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A STUDY OF CATASTROPHE FLOOD IN SEPTEMBER 2000 OVER GANGETIC WEST BENGAL BY A RATIONAL METHOD OF RAINFALL – RUNOFF

A severe devastating flood occurred in nine districts of West Bengal *viz.*, Birbhum, Murshidabad, Nadia, Burdwan, Malda, Hoogli, Howrah, Midnapur and North 24-Parganas in the basin of Bhagirathi- Hoogli system and Ichamati basin since 18th September 2000 to second week of October 2000. Among these districts, Nadia, Murshidabad, Birbhum, North 24-Parganas and Burdwan were worst affected by this catastrophe flood. This flood sustained for longer duration which surpassed all previous records in the flood history of West Bengal. Heavy to very heavy rainfall occurred in the river basins of Hoogli, Bhagirathi, Mayurakshi, Ajay, Damodar, Barakar, Bhairabi, Jalangi, Brahmani from 17 to 22 September 2000. Continuous heavy rainfall over these basins during the rainstorm period and heavy discharge of water from these basins surpassed the carrying capacities of these rivers. The reduction of holding capacity of water in these rivers are mainly due to siltation in river beds. Moreover, high discharges through these rivers fell in the Bhagirathi river which submerged low lying areas in the neighbourhood and the resulting flood sustained for longer period due to poor drainage discharge downstream. To study this catastrophe flood, our aim is to find out a relationship between rainfall and runoff during the rainstorm period.

So many authors have studied occurrences of floods in different ways. Goldar and Basu (1996) in their earlier work has studied unprecedented flood in September 1992 over Purulia district of West Bengal by DAD (depth-area-duration) analysis of rainfall data during the rainstorm period alongwith the return period analysis of one-day peak rainfall data of Purulia. Basu (1989) in his earlier work has presented a mathematical model of relationship between rainfall and runoff over a basin area during rainstorm period. Dhar and Changraney (1966) have studied floods over Assam during monsoon months responsible for meteorological conditions. Chaudhury (1966) has studied the meteorological conditions responsible for heavy rain and flood in the Ajay catchment areas.

In this paper, a simple rational method of estimating discharge on watersheds by using rainfall intensity during the rainstorm period has been utilised for study of the catastrophe flood in September 2000 over Gangetic West Bengal with an emphasis on synoptic weather situations responsible for incessant rainfall over the area.

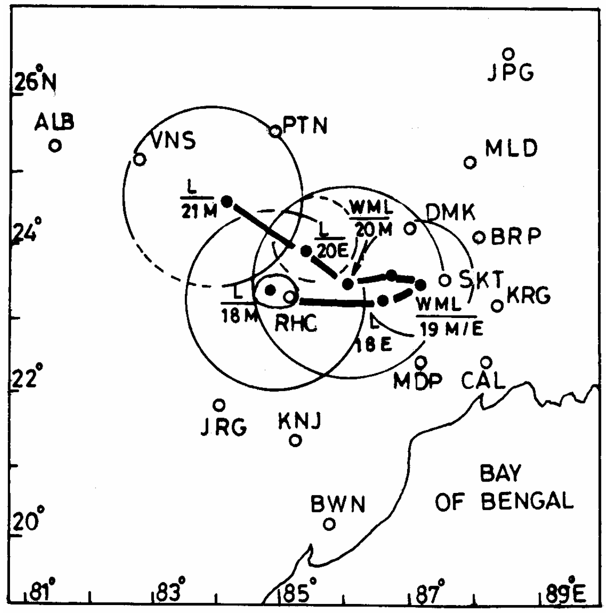

Fig. 1. Synoptic weather situations during 18-21 September 2000 for heavy rainfall

2. (a) *Discharge on watersheds* - The relationship between rainfall and runoff on small watersheds may be represented by many empirical formulae. But, these empirical formulae are required to be subjective for estimating the coefficients involved. The study of discharges by rational method, as suggested by Klemes, (1973), is a simplest one for its wide applicability for synthesis of flood.

