

## ANALYSIS OF SEVERE RAINSTORM OF 23-25 JULY 1989 OVER NORTHERN HALF OF THE INDIAN PENINSULA.

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**ABSTRACT:** The rainstorm of 23-25 July, 1989 over the northern peninsular states of Maharashtra, Andhra Pradesh and adjoining regions has been analysed by the Depth-Area-Duration (DAD) technique. This rainstorm was associated with the movement of a cyclonic disturbance from the Bay. Unlike July cyclonic disturbances, this disturbance originated in a more southerly latitude and crossed the northern half of the Indian peninsula from south-east to northwest during 23 to 26 July. This rainstorm was an unique one as it gave two separate distinct rainstorm cells with centres at Bhir (Lat.  $19^{\circ}00'$  Long.  $75^{\circ}46'$ ) and Bhira (Lat.  $18^{\circ}27'$  Long.  $73^{\circ}24'$ ). Comparison of DAD statistics of this rainstorm with similar data of past severe rainstorms of the region has shown that this rainstorm can be considered to be one of the major severe rainstorms of this region.

### Introduction :

Incidence of intense rainfall normally occurs over some part or other of the country during the southwest monsoon months of June to September in association with meteorological situations like passage of depressions/cyclonic storms. In the last week of July, 1989, northern peninsular states of Maharashtra and Andhra Pradesh experienced one of the worst cyclonic storms/depressions from the Bay in recent years, due to which torrential rains lashed many parts of these two states. Heavy to very heavy rainfall were reported by many stations and interestingly a good number among them were from the low rainfall regions of Marathwada, Madhya Maharashtra, Rayalaseema and Telangana. Rainfall was exceptionally heavy during 23-25 July which caused terrible human hard-

ships and resulted in heavy loss of life and property by inundating low lying areas, disrupting rail and road communications, breaching of many irrigation tanks and causing floods in different rivers of the two states. This cyclonic disturbance claimed more than 140 lives in Andhra Pradesh while high winds accompanied with heavy rain and flash floods took a toll of about 916 lives in Maharashtra state. Damage to roads, buildings and power stations in rural areas of Maharashtra alone was estimated to cost over Rs. 91 crores (Gupta et al, 1990).

Considering the above, an attempt has been made in this study to analyse heavy rainspell of 23-25 July, 1989 in order to know whether it was an unprecedented rainspell over the northern peninsular states of Maharashtra and Andhra Pradesh or not? This information may

