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A study of July 1927 rain-storm which caused severe floods in the Baitarani delta

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ABSTRACT. The rain-storm of 28-30 July 1927 over the Baitarani basin in Orissa is reported to have produced severe floods in the deltaic area of the Orissa coast. This rain-storm was analysed by both depth-duration and depth-area-duration methods. The depth-area-duration analysis of the rain-storm showed that the average depth of 20 inches of rain occurred over an area of 5000 sq. miles in three days. The return period of this storm was calculated statistically and 2-day rainfall depth of 16·4 inches over the Baitarani basin was found to have a return period of about 525 years.

1. Introduction

Towards the end of July 1927, a severe flood occurred in the deltaic region of the Baitarani river in Orissa. The river gauge at Akhyapada, which is located at the head of the delta (Fig. 1) remained above the danger level of 63 feet for three days continuously. Mahalanobis (1941) estimated that the river would have touched the peak gauge of about 71 ft in the early hours of 30 July thereby remaining about 8 ft above the danger level. No proper estimate of the peak discharge is available for this flood and various estimates have been made which vary from 3 lakh to 11 lakh cusecs (1962). Since the primary cause of flood is the incidence of heavy rainfall in the catchment area of a river, in this note an estimate of the total rainfall that the Baitarani basin received during the three-day period of the rain storm has been made. In order to determine the return period of this rain storm, all the major rain storms over this basin since 1901 to 1961 (61 years) have been analysed by depth-duration method. Estimates of catchment rainfall have also been made for all those major flood-producing rain storms which occurred over the basin during the period 1921 to 1961 for comparison with the July 1927 rainfall depths.

2. Synoptic situation of 28 to 30 July 1927 rain storm

The flood was caused by a depression which originated in the head Bay of Bengal on 26 July. It intensified into a cyclonic storm with centre near about 20·5°N, 89°E on 27 July. On 28th morning it was centred about 75 miles eastsoutheast of Saugor Islands. It crossed coast during the course of day, weakened and lay on the evening of 28 July close to Calcutta as a depression. It moved in a westerly direction and was centred near Midnapur on 29 July morning while causing heavy rainfall in the southwestern sector. The heavy rain centre on this day was located at Karanjia which recorded 14 inches of rainfall in 24 hours ending at 0800 IST of 29th. The depression moved further in westnorthwesterly direction and weakened gradually as it moved over the Chhota Nagpur plateau. On the morning of 30 July, its centre lay between Chaibasa and Ranchi. The heavy rain centre on this day (*i.e.*, 30 July) shifted in a northnorthwesterly direction to Champua which recorded 22·3 inches in 24 hours ending at 0800 IST of 30 July. Rainfall at previous day's rain centre, *viz.*, Karanjia, on this day was 14·3 inches. Fig. 2 shows the track of the storm and the corresponding positions of heavy rain centres on different days of the storm. Notable rainfall amounts, above 10 inches, recorded at some of the raingauge stations located in and near the Baitarani basin during the 3-day period from 28 to 30 July are given in Table 1. The total isohyetal map of the storm is shown in Fig. 3 from which it can be seen that compared to the upper reaches of the Baitarani basin, the total rainfall in the delta area below Akhyapada was rather less. During the three-day period Akhyapada, Chandbali, Bhadrak and Rajkanika (raingauge stations within the delta area) recorded rainfall amounts of 4·1″, 3·3″, 4·8″ and 3·1″ respectively. From this it is evident that the Orissa coastal area was located only on the periphery of the rain-storm and was not very much affected by the heavy rains although the subsequent floods due to heavy rains in the upper reaches caused severe devastation in this area.

As a result of exceptionally heavy rains in the head water reaches, the Baitarani rose to an unprecedented height of 71 ft (estimated by Mahalanobis) at Akhyapada on the 30th morning. The worst affected area by the unprecedented floods was the Orissa delta east and south of Akhyapada. In this area the flood water is reported to have stood 8 to 10-ft deep in the villages and farms. The railway line between Bhadrak and the Baitarani Road was washed away and Cuttack town was cut off from the rest of the country for about a week. It is reported that the force of the flood water was so terrific at places that iron girders of

Fig. 1. Baitarani Basin upto Akhyapada

TABLE 1

Station	Rainfall (inches)	Station	Rainfall (inches)
Karanjia	29·4	Manoharpur	16·1
Champua	29·1	Jagannathpur	15·8
Rairangpur	20·3	Bonai	14·2
Keonjhargarh	19·2	Pallahara	12·5
Kathari	17·0	Bahargora	12·4

a railway bridge in the delta area were torn out and washed away (India met. Dep. 1929).