The rational formula for discharge 'Q' on small watersheds is given by

$$Q = C I A$$

where, 'C' is a runoff coefficient depending on geomorphic character of the place; 'I' is the rainfall intensity per hour; 'A' is the area of watersheds.

(b) *Rainstorm analysis* - Rainfall data of all the stations during the rainstorm period from 18 to 22 September 2000 have been plotted on maps for each day and the rainstorm analysed by isohyetal method. The day-to-day shifting of rainfall maxima during the rainstorm period have been examined with associated meteorological conditions, responsible for heavy rainfall.

3. *Data sources and its uses* - Rainfall data of all available stations during rainstorm period from 18 to 23 September 2000 over the area have been collected from RMC, Kolkata and Flood Met. Office, Asansol and plotted on basin maps for analysis.

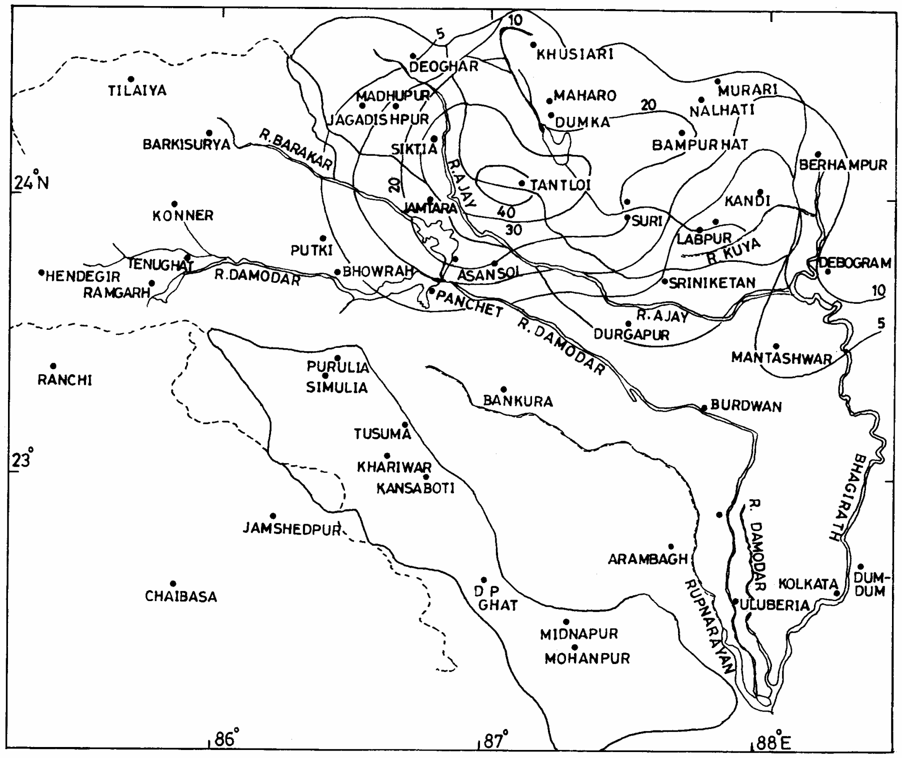

Fig. 2. Isohyets (cm) of watershed areas for the rainstorm on 18 September 2000

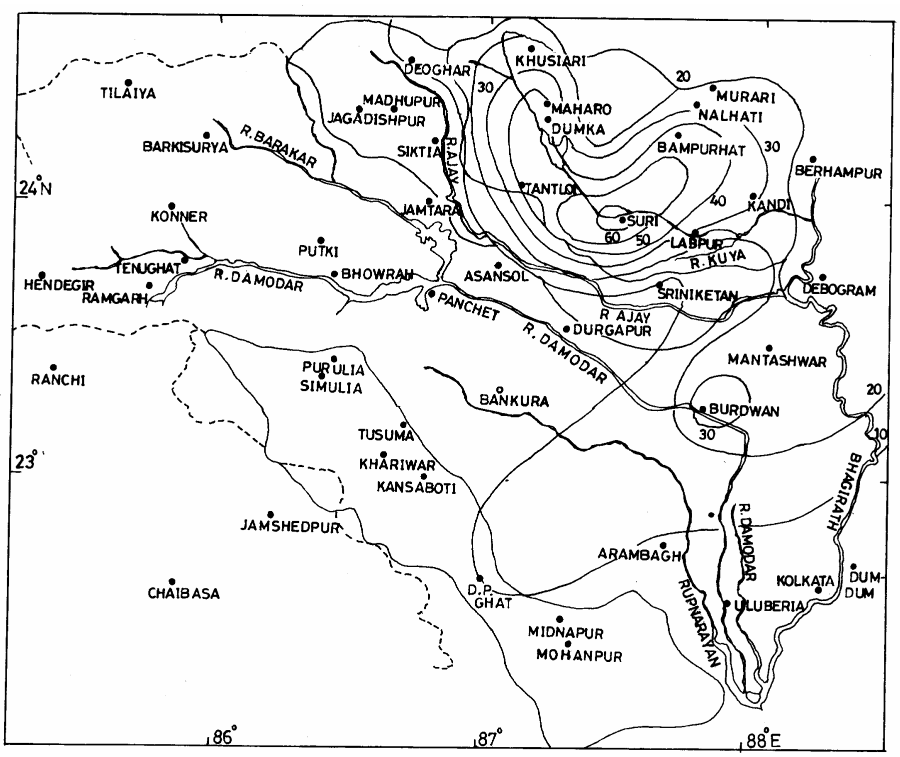

