cumulative rainfall was 25 to 50 per cent in deficit over northeast India, Punjab, Jammu & Kashmir and Madhya Pradesh West. It was normal over the rest of the country except over Rayalaseema, Madras State and Interior Mysore where it was 25 to 50 per cent in excess.

August — During the month of August rainfall was well distributed over the country outside northeast India, Gujarat, Maharashtra State and Andhra Pradesh where monsoon activity was weak. Quite a few spells of heavy rain occurred over Uttar Pradesh, Punjab and Himachal Pradesh (Fig. 1). At the end of the month the cumulative rainfall was 25 to 50 per cent in deficit in Bihar Plains and Jammu & Kashmir, 25 to 50 per cent excess in west Uttar Pradesh, Punjab, Himachal Pradesh, Saurashtra & Kutch and Madras State. The departures of cumulative rainfall elsewhere were between ± 24 per cent.

September — During the three-week period ending on 20 September, the rainfall was fairly well distributed over the country outside Saurashtra & Kutch and entire Peninsula where rainfall was in deficit. Thereafter the withdrawal of the monsoon from northwest India started and during the remaining period of the month, monsoon became active over the Peninsula and rainfall was very much in excess over there.

Rainfall has been 25 to 50 per cent deficit from July to mid-September over Bihar Plains, July to mid-August over Gangetic West Bengal, from mid-June to July over Orissa, mid-June to mid-August over Bihar Plateau and from last week of July to mid-September over Jammu & Kashmir.

Percentage departures of rainfall from normal for the season as a whole are within ± 24 per cent indicating normal rainfall distribution in respect of all th sub-divisions of the country except Uttar Pradesh West, which recorded a departure of +33 per cent. Thus it may be said, in general, that the activity of the monsoon over the country has been normal this year.

4. Chief Floods and heavy rainfall situations

Most of the States in the country were generally free from disastrous floods during 1967 except Uttar Pradesh, Haryana and Rajasthan where heavy and widespread rain caused flooding in several rivers. The State of Gujarat, Maharashtra and Bihar also experienced some heavy spells of rain resulting in serious inundation of a few places. Important floods and heavy rainfall situations during the monsoon season are listed as follows.

(*i*) Rise in the level of rivers in northwest India, Bihar and Uttar Pradesh during 8–17 July in association with 'break monsoon conditions.'

(*ii*) Widespread rains in Gujarat and Maharashtra States during the last week of July.

(*iii*) Floods in Orissa and Madhya Pradesh during the first week of August.

(*iv*) Floods in northwest India and Uttar Pradesh from August to mid-September.

(*v*) Exceptionally heavy rain at Patna on 20 September.

A detailed account of chief floods and heavy rainfall situations is given here.

4.1. *Heavy rains in Gujarat and Maharashtra States in the last week of July*

On 25 July a low pressure area formed over north Gujarat State and adjoining West Pakistan and Rajasthan with upper air cyclonic circulation extending up to 6 km and persisted till 28th. Also a deep depression which crossed the north Orissa coast near Balasore on 27th morning moved in a westnorthwesterly direction and lay as a depression centred 100 km northeast of Ratlam on 29th. Later it weakened into a low pressure area and moved northwestwards over south Rajasthan and adjoining areas on 30th morning and eventually merged into the seasonal low on 31st.

Under the influence of these systems there was sustained monsoon activity over Gujarat and Maharashtra States during the above period. The Chief amounts of rainfall recorded from 25th to 30th are as under —

Kandla, Kutch and Mahabaleshwar 19 cm each and Bhuj 10 cm on 25th, Mahabaleshwar and Dwarka 10 and 15 cm respectively on 26th, Bhira 35, Mahabaleshwar 31 and Khandala 25 cm on 27th, Mahabaleshwar 28, Khandala 26 and Bhira 25 cm on 28th; Bhira 43, Khandala 40, Ahmedabad 32 and Bhuj 11 cm on 29th and Mahabaleshwar 22, Khandala 20 and Rajkot 12 cm on 30th.

Continuous heavy rains in this region caused floods in most of the rivers in this region. According to press reports Kutch district was the worst affected. More than 5000 houses collapsed and roads and bridges were badly damaged. The rainstorm of 28 to 30 July over Gujarat State has been analysed and the depth-area values are shown below for standard areas.