3. Analysis of the rain storm of 28 to 30 July 1927

The three-day rain storm was analysed by the depth-duration method with a view to find out the amount of rain water that was precipitated over the Baitarani basin upto Akhyapada. Rainfall data of about 75 raingauges in and near the basin were plotted on the base maps of the basin for individual days of storms and the weighted average depths over the whole basin upto Akhyapada (area 4200 sq. miles) were worked out by the isohyetal method. The average depths of rainfall received over the basin during different durations of the rain storm are: 1 day–9·5″, 2 day–16·4″ and 3 day–18·1″.

From the above it can be seen that the catchment up to Akhyapada received a total depth of about 18 inches during a period of 3 days. In other words about 176×10^3 million cubic feet of water was precipitated over the basin during the course of three days.

In order to know whether the rain storm of 28 to 30 July 1927 was really unprecedented, all the major rainstorms affecting the basin during the 61-year period from 1901 to 1961 were examined and the heaviest rain spell for each year was

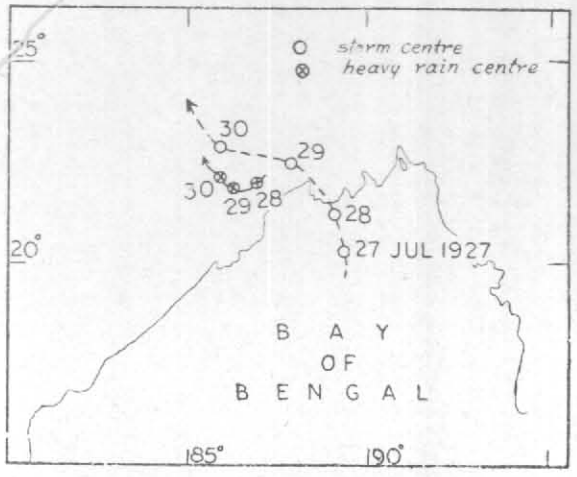

Fig. 2. Storm tracks

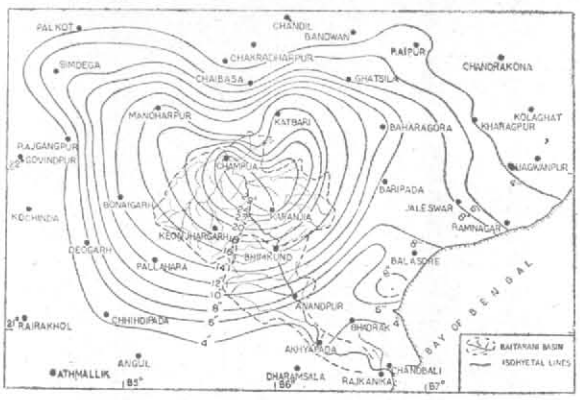

Fig. 3. Total isohyetal pattern of 28-30 July 1927

first determined. All the 61 heavy rain spells thus selected were subjected to depth-duration analysis by the isohyetal method. The rain-depths for different durations for each rain storm were then plotted as depth-duration curves. In this way 61 such curves for 61 rain storms were drawn which are shown in Fig. 4. It can be seen from this figure that the depth-duration curve for the July 1927 rain storm envelopes all the remaining 60 curves indicating thereby that rainfall associated with this storm was unprecedented.

4. Rainfall associated with other major floods

Table 2 gives practically all the occasions during the 41-year period from 1921 to 1961 when the Baitarani crossed the danger level of 63 ft at Akhyapada (1962) along with the weighted average rainfall depths received by the basin on 1st, 2nd and 3rd day of the associated rain spell. From this table it is evident that major rain storms over the basin were those of July 1927, July 1940 and August 1943. It is also seen from this table that although the next highest gauge recorded during the August 1960 floods stood at 69·5 feet, the three day rainfall associated with this flood was nearly one third of that recorded