Fig. 3. Isohyets (cm) of watershed areas for the rainstorm on 19 September 2000

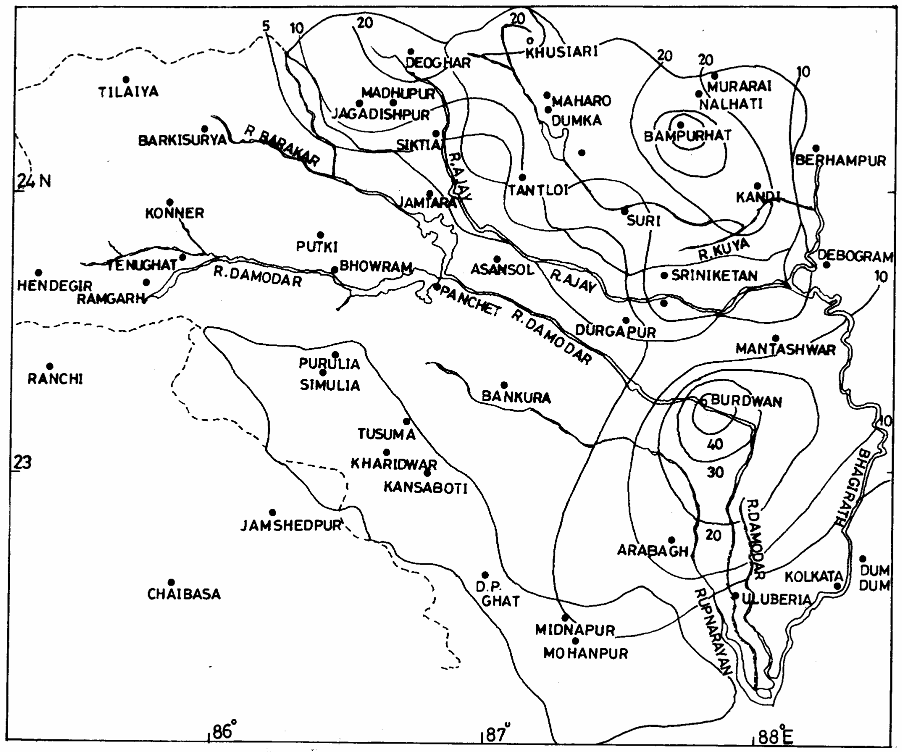

Fig. 4. Isohyets (cm) of watershed areas for the rainstorm on 20 September 2000

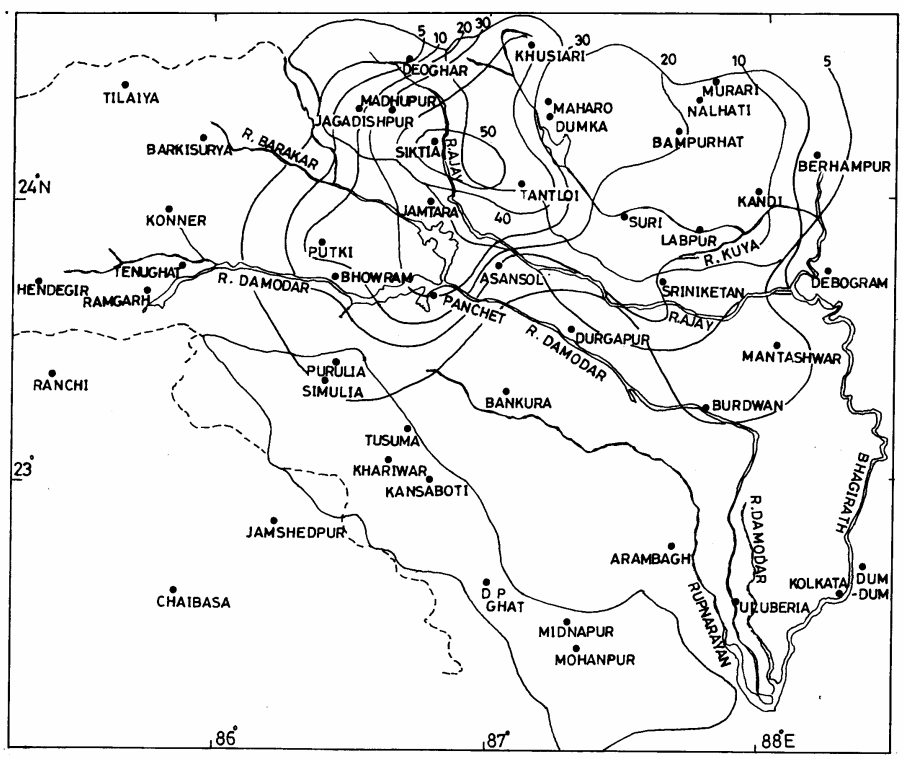

Fig. 5. Isohyets (cm) of watershed areas for the rainstorm on 21 September 2000

TABLE 1

Rainfall data (mm) of stations during the period from 18 to 23 September 2000

		Dates					
District/ Region (1)	Stations (2)	18 Sep (3)	19 Sep (4)	20 Sep (5)	21 Sep (6)	22 Sep (7)	23 Sep (8)
Malda	Malda	48.1	85.8	104.0	43.4	41.8	8.6
	Chanchal	83.8	30.1	41.2	42.3	37.8	1.2
Murshidabad	Berhampur	94.0	260.0	60.0	56.0	21.0	11.0
	Kandi	42.6	332.6	Flood	Flood	Flood	Flood
Nadia	Krishnanagar	23.0	215.0	148.2	25.0	14.0	15.0
	Nakashipara	35.0	300.4	1.8	NA	NA	NA
	Ranaghat	56.2	130.2	65.7	NA	NA	NA
Birbhum	Bolpur	43.0	73.8	126.2	86.2	NA	32.4
	Gheropara	37.4	85.0	109.0	104.4	NA	54.0
	Narayanpur	49.0	327.0	208.8	162.2	110.0	22.0
	Suri (CWC)	217.0	618.0	95.8	135.4	16.8	21.2
	Sriniketan	48.8	72.7	139.3	93.7	29.9	26.2
	Rampurhat	247.0	488.6	403.7	237.8	81.3	7.6
