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A study of the rainfall distribution of the unprecedented September 1978 floods in West Bengal with particular reference to the contribution from Damodar catchment*

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सार – पश्चिम बंगाल में सितम्बर 1978 में अन्तिम सप्ताह में आई बाढ़ का पश्चिम बंगाल में आई बाढ़ों में विशेष महत्व है क्योंकि इसमें जन धन का अप्रत्याशित परिमाण में विनाश हुआ था। इसमें पश्चिम बंगाल में भीषण वर्षा से संबद्ध मौसम संम्बधी सिनाप्टिक दशा को दर्शाने का और वर्षा के इस दौर में वर्षा के बंटन का अध्ययन किया गया है। यह दामोदर घाटी क्षेत्र से अन्तवाहु के योगदान को भी दर्शाता है तथा इसमें 1978 से पहले के पांच या छह दसकों में आई भीषण बाढ़ से इसकी तुलना भी की गई है।

ABSTRACT. The flood in West Bengal during the last week of September 1978 has a special significance in the annals of floods in West Bengal due to the havoc it caused in terms of widespread destruction and tremendous loss of life and property in an unprecedented magnitude. A study has been made to indicate the synoptic Meteorological condition associated with this very heavy rainfall in West Bengal and the rainfall distribution during this rainspell. The contributions to the inflow from the Damodar valley area has also been indicated. A comparison with the highest flood in the last five or six decades prior to 1978 has also been made.

1. Introduction

Though floods are not a rare phenomenon to the people of West Bengal, the catastrophic floods during the last week of September 1978 in West Bengal was reported to have been unprecedent in character on the points of magnitude, extent of damage to standing crops and loss of life and livestocks. According to the press report this flood had affected twelve agricultural districts of West Bengal and the State has suffered a colossal loss and damage worth more than rupees 1500 crores (Bose 1978)

During the period from the third week of August to early first week of October 1978, the State of West Bengal excluding the districts of Darjeeling, Jalpaiguri, Cooch Behar and Purulia was hit by three spells of floods.

The first spell of flood during the third week of August was caused by the *Ganga*, *Bhagirathi* and *Jalangi* overflowing their banks following heavy rainfalls in the upper basins in the districts of Murshidabad, Malda and Nadia.

The second spell of flood in the first week of September (31 August 1978 to 3 September 1978) was casued by the rivers of *Kansabati*, *Silabati*, *Darakeswar*, *Damodar*, *Mundeswari* and *Subarnarekha*. The heavy rainfall in this spell was concentrated mainly in the districts of Midnapur, Bankura, Purulia and part of Burdwan including Damodar catchment area in Bihar Plateau.

The third spell of flood during the last week of September (27 September 1978 to 30 September 1978) when almost all the rivers in the southern districts of the State experienced unprecedented

