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A severe flood in Luni basin, western Rajasthan during July 1979 — A case study

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सार — 15 से 17 जुलाई 1979 के दौरान राजस्थान में सक्रिय से भयानक मानसून दशाओं के कारण एक सुस्पष्ट निम्न का प्रार्दुभाव हुआ जिससे पश्चिमी राजस्थान की लूनी बेसिन में विनाशकारी बाढ़ आई ।

इस बेसिन की अनुकूल पूर्ववर्ती नम दशाओं, भू आकृतिज्ञ लक्षणों तथा मिट्टी के बांधों के टूटने से बाढ़ की स्थिति और भी बुरी हो गई ।

ABSTRACT. A well marked low resulting in active to vigorous monsoon conditions in Rajasthan during 15 to 17 July 1979 resulted in devastating flood in Luni Basin, western Rajasthan.

Favourable antecedent moisture condition, geomorphological characteristics of this basin and breaches in the earthen dams worsened the flood situation.

1. Introduction

The *Luni* with its tributaries, *viz., Jojri, Guhiya, Bandi, Sukri, Mitri, Jawai, Khari, Bandi, Khari* and *Sagi* forms the only integrated drainage system in the arid western Rajasthan. It rises in the Aravalli hill ranges near Ajmer (26° 27′N, 74° 39′E) and after an initial SW/W course towards Barmer flows SW until it drains into the NE corner of the Rann of Kutch (Fig. 1). This river system is occasionally in spate due to torrential rains during monsoon period and remains dry during rest of the year. The approximate basin area of the *Luni* is 34,866 sq km (CAZRI 1963). The peculiarity of this river system is that it tends to increase its width rather than deepen the bed. This is because floods develop and disappear so rapidly that they have no time to scour the bed and develop stable channel section. As a result it has a mean depth of 2.4 m and width of 1159 m (CAZRI 1963).

The entire Luni basin is situated on hard rock and massive rock formations composed of volcanics, crystallines and metamorphics. All these formations occur at very shallow depths below alluvium and/or below sand cover varying from less than 1 m to over 4 m. Occurrence of lime carbonate pan, which is hard, massive and impervious; is a common characteristics of the terrain and is encountered at depths varying from 13 to 112 cm in river courses and 48 to 152 cm in the planes (Roy *et al.* 1969).

A devastating flood occurred during July 1979 due to widespread heavy to very heavy rains from 15 to 19 July 1979 in the catchment areas of *Luni, Guhiya, Jojri* and *Bandi* rivers. This flood caused enormous destruction to agricultural fields, irrigation projects and movable and immovable properties in the catchments of these rivers and also in the downstream of river *Luni*. An analysis of this flood is attempted in this paper.

2. Synoptic situation

Monsoon had advanced into northeast Rajasthan on 11 July. A well-marked low pressure area lay over northeast Rajasthan and neighbourhood on 15 July. Moving to the west it lay over west Rajasthan on 16 and persisted there till 18 July. Then it moved northwards, weakened and merged with the seasonal trough on 19th. Under its influence monsoon advanced into west Rajasthan on 15th. Active to vigorous monsoon conditions prevailed over Rajasthan from 15 to 19 July.

3. Material and methods

Water balance study of the Luni basin has been initiated from 1979 under the water resources survey scheme of this institute (CAZRI). Under this study a raingauge network comprising of 241 standard raingauges has been installed in addition to the 100 raingauges maintained by

