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# Rainfall and Floods during 1964 Southwest Monsoon period*

## 1. Introduction

The seasonal rainfall during the southwest monsoon period was nearly normal except in Punjab, west Uttar Pradesh, Andhra Pradesh and Mysore where rainfall was appreciably above normal. The States which were affected by floods were Assam, Andhra Pradesh, Bihar, Punjab, Rajasthan, Uttar Pradesh, West Bengal and Union Territory of Delhi. Heavy incessant rains in the plains of north India caused local flooding and damage. In West Bengal and Assam, floods occurred as a result of excessive rains over the upper reaches of the catchment areas and subsequent overflowing of the rivers. The outstanding features of the season are —

(1) Highest ever rainfall recorded during July in Delhi,

(2) Heavy rains and consequent floods in Punjab (India) and adjoining areas during the month of July, and

(3) Heavy rainfall in the coastal districts of Andhra Pradesh and Guntur, Kurnool and Mehbubnagar districts during the last week of September resulting in high floods in coastal rivers and also Krishna river.

According to a statement made in the Parliament on 7 September 1964, it was estimated that the total area affected by floods during the year till then was 55 lakh acres including 24 lakh acres of cropped area. The total number of villages affected was 15,714. The loss of crops was estimated at Rs. 19·5 crores and 65 human lives were lost. Subsequent to this statement in the Parliament, Andhra Pradesh received heavy rains during the last week of September.

## 2. Chief features of rainfall

The Arabian Sea Branch of southwest monsoon set in over south Kerala on 5 June 1964, about 5 days behind the normal date. A low pressure area over the east central Arabian Sea off the Kanara coast moving in a northerly direction intensified into a severe cyclonic storm of small extent with a core of hurricane winds by 11th, centred about 100 km southwest of Veraval. It recurved and crossed the coast near Naliya on the next day, rapidly weakened and by 14 June dissipated over the Western Himalayas. Under its influence monsoon rapidly advanced northwards and set in over rest of the west coast by 12 June. Heavy rains also occurred in Gujarat, Rajasthan and Punjab (India). According to press reports, the cyclonic winds and tidal waves which rose to a height of about 15 feet caused considerable loss of life and property along the Kathiawar coast.

The Bay Branch of monsoon extended over Assam by 11 June and over the rest of northeast India by 15th. A low pressure area which formed over northwest Bay of Bengal on 18 June moved inland on 20th and lay over northeast Madhya Pradesh and adjoining east Uttar Pradesh uptill 25th. Under its influence monsoon extended into east Uttar Pradesh and most parts of Madhya Pradesh and Gujarat State by this date. A low pressure area which developed over north Orissa and adjoining West Bengal