	Tantloi	411.2	398.8	175.6	495.4	15.2	110.6
	Tilpara Barage	163.0	553.0	94.2	100.4	16.6	14.2
Burdwan	Asansol	148.6	55.7	13.0	76.8	8.6	72.7
	Burdwan (S)	10.4	324.0	421.2	55.0	1.4	0.0
	Durgapur	38.9	31.4	18.8	40.2	4.9	9.8
	Kanksa (BSF)	46.0	24.0	19.0	17.0	20.4	10.2
	Katwa	19.2	275.0	157.0	35.4	NA	NA
	Kalna	61.2	207.8	121.2	34.7	Flood	19.4
Hoogly	Arambagh	2.4	98.2	125.4	35.4	1.2	28.8
	Harinkhola	3.8	126.6	212.8	33.4	2.8	38.6
	Magra	32.0	191.0	43.0	28.0	3.6	17.0
Howrah	Uluberia (D)	16.0	71.0	16.4	30.6	25.4	5.2
	Jagatballavpur	16.2	70.1	18.1	9.8	4.0	8.2
N. 24 Parganas	Bongaon	5.0	118.0	60.0	56.0	10.0	24.0
	Basirhat (D)	100.6	167.4	36.4	5.2	12.8	10.0
	Deganga	9.0	77.2	25.0	31.0	27.6	43.6
	Dum Dum	18.6	63.0	17.7	7.3	0.8	2.7
Midnapur	Digha	14.6	48.6	0.0	10.4	12.3	3.2
	Durgachak	16.0	81.9	43.3	11.4	18.3	2.4
	Kharagpur	21.5	6.1	6.0	10.0	15.2	1.8
	Danton	27.0	5.2	7.8	51.0	11.0	0.0
	D.P.Ghat	2.0	139.2	35.4	0.0	0.4	5.8
	Midnapur (D)	6.4	8.0	59.0	8.2	5.2	5.2
	Mohanpur	6.8	18.2	25.8	9.6	14.0	18.2
	Nandigram	3.2	61.0	3.0	9.4	36.2	4.2