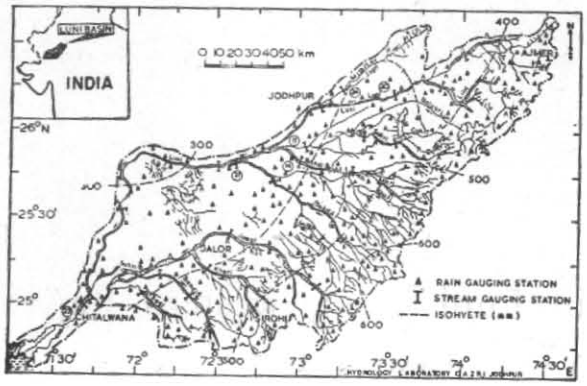

Fig. 1. Luni basin showing observation network for water balance study

TABLE 1

Individual and cumulative rainfall (mm) of 15 - 19 July 1979

Station	15 July	16 July	17 July	18 July	19 July	Total
Jojri						
Gagrana	139.0	54.3	81.2	40.5	50.4	365.4
Koaspura	38.8	227.3	64.0	55.0	85.6	470.7
Kosana	12.5	103.0	507.6	50.0	100.0	773.1
Kaparda	10.0	150.0	155.0	65.0	67.5	447.5
Binawas	25.0	190.0	262.5	232.5	—	710.0
Luni						
Deonagar	37.5	124.5	50.0	—	300.0	512.0
Nand	190.5	130.0	10.0	190.5	—	521.0
Nagelao	187.5	162.5	42.5	175.0	—	567.5
Suhawa	84.7	75.0	65.0	50.0	2.0	276.7
Babra	75.5	100.1	102.5	37.5	212.5	528.1
Gorawar	262.5	212.5	225.0	150.0	75.0	925.0
Nimbol	50.0	175.0	300.0	200.0	112.5	837.5
Bhavi	25.0	150.0	200.8	175.0	118.8	668.8
Olwi	171.3	197.5	183.0	31.3	—	583.1
Dhundara	28.4	221.0	134.6	60.6	—	444.6
Kusip	4.5	19.5	50.0	20.0	16.3	110.3
Padru	—	58.8	57.5	—	—	116.3
Tilwara	2.5	160.0	—	30.0	—	192.5
Sindari	—	25.0	68.8	—	—	93.8
Bhakarpura	18.8	58.8	35.0	3.8	—	116.4
Gadevi	80.0	50.0	30.0	—	—	160.0
Ranodar	18.0	36.3	3.8	—	—	58.1
Guhiya						
Lotiana	12.5	150.0	60.5	61.3	107.6	391.8
Piplia	62.5	73.6	125.5	124.0	126.5	512.1
Sarangwas	12.5	208.8	208.8	207.0	2.5	639.6
Chandawal	170.0	114.3	152.4	215.9	76.2	728.8
Jawai						
Bisalpur	56.3	125.0	93.8	12.5	—	287.6
Ludara	143.0	156.0	118.0	35.0	—	452.0
Posalia	39.0	183.7	185.4	5.1	—	413.2
Bamnera	37.5	82.5	97.5	—	—	217.5
Bithia	133.4	146.1	101.6	12.7	—	393.8
Guda Balotan	45.0	150.0	82.5	80.0	—	357.5
Ajitpura	2.8	20.3	90.3	74.2	9.0	196.6
Nosra	11.3	60.0	206.3	80.0	11.3	368.9
Keshwana	20.0	75.0	112.5	41.3	—	248.8
Khari						
Sindrath	34.0	50.0	37.5	12.5	—	134.0
Jawal	25.0	50.0	30.0	—	—	105.0
Mohabbatnagar	26.3	60.0	54.3	8.3	—	148.9
Ramseen	83.0	185.0	127.0	14.0	—	409.0
Akoli	90.0	215.0	190.0	42.0	—	537.0
Dhansa	3.8	11.3	48.8	41.3	—	105.2
Bhagli	25.0	37.5	37.5	10.0	—	110.0
Bandi A						
Sanpur	19.5	62.5	42.5	8.5	—	133.0
Chandur	95.0	175.0	150.0	38.0	—	458.0
Gadi	1.3	28.8	80.0	70.0	2.5	182.6
Khera	—	50.0	50.0	50.0	—	150.0
Narta	28.8	100.0	75.0	5.8	—	209.6
Daspan	45.2	198.4	202.5	51.6	—	497.7
Bagawas	27.0	235.0	140.0	—	—	402.0

TABLE 1 (*contd*)