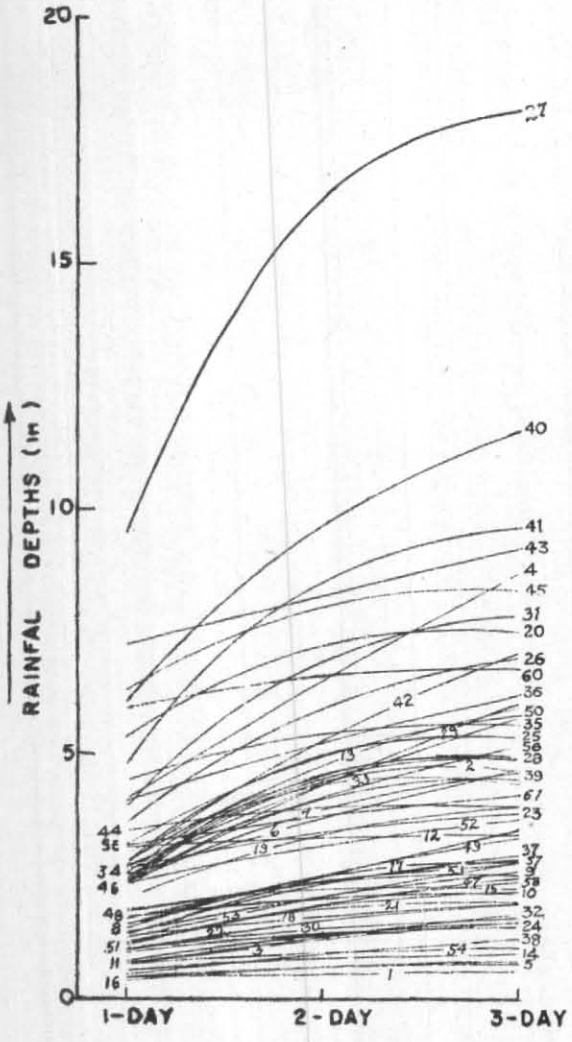

Fig. 4. Depth-duration curves for 61 heavy rain spells over Baitarani basin upto Akhyapada during 1901-1961

during July 1927 flood. From a study of Table 2, it can be said that major floods generally occur in this basin during July, August and September and rarely in October and none in June.

5. Return period of July 1927 rain storm depths

In order to ascertain the return periods of the rainfall depths received during different durations of the July 1927 rain storm, the extreme annual rainfall values for different durations experienced over the basin during the 61-year period (1901 to 1961) were analysed by Gumbel's frequency analysis method (Gumbel 1954). Fig. 5 shows the three Gumbel frequency lines plotted on extreme probability paper and computed by least square method for 1, 2 and 3-day durations. For each computed line the formal theoretical relationships obtained are given below —

1-day	$Y_1 = 0 \cdot 4013 - 3 \cdot 4587\, b_1$
2-day	$Y_2 = 0 \cdot 7085 - 5 \cdot 1030\, b_2$
3-day	$Y_3 = 0 \cdot 8907 - 5 \cdot 7469\, b_3$

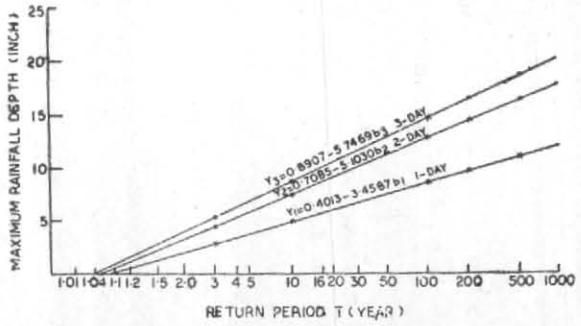

Fig. 5. Frequency curves (Gumbel method) for the Baitarani catchment

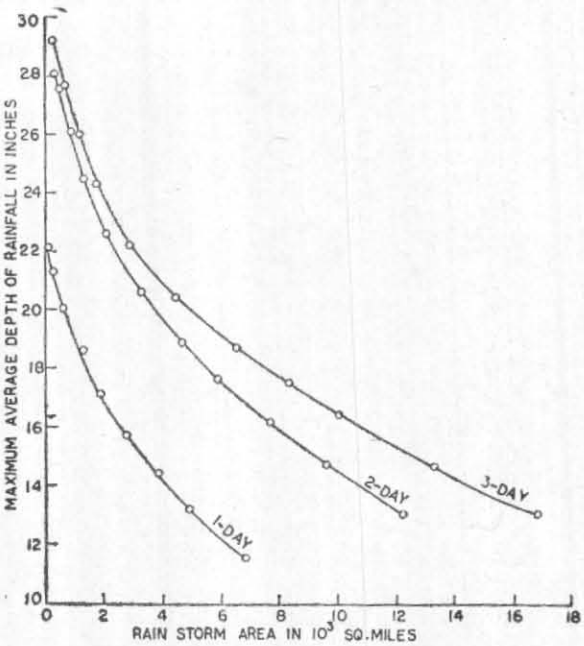

Fig. 6. Depth-area-duration curves

where, Y is the extreme rainfall in inches for the respective duration and b is the reduced variant related to the return period T years by the equation —