TABLE 1 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bihar	Sikadia	340.6	13.4	66.8	569.2	21.8	22.8
& Jharkhand	Messanjore	292.4	171.2	159.0	246.4	8.8	11.0
	Maharo	178.0	438.8	182.4	281.4	32.2	106.4
	Khusiari	189.6	221.4	211.6	450.6	87.8	6.0
	Jagadishpur	88.2	30.2	165.4	160.2	30.2	23.0
	Madhupur	24.0	70.0	170.0	350.0	30.0	76.4
	Deoghar	45.0	150.0	265.0	42.4	15.4	67.0
Bihar &	Maithon	281.2	6.0	49.2	355.2	0.0	7.2
Jharkhand	Panchet	56.0	7.2	16.4	299.2	0.0	10.6
	Tilaiya	7.2	2.8	1.8	1.2	35.8	5.4
	Konner	21.4	28.2	0.2	9.2	5.4	26.2
	Tenughat	15.4	3.0	4.8	36.6	0.0	11.6
	Ramgarh	15.4	1.0	5.0	5.2	1.2	59.4
	Hindigir	29.6	10.6	4.2	0.0	3.4	16.6
	Nandadih	47.4	12.6	39.3	123.2	17.6	4.4
	Bhowrah	18.4	3.6	44.0	118.6	0.0	38.4
	Putki	27.2	7.6	32.0	240.4	0.0	11.6
	Barkisurya	44.6	3.0	13.0	34.4	260.4	6.4
	Jamshedpur (AP)	22.2	NA	10.1	6.4	2.6	23.9
	Ranchi	40.6	14.9	Trace	15.6	Trace	0.0

TABLE 2

Discharges and run-off coefficients during rainstorm period from 18 to 21 September 2000

	Mayurakhshi catchment to Messanjore Dam (Area 1860 sq.km.)			Messanjore Dam to Tilpara Barrage (Area 1349 sq.km.)		
Date	Discharge Q (cumec)	Rainfall intensity I (cm/hr)	Runoff coefficient C	Discharge Q (cumec)	Rainfall intensity I (cm/hr)	Runoff coefficient C
18 Sep	2803.74	0.917	0.5916	3058.62	1.099	0.7430
19 Sep	3625.03	1.155	0.6075	4049.84	2.180	0.4958
20 Sep	3653.36	0.768	0.9206	4237.45	0.508	1.8390
21 Sep	5664.12	1.359	0.8067	5964.56	1.015	1.5660
18-21 Sep	15746.25	1.049	0.7267	17310.47	1.201	0.9616

Discharge / gauge height data at different points have been collected from Annual Flood Report (2000), Irrigation & Waterways Directorate, Govt. of West Bengal during the rainstorm period. These data at different dam-sites/reservoirs and important river gauge levels responsible for the catastrophic flood in some districts of Gangetic West Bengal have been utilised for the study.