Station	15 July	16 July	17 July	18 July	19 July	Total
Guhiya						
Rundia	150.0	250.0	200.0	170.0	—	770.0
Jhepelao	60.0	170.0	220.0	240.0	45.0	735.0
Bhakriwalagaon	150.0	150.0	200.0	100.0	—	600.0
Sonei Lakha	12.5	206.3	200.0	87.5	25.0	531.3
Bandi B						
Bhopari	112.5	175.0	137.5	182.5	82.5	690.0
Panota	21.0	175.0	134.0	188.0	12.0	530.0
Dhamli	17.5	104.0	133.8	91.0	16.8	363.1
Kherwa	150.0	200.0	212.5	55.0	35.0	652.5
Jetpur	155.0	220.0	150.0	82.8	—	607.8
Sukri B						
Rajpura	17.5	104.0	133.8	91.0	16.8	363.1
Narlai	109.0	127.0	72.0	24.0	—	332.0
Bijowa	10.0	87.0	64.0	91.5	17.3	269.8
Sanchori	—	233.7	129.8	193.0	55.0	611.5
Khod	—	112.5	162.5	137.5	37.5	450.0
Madri	20.0	80.0	100.0	85.0	—	285.0
Bhanwari	101.6	215.9	157.5	55.9	—	530.9
Bankli	12.5	12.5	175.0	150.0	22.5	372.5
Lalia	2.5	15.4	157.5	—	—	175.4
Sagi						
Malwara	9.0	75.0	62.5	12.5	—	159.0
Lokhawas	—	200.0	230.0	180.0	40.0	650.0
Pavli	28.8	75.0	42.5	10.5	—	156.8
Ropsi	—	110.0	130.0	150.0	—	390.0
Bhagal Bheem	—	17.5	87.5	75.0	—	180.0
Sewari	—	71.8	36.5	5.5	—	113.8
Thoban	—	76.8	50.0	—	—	126.8
Borli	7.5	52.5	36.3	—	—	96.3
Sukri A						
Bala	6.0	48.8	216.3	80.0	12.5	363.6
Rama	—	63.8	164.5	81.3	13.8	323.4
Ramniya	3.3	10.8	25.8	42.5	14.8	97.2
Otwala	40.0	100.0	180.0	35.0	—	355.0
Posana	—	13.3	68.3	62.5	8.0	152.1
Tilora	7.6	63.5	57.2	—	—	128.3
Jaisawas	—	73.2	58.4	8.9	—	140.5
Bagora	—	66.0	55.0	10.0	—	131.0
Ankhol	12.7	123.8	60.3	—	—	196.8
Mitri						
Latara	68.6	145.8	98.0	10.0	—	322.4
Dujana	66.0	120.0	70.0	5.5	—	961.5
Koselao	65.6	82.2	64.3	45.5	4.3	261.9
Pawa	10.0	93.8	11.3	75.0	21.3	211.4
Panchota	71.3	200.0	118.8	5.0	—	395.1
Nimbla	31.3	218.8	78.8	93.0	32.5	454.4
Mohiwara	62.5	125.0	200.0	—	—	387.5

various State Departments and Railways. For recording stream gauging data 23 stream gauging stations have also been established.

At each gauging site staff gauges have been installed and hourly gauge heights were recorded during the flow period. River cross-sections and L-sections were surveyed before and after the flood and average cross-sectional areas have been used to calculate the flow. Discharge at each site was calculated by Manning's formula taking value of rugosity coefficient as 0.02 (Hiranandani and Chitale 1964). From above analyses hydrographs between discharge and time were plotted and total volume of flood water passed through each site has been calculated.

4. Rainfall distributions

During this period most of the rainfall stations in the upper Luni basin have recorded far above their annual average rain (300-400 mm). The daily and cumulative rainfall of some of the individual stations, out of 341 raingauges is shown in Table 1. The total precipitation has been calculated based on the arithmetic means and is given in Table 2 along with the volume of water released by this storm in each catchment. The rainfall received during these five days was highest in Guhiya (613.5 mm) followed by upper Luni (586.5 mm), Bandi B (568.8 mm) and Jojri (553.3 mm) catchments. In comparison, during this period the catchments of central and lower Luni basin received the total rainfall of the order of 200-300 mm only. The highest 24 hour rainfall as can be seen from the Table 2 occurred on 17 July 1979 in Jojri and Guhiya catchments and on 16 July 1979 in upper Luni and Bandi B catchments. In general all of the sub-catchments of river *Luni* system recorded high rainfall on 16 and 17 July 1979.