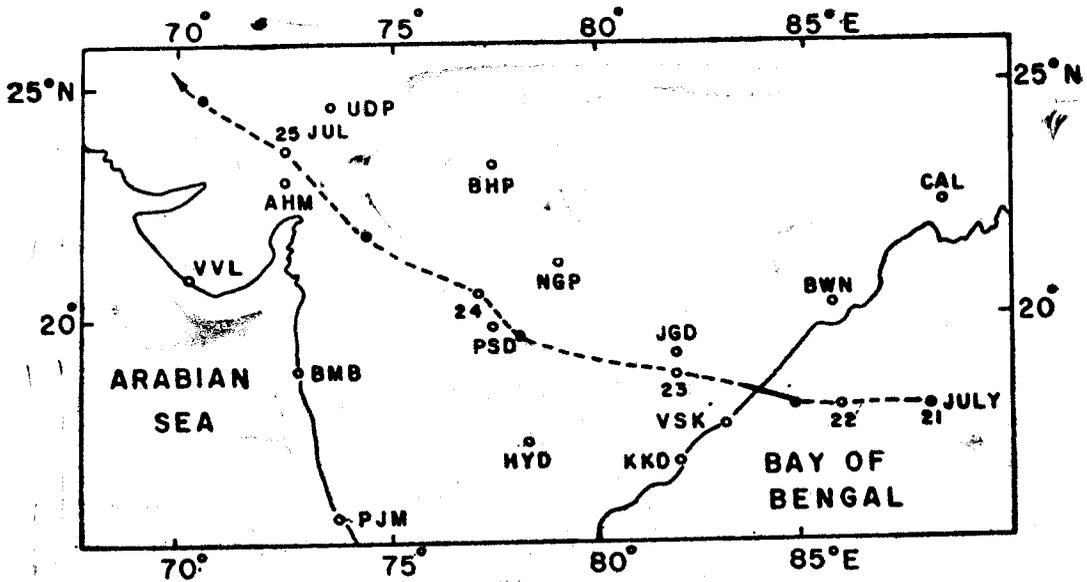


FIG-1 : TRACK OF THE JULY, 1989 CYCLONIC STORM / DEPRESSION

— CYCLONIC STORM  
 - - - DEPRESSION

• POSITION AT 12 UTC  
 ◦ POSITION AT 03 UTC

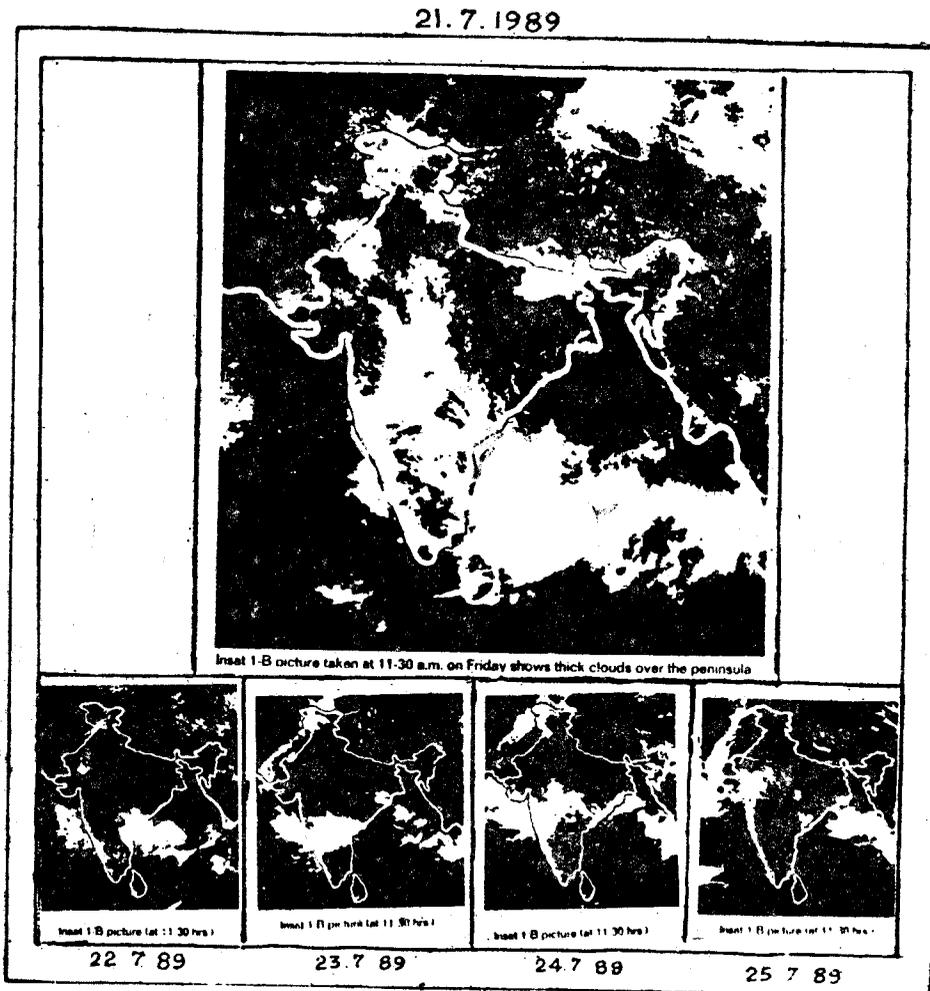
also be helpful to various agencies dealing with planning and design of water resources projects of that region.