*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

## TABLE 1

### Southwest Monsoon 1964

### Percentage departure from normal rainfall for week ending

| METEOROLOGICAL SUBDIVISIONS | JUNE | | | | JULY | | | | | AUGUST | | | | SEPTEMBER | | | | | 1 JUN TO 30 SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 10 | 17 | 24 | 1 | 8 | 15 | 22 | 29 | 5 | 12 | 19 | 26 | 2 | 9 | 16 | 23 | 30 | |
| ASSAM (INCLUDING MANIPUR & TRIPURA) | -78 | +67 | -46 | -24 | +10 | -29 | -11 | -13 | +27 | +90 | -62 | -45 | +7 | -5 | +36 | -50 | -1 | -53 | +2 |
| SUB - HIMALAYAN WEST BENGAL | -68 | -37 | +84 | -21 | -7 | -33 | +54 | +96 | +32 | +200 | -67 | -17 | -81 | -15 | +21 | +110 | -4 | -60 | +15 |
| GANGETIC WEST BENGAL | -81 | -90 | -51 | -57 | -29 | -48 | +115 | -16 | +2 | -18 | -37 | -52 | +28 | -19 | +80 | -85 | +10 | +6 | -20 |
| ORISSA | -76 | -86 | -86 | +7 | -48 | +97 | +37 | -50 | -38 | -40 | +29 | +30 | +48 | -50 | -17 | -66 | -2 | +93 | +8 |
| BIHAR PLATEAU | -96 | -97 | -44 | -31 | +28 | -44 | +115 | -37 | -43 | -69 | -48 | -7 | +46 | -22 | +102 | -86 | -11 | +18 | -6 |
| BIHAR PLAINS | -100 | -100 | -53 | -26 | +27 | -56 | +131 | +64 | -24 | +13 | -71 | -44 | -48 | -28 | +101 | -42 | +17 | -30 | -7 |
| U P EAST | -100 | -100 | -88 | -21 | -62 | -62 | +65 | -45 | +18 | -20 | -90 | -59 | -34 | +60 | -14 | +93 | -38 | +62 | -5 |
| U P WEST | -94 | -99 | -90 | -35 | +3 | -33 | +135 | -77 | +80 | -71 | -65 | +37 | +9 | +20 | -51 | +6 | -36 | +31 | +26 |
| PUNJAB (I) INCLUDING DELHI | -93 | -85 | -42 | -98 | -36 | +60 | +110 | +49 | +176 | -86 | -49 | +143 | +141 | +117 | -60 | -38 | -80 | +10 | +60 |
| HIMACHAL PRADESH | -100 | -69 | -3 | -24 | -11 | -60 | +89 | -77 | -33 | -26 | -16 | +10 | +33 | -30 | -13 | -3 | -97 | +52 | -14 |
| JAMMU & KASHMIR | -72 | +3 | +6 | -94 | -82 | -49 | -1 | -50 | +11 | -89 | -49 | -63 | +64 | +26 | -73 | -46 | -78 | +25 | +4 |
| RAJASTHAN, WEST | +178 | -77 | +53 | -100 | -94 | +81 | -31 | -70 | +77 | -85 | +23 | +60 | +69 | +117 | -96 | -96 | +13 | -99 | +23 |
| RAJASTHAN, EAST | +97 | -61 | -87 | -45 | -25 | +6 | -20 | -76 | -2 | -99 | -41 | +64 | +122 | +35 | -79 | -59 | +34 | -61 | -3 |
| MADHYA PRADESH, WEST | -17 | -94 | -84 | -14 | +77 | +51 | -54 | -59 | -38 | -79 | +10 | +53 | +62 | -12 | -74 | -42 | +103 | -47 | +1 |
| MADHYA PREDESH, EAST | -85 | -97 | -65 | +11 | +155 | +24 | -19 | -24 | -58 | -62 | +30 | +10 | +73 | -12 | -61 | -42 | -7 | +84 | +10 |
| GUJARAT REGION | -57 | -79 | -5 | -84 | +10 | +176 | -44 | -85 | -29 | -72 | -9 | +268 | -33 | -52 | -96 | -74 | +203 | -79 | +18 |
| SAURASHTRA & KUTCH | -100 | +31 | +293 | -96 | +54 | +48 | -68 | -47 | -36 | -63 | +116 | +108 | -87 | +44 | -97 | -98 | +519 | -96 | +24 |
| KONKAN | -100 | -70 | +36 | -54 | +62 | -10 | +6 | -44 | -26 | +102 | +153 | -9 | -54 | -58 | -83 | -50 | +102 | +54 | +7 |
| MADHYA MAHARASHTRA | -95 | -41 | -46 | +8 | +70 | +45 | -66 | -38 | -26 | +17 | +125 | +15 | -23 | -28 | -71 | +217 | +31 | +45 | +24 |
| MARATHWADA | -91 | -34 | -65 | -26 | -38 | -50 | -55 | +170 | -23 | +41 | -2 | -4 | -65 | +27 | -39 | -54 | +55 | -53 | -11 |
| VIDARBHA | -97 | -76 | -75 | +68 | +19 | -11 | -51 | -42 | -30 | -58 | +106 | -80 | +16 | -45 | -85 | -43 | +168 | -38 | +2 |
| COASTAL ANDHRA PRADESH | +14 | -75 | +1 | -22 | -31 | -55 | -60 | +106 | +35 | +29 | +103 | -31 | -71 | +33 | +29 | +158 | +18 | +248 | +38 |
| TELANGANA | -98 | -34 | -24 | -36 | -20 | -67 | -37 | +13 | -17 | -20 | +65 | -18 | -24 | -27 | -3 | +150 | +35 | +145 | +6 |
| RAYALASEEMA | -100 | +76 | +70 | -14 | +6 | +56 | -4 | +160 | +172 | +323 | +11 | -85 | -89 | +37 | +94 | +481 | -85 | +26 | +75 |
| MADRAS STATE | +160 | +31 | -69 | -68 | -87 | -41 | +25 | +165 | +55 | +9 | -29 | +54 | -46 | +19 | +70 | +99 | -52 | -91 | +30 |
| COASTAL MYSORE | -99 | -23 | -24 | -3 | -32 | -21 | +17 | -57 | -43 | +152 | 0 | -35 | +45 | -26 | -75 | +31 | +290 | +13 | -3 |
| INTERIOR MYSORE NORTH | -80 | -74 | -20 | +41 | +39 | +34 | -52 | +66 | -17 | +180 | +14 | -56 | -42 | +46 | +87 | +202 | +18 | +179 | +53 |
| INTERIOR MYSORE SOUTH | +19 | +47 | -51 | -8 | -34 | +55 | -7 | +36 | +31 | +217 | +245 | -65 | -67 | -18 | +186 | +140 | -50 | -72 | +45 |
| KERALA | -94 | -24 | -67 | -26 | -56 | +91 | 0 | -27 | +14 | +4 | +142 | -63 | -49 | -7 | +84 | +241 | +125 | -72 | +1 |

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

⊗ FIGURES TAKEN FROM IDWR SUPPLEMENT DATED 28-10-1964

on 29 June lay over Bihar Plateau the next day. Moving westwards, it merged with the seasonal low by 3 July. Another low pressure area formed over the Head Bay on 2 July 1964, intensified into a depression by 3rd. The Bay depression crossed coast near Contai on 4th. Moving in a northwesterly direction, it weakened into a low pressure area over west Uttar Pradesh on 7 July and merged with seasonal low on the next day. Under the influence of these two low pressure systems, the monsoon extended further northwestwards and covered the entire country by 5 July which was about 10 days earlier than the usual date.