TABLE 2

Catchment aerial precipitation and volume of water released by the rainstorm of 15-19 July 1979

S. No.	River/ catchment	The aerial precipitation (mm)						Volume* of water released ($m^3 \times 10^8$)
		15 July	16 July	17 July	18 July	19 July	Total	
1	Jojri	45.1	144.9	214.1	88.6	60.6	553.3	6.42
2	Upper Luni	111.3	154.8	131.3	107.0	82.1	586.5	28.16
3	Lower Luni	17.7	58.3	35.0	7.7	2.3	121.0	4.80
4	Guhiya	78.7	165.4	170.9	150.7	47.8	613.5	25.41
5	Bandi B	91.2	174.8	153.6	119.9	29.3	568.8	17.67
6	Sukri B	30.3	109.8	128.0	82.0	16.6	376.7	11.82
7	Mitri	53.6	140.8	91.6	33.4	8.3	327.7	4.37
8	Jawai	54.1	110.9	120.9	37.9	2.3	326.1	7.11
9	Khari	41.0	87.0	75.0	18.3	—	221.3	3.90
10	Bandi A	31.0	121.4	105.7	32.0	0.4	290.5	1.75
11	Sagi	5.7	84.8	84.4	54.2	5.0	234.1	1.88
12	Sukri A	7.7	62.6	98.4	35.6	5.5	209.8	3.61
	Total							116.9 11690 mcm

*Calculated from the isohyetal map, Fig. 2

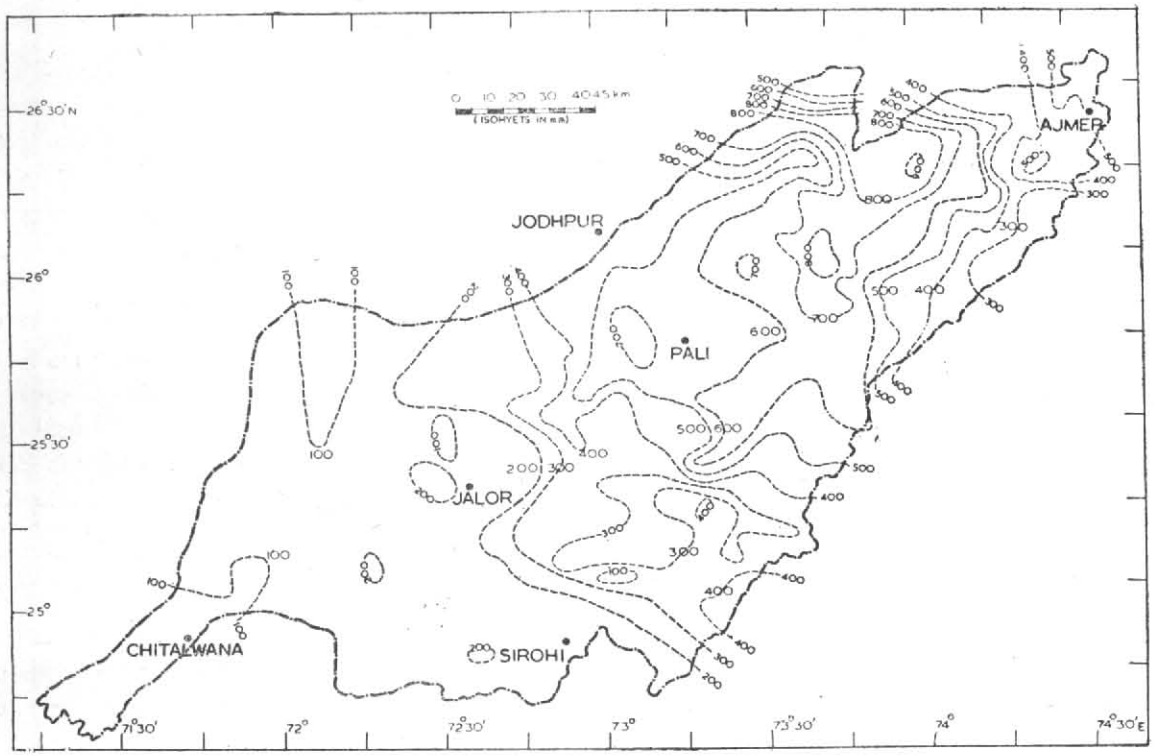

Fig. 2. Isohyets during 15-19 July 1979

Isohyetal map (Fig. 2) for these dates indicates that the maximum rainfall, *i.e.*, of the order of 700 to 900 mm occurred over Bilara, Jaitaran, Sojat and Kosana area in the upper Luni, Guhiya and Jojri catchments whereas 600 mm isohyet was concentrated over Bandi B catchment.