## 2. Attendant meteorological situations which caused heavy rainfall during 23-25 July, 1989 :

A deep depression was formed over the west central and adjoining northwest Bay and was centred near Lat.  $18^{\circ}\text{N}$  and Long.  $86^{\circ}\text{E}$  at 0830 hrs IST of 22 July. It intensified into a cyclonic storm by the evening and lay centred at 1730 hrs IST near Lat.  $18^{\circ}\text{N}$  and Long.  $84.5^{\circ}\text{E}$ . Moving westwards it crossed north Andhra Pradesh coast near Visakhapatnam in the early morning of 23 July and weakened into a deep depression in the same evening close to Pusad. It weakened further into a well marked low pressure area over southern parts of Rajasthan and adjoining Kutch and south

Pakistan on 26 July and became unimportant on 27 July. Figure 1 shows the track of the above Bay cyclonic storm/depression during its travel across the country. Heavy rainfall over the northern peninsular Indian region in association with the passage of the above cyclonic system was found to be due to the following reasons:—

- i) Track of the depression was across these regions,
- ii) There was strong low level wind shear.
- iii) Long travel of the intense system over the land areas and
- iv) This system had a southerly tilt with height causing extension of rainfall belt upto a more southerly latitude than usual.



(Fig. 2)

Figure 2 shows the satellite cloud patterns associated with the passage of the above cyclonic system during its life span of 21-25 July, 1989.

Heavy rainfall was also reported by many stations from the coastal belt of Maharashtra and adjoining regions. Reasons for this heavy rainfall have been looked into. Paul et al, (1990) while analysing the flux of moisture into the July, 1989 depression field have stated that because of more southward location of the track during its westward travel and nearness to the sources of moisture

on both sides (Bay of Bengal to the east and Arabian Sea to the west) the July, 1989 depression found itself in an environment of deep moist monsoon air throughout its long travel over the land area. The upper air circulation field during the passage of the depression showed that the depression had a southward tilt with height by about  $3^{\circ}$  latitude from surface to 500 mbs level which was perhaps responsible for causing southward shift of the rainbelt. Rao et al, (1990) while analysing the Lower Krishna Floods of July, 1989 had also stated that when the above depression crossed Long.  $78^{\circ}\text{E}$ .

on 23 July around 1200 hrs IST, currents from the Arabian Sea also started feeding moisture into the system and moisture depth during this cyclonic system was upto a height of about 6 km. A trough of low on sea level chart off the west coast was also observed during this period.

### 3. Rainfall data used and methodology adopted for analysis:

Daily rainfall data of state rain gauge stations numbering about 260 in Maharashtra for the period 23-25 July, 1989 were collected from the Agriculture Department, Pune, while rainfall data of observatory stations were obtained from the Weather Central, IMD, Pune. Daily rainfall data for the same period for some stations in Andhra Pradesh, Karnataka, Madhya Pradesh and Gujarat were also collected from various Weather Bulletins of IMD.

Heavy rain spell of 23-25 July, 1989 has been analysed by Depth-Area-Duration (DAD) technique following the procedures as laid down in WMO (1969) and IMD (1972) manuals on hydro-meteorological analysis of rainstorms. By analysis a rainstorm using the DAD technique, a three dimensional relationship is obtained between maximum average rain-depth (D), over different areas (A) which came under the influence of the rainstorm, during different durations (D) of the rainstorm.

### 4. Maximum one-day rainfall :

While scrutinizing the daily rainfall data of 23-25 July, 1989 rainstorm it was found that many stations received heavy to very heavy rainfall. Stations which re-

corded 30 cm or more of rainfall in a 3-day period have been extracted and are given in Table 1. This table also shows highest ever recorded 1-day rainfall, 100-yr one-day rainfall (Dhar et al, 1982, Rakhecha et al, 1990) and one-day probable maximum precipitation (PMP) (IITM, 1989) values for these stations. From a perusal of Table 1 it is seen that there were 21 stations which have recorded 30 cm or more of rainfall during the 3-day period. It is seen from this table that Bhira, a station in Raigarh district of Maharashtra recorded 71.3 cm of rainfall on 24 July. This amount was found to be the highest 1-day rain amount recorded by any station in India during 1989 monsoon season.