4. (a) *Synoptic weather situations* - An upper air cyclonic circulation (CYCIR) extending upto 3.1 kms.

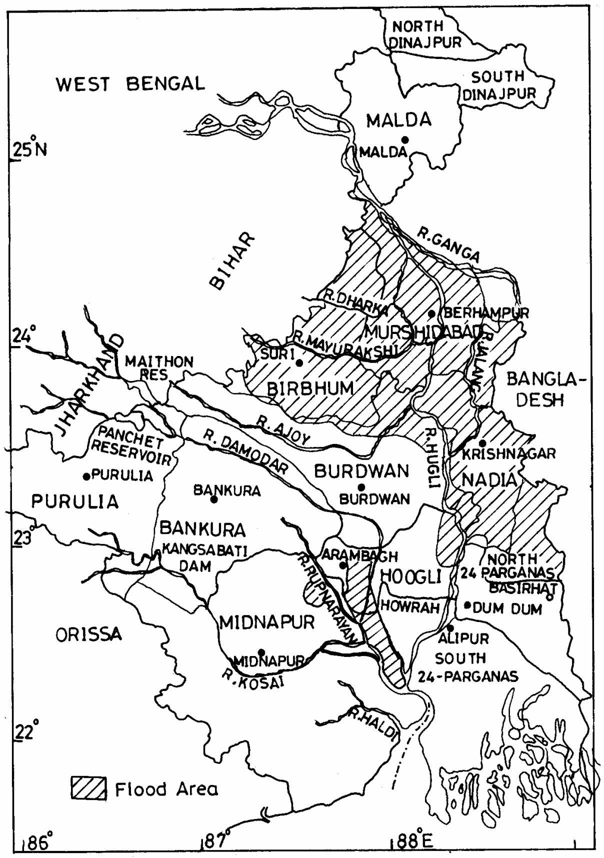

Fig. 6. Inundated area of West Bengal during September 2000 flood

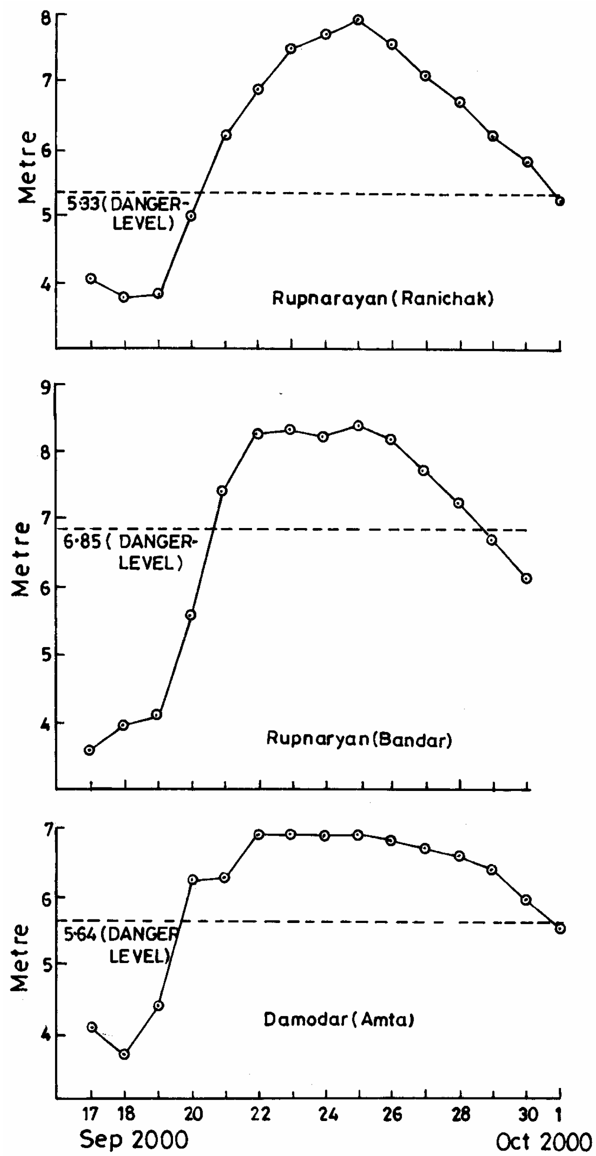

Fig. 7. River gauge levels of different gauge-stations over Rupnarayan and Damodar rivers