5. Flood situation

The details of the floods occurred during July 1979 are as follows :

(a) *River Jojri* (Gauging site No. 24, Fig. 1)

The *Jojri* river started flowing at 1000 IST on 16 July 1979 attaining a rise in the peak flow value of 6.40 m at 2345 IST on the same day. The corresopnding river discharge at this site reached the peak value of 6530 cumecs which continued for a little over 3 hours. Thereafter, it gradually receded to 1.5 m (460 cumecs) at 1500 IST on 20 July 1979. Total volume of flood passed during these days from this gauging site was 3.31×10^8 cu m which is equivalent to 51.6 per cent of the rainfall received in the catchment above this station.

(*b*) *River upper Luni* (Gauging site No. 20, Fig. 1)

This river started flowing at 0630 IST on 16 July 1979, crossed the danger level of 2.80 m at 1840 IST and recorded a peak flow of 4.50 m at 2000 IST on the same date. Peak discharge corresponding to this value was 5240 cumecs which continued for about 2 hours and thereafter dropped to 3.0 m (3000 cumecs) at 0800 IST on 17 July 1979. At this stage side bunds of the Jaswantsagar dam in upstream breached due to which the flow continued for a little over 72 hours with practically no change in the water level. Water level dropped below the danger mark at 0845 IST on 20 July 1979 and receded further to 1.5 m (80 cumecs) height on 21 July 1979 at 2000 IST. During this period the total water flow from this gauging site was 10.51×10^8 cu m which is equivalent to 47.8 per cent of the rainfall received in the catchment above this site.

(*c*) *River Guhiya* (Gauging site No. 17, Fig. 1)

Flow at this gauging site located near Rohat railway bridge was recorded on 16 July 1979 at 0700 IST. It crossed danger level of 2.70 m at 1130 IST and attained a peak, height of 3.0 m at 1200 IST on the same date. Peak discharge corresponding to this flow was 2420 cumecs. On the same day the river receded and dropped for a short duration below the danger level by 1600 IST. The flood level again started rising and crossed the danger mark at 0100 IST on 17 July 1979. During this pulse it attained a peak height of 4.0 m at 0900 IST on the same day. The discharge rate corresponding to this flow was 5800 cumecs which continued for 32 hours and dropped below the danger mark at 1100 IST on 20 July 1979. The receding to 1.15 m (95 cumecs) took place on 22 July 1979 at 1200 IST. During this period a total volume of 12.40×10^8 cu m flood water had passed through this gauging site which is equivalent to 48.8 per cent of rainfall received above this site in the catchment.

(*d*) *River Bandi B* (Gauging site No. 14, Fig. 1)

On filling up of the Hemawas reservoir constructed on this river, water started flowing through its channel which was recorded at gauging site located at Jetpur road culvert on 16 July 1979 at 0400 IST. The flow attained a peak height of 3.92 m at 1100 IST on the same date. The discharge rate corresponding to this peak flow was 1250 cumecs. The flow receded slowly to a height of 1.10 m (63 cumecs) on 21 July 1979 at 1730 IST. A total volume of flood water 2.53×10^8 cu m passed through this gauging site during this period, which is equivalent to 14.3 per cent of the rainfall received above the site in the catchment.