Comparison of heavy rainfall for stations of July, 1989 rainstorm with those of highest ever recorded one-day rain amounts for the same stations (see Table 1), shows that there were 6 stations in the present rainstorm which had surpassed their previous highest one-day rainfall. It is also seen from Table 1 that there were 7 stations which had exceeded their respective estimates of 100-year one-day rainfall. Probable maximum precipitation (PMP) is defined as the upper limit of rainfall for a given station or an area for a given duration. It is seen from Table 1 that rainfall of 34.6 cm on 24 July recorded at Bhir station was almost equal to its one-day PMP. On the day of landfall of the depression on 23 July some stations along the east coast also reported very heavy rainfall which are not given in Table 1. Those are Aatreypuram (E. Godavari) 63 cm, Koderu (W. Godavari) 42 cm, Nidadevolu (W. Godavari) 39 cm, Chintalapudi (W. Godavari) 37 cm and Kak'nada (E. Godavari) 30 cm.

Table 1 : List of stations which have recorded 30 cm or more rainfall during 23-25 July, 1989.

Sr. No.	Name of the station	District	State	23/7	24/7	25/7	3-day total rainfall (cm)	Highest ever 1-day rainfall (cm)	100-year 1-day rainfall (cm)	1-day PMP (cm)
1.	Bhir	Bhir	Maharashtra	2.8	34.6	1.8	39.2	19.2	19.5	35.0
2.	Bhira	Ra'ghar	"	2.2	71.3	22.2	95.7	—	43.0	79.0*
3.	Bhivandi	Thana	"	10.8	30.8	4.3	45.9	37.8	38.9	64.7
4.	Billoli	Nanded	"	11.0	20.2	0.5	31.7	—	19.0	47.0
5.	Bombay (Colaba)	Colaba	"	7.5	18.3	10.7	36.5	57.0	38.0*	78.0*
6.	Chandgad	Kolhapur	"	16.4	27.6	15.3	59.3	26.6	28.9	50.0
7.	Dapoli	Ratnagiri	"	25.1	33.7	9.7	68.5	28.0	33.3	51.3
8.	Gagan-bavada	Kolhapur	"	25.0	49.9	8.7	83.6	36.8	41.1	54.9
9.	Guhagar	Ratnagiri	"	27.2	14.4	8.6	50.2	27.4	33.8	55.8
10.	Harnai	Ratnagiri	"	20.5	10.2	4.9	35.6	80.0	40.0*	82.0*
11.	Lanja	Ratnagiri	"	23.5	24.5	7.4	55.4	25.4	32.3	50.9
12.	Mahabale-shwar	Satara	"	5.4	33.1	28.1	66.6	45.8	51.8	67.8
13.	Murbad	Thana	"	5.2	33.7	7.7	46.6	38.6	35.6	61.3
14.	Radha-nagari	Kolhapur	"	22.0	39.0	11.1	72.1	31.2	34.0	52.7
15.	Rajapur	Ratnagiri	"	22.3	26.7	5.3	54.3	34.4	35.3	56.4
16.	Ratnagiri	Ratnagiri	"	23.8	19.5	4.6	47.9	35.6	36.1	57.8
17.	Agumbe	Shimoga	Karnataka	26.8	23.4	20.7	70.9	62.0	57.6	76.2
18.	Bodhan	Nizamabad	Andhra Pradesh	20.0	18.0	—	38.0	25.0*	—	52.0*
19.	Karim-nagar	Karimnagar	"	13.3	19.0	—	32.3	16.6	19.8	40.8
20.	Khammam	Khammam	"	25.3	6.4	0.9	32.6	29.9	23.6	52.4
21.	Medak	Medak	"	17.0	16.0	0.1	33.1	21.0	23.1	46.3

\*Values picked up from the respective generalized maps of the region.