The retreat of monsoon commenced during the last week of September from northwest India in association with upper air troughs in westerlies which moved eastwards across Western Himalayas from West Pakistan and adjoining areas. The duration of the monsoon period in northwest India was thus about two weeks longer than normal. The duration of monsoon over northwest India was prolonged under the influence of a series of low pressure systems during September in the head Bay of Bengal and their subsequent movement into the region. The monsoon retreated from Uttar Pradesh, most parts of Madhya Pradesh, Gujarat, north Madhya Maharashtra and north Konkan during the first week of October, and from northeast India (except Assam), Vidarbha, southern portions of Maharashtra State and southeast Madhya Pradesh during the second week of October. Finally the monsoon withdrew from the rest of the country during the third week of October except south Peninsula.

### 3. Weekly account of monsoon rainfall

Rainfall week by week, for the period 1 June to 30 September 1964, for all the 31 meteorological sub-divisions is given in Table 1. The table indicates the percentage departure (deficit or excess) of actual seasonal rainfall (during June to September) from normal for the same period.

The significant features of the monsoon rains as revealed by this table are —

(*i*) Rainfall during the southwest monsoon was nearly normal over the country outside Punjab in the north and Rayalaseema and inland Mysore in the south,

(*ii*) Rainfall was nearly double the normal in Gangetic West Bengal, Bihar, west Uttar Pradesh and Punjab during the second week of July,

(*iii*) Abnormally heavy rainfall occurred during the months of July and August in Punjab,

(*iv*) Kerala had a comparatively dry season, 10 out of 18 weeks having deficit rains,

(*v*) More than 200 per cent excess rainfall in coastal Andhra Pradesh during the last week of September,

(*vi*) Central parts of the country received heavy rain during second fortnight of August, and

(*vii*) Heavy rain in June in Kutch, Saurashtra and adjoining Rajasthan, being rather early for the region.

A study of the meteorological situations which were mainly responsible for the rainfall distribution mentioned above reveals the following —

(*i*) Development of a severe cyclonic storm in early June in southeast Arabian Sea which moved northwards and recurved into Saurashtra and Kutch,

(*ii*) The axis of the seasonal trough being little north of its normal position at the western end during most of the season (except during late August and September when it was rather south of its normal position),

(*iii*) Movement of large number of low pressure systems from Bay (some as depression) across the country to the west Uttar Pradesh and plains of Punjab during July,

(*iv*) Movement of a series of Bay depressions westwards during the month of August in addition to a cyclonic storm in the Arabian Sea off Bombay during the month of August,

(*v*) The formation of depression at the head Bay of Bengal on 23 September and its subsequent northwestwards movement over Punjab, and

(*vi*) The formation of Bay depression at rather low latitude than normal during the end of September.

A cyclonic storm which formed over east of central Arabian Sea, intensified into a severe cyclonic storm of small extent by 11 June and was centred about 100 km southwest of Veraval. Recurving northeastwards it crossed the coast near Naliya on 12th. Moving further northeastwards it dissipated over Western Himalayas but not before causing heavy rain over Rajasthan and Saurashtra and Kutch.

Monsoon activities revived with a depression which developed on 3 July 1964 centred near Lat. 21°N and Long. 89·5°E. Moving northwestwards, it crossed the coast near Contai on 4th evening and continued to move northwestwards as a low. It lay over west Uttar Pradesh on 7th morning and later merged with a seasonal low. The series of low pressure waves or land lows moving across the country resulted in heavy rainfall distribution over the central part of the country during July. The month of August saw the usual activities of Bay depressions, four of which moved across the country more or less in northwest direction. The rainfall activities remained uniformly distributed during the month of September due to westward movement of low pressure systems from the Bay of Bengal across the country. The low pressure systems gave rise to two depressions one of which formed over the head Bay on 23rd and moved northwestwards and dissipated over Punjab and another formed over west of central Bay on 27th and moved over Telangana and neighbourhood by 30th causing heavy rain towards the close of monsoon over Rayalaseema, Telangana and Interior Mysore.

#### 4. Chief Floods of 1964

As there were very few break monsoon conditions, there were no serious floods in Himalayan rivers except in Brahmaputra and its tributaries in Assam which were swollen practically throughout the season. Some rivers of Peninsular India were in floods particularly during the end of the season. Central India was also comparatively free from floods except southwest Madhya Pradesh during the 2nd week of August. The unusual feature of the monsoon season this year was sustained rainfall activity in the plains, *i.e.*, the lower reaches of Himalayan rivers. The areas affected by flood during the season are shown in Fig. 1.