Area (sq. km)	Average depth over Saurashtra & Kutch (cm)	Average depth over Gujarat region (cm)
1000	49.2	27.4
5000	38.7	25.5
10,000	32.0	23.7
25,000	23.1	21.4
50,000	19.7	18.7
75,000	16.1	16.2

4.2. *Floods of Orissa and Madhya Pradesh in the beginning of August*

On 31 July a depression formed over the north Bay, intensified and crossed the Orissa coast as a deep depression and lay centred near Bhubaneshwar on 2 August. It weakened into a low pressure

Percentage departures from normal rainfall for the period 1st June to week ending

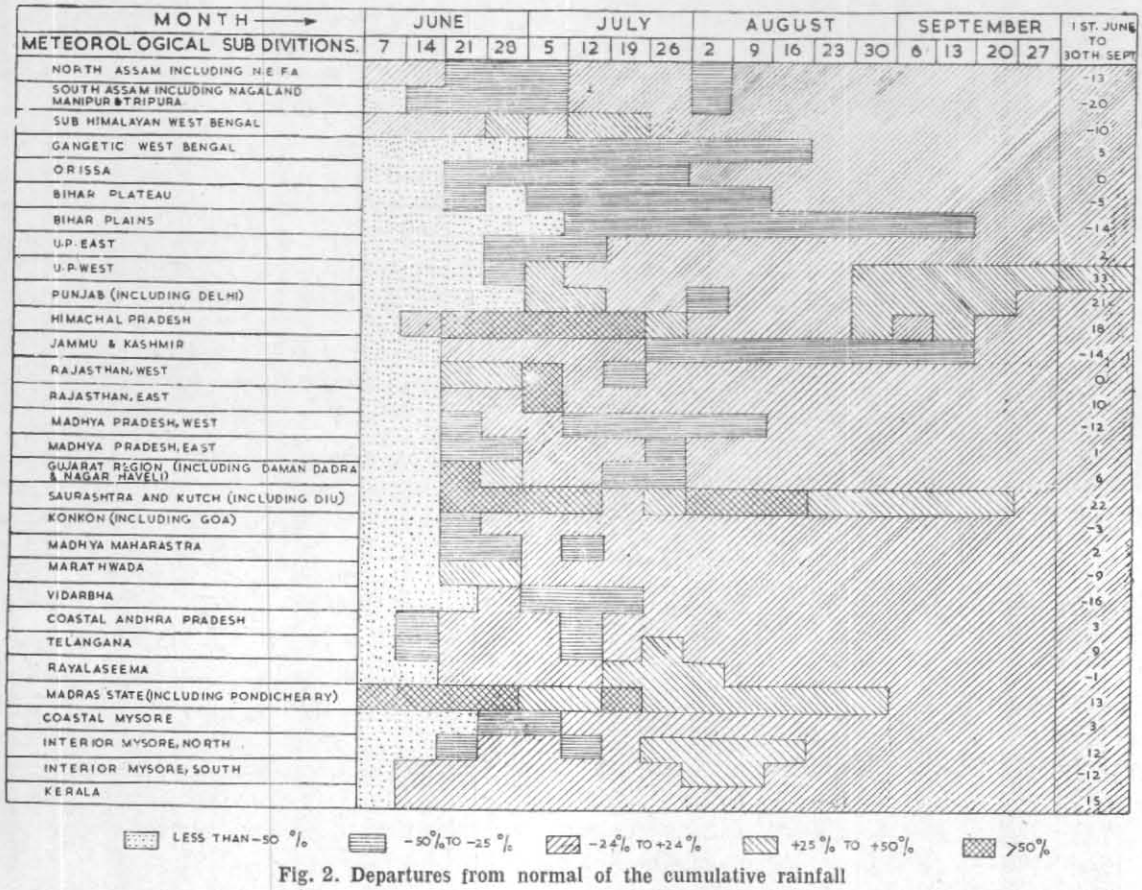

Fig. 2. Departures from normal of the cumulative rainfall

Note — Changes on account of re-organisation of States from 1 November 1966 not incorporated in the map

area as it moved into east Madhya Pradesh on 3rd and finally merged into the seasonal trough on the 4th.

In association with this, monsoon was active over Orissa and Madhya Pradesh. Following heavy rains during this period, the river *Mahanadi* rose in floods inundating several villages in Orissa and seriously affecting several others in Raipur district of Madhya Pradesh.

Rivers *Indravati* and *Wainganga* also rose in floods in Raipur district. It was reported that 20,000 acres of land including paddy fields were submerged.

4.3. *Heavy rains in the States of Uttar Pradesh, Haryana, Punjab and the adjoining areas during the second half of August*

4.3.1. *Widespread rains in the 3rd week of August* — In the beginning of the 3rd week there had been widespread rains over Uttar Pradesh West, Haryana, Punjab and Rajasthan East due to active monsoon conditions prevailing over these regions. The axis of the seasonal trough passed through Ferozepur, Hardoi and Tura.

On 16th a low pressure area formed over north Bay of Bengal, intensified further on 17th and concentrated into a depression within half a degree of Lat. 21°N, Long. 90°E on 18th. As a result, the monsoon activity was well maintained in northwest and central India and rain or thundershowers had been fairly widespread in the above regions.