(*e*) *River Luni* (Gauging site No. 21, Fig. 1)

This gauging site is located in the middle course of river *Luni* where all of the above rivers join its main channel. The flow had reached at 0800 IST on 17 July 1979 at this site and crossed the danger level within 3 hours. Attaining

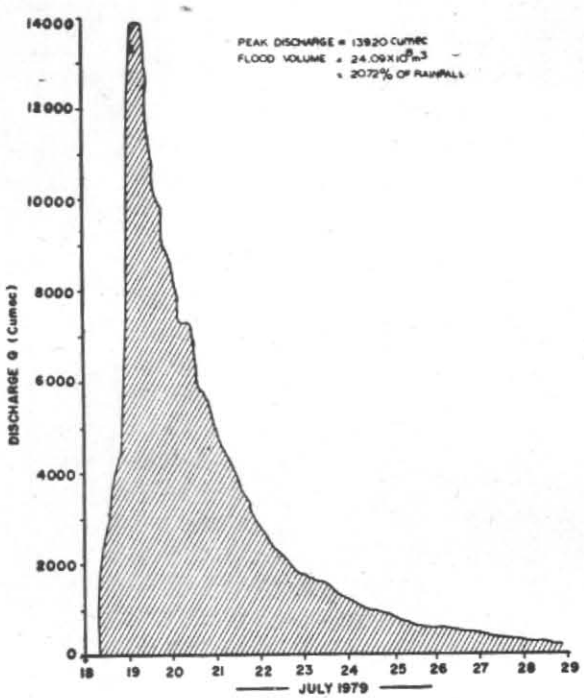

Fig. 3. Hydrograph at Gandav gauging site (site No. 23)

TABLE 3

Some hydrological characteristics of July 1979 flood in Luni basin, western Rajasthan

S. No.	Sub-basin/ basin	Gauging station	Peak discharge (cumec)	Flood volume (M cu. m)	Proportion of rainfall received above the station (%)
1	Mitri/Jojri	Bisalpur	6527	331	51.56
2	Guhiya	Rohat	5800	1240	48.80
3	Bandi B	Jetpur	1250	253	14.30
4	Luni	Bilara	5240	1051	47.80
5	Luni	Samdari	10520	2327	26.55
6	Luni (Basin out-flow)	Gandav	13920	2409	20.72

of peak flood height was delayed and reached 4.60 m on 18 July 1979 at 1400 IST. The corresponding computed peak discharge worked out to be 10520 cumecs. At 1700 IST on the same date water level started receding in different staged, *i.e.*, lowering the peak reached below the danger level and dropped to a height of 1.15 m at 2200 IST on 22 July 1979. The total volume of flood water passed through this gauging station during above period was 23.27×10^8 cu m; which is equivalent to 26.55 per cent of rainfall received above the site in the catchment.

(*f*) *Luni basin out-flow* (Gauging site No. 23, Fig. 1)

The basin outflow of river *Luni* before it culminates into Rann of Kutch was measured at Gandav road bridge site. The flood water reached at this site on 18 July 1979 at 0730 IST and crossed the danger mark attaining a peak height of 5.49 m on 19 July 1979 at 0100 IST. The corresponding discharge rate at this flood level was 13920 cumecs. From 0600 IST on the same date the water level receded gradually in stages, *i.e.*, lower below the danger mark and recorded a height of 1.52 m (960 cumecs) at 0900 IST on 24 July 1979. The total volume of flood water passed through this section during above period was 24.09×10^8 cu m which is equivalent to 20.70 per cent of the entire basin rainfall.

The above informations on peak discharge, flood volume and other hydrological characteristics of