The major floods which resulted in human suffering and widespread loss of property are listed below —

(1) Widespread floods in upper and lower Assam during the third and fourth week of June 1964,

(2) Unusually heavy rains in Punjab (India) including Union Territory of Delhi in the month of July, particularly during the period 10–17 July 1964 resulting in heavy floods in the regions,

(3) Floods in Assam during the last week of July

(4) Floods in southwest Madhya Pradesh during second week of August 1964

(5) Rivers of Uttar Pradesh and Punjab (India) in floods during the second and third weeks of August 1964

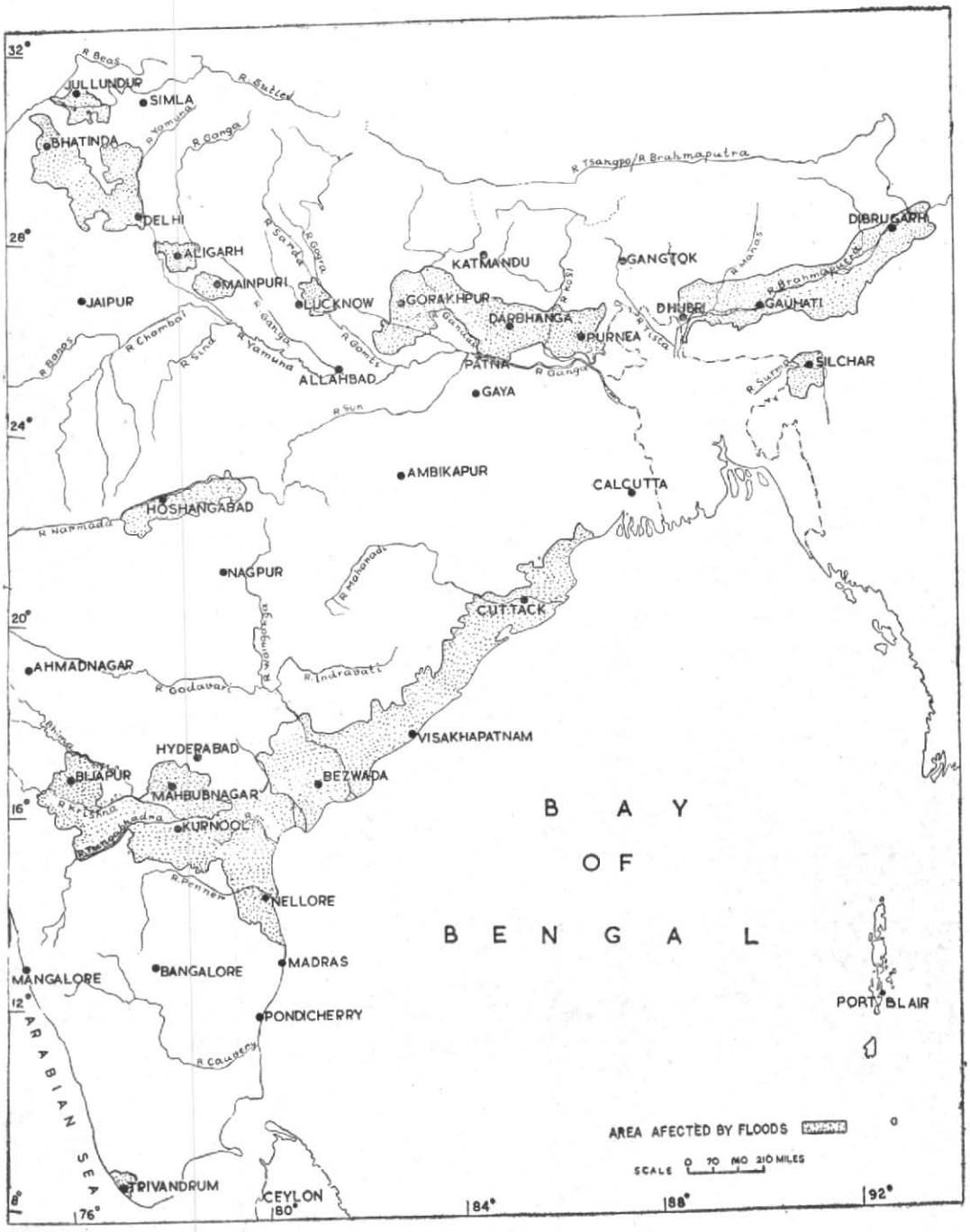
R Beas
JULLUNDUR
SIMLA
R Sutlej
R Yamuna
R Ganga
BHATINDA
DELHI
R Tsangpo/R Brahmaputra
DIBRUGARH
ALIGARH
KATMANDU
GANGTOK
R Manas
R Brahmaputra
MAINPURI
JAIPUR
LUCKNOW
GORAKHPUR
DARBHANGA
DHUBRI
GAUHATI
R Chambal
R Banas
R Sind
R Yamuna
R Ganga
R Gomti
R Gandak
R Kosi
R Tista
PURNEA
PATNA
ALLAHBAD
R Ganga
SILCHAR
R Surma
GAYA
R Sun
AMBIKAPUR
CALCUTTA
HOSHANGABAD
R Narmada
NAGPUR
R Mahanadi
CUTTACK
R Wainganga
AHMADNAGAR
R Godavari
R Indravati
VISAKHAPATNAM
HYDERABAD
BIJAPUR
BEZWADA
MAHBUBNAGAR
KURNOOL
R Tungabhadra
R Penner
NELLORE
B A Y
O F
B E N G A L
MADRAS
BANGALORE
MANGALORE
PONDICHERRY
R Cauvery
PORT BLAIR
ARABIAN SEA
TRIVANDRUM
CEYLON
AREA AFECTED BY FLOODS
SCALE 0 70 140 210 MILES
32°
28°
24°
20°
16°
12°
8°
76°
80°
84°
88°
92°