$$b = \log_{10} \log_{10} (T/T-1).$$

The return periods of July 1927 rain storm for different durations as picked up from Fig. 5 are given in Table 3.

From the above it is evident that July 1927 rain storm was responsible for causing unprecedented rain depth over the Baitarani basin which have not been equalled or exceeded so far.

6. Depth-area-duration analysis of the July 1927 rain-storm

The July 1927 rain-storm was further analysed taking the storm as a unit. Depth-area-duration curves for durations of 1, 2 and 3 days for this storm are shown in Fig. 6. The average depths of rainfall produced by this storm over different areas (upto 5000 sq. miles) during durations of 1, 2 and 3 days are given in Table 4.

TABLE 2

Flood producing rain storm during 1921 to 1961 and the associated rainfall depths over the Baitarani Basin

Date when the gauge at Akhyapada stood above the danger level of 63 ft	Peak gauge at Akhyapada (feet)	Average storm rainfall depths (inches) on			
		1st day	2nd day	3rd day	Total
23 Aug 1925	R.L. 64·0	0·3	2·2	2·8	5·3
30 Jul 1927	70·8*	1·7	6·9	9·5	18·1
28 Jul 1928	63·9	0·4	2·5	2·1	5·0
21 Aug 1931	63·0	0·9	3·0	3·9	7·8
2 Jul 1940	65·6	1·9	6·0	3·6	11·5
11 Jul 1941	67·8	0·2	4·2	0·5	4·9
1 Aug 1943	67·5	1·0	1·0	7·2	9·2
5 Oct 1944	63·0	0·5	3·4	..	3·9
4 Sep 1955	64·1	1·8	3·2	0·8	5·8
16 Aug 1960	69·5**	0·2	0·7	5·9	6·8
8 Sep 1961	64·2	0·5	1·7	1·3	3·5
14 Sep 1961	63·9	0·4	1·2	1·1	2·7
30 Sep 1961	63·7	0·5	3·1	0·6	4·2

*According to Mahalanobis' (1941) estimates the peak gauge of R.L. 70·8 ft would have been reached at about 4 A.M. on 30 July 1927. The highest recorded gauge for this flood was 68·3 feet

**According to the Orissa Government flood enquiry committee report (1962) the highest gauge recorded was 69·5 ft on 16 Aug 1960. But according to C.W. & P.C. (1965) the peak gauge reached on this day was R. L. 72 ft which appears to be doubtful

TABLE 3

Duration (days)	Rainfall depth (inches)	Corresponding return period (years)
1-day	9·5	200
2-day	16·4	525
3-day	18·1	400

TABLE 4

D.A.D. statistics of July rain storm upto 5000 sq. miles

Duration	Average rainfall depths (inches) for					
	100	500	1000	2000	3000	5000 sq. miles
1-day	22·0	20·2	18·8	16·8	15·4	13·1
2-day	29·0	27·5	25·6	22·8	20·9	18·5
3-day	29·5	28·2	26·4	23·8	22·1	20·0

The rainfall depths indicated in Table 4 show that in a period of 3 days the July 1927 rain storm actually produced an average depth of 20 inches over an area equal to 5000 sq. miles.

7. Conclusions

The rainfall depths obtained from the July 1927 rain storm over the Baitarani basin were unprecedented. The rain storm produced an average depth of about 18 inches over the basin in the course of three days which is equivalent to about 176×10^3 million cubic feet of water. Compared to this, the average rainfall depth during the three-day period of August 1960 storm was hardly 7 inches. The return period for a 2-day depth of this rain storm over the Baitarani basin was found to be of the order of about 525 years. The D.A.D. analysis of this rain storm has shown that an average depth of 20 inches was produced over an area of 5000 sq. miles in the course of 3 days.

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