Continuous rainfall activity over this region caused rise in the level of the rivers *Yamuna* and the *Ganga*. The rainstorm of this period (15-18 August 1967) has been analysed for depth-area values. Average depth of rain for standard areas over the *Yamuna* and *Ganga* catchments are given below —

Area (sq. km)	Average depth of rain (cm) over	
	Yamuna catchment	Ganga catchment
1000	34.0	22.0
5000	27.6	18.5
10,000	23.7	16.8
25,000	18.8	14.8
50,000	14.1	12.1
75,000	12.0	10.3

In Delhi, on account of intense rainfall, there had been water logging in rural and urban areas. River *Yamuna* rose in floods causing drainage congestion and inundation of several villages. More than 25 villages were affected due to floods and 71 villages were affected due to drainage congestion. Damage to more than 3000 houses was reported. A cropped area of 17,000 acres was inundated. Out of this, crops in an area of 4000 acres were completely destroyed.

4.3.2. *Widespread heavy rains in the last week of August* — A low pressure area formed over northwest Bay of Bengal and adjoining coastal areas on 22nd and moved into Bihar Plateau on 23rd. Moving in a westnorthwesterly direction the low merged into the monsoon trough on 24th. One upper air cyclonic circulation over Gangetic West Bengal and another over southwest Rajasthan persisted from 24th to 26th.

Under the influence of these systems monsoon was active in the States of Uttar Pradesh, Haryana, Punjab and Rajasthan. Chief amounts of rainfall are —

Bareilly 10 cm on 23rd; Amritsar 13, Mussoorie 12, Alwar 8 and Jhansi 7 cm on 25th; New Delhi 12 cm, Najibabad and Gurgaon 11 cm each and Ambala 10 cm on 26th.

The rainspell of 4 days, *viz.*, 23 to 26 August covering *Yamuna* and *Ganga* catchments has been analysed for depth-area values. The isohyetal pattern for this storm is shown in Fig. 3. Depth-area values for standard areas are as follows —

Area (sq. km)	Average depth (cm) over	
	Yamuna catchment	Ganga catchment
1000	25·8	28·0
5000	22·7	23·5
10,000	20·8	21·2
25,000	18·0	19·8
50,000	14·5	17·8
75,000	12·4	15·6

The *Ganga* was above the warning stage at Ghazipur on 26 August. The *Great Gandak*, a tributary of the *Ganga* river, was also in floods. Chitauni Bund on the *Great Gandak* was breached on 23rd.

The *Yamuna* at Delhi Railway Bridge crossed warning stage of 672.0 ft at 0100 IST on 26th. The level continued to rise steadily and reached a maximum of 676·50 ft on the night of 29 August. These floods had affected an area of 62,300 acres including a cropped area of 29,730 acres till 29th. It was reported that *Kharif* crops in an area of 22,298 acres had been destroyed completely. About 75 villages were affected due to drainage congestion and 33 villages were affected due to floods in the *Yamuna*. Damage was caused to more than 1500 houses.

In Rajasthan the river *Ghaggar* was in floods. It caused three breaches in the diversion channel affecting an area of 2,600 acres including cropped area of 206 acres and disrupted road and rail traffic. Floods were caused in Bharatpur district due to heavy rains and overflowing of irrigation tanks.

4.4. *Renewed floods in Uttar Pradesh, Haryana, the Punjab and Rajasthan during 1st and 2nd weeks of September*

A low pressure area over northeast and adjoining central Bay on 28th moved over northwest Bay and adjoining parts of west central Bay and Orissa on 29th. It continued to move further in a westnorthwesterly direction and lay over central parts of Madhya Pradesh and adjoining Uttar Pradesh on 1 September.

Another low pressure area formed over the head Bay on 2 September, intensified into a deep depression and crossed Orissa coast near Contai on 3rd. Moving in a westnorthwesterly direction it weakened and lay centred near Kota on the 6th and finally merged into the seasonal trough on 9 September.

In association with these systems active monsoon conditions prevailed in north and central parts of India up to 10 September. Chief amount of rainfall are —

Indore 14 cm on 31 August ; Shivpuri 13 cm on 2 September; Gwalior, Lucknow and Hardoi 7 cm each and Kota and Dholpur 5 cm each on 3rd; Jhansi 13 and Guna 10 cm on 4th; Rewa 15, Satna, Shivpuri and Sidhi 9 cm each on 5th; Neemuch 15, Bhilwara and Guna 11 cm each and Shivpuri 9 cm on 6th; Abu 19, Jodhpur 7 and Udaipur 6 cm on 7th.