Fig. 1

(6) Unprecedented floods in Andhra Pradesh and Interior Mysore during the last week of September and first week of October.

A detailed account of some of the noteworthy floods and the associated meteorological situations causing damage are described in the following paragraphs —

1. *Unprecedented heavy rains and floods in Punjab including Union Territory of Delhi during the period 10–17 July 1964*

The Union Territory of Delhi experienced an unprecedented monsoon activity in July 1964 when New Delhi (Safdarjung) recorded 538·2 mm of rain (which surpassed the previous record for July of 464·3 mm in the year 1949) against the normal figure of 165·1 mm. It was 81·5 per cent of the annual normal rainfall and 96 per cent of the seasonal (June—September) rainfall. The rainfall was 128 per cent above normal for Punjab (India) and 60 per cent excess for west Uttar Pradesh for the month of July. In its wake an unprecedented local flood occurred particularly in Delhi and Punjab where considerable loss of life and property was reported. The outskirts of the Capital were under several feet of water and about 680 persons and 4185 heads of cattle were evacuated to safer places. Rivers Yamuna and Ghaggar were in high floods. The area affected in Delhi was about 14,721 acres including 3925 acres under crops in 65 villages. In Punjab about 50 villages and about 7000 acres of land in the districts of Gurgaon, Bhatinda and Hissar were affected.

The synoptic situations responsible for this highest rainfall for the month of July for Delhi have been studied in detail in a separate paper.* A brief description of the meteorological situations responsible for a heavy rain spell of 10—17 July are given below.

The western end of the axis of the monsoon trough lay north of its normal position during the period and extended to the foot of the Himalayas on 15 and 17 July. Also a well marked trough in the westerlies extending upto 35°N at 500-mb level was moving eastwards. As a result of these the monsoon activity increased in north India where heavy to very heavy falls occurred at a number of places in the hills of West Himalayas and adjoining plains of northwest India. The stations in the region where more than 10 cm of rain occurred are the following —

Jhalwar 14 cm on 8th, Bareilly 11 cm on 8th, Agra 18 cm on 10th, Dehra Dun 16 cm on 10th, Gorakhpur 14 cm on 10th, Dholpur 12 cm on 10th, Najibadad 10·6 cm on 15th, Nainital 13 cm on 15th and Ludhiana 10·7 cm on 16th.

The total isohyetal pattern of 14—16 July 1964 (3 days of maximum rainfall during the spell 9—17 July spell) over Punjab and adjoining west Uttar Pradesh is shown in Fig. 2. It is seen that the rain storm had several heavy rainfall centres in the plains, the highest of these being at Nahan where more than 35 cm of rain was recorded during the storm period. Depth-Duration-Area statistics for the 3-day storm are given in Table 2.

TABLE 2

| Area (sq. miles) | Rainfall depths (cm) 14 to 16 July | Area (sq. miles) | Rainfall depths (cm) 14 to 16 July |
|---|---|---|---|
| 500 | 26·2 | 10,000 | 16·9 |
| 1000 | 23·4 | 20,000 | 14·5 |
| 2000 | 21·7 | 50,000 | 11·5 |
| 5000 | 19·2 | 100,000 | 8·2 |

2. *Floods in southwest Madhya Pradesh during the period 9 to 13 August 1964*

Newspaper reports state that widespread destruction was caused to life and property in villages of Narsinghpur and Hoshangabad districts due to floods in the river Shakkar. As a result of heavy rains which occurred

*Submitted for publication in *Indian J. Met. Geophys.* by R. K. Datta, T.G. Changraney and J. N. Choudhury