**Table 2 : DAD raindepths (cm) of 23-25, July, 1989 rainstorm cell over Maharashtra and Andhra Pradesh region and its comparison with past severe rainstorms of the region**

Sr. No. Rainstorm	Storm Centre (District)	Point	Areas in hundreds of sq. km								
			5	10	30	50	100	200	300	400	500
1. 27 June 1914	Parabhani (Parabhani)	40.1	38.5	36.7	31.9	28.6	24.2	21.1	19.7	18.4	17.3
2. 17 June 1927	Arvi (Wardha)	29.1	28.2	27.5	24.7	22.1	17.8	14.5	12.9	11.5	10.5
3. 14 Aug. 1953	Ahiri (Chanda)	32.0	31.0	30.6	28.5	26.8	23.8	19.2	16.2	14.2	12.8
4. 13 Aug. 1986	Rajura (Chanda)	31.0	29.4	28.4	26.6	25.5	23.5	22.0	19.6	18.8	18.1
5. 27 Sept. 1908	Sangareddy (Medak)	30.7	30.1	28.9	26.6	25.0	23.0	20.6	18.6	16.8	15.3
6. 15 July 1965	Nizam Sagar (Nizam Sagar)	50.6	44.5	39.4	28.9	24.5	20.2	16.4	14.5	13.6	12.8
7. 23 July 1967	Bhopalpatnam (Bastar)	14.4	14.2	14.0	13.3	12.6	11.0	8.6	7.0	6.2	5.9
8. 9 Aug. 1983	Huzurabad (Karimnagar)	32.0	30.5	29.0	24.7	21.2	20.0	17.1	15.5	14.1	13.5
9. 24 July 1989	Bhir (Bhir)	34.6	31.9	28.6	22.9	20.7	18.6	17.0	16.3	15.8	15.3

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**Table 2 Contd.**  
**Table 2 : DAD raindepths (cm) of 23-25, July, 1989 rainstorm cell over Maharashtra and Andhra Pradesh region and its comparison with past severe rainstorms of the region**  
 (2 - day Duration)

Sr. No.	Rainstorm	Storm Centre (District)	Point	Areas in hundreds of sq. km									
				5	10	30	50	100	200	300	400	500	
1.	26-27 June 1914	Parbhani (Parbhani)	35.8	55.2	54.8	53.5	51.3	46.7	38.7	34.2	31.3	28.8	
2.	17-18 June 1927	Arvi (Wardha)	37.7	35.8	34.2	29.3	26.2	23.2	20.4	18.7	17.2	16.1	
3.	13-14 Aug. 1953	Ahiri (Chanda)	47.2	46.5	45.8	43.0	40.5	36.2	29.9	26.0	23.0	21.0	
4.	13-14 Aug. 1986	Rajura (Chanda)	61.2	59.8	58.3	54.0	50.9	46.0	39.8	35.2	32.1	29.9	
5.	27-28 Sept. 1908	(Hyderabad) Ibrahimpatam	48.0	46.0	43.1	36.8	35.1	33.0	30.5	28.4	26.5	24.7	
6.	14-15 June 1965	Nizam Sagar (Nizam Sagar)	53.6	43.7	40.8	31.3	27.1	23.0	20.0	19.0	18.3	17.8	
7.	23-24 July 1967	Nagasampalli (Medak)	36.7	33.6	30.0	23.8	20.9	17.6	14.2	12.4	11.7	11.1	
8.	9-10 Aug. 1983	Huzurabad (Karimnagar)	37.0	36.0	35.0	31.9	29.0	24.0	21.0	19.3	18.0	17.4	
9.	23-24 July 1989	Boddhan (Nizamabad)	38.0	37.8	37.4	36.7	36.0	34.6	32.3	30.4	28.9	27.5	

