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Rainfall and floods during 1960 southwest monsoon period

1. Introduction

The first article dealing with the rainfall and floods during 1959 monsoon period appeared in the July 1960 issue of this Journal and it was decided that this feature should appear regularly every year*. The following is a review of the rainfall during the southwest monsoon period of 1960 and the associated floods.

2. Chief features of the rainfall

The southwest monsoon established itself over the south Peninsula in May about a fortnight in advance of the normal date and temporarily advanced in Gangetic West Bengal and Assam towards the end of May but its further advance was not maintained. The Arabian Sea branch of the monsoon advanced in south Konkan on 8 June and continued to advance and reach east Gujarat by the end of 3rd week of June. The Bay of Bengal branch of monsoon also became active and reached Bihar at about the same time, Rajasthan and Uttar Pradesh by 23 June and Punjab by 29 June. The monsoon advanced into Jammu and Kashmir State by 6 July 1960. It withdrew gradually from most of the country after the 1st week of October 1960 being confined later to south Peninsula only.

Week by week rainfall for the period June to September 1960 over the 27 meteorological sub-divisions of India is given in Table 1. The figures indicate the percentage departure of the week's rainfall from the normal rainfall. The departure in excess of 25 per cent and in defect by more than 25 per cent have been shown separately. A study of this table shows the following principal features—

(*i*) Deficient rain during successive weeks in June and July in Bihar Plains, east Uttar Pradesh, Rajasthan, Jammu and Kashmir but more pronounced in Rajasthan and Uttar Pradesh.

(*ii*) Excess of rain in successive weeks during August in west Uttar Pradesh and Punjab followed by heavy rainfall in Punjab, Uttar Pradesh before the withdrawal of the monsoon.

(*iii*) Spell of heavy rain in east Gujarat, Saurashtra, Kutch and Konkan during the early months of monsoon followed by drought conditions during many consecutive weeks in August and September.

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TABLE 1

Southwest Monsoon 1960

Percentage departures from normal of rainfall for week ending

METEOROLOGICAL SUB-DIVISIONS	JUNE				JULY				AUGUST					SEPTEMBER				OCT
	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5
Assam	-41	14	-15	-43	-44	29	11	24	15	24	-44	-39	129	-42	25	71	-13	-69
Sub-Himalayan West Bengal	-40	-38	-61	-66	-90	-12	67	13	-69	-43	-57	-61	-20	-8	214	-34	39	11
Gangetic West Bengal	-86	-52	14	-79	113	-20	26	40	-50	-28	9	-47	50	34	19	-41	14	183
Orissa	28	-89	37	-34	87	71	-28	-25	-6	32	83	-51	-21	-52	43	-44	18	224
Bihar Plateau	-94	-83	39	-93	19	21	-30	-66	-56	6	22	-55	132	-20	50	-89	80	192
Bihar Plains	-33	-53	-15	-96	-37	65	61	-67	-93	-43	-33	-40	68	137	-14	-60	159	85
Uttar Pradesh East	-100	-45	187	-63	-30	213	69	-98	-3	-47	-44	-44	21	-19	53	-97	-44	65
Uttar Pradesh West	-85	-47	-70	-9	-28	115	81	-38	-27	-48	67	87	37	-44	55	-91	45	293
Punjab (India)	21	390	-93	8	-30	96	51	-98	-67	4	20	254	39	-96	-67	-87	-99	164
Jammu and Kashmir	-100	-31	-53	-96	-72	189	-84	-100	-89	51	-59	-32	-88	-45	-97	-90	24	-100
Rajasthan West	-100	-100	182	16	250	111	-93	-99	-83	-17	-76	16	-96	-100	-100	-90	-100	-100
Rajasthan East	-60	-97	117	45	33	-80	-57	-27	30	92	-61	52	-93	-99	-53	-99	-80	-97
Madhya Pradesh West	-76	-73	-12	-21	48	-32	-60	-58	23	111	91	89	-46	-92	-43	-83	-75	199
Madhya Pradesh East	-29	-68	1	-45	33	-3	-14	-58	-5	-27	5	-23	-42	-66	-33	-54	-56	81
East Gujarat State	-100	23	4	55	46	-40	-99	-50	-49	83	-36	-77	-95	-93	20	-91	-39	-100
Saurashtra and Kutch	-100	-42	-35	492	263	-94	-100	44	49	-50	-62	-82	-94	-87	-92	-79	70	-100
Konkan	-17	118	36	76	-7	-85	-72	71	102	-6	-51	-47	-66	-59	-53	-53	26	-64
Deccan including Marathwada	-16	-57	-1	96	37	-94	-41	25	95	5	-75	-82	-96	1	11	37	91	-17
Vidarbha	-20	-45	11	-29	127	-66	-41	-45	104	-2	-52	-81	-93	-45	-14	-67	22	46
Coastal Andhra Pradesh	-99	-72	8	112	206	-13	-50	12	74	-79	-94	1	-15	26	-10	148	145	190
Telengana	-8	-97	-39	116	82	-69	-81	-82	40	-55	10	-93	-55	-43	-15	52	70	292
Rayalaseema	11	-100	-98	31	-8	-36	24	-39	-29	-99	-95	-97	-72	160	-17	252	23	173
Madras State	-60	-10	148	-8	86	312	384	-12	-80	-74	-91	-74	21	-36	96	47	-16	-2
Coastal Mysore	-39	-8	-66	16	-17	-88	-79	153	27	-2	-48	-8	-79	-41	-75	269	278	97
Interior Mysore North	-46	-61	-54	106	58	-92	-37	-36	40	-63	-53	-79	-90	7	-1	383	256	47
Interior Mysore South	-48	-52	-60	18	119	-73	100	-38	-21	-47	-82	-88	-78	-86	-36	133	-7	14
Kerala	-15	-32	-66	-38	21	-70	-8	72	47	50	-62	-30	-74	-58	51	219	360	83