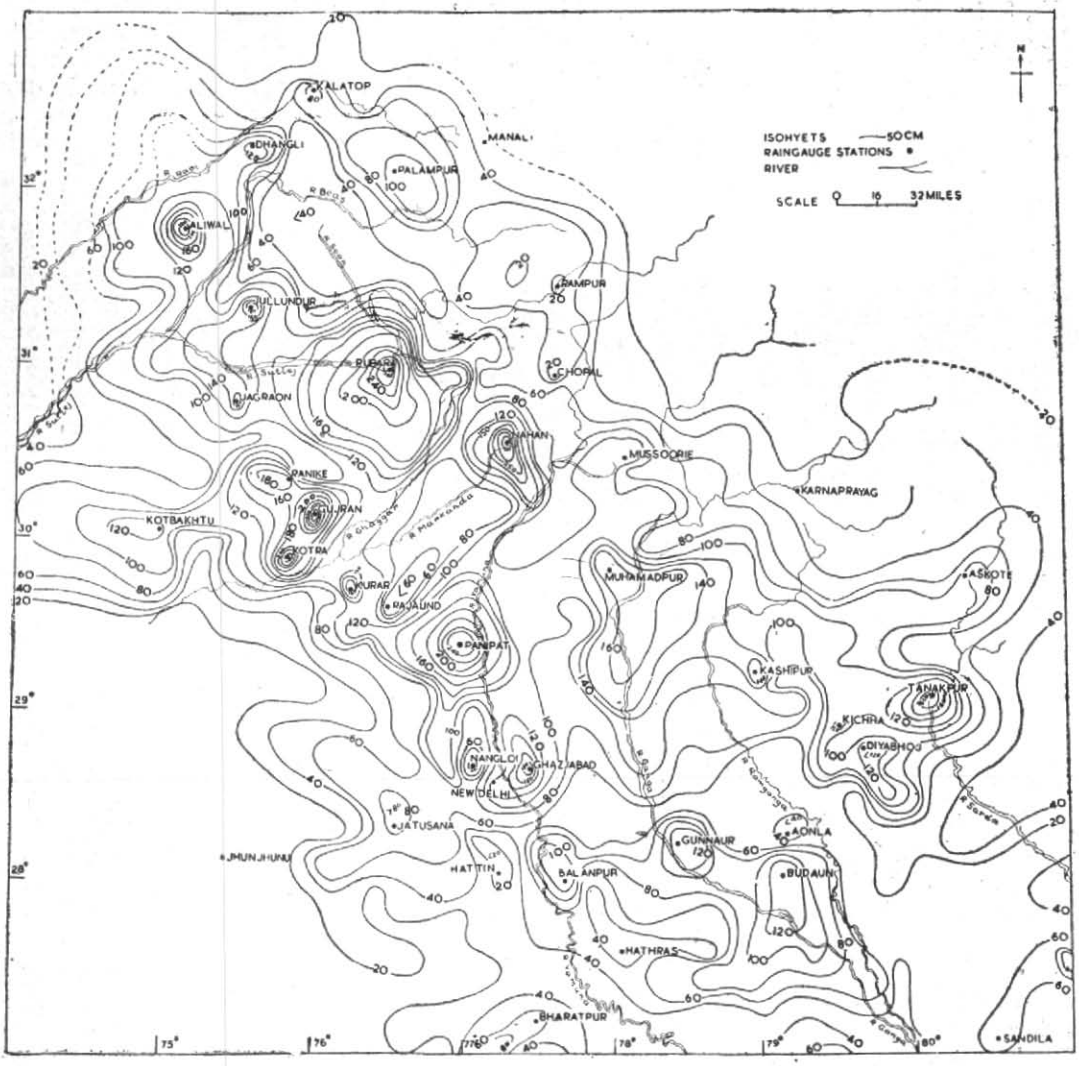


**Fig. 2. Storm of 14–16 July 1964 for Punjab and adjoining areas**

(Rainfall in cm)

over southwest Madhya Pradesh and adjoining areas of northeast Madhya Pradesh during the period from 9 to 13 August 1964, the rivers Narmada, Shakkar, Sitarewa and Dudhi were in spate. One person lost his life, 366 cattle heads were swept away, 975 houses in 40 villages were partially or completely damaged and widespread damage to crops was reported.

Synoptic situations responsible for widespread rain during the period are described below —

A low pressure area lay over northwest Bay of Bengal and neighbourhood on 4 August and concentrated into a depression by the next day, centred near Lat. 19·5°N and Long. 88·0°E. Moving westwards it further intensified into a deep depression by the following day and crossed coast near Puri on the same evening. Thereafter it weakened rapidly into an extended low pressure area over Madhya Pradesh on 8th and subsequently merged with the seasonal low over Rajasthan. Under its influence monsoon was strong to vigorous over southwest Madhya Pradesh on 9th. Hoshangabad and Pachmari recorded 10 cm each, Bhopal 9 cm, Chandi 8 cm and Satna 7 cm on 9th. The monsoon conditions continued relentlessly under influence of another low pressure area formed over north Bay of Bengal on 8th which intensified into a deep depression by the morning of 10th, centred near 19·5°N and 87·9°E. It crossed Orissa coast near Chandbali by 11th, weakened and lay over north Madhya Pradesh and neighbourhood as a depression with its centre between Jabalpur and Sagar on 12th. It further weakened into a low pressure area and lay over northwest Madhya Pradesh and adjoining parts of Uttar Pradesh and Rajasthan on 13th. The chief amounts of rainfall were Mandla 9 cm and Narsinghpur 8 cm on 11th, Seoni—Malwa (Hoshingabad) 19 cm, Kannod (Indore District) 18 cm, Gadarwada (Narsinghpur District) 17 cm, Pachmari 15 cm, Mandla 11 cm, Chindwara and Hoshingabad 9 cm each, Narsinghpur 8 cm and Betul 7 cm on 12th.