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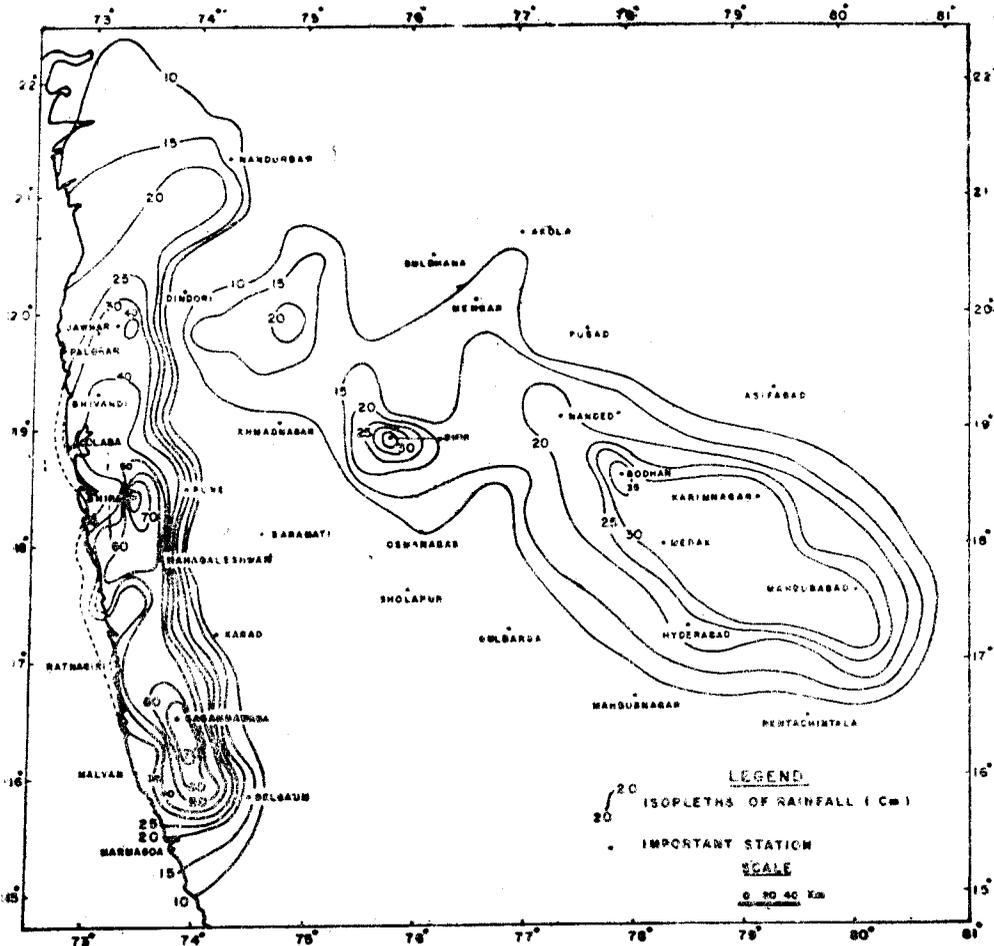
(3-day Duration)

Sr. No.	Rainstorm	Storm Centre (Distr.ct)	Point	Area in hundreds of sq. km.								
				5	10	30	50	100	200	300	400	500
1.	17-19 June 1927	Arvi (Wardha)	38.4	36.6	35.1	31.0	28.4	25.8	23.4	22.2	21.2	20.2
2.	13-15 Aug. 1953	Ahiri (Chanda)	49.2	48.8	48.2	46.6	44.9	40.9	35.2	31.8	29.1	27.1
3.	12-14 Aug. 1986	Rajura (Chanda)	66.2	64.4	62.8	58.1	54.8	49.0	43.0	39.8	38.2	37.2
4.	27-29 Sept. 1908	Ibrahimpatam (Hyderabad)	48.5	46.0	43.4	39.6	38.2	35.9	33.0	30.7	28.6	26.8
5.	13-15 July 1965	Nizam Sagar (Nizam Sagar)	59.7	49.4	45.4	35.8	29.9	26.8	22.6	20.6	19.7	19.0
6.	22-24 July 1967	Nagasampalli (Medak)	42.2	38.0	34.9	27.1	24.0	20.5	17.5	15.7	14.0	12.7
7.	9-11 Aug. 1983	Nizamabad (Nizamabad)	47.0	44.2	42.5	37.3	34.0	28.0	26.8	25.7	24.7	24.0
8.	23-25 July 1989	Bhir (Bhir)	39.2	38.9	38.8	38.1	37.5	36.1	33.7	31.7	29.8	28.3