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

(*iv*) Slight to moderate defect in Assam and sub-Himalayan West Bengal during consecutive weeks in the months of June, July and August.

(*v*) Moderate to large defect in Peninsula outside coastal Mysore upto mid-September followed by large excess of rainfall during subsequent weeks.

From the study of the distribution of rainfall mentioned above it can be inferred that there was a lack of monsoon depressions moving across the country from the Bay of Bengal during the months of June and July, most of depressions having occurred in the month of August. It could also be inferred that 'Break monsoon' conditions were few or none at all and that movement of depression, troughs or low pressure waves during the month of September across Peninsula causing large excess of rain for consecutive weeks towards the end of September and early October may have occurred. A study of the synoptic charts of the monsoon season brings out the following facts—

During the months June and July, only one depression moved NNW to NW from Bay of Bengal in the first week of July although a few upper air troughs did move westward. There was only one typical 'Break' condition for about 10 days, which lasted upto 18 July; another feeble 'Break' condition occurred only at the end of the first week of September. The month of August had the maximum number of depressions forming in the Bay of Bengal. These moved more or less on their usual course or slightly north of it. The seasonal trough lay most of the time in its normal position or slightly north of it. This explains to some extent the absence of floods in rivers of central and Peninsular India as may be noticed from the list of chief floods of 1960 mentioned here.

3. Chief floods of 1960

In 1960, Punjab, Himachal Pradesh, Uttar Pradesh and Orissa and Saurashtra experienced severe floods due to heavy and concentrated rainfall. There were medium floods in Assam, West Bengal and Bihar. The *Flood Newsletters* issued by the Central Water and Power Commission show that apart from the usual minor and medium floods, the following were the noteworthy floods of the 1960 monsoon season—

(1) Floods in Saurashtra and Kutch	1st week of July
(2) Bihar floods	3rd week of July
(3) Brahmaputra in high floods	2nd week of July
(4) Punjab floods	16-19 July
(5) Uttar Pradesh floods	17-18 July
(6) Himachal Pradesh floods	17-19 July
(7) West Bengal floods	18-20 July
(8) Assam floods	20-22 July
(9) Orissa floods	14-17 August
(10) Punjab floods	21-22 August
(11) Himachal Pradesh floods	29-31 August
(12) Assam floods	13-18 September
(13) Gomati in high floods	3-7 October

It will be seen that during 1960, the rivers in the belt from Punjab (India) to Assam and those of Orissa had the maximum number of floods. The incidence of floods corresponded closely to the pattern of heavy rainfall over the country during this monsoon season.