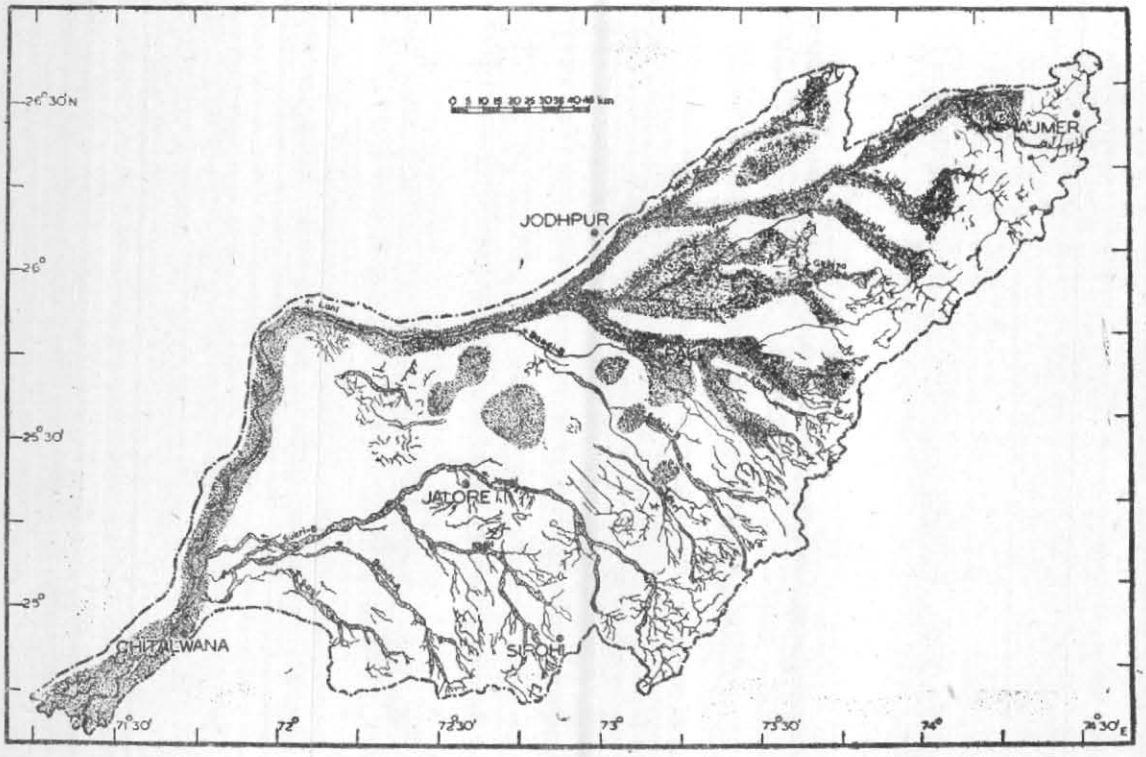

Fig. 4. Flood affected area in Luni basin, July 1979

TABLE 4

Changes in river sections due to flood of July 1979 in Luni basin, western Rajasthan

S. No.	Gauging station	Width of river section (m)		Approximate depth of sediment deposition (m)
		Before flood	After flood	
1	Bisalpur	112.4	523.5	1.50
2	Bhavi	40.0	667.2	2.80
3	Rohat	219.3	1361.8	0.95
4	Jetpur	506.5	506.5	Nil
5	Samdari	505.9	1185.9	1.00
6	Gandav	747.4	747.4	Nil

different sub-basins are given in Table 3 and a typical hydrograph recorded at the Gandav gauging station (basin out-flow) is depicted in Fig. 3.

6. Discussion

In all about 6846.5 sq. km (19.6 per cent of basin area) area of the Luni basin was affected due to this storm (Fig. 4).

An appraisal of the literature for the period 1917 - 1979 revealed that there are instances of heavy rainfall over the Luni basin in localised areas, *i.e.*, September 1924, August 1927, August 1931, July 1935, July 1943, September 1961, September 1967, July 1968 (Ramaswamy 1975), August 1973, August 1975 and August 1976(Rakhecha *et al.* 1979). No quantitative flood data were collected for these years. However, the volume of flood water generated during the present storm is 9.5 times of the annual average monsoon flow of 2.54×10^8 cu m (CAZRI, 1963), which gives an idea of the severity of present flood.

The changes in the river sections and allied feaures at the varous gauging stations are shown in Table 4. It has been generally observed that the sediments deposited during the current flood are mostly composed of coarse sand and gravels which is again indicative of torrential nature of rainfall and short distance transport of sediments.

7. Conclusion

From the above descriptions and discussions it is apparent that this flood was the result of a well marked low which caused widespread rains of five days duration over the drainage basin. Again rain, amounting to 45.1 to 111.3 mm had fallen on preceding day of 15 July 1979 in the upper Luni basin resulting into a favourable antecedent moisture condition. This together with the typical geomorphological features of the drainage basin already described must have favoured a rapid and massive expansion of the flood. The situation was further aggravated due to failure of the earthen dams. However, as usual in such a terrain, the flood water quickly ran out and did not remain standing for a long period in the flood plains.

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