River *Yamuna* at Agra rose to 500·00 ft against the warning stage of 499·00 ft on 1 September. On 3rd the level rose further to 502·90 ft and continued to rise further. On 6th the river crossed the high flood level at Partappur (Allahabad) and Hamirpur and it again crossed the high flood level at Pratappur on 8th.

River *Yamuna* was in floods at Delhi also. The drainage congestion due to heavy rains had affected an area of 70,000 acres including a cropped area of 34,428 acres up to 3 September, Out of this, *Kharif* crop in an area of about 26,000 acres had

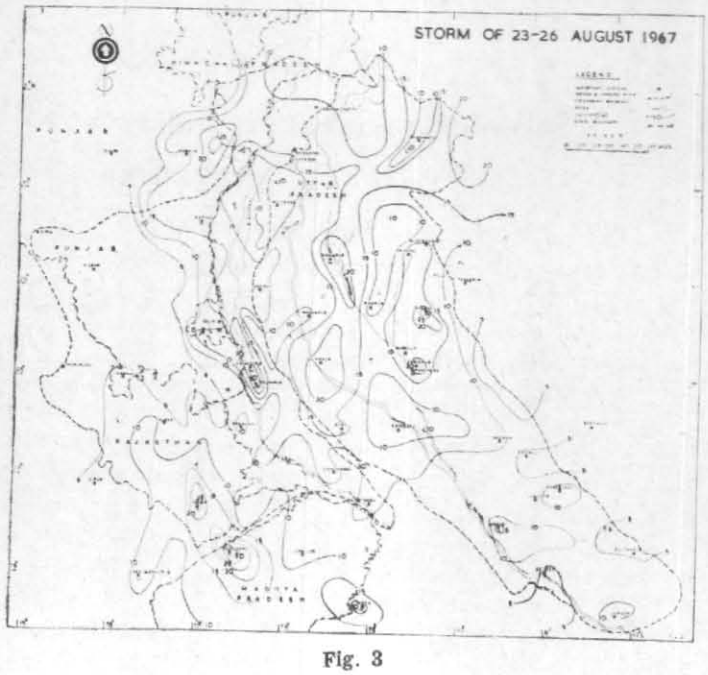

Fig. 3

been damaged. Damage to more than 10,000 houses was also reported.

River *Ganga* approached the warning stage at several places in Uttar Pradesh during the period upto 3 September. It was 4 ft above the warning stage at Ghazipur on 6th and crossed the high flood level of 1956 on 8th.

River *Ghaggra* at Chowkaghat and Turtipur was in high floods. The level at Chowkaghat was 348·84 ft on 3 September and 348·66 ft on 5th as against warning stage of 344·00 ft. River tributaries *Betwa, Ken* and the *Tons* were also in floods.

The floods in Uttar Pradesh had affected a cropped area of 17·44 lakh acres in 39 districts. A population of 36·78 lakhs in 15,498 villages were affected. It is reported that damage was caused to 1·2 lakh houses and 181 human lives and 1078 heads of cattle were lost.

Ghaggar in Rajasthan rose in floods. Flood waters had entered into depressions near Anupgarh. An area of about 1 lakh acres of land had been submerged including 5000 acres under *Kharif* crops. Railway line near Barmer had been submerged under 4 ft of water as a result of which the Jodhpur-Barmer Express carrying about 400 passengers was stranded for days.

4.5. *Exceptionally heavy rain at Patna on 20 September*

A low pressure area formed over the northwest and adjoining west central Bay of Bengal on 15th. It shifted northwards over Bihar Plateau and persisted there on 17th and 18th. Later it weakened and persisted as a trough of low pressure over Bihar State till 20 September. Under its influence there was fairly good monsoon activity over north and central India. The *Ganga* and other rivers in Bihar and east Uttar Pradesh rose above danger marks due to heavy rains, causing renewed floods in those areas.

Patna City recorded exceptionally heavy rainfall of 35·6 cm in 24 hours ending 0830 IST of 20th. On 21st 6·2 cm of rain was further recorded. The level of the *Ganga* rose to 165·11 ft on 21st, almost touching the warning stage at Patna (Digha). The flood waters, through the gaps in embankments, entered several parts of the Patna City.

The river *Falgu*, a tributary of the *Ganga*, was also in floods. The flood waters submerged large areas in Gaya City.

5. Summary

The monsoon rainfall in the first half of June was in deficit over most parts of the country but the situation improved considerably after the middle of June. The season's total rainfall was normal (± 24 per cent) in all the sub-divisions except in Uttar Pradesh West where it was in slight excess. There were no serious and disastrous floods in the country except in Uttar Pradesh where the river *Ganga* and its tributaries caused considerable damage to the crops and property and took 181 human lives. There were two 'break monsoon' situations, one in the second week of July and the other in the first week of August.