TABLE 2

Comparative statement of gauge records for the years 1955, 1959 and 1960

River system	River	Gauge station	Zero of the guage (G.T.S.)	Danger level	Highest known record prior to 1955	Highest records			Duration of 1960 peak flood	Remarks
						1955	1959	1960		
The Mahanadi	Mahanadi	Jobra (above)	0·81	73·00	75·95 (1872)	76·20 (5-9-55)	73·60 (14-9-59)	74·30 6 hrs	1 hour	
	Kathjuri	Bell-evue	54·90	25·00	27·80 (1892)	27·00 (5-9-55)	24·85 (14-9-59)	25·50 23 hrs (17-8-60)	4 hours	
The Brahmini	Brahmini	Ta!char		24·00	30·40 (1940)	34·00 (Sep.)	24·00 (12-9-59)	44·00 upto 6 hrs (16-8-60)		Gauge not readable beyond 44·00
		Jaunpur (above)	0·89	66·00	71·30 (1943)	72·20 (4-9-55)	67·40 (13-9-59)	74·60 (approx.) (16-8-60)		Gauge not readable beyond 73·20
The Baitarani	Baitarani	Akhua-pada	1·18	63·00	67·80 (1927)	64·10 (4-9-55)	60·10 (14-9-59)	72·00 12 hrs (16-8-60)		

4. Analyses of the more important floods of the season

The special features of this year's floods were that the Brahmini, the Baitarani and the Salandi in Orissa, the Brahmaputra in Assam, the Gomati in Uttar Pradesh and the Suketinadi in Himachal Pradesh reached unprecedented levels. In Punjab, as a result of the excessive discharge and subsequent water logging, parts of Rohtak town were seriously flooded and there was widespread damage. Parts of Lucknow town were also inundated in the first week of October 1960 as a result of unprecedented rise in the level of Gomati. Some parts of Rajasthan and Gujarat States also experienced floods on account of concentrated rainfall in the first week of July. The other parts of the country were practically free from major floods this year.

The major floods of the year that were responsible for human suffering and damage to property were—

(*i*) Brahmaputra in high floods	2nd week of July
(*ii*) Orissa floods	14-17 August
(*iii*) Punjab floods	21-22 August
(*iv*) Himachal Pradesh floods	29-31 August
(*v*) Gomati in high floods	3-7 October

A detailed account of these floods and the meteorological situation associated with each are described below—

(*i*) *High floods in Brahmaputra during 7-9 July*—The seasonal trough shifted northwards between 7 and 8 July and its axis lay along the foot of Assam Himalayas. Heavy rain occurred in the lower reaches of the Brahmaputra on 7 and 8 July. The river rose to unprecedented level of 344·2 ft at Dibrugarh on 9 July. The tributaries of Brahmaputra like the Subansiri, Dhansiri, Mittong as also those of Barak river like Baleshwar and Katakhal were also in medium to high floods. An area of 3·76 lakhs acres was involved in the flood which took a toll of 9 human lives and a number of heads of cattle. Although the full estimate of the damage has not been made, an estimated damage to crops worth Rs. 5·22 lakhs was caused.

(*ii*) *Orissa floods of 14-17 August*—Concentrated heavy rainfall occurred in the catchment of Brahmini, Baitarani, Mahanadi and Salandi rivers between 14 and 17 August 1960. All these rivers except Mahanadi recorded exceptionally high floods. The flood gauge at Talchar on river Brahmini and at Akhuapada on Baitarani on the 14th were 10 ft and 8 ft respectively higher than the gauge record of the previous high floods of 1955. A comparative statement of these gauge records compiled by the Central Water and Power Commission is reproduced in Table 2. It will be seen that so far as river Baitarani is concerned the floods in this subbasin had been severest in its recorded history. Due to protective action of the dam at Hirakud, the floods in Mahanadi delta were largely controlled.