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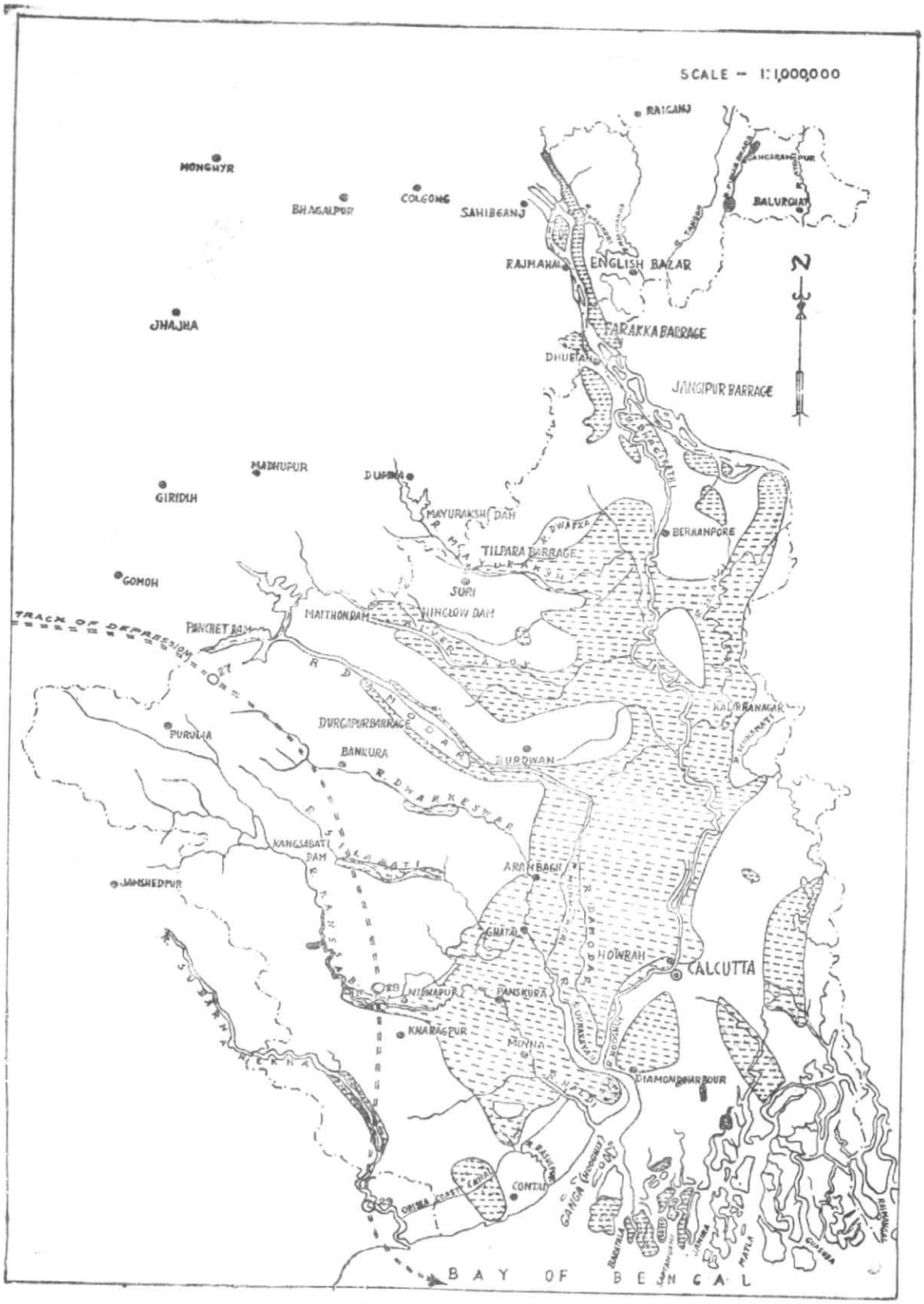

Fig. 1. Map showing flood affected areas during 1978

flood was the most severe amongst all the spells. During this spell widespread heavy rain with a few very heavy falls occurred at many places in the Damodar basin area, Bankura, Birbhum, Murshidabad, Nadia, Burdwan, Hooghly, Howrah, 24 Parganas and Calcutta.

Large part of the city of Calcutta was under three or four feet of water for days together paralysing the city life. The maximum rainfall recorded at Calcutta (Alipore) was as high as 36·96 cm in a day on 28 September, the highest ever recorded at Alipore.

The purpose of this paper is to present some features of rainfall distribution and the synoptic Meteorological conditions associated with the heavy rainfall in West Bengal during the last spell of flood in September 1978 with particular reference to the contribution from the DVC system of dams.

2. Past floods in West Bengal

In order to answer the question whether very heavy rainfall during the period of late September and early October giving rise to extensive flood in West Bengal had been known in the past, Bose (1958) had examined all previous records of rainfall in West Bengal dating from 1891 to 1956. In all the cases studied by Bose it was found that extensive heavy rainfall was experienced in the central parts of West Bengal with heavy rain extending into areas of southwest and south Bengal during 22-25 September 1899, 21-28 September 1922, 14-18 September 1946 and 25-26 September 1956 causing floods in West Bengal. But none of the above floods can be compared with the magnitude and extent of floods experienced during the late September 1978 flood. The highest flood in the the last five or six decades prior to 1978 is reported to have occurred in October 1959 (Report 1978).