Under the combined influence, southeast Madhya Pradesh and adjoining northeast Madhya Pradesh (the source region of the rivers mentioned above) had heavy rainfall and large areas of Gadarwada and Narsinghpur Tehsils were flooded.

3. *Rivers in Uttar Pradesh and Punjab in floods during the second and third weeks of August 1964*

In Uttar Pradesh, Ghagra, Narora and Ganga (at Chowkaghat) were above danger level on several days during the above period. River Rapti was also in floods during the period. Area of more than 2 lakh acres, 603 villages and 1307 houses and about one and half lakh people were affected due to flooding of these rivers in Uttar Pradesh. Also due to floods in Yamuna, overflow from Drain No. 6 and release of water from Dhansa Bund, immense damage and devastation to property and crops worth several lakhs and pollution of water supply were reported in and around the Union Territory of Delhi.

These floods were caused by the movement of three Bay depressions in quick succession through central and northwestern parts of the country during the period. The movement of two of these depressions have already been discussed in connection with floods in southwest Madhya Pradesh. A third depression formed over northwest Bay on 15th with centre near 21·0°N and 87·5°E. It moved northwestwards, crossed coast near Balasore and weakened into a low pressure area over northeast Madhya Pradesh and east Uttar Pradesh on 17th. It merged into a seasonal low on 18th. Under the influence of these pressure systems monsoon was active during the second and third weeks of August over Uttar Pradesh and adjoining Punjab (India). Fairly widespread rain with scattered heavy falls occurred in the area. The chief amounts of rainfall were —

Lucknow (Amausi) 15 cm on 6th, Aligarh 18 cm on 15th, Meerut 17 cm on 15th, New Delhi 13 cm on 15th, Ferozpur 19 cm on 18th and Bhatinda 13 cm on 18th.

4. *Unprecedented floods in Andhra Pradesh and Interior Mysore during the period 27 September and 3 October 1964*

Heavy and unprecedented rains occurred in Kurnool, Mehbubnagar and other coastal districts of Andhra Pradesh. The first report about floods in Andhra Pradesh, described as unprecedented and worst in living memory, appeared in newspapers on the evening of 29 September. The three coastal districts of Krishna, west Godavari and Guntur were worst affected. Some areas of Mysore State also received heavy rains during the end of September. According to newspaper reports, 450 fishermen who left the shores of Kakinada and neighbouring villages in 75 boats on 26th and 27th were reported to be missing on high seas (but all except a few of them returned safely later). In Krishna and Godavari districts rivers Krishna, Bhumsa, Budamern were in high floods as a result of heavy rains in the catchment areas. Several parts of Vijayawada town were reported to be under 8 feet of water. The city was cut off from the rest of the country due to complete dislocation in rail, road and telegraphic communications. Large areas of paddy fields were also under water. High floods in Chandravanka river and breaches in an irrigation tank inundated Macherla Town (in Guntur district) in the early hours of 29th. Several villages in Krishna and Guntur districts were marooned. On 30th, the maximum discharge of the Krishna at Vijayapuri at the Bridge site below the Nagarjunasagar dam was estimated as 12 lakh cusecs. As a result, some spans of the newly constructed bridge across Krishna at Vijayapuri were washed away. The floods took a toll of 80 human lives including 70 in Machrela. Bijapur district in Mysore State was also affected by heavy rains and 21 deaths were reported to have occurred in various parts of the district mainly due to house collapse.

According to the Union Ministry of Irrigation, crops over 8 lakh acres were affected and loss of paddy was estimated as worth Rs. 24 crores.

The heavy rains in Andhra Pradesh and other parts of the north Peninsula were caused by a deep depression in the Bay during its westward movement across Andhra Pradesh between 27 September and 1 October 1964. A well marked low pressure area moved from east into the central Bay of Bengal where it concentrated into a deep depression by the evening of 27 September when it was centred near 17·0°N and 85·5°E. It crossed coast near Kakinada during the night of 27-28th and weakened into a low pressure area over Telangana and adjoining north Interior Mysore by 30th. Heavy rainfall, mostly confined to a narrow belt comprising Krishna district and southern portion of east and west Godavari districts was reported on 28th. By the next morning, heavy rainfall had extended westwards along the catchment of the Krishna river upto Raichur, the area of heavy rainfall being confined to about 50 miles on either side of river Krishna. The heaviest rainfall in and around Rentachintala covering the extreme northern parts of Guntur district and adjoining Krishna district on 28th and 29th was responsible for the heavy floods. The heavy rainfall area shifted westwards and on 30th morning the maximum rainfall was in Raichur and other districts of north Interior Mysore, Telangana and Rayalaseema.