Flood waters of river Brahmini overtopped its embankments and breaches occurred at many places. Roads and rail communications were cut off at several places and extensive damage was caused to standing crops. The floods took a toll of 45 human lives and many heads of cattle. Although the extent of loss has not been completely assessed, damage to crops and property was estimated to about Rs 15 to 20 crores. The synoptic situation responsible for this unprecedented floods in rivers Brahmini and the Baitarani and Salandi was as follows—

TABLE 3

Name of basin	Period of storm	Average storm rainfall (cm)
River Baitarani River Brahmini	14-17 August 1960	25·0
River Mahanadi (below Hirakud)	14-17 August 1960	15·2

A low pressure area moved across Central Burma into the head Bay where a depression formed on the 12th evening. The depression deepened and was centred on the 14th morning close to Sunderban coast about 75 km SE of Saugar Islands. It crossed inland the same night and moved in west-northwesterly direction and lay as deep depression about 50 km east of Contai on 15th morning. Thereafter, it weakened, moved northwestwards and lay on 16th morning as a depression with centre 50 km southwest of Chaibasa. It continued to move northwest and was centred near Ambikapur on the 17th morning and near Nowgong on the 18th morning. Thereafter, it continued to move northwest and lay as a low pressure wave over the Punjab and northwest Uttar Pradesh on 21st. It caused very heavy rainfall in and near Orissa during 14 to 17 August. Principal amounts of rainfall recorded during 24 hours were Balasore, Baripada and Keonjhar 25·5 cm, 19·8 cm, and 16·2 cm respectively on 15th; Sambalpur, Hirakud, Sonepur, Sohella 29·1 cm, 24·0 cm, 20·0 cm, and 17·5 cm respectively on 16th; and Raigarh 19·3 cm on 17th.

It may be noticed that although the centre A (Fig. 1) of the rainstorm lay near Hirakud, the inner core of the storm spread considerably inside the Brahmini/Baitarani catchment. The storm rainfall in the various subcatchments is given in Table 3.