above mean sea level lay over central Bihar and adjoining Gangetic West Bengal and Sub-Himalayan West Bengal in the morning of 17 September 2000. It was the remnant of the low pressure area (LOPAR) which formed over east central Bay of Bengal on 12 September 2000 and subsequently moved west-northwestwards across north Bay, West Bengal (Midnapur, Bankura and Purulia districts) and Jharkhand. It weakened on 16 evening over Jharkhand and adjoining Uttar Pradesh and Chattisgarh and persisted as an upper-air CYCIR. On 17 night, a LOPAR appeared over Jharkhand and adjoining Bihar which moved eastward on 18 morning towards Gangetic West Bengal and became well-marked low pressure area (WML) on 19 morning and remained practically stationary over Birbhum, Burdwan, Purulia and Bankura districts of West Bengal and adjoining Jharkhand till 19 evening. Then, this WML moved westward towards Jharkhand and adjoining Gangetic West Bengal and gradually weakened into a LOPAR in the afternoon of 20 (Fig. 1). It moved further in a north-westerly direction and persisted as an upper air circulation over east Uttar Pradesh and north-east Madhya Pradesh on 21 evening onwards.

(b) *Occurrences of heavy rainfall* - Under the influence of above synoptic situations as mentioned in 4(a), Jharkhand and mainly three districts of West Bengal *viz.*, Birbhum, Burdwan and Murshidabad were affected by heavy to very heavy rainfall from 18 to 22 September 2000. The concentration of rainfall maxima in the order of 40 cm occurred on 18 near Tantloi in the area over west Birbhum district of West Bengal and east Jharkhand (Fig. 2). On 19, the concentration of rainfall maxima of the order of 60 cm occurred near Suri in central Birbhum district of West Bengal, *i.e.* the occurrence of maximum rainfall shifted eastward with the shifting of weather system (Fig. 3). On 20, the concentration of rainfall maxima of the order of 40 cm occurred near Rampurhat,

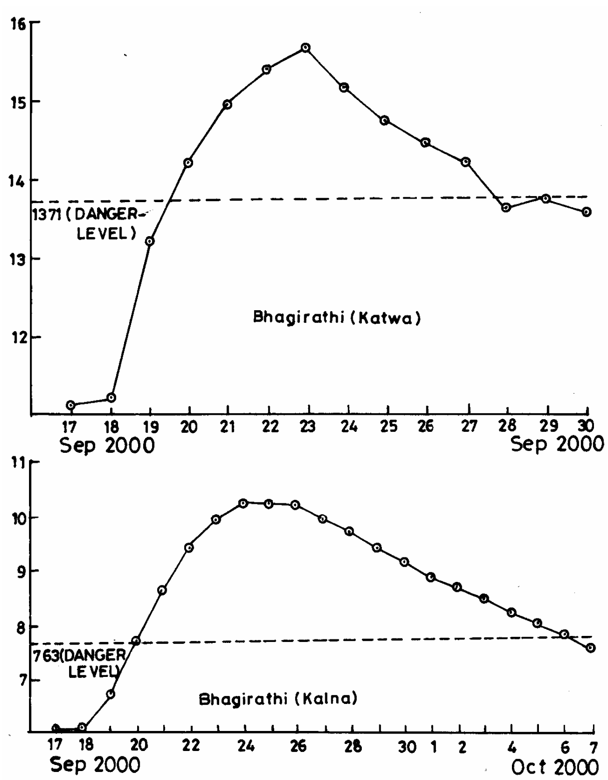

Fig. 8. River gauge levels at different gauge-stations over Bhagirathi river

north of Birbhum district and also near Burdwan, north of Burdwan district as the weather system was practically stationary over Birbhum and Burdwan districts of West Bengal (Fig. 4). On 21, the concentration of rainfall maxima of the order of 50 cm occurred near Sikatia in east Jharkhand, as the weather system moved westwards towards Jharkhand (Fig. 5). On 22, the concentration of rainfall maxima of the order of 20 cm occurred near Barkisuriya around central Jharkhand, as the weather system weakened and moved further westwards.