**5. Depth-Area-Duration (DAD) analysis of July, 1989 rainstorm :**

In order to know the areal extent and raindepths over different areas and durations of the July, 1989 rainstorm, heaviest 1, 2 and 3-day rainfall of all available stations in and around the affected regions of Maharashtra and Andhra Pradesh were plotted on large scale base maps for detailed analysis. Scrutiny of rainfall data showed that there were two separate distinct rainstorm cells during

the same period of 23-25 July, one over the plain area regions of Maharashtra and Andhra Pradesh and another along the coastal belts of Maharashtra and Karnataka. Occurrence of two distinct rainstorm cells simultaneously during this rainspell is the most interesting feature of this rainstorm. Isohyetal maps of 1 to 3 days for each of these two rainstorm cells were drawn for DAD analysis. The isohyetal patterns of the rainstorm over the coastal region have been drawn keeping in view the orography of the region.



**FIG. 5: ISOHYETAL PATTERN OF THREE-DAY (23-25 JULY, 1989) RAINSTORM OVER MAHARASHTRA AND ANDHRA PRADESH.**

DAD statistics of the first cell of the rainstorm over the plains of northern peninsula are given in Table 2 upto an area of 50,000 sq. kms and for 1, 2 and 3-day durations. Centre of this cell was at Bhir in the Bhir district of Maharashtra which recorded 34.6 cm, 37.4 cm and 39.2 cm of rainfall during 1, 2 and 3-day durations respectively while over 50,000 sq. km area it yielded raindepths of the order of 15.3 cm, 27.3 cm and 28.3 cm respectively during 1 to 3-day durations. DAD analysis of this rainstorm cell has, however, shown that it has contributed raindepths upto an area 1,50,000 sq. km but areal raindepths upto 50,000 sq. km area are only given in this study. Figures 3 to 5 show the isohyetal patterns of 1, 2 and 3-day durations of the above rainstorm cell over the northern peninsular states of Maharashtra and Andhra Pradesh.

Areal raindepths obtained from the DAD analysis of the second cell of the rainstorm over the coastal regions of Maharashtra and Karnataka are shown in Table 3 for 1, 2 and 3-day durations upto 50,000 sq. km area. The centre of this coastal rainstorm was at a station called Bhira in the Raigarh district of Maharashtra which recorded 71.3 cm, 73.5 cm and 95.7 cm of rainfall during 1, 2 and 3-day durations respectively. This rainstorm has yielded raindepths of 25.0 cm, 41.7 cm and 51.0 cm for 1, 2 and 3-day durations respectively over 30,000 sq. km area. Isohyetal map of 3-day of this rainstorm is shown in Figure 3.

#### **6. Comparison of July, 1989 rainstorm with the past severe rainstorms of the region :**

DAD values of the July, 1989 rainstorm cells over plains of Maharashtra and Andhra Pradesh have been com-

pared with similar DAD data of past severe rainstorms which occurred in and around the northern peninsular region. Dhar et al (1990) while analysing severe rainstorms over the peninsular states of Maharashtra, Andhra Pradesh and Karnataka had identified 9 severe rainstorms from each of these states. From an examination of these rainstorms, it was found that in and around the region of occurrence of the July, 1989 rainstorm, 8 severe rainstorms in the past have occurred, based on the analysis of rainfall data of 1891 to 1986. Raindepths of these 8 severe rainstorms for 1 to 3-day durations and upto an area of 50,000 sq. km are given in Table 2 along with DAD values of the July, 1989 rainstorm. From the comparison of DAD values of July, 1989 rainstorm with those of past severe rainstorms it is seen that the rainstorm of 12-14 August, 1986 with centre at Rajura in Chanda district and 26-27 June, 1914 with centre at Parabhani in the Parabhani district of Maharashtra were more severe than the July, 1989 rainstorm. The DAD values of July, 1989 rainstorm were, however, found to exceed or equal to raindepths of other past severe rainstorms given in Table 2 over certain size of areas for durations of 1 to 3-day. Thus the DAD of July, 1989 rainstorm though not unprecedented, it can be considered as one of the severe rainstorms of northern peninsular region.