Some of the heavy falls recorded were — Gannavaram 10 cm on 28th and 12 cm on 29th, Kurnool 13 cm on 29th, Raichur 15 cm on 30th, Sholapur 12 cm on 30th, Bijapur 11 cm on 30th, Mahbubnagar 10 cm on 30th and Jeur 10 cm on 30th.

Detailed storm study of this heavy rainfall could not be carried out due to non-receipt of daily rainfall data from the State Raingauge stations in Andhra Pradesh and Mysore. The schematic representation of rainfall during the rainspell of 27 September to 3 October 1964 (supplied by the Regional Meteorological Centre, Madras) for the affected areas of Andhra Pradesh and Interior Mysore is given in Fig. 3.

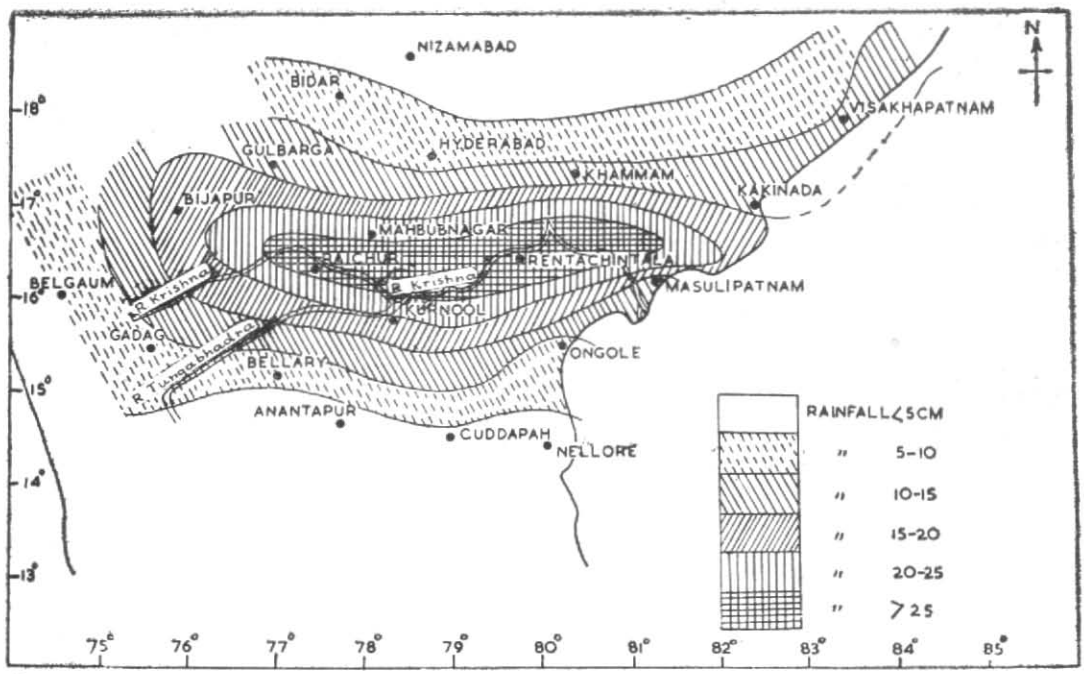


**Fig. 3. Schematic representation of rainfall in Andhra Pradesh and Interior Mysore during 27 Sep — 3 Oct 1964**

### 5. Conclusions

The salient features of the monsoon rainfall during the southwest monsoon season of 1964 and the associated floods over the country may be summarised as follows —

(1) Due to absence of prolonged 'breaks' in monsoon there were no major floods in the upper catchments of Himalayan rivers except Brahamaputra.

(2) As the axis of the seasonal trough lay mostly to the north of its normal position, most of the catchment areas of central India and Peninsular India (except Krishna catchment during end September) did not receive heavy rain and major floods did not occur in the rivers like Mahanadi, Godavari, Narbada and Tapti.

(3) Abnormal rains occurred over the plains of north India in the month of July particularly in Punjab including the Union Territory of Delhi and adjoining U. P. where Delhi recorded an all-time high rainfall of 538·2 mm for the month of July which was more than three times the normal figure. This resulted in heavy local flooding in Greater Delhi and surrounding areas.

(4) Rajasthan which witnessed unusually severe drought conditions during the previous monsoon season received more than normal rainfall during 1964 and generally no region experienced droughts during the season.

(5) Unusually heavy rains and floods occurred in Andhra Pradesh and adjoining Interior Mysore during the last week of September in association with westward movement of Bay depression across north Peninsula.