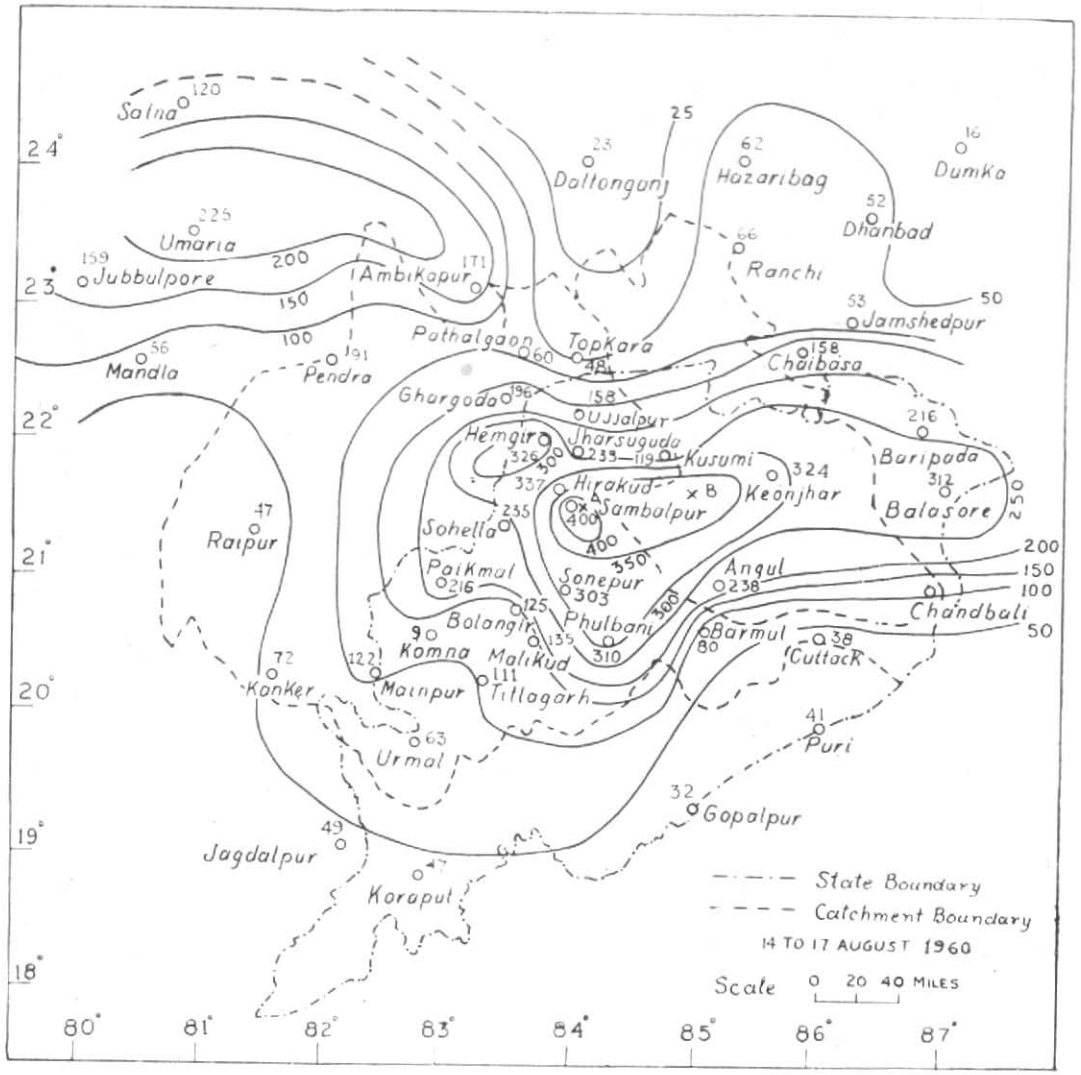

Fig. 1. Isohyets of Orissa storm rainfall (in mm)—14 to 17 August 1960

(*iii*) *Punjab floods of 21-22 August 1960*—River Ghagger, Markanda, Sutlej, Ravi and Beas went into high floods and a number of breaches occurred in the railway lines causing dislocation in traffic. The situation in Rohtak town became very serious towards the end of August as rain water overtopped drain No. 8 passing near Rohtak and ran into the countryside. The flood situation was, however, further aggravated when a fresh Bay depression moved northwest and lay as a low over Uttar Pradesh and neighbourhood on 28 August. On 29th a breach occurred on the left bank of the drain and water spread against the 4 mile long railway embankment which could not stand the strong gushing water. As a result, breaches were caused at several places submerging vast tracts of land. Army personnel were called to assist the civil authorities in filling up the breaches and removing the marooned men, material and cattle to safety. The flood took a toll of 77 human lives and numerous heads of cattle. The total damage to crops and property was estimated to be around Rs. 19·30 crores. The synoptic situation responsible for this unprecedented floods at Rohtak is described below—

The depression which caused the unprecedented floods in Orissa described earlier moved in northerly direction from west Uttar Pradesh to Punjab and lay as a low pressure area over south Punjab, adjoining Rajasthan and west Uttar Pradesh on the 20th morning and over south Punjab and northwest Uttar Pradesh on the 21st morning. Moving northeastwards it lay the same evening at the foot of Himalayas and broke off by the 22nd morning. Well distributed heavy rain occurred over the Punjab hills, Himachal Pradesh and the terrains of the southeast Punjab and Himachal Pradesh between 20th and 22nd. Patiala recorded 16 cm, Ambala 15 cm, Gurgaon 14 cm and Karnal 11 cm on 21 August and Chandigarh 8 cm on 22 August. Before the water logged areas had time to dry out, another depression travelling from the Bay, affected the area and lay as a low over the west Uttar Pradesh on 28 August. It merged with the seasonal trough by 30th but the rain caused by this, seriously aggravated the flood situation over the waterlogged areas with consequences already described above.

(*iv*) *Himachal Pradesh floods of 29-31 August*—Due to heavy rain on 29 and 30 August in Himachal Pradesh and adjoining Punjab hills, Suketinadi went into unprecedented flood on 31st morning and breached the road communication at several places. Considerable damage was caused in Mandi District. 879 villages were affected. The flood took a toll of 103 human lives and 640 heads of cattle. Many houses collapsed. The synoptic situation responsible for the floods in the Suketinadi has been partly described in the preceding paragraph.

A depression formed in the northwest Bay on 24th and moving across the country, it lay as a low pressure area over west Uttar Pradesh and adjoining Punjab and east Rajasthan on the 28th morning. It moved northwards across Himachal Pradesh and Punjab-Kumaon hills on the evening of 29 August. Chief amounts of rainfall recorded were Dharamshala 5 cm on 29 August and Pathankot 7 cm and Dalhousie 5 cm on 30 August.