5. *Runoff associated with heavy rainfall* - Discharge of water from river-Dams/Barrages due to heavy rain spells recorded during 18-23 September 2000 (Table 1), caused catastrophic flood in September 2000 in West Bengal, which were associated with the synoptic weather systems, as discussed in 4(a). The total inundated areas of West Bengal during September 2000 flood is shown in Fig. 6. The study of September 2000 flood in West Bengal focuses on some of the worst flood affected districts of West Bengal, where, flood water inundated areas about 2016 sq. km. (49%) in North 24-Parganas, 3731 sq. km. (95%) in Nadia, 4525 sq. km.(85%) in Murshidabad and 3182 sq. km. (70%) in Birbhum.

Mayurakhshi river originates from the high land of Jharkhand and passes through Birbhum district of West Bengal with its tributary Babla, falling into Bhagirathi river through Murshidabad district. Inundation was caused by discharge of water from Massanjore Dam and Tilpara Barrage over Mayurakhshi river. The runoff coefficients 'C' have been calculated by rational method as discussed in section 2(a) for Massanjore Dam and Tilpara Barrage during the rainspell periods 18-21 September 2000 where rainstorm prevailed during the said period. The runoff coefficients 'C' upto Massanjore Dam and from Massanjore Dam to Tilpara Barrage during the rainstorm period are calculated and shown in Table 2.

The flood also badly affected areas of Burdwan, Hooghly and Howrah districts of West Bengal by inundating 2458 sq. km (35%), 912 sq. km (29%) and 293 sq. km (20%) respectively due to the combined discharges from Damodar Valley Corporation reservoirs from Maithon over Barakar, Panchet over Damodar rivers and through Durgapur Barrage during the period of heavy rainspells. The contribution of excess water from Rupnarayan, Ajay and Damodar rivers enhanced the flood situation. This is clearly seen from the river gauge levels of Rupnarayan river at Ranichak and Bandar, Damodar river at Amta (Fig. 7) and at Kalna and Katwa of Bhagirathi and Ajay rivers respectively (Fig. 8), where river levels remained above danger levels for long period.

It is interesting to note that the catastrophic flood commenced in Nadia and North 24 Parganas districts from 23rd after rainfall has practically stopped over these districts since 22nd. This indicates that the inflow of surface discharge was responsible for flood over these districts. The floodwater stagnated for longer duration for more than a month in North 24 Parganas district, which is most uncommon in the flood history of West Bengal. The rainfall received in this district was much less in comparison to other flood-affected districts of West Bengal. The contributions of water from the main river Bhagirathi and the river Ichamati were the prime cause for this flood and the flood water were stagnant for longer period due to drainage problem of the water from the area in North 24 Parganas district. The devastating flood also inundated very small area in the two districts of West Bengal, namely Malda and Midnapur.

6. By the above study, the following salient features have been revealed :

(*i*) Concentration of rainfall maxima over the areas during the rainstorm period from 18 to 23 September 2000 shifted with the movement of the synoptic weather situations during the period.

(*ii*) Although the two districts namely, Murshidabad and Birbhum were most affected by heavy to very heavy rainfall, the flood water receded from these two districts within two weeks but in case of Nadia and North 24-Parganas districts, rainfall played an insignificant role for causing flood (Table 1) and it persisted for a longer period.

(*iii*) Longer duration catastrophic flood over two districts namely, Nadia and North 24-Parganas for more than a month was due to stagnation of flood water by inadequate drainage system and low capacity of river system due to siltation.

(*iv*) The situation further aggravated due to sudden release of flood water from different dams and reservoirs, simultaneously.

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