The second cell of the rainstorm occurred along the Maharashtra-Karnataka coast and its pattern was exactly like the storm pattern of the 1-3 July, 1941 rainstorm. The July, 1941 rainstorm is the most severe rainstorm over the Indian region (Dhar et al, 1984) whose raindepths have not been surpassed by any other severe rainstorm uptill now. DAD

Table 3 : DAD statistics (in cm) of 23-25 July, 1989 rain storm cell, over coastal Maharashtra and adjoining regions and 1-3 July, 1941 rainstorm over south Gujarat-north Konkan region.

Area (Sq. km)	1-day		2-day		3-day	
	24/7/89	2/7/1941	23-24/7/89	2-3/7/1941	23-25/7/89	1-3/7/1941
Point	71.3	98.8	74.9	127.0	95.7	144.8
500	52.5	90.4	72.2	122.5	86.0	138.0
1,000	47.0	84.5	71.0	118.0	83.5	133.5
3,000	38.2	71.7	64.5	105.0	76.0	123.5
5,000	35.2	65.0	59.7	97.0	71.0	117.0
10,000	32.0	53.5	52.5	83.2	64.0	104.5
20,000	28.0	42.5	46.5	66.0	56.2	86.0
30,000	25.0	36.0	41.7	55.5	51.0	75.5
40,000	—	31.0	38.2	48.0	46.0	66.5
50,000	—	27.5	34.9	43.0	42.0	59.0

values of July, 1989 coastal rainstorm cell has been compared with those of July, 1941 rainstorm (see Table 3). This comparison, however, confirms that the July, 1941 rainstorm was far more severe in comparison than the July, 1989 rainstorm. The isohyetal patterns of such coastal rainstorms may not be used for transposition in the interior of the region as the coastal rainstorms cannot be transposed far into the interior because they lose most of their rain giving characteristics. It is, however, suggested that the isohyetal patterns of July, 1989 coastal rainstorm may be used for transposition purpose along and up and down the Maharashtra-Karnataka coast.

### 7. Summary and conclusions :

From the foregoing the following conclusions have emerged from this study:—

- i) The Bay cyclonic system responsible for July, 1989 rainstorm which had had a southerly tilt with height cause extension of rainfall belt up to a more southerly latitude than usual.
- ii) During July, 1989 rainstorm, some of the stations located in the drought prone areas of northern peninsula like Marathwada, Telangana, etc. received heavy rainfall.
- iii) During a 3-day period of 23-25 July, 21 stations received 30 cm or more rainfall. Bhir, centre of the rainstorm cell over the central plains recorded 34.6 cm of rainfall on 24 July, 1989 which is found to be almost equal to its PMP magnitude. Bhira, centre of the rainstorm cell over coastal region of Maharashtra recorded 71.3 cm of rainfall on 24 July which is the highest one-day

rainfall recorded by any station in India during 1989 monsoon season.

#### iv) Comparison of DAD values of July,

1989 rainstorm cell over the plains of northern peninsula with similar data of past severe rainstorms of this region has shown that raindepths of July, 1989 rainstorm were not unprecedented. However, average raindepths of this rainstorm were found to exceed or equal to raindepths of some of the past severe rainstorms which occurred in and around the region. Considering this fact the July, 1989 rainstorm cell over the plains of northern peninsula may be considered as one of the severe rainstorms in the region.

#### v) The rainspell of 23-25 July, 1989

has been found to be an unique one as it has given two separate cells of rainstorm patterns during the same period. Occurrence of such incidence perhaps is the first instance in the analysis of rainstorms.

It may, however, be mentioned that though the heavy rainfall associated with this rainstorm caused devastation and damage to crops and also local flooding, on examination of flood levels of major rivers of the region, it is seen that nowhere any major floods occurred. This indicates that these rivers have greater channel capacities to sustain such heavy spells of rain.

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