(*v*) *High floods in Gomati during 3-7 October 1960*—Heavy rain occurred in the Gomati catchment between 3 and 7 October 1960. The river rose to an unprecedented level of 371·4 ft at Lucknow on 9th evening breaking the highest ever level of 368·5 ft recorded in 1923. The waterway provided for the flood flow under the Monkey bridge at Lucknow was unable to cope with the heavy discharge and as a result the bunds were breached at many places, and Lucknow experienced the severest flood in its history. Food and medical supplies had to be air dropped for the marooned people. The General Post Office, the State Bank building, Hazarat Ganj (an important shopping centre), Zoological Gardens, Daliganj and Mahanagar areas were submerged and at places

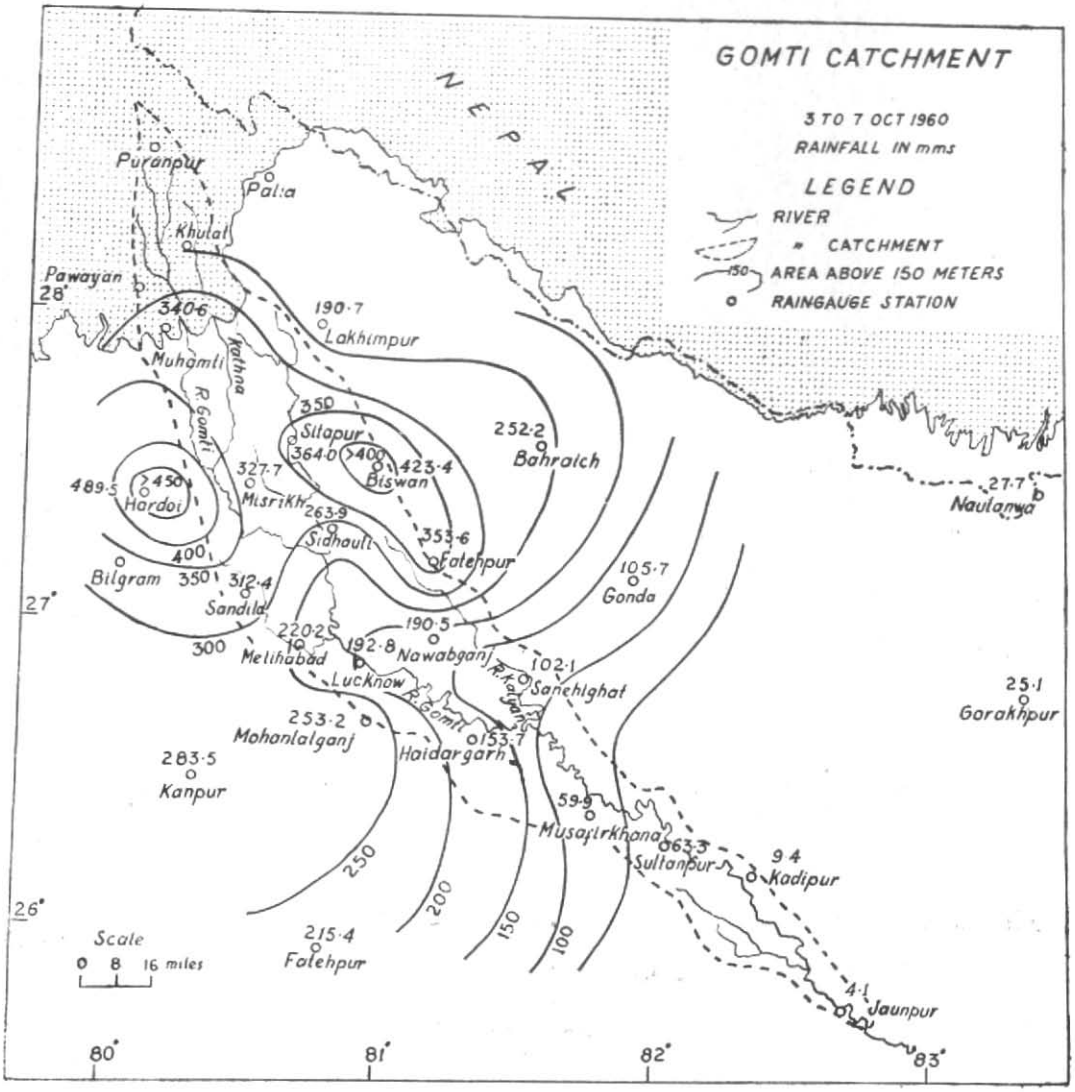
GOMTI CATCHMENT
3 TO 7 OCT 1960
RAINFALL IN mms
LEGEND
RIVER
CATCHMENT
150 AREA ABOVE 150 METERS
RAINGAUGE STATION
NEPAL
Puranpur
Palia
Khutar
Pawayan
340·6
190·7
Lakhimpur
Muhamli
Kathna
R. Gomti
350
Silapur
364·0
>400
423·4
Biswan
252·2
Bahraich
327·7
489·5
>450
Hardoi
Misrikh
263·9
353·6
Fatehpur
Sidhauli
400
Bilgram
350
312·4
Sandila
105·7
Gonda
27·7
Naulanya
300
220·2
10
192·8
Nawabganj
190·5
Melihabad
Lucknow
R. Gomti
Kalyani
102·1
Sarehighat
25·1
Gorakhpur
253·2
Mohanlalganj
153·7
Haidargarh
283·5
Kanpur
59·9
Musafirkhana
063·3
Sultanpur
9·4
Kadipur
250
200
150
100
Scale
0 8 16 miles
215·4
Fatehpur
4·1
Jaunpur
80°
81°
82°
83°
26°
27°
28°

Fig. 2

water stood 8-ft deep inside the houses. The worst flood affected areas were in and around Lucknow district in which alone 1,36,000 acres of land involving 452 villages were affected. Many people lost their lives in house collapse and about 1 lakh houses were estimated to have been damaged due to floods in Gomati. All the rain producing storms between 1921-1960 were examined and it was discovered that this was the biggest ever 5-day storm that occurred in the Gomati catchment and the biggest rain producing storm for this area in the month of October, average rain yield being 21·4 cm. Fig. 2 giving the isohyets for this storm, indicates that the storm centre lay immediately north of Lucknow and the flood water flow of the sub-basins of river Sarayan into Gomati whose confluence lies in the immediate vicinity of the city was probably the deciding factor causing this unprecedented flood in this city. The synoptic situation responsible for this event is described below.

A low pressure wave which lay over the west central Bay off Orissa-Circars coast on the morning of 1 October and moved over the Peninsula, was located over central parts of the country as a trough of low on the 3rd. It revived the monsoon over east Uttar Pradesh. Concentrated heavy rainfall occurred over lower Gomati catchment between 3 and 4 October. The low further accentuated and lay over Madhya Pradesh on the 5th morning and heavy rain extending into northwest Uttar Pradesh also occurred on the 5th and 6th morning. It became unimportant on the 7th morning. The principal amounts of rainfall recorded were Banda 11, Lucknow 10 and Kheri 8 cm on 3 October; Kanpur 6 cm and Lucknow 5 cm on the 4th; Mainpuri 6 cm on the 6th; Hardoi 24 cm, Nainital 13 cm, Lucknow 11 cm, Kanpur 10 cm, Orai 8 cm and Mukateshwar 7 cm on the 5th. Other heavy rainfall amounts reported from the State Raingauge Stations were Sahaswan (Badaun) 16 cm, and Shahjehanpur 15 cm on 5th and Chhibram (Farukhabad) 13 cm on 4 October 1960.

5 Conclusions

The main features of the rainfall distribution during 1960 monsoon season and its major floods may be summarised as follows—

(*i*) This year too, as in the 1959 monsoon season, the number of 'break' monsoon conditions were few—such a condition occurred only once. The seasonal trough with its axis lay mostly in its normal position, which explains the remarkable feature that the rainfall over most of the country, for the season as a whole, was within 20 per cent of the normal.

(*ii*) As a result of (*i*), the Central India rivers like Tapti, Godavari and Narbada were free from major floods.

(*iii*) The rainfall in the catchment of river Gomati was abnormal for the month of October but not so when the season as a whole is considered.

(*iv*) The flood in Punjab in late August was more a problem of waterlogging rather than major river floods.