3. The river system in West Bengal

The river system and important tributaries causing floods in West Bengal south of the *Ganga* can be classified into the following four distinct systems :

(*i*) Mayurakshi-Dwarka-Brahmani
(*ii*) Ajoy
(*iii*) Damodar-Mundeswari-Rupnarayan
(*iv*) Dwarakeswar-Silabati-Haldi

A part of Nadia district and 24 Parganas is however, drained by the Ichhamati and a small area in Purulia and Midnapur districts is drained by the *Subranarekha* (Fig. 1).

The problem of *Damodar* river as well as other western tributaries lower down is the extremely deteriorated carrying capacity and heavy embankments. Once these areas have flooded it takes a very long time to drain out.

4. Brief history of the meteorological situation

The flood during the period 27-30 September 1978 was due to a depression over the Gangetic West Bengal. On 26th morning, the low over Bihar and neighbourhood concentrated into a depression and centred near Daltanganj. This then recurved towards east on 26th morning and moved rather fast with a mean speed of about 350 km a day between 26 and 27 September. It further intensified into a deep depression and lay by 27th morning over Gangetic West Bengal and adjoining Bihar plateau with its centre close to Asansol. Thereafter, it moved slowly southwards with a mean speed of about 150 km a day between 27th & 29th across the western districts of Gangetic West Bengal and emerged into the northwest Bay on 30th morning and merged with another well marked low pressure area. The combined system intensified into probably a cyclonic storm and commenced moving towards the state giving rise to scatted heavy rainfall. The track of the depression between 26 to 30 September is shown in Figs. 1 and 2.

The southerly movement of the depression at this time of the season was unusual. In fact, there had not been any case of a september-October depression moving southward over Gangetic West Bengal during the last hundred years.

5. Distribution of rainfall

A number of raingauge stations are being maintained by the India Met Dep., the DVC and the State rainfall registration authority of West Bengal over the areas affected by heavy rains and floods. The rainfall records of these stations were utilised for the purpose of determining the distributions of rainfall during the period of rainstorm.

During the third spell the system caused widespread rain with a few very heavy falls in the upper catchment areas of Damodar valley in Bihar pleateau from 26th to 28th and in Gangetic West Bengal from 27 to 29 of September 1978. Isolated heavy rain also occurred on 30 September.

The heavy rainfall belt during the monsoon season occurs towards the southwest of the central region of the depression, *i.e.*, to the left forward sector of its track. But the moment the system recurves, its heavy rainfall belt almost simultaneously switches on to the diametrically opposite northeast region, *i.e.* to the right forward sector of its track. The above situation has been realised in the case of movement of 26-30 September 1978 depression.

The total isohyetal pattern of rainfall during the period 27 to 30 September 1978 is shown in Fig. 2.

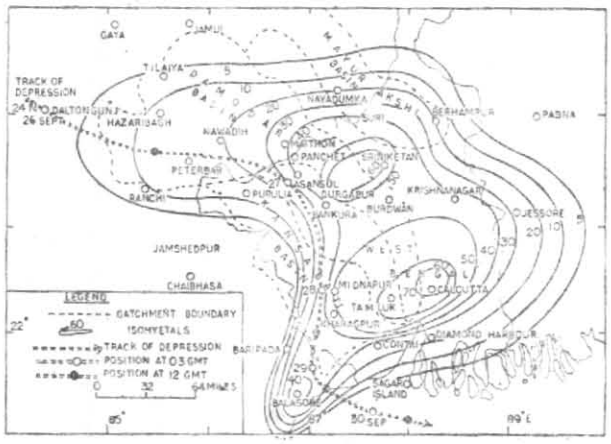

Fig. 2. Total storm isohyetals 27-30 September 1978

From Fig. 2 it will be seen that heaviest rainfall in these three days was experienced in and around the district of Calcutta, Howrah and in the district of Bankura and also in Durgapur and Panagarh in the district of Burdwan. The depth-area-duration curves for this rainstorm for the period 27-30 September were determined. The average maximum depths of rainfall for different durations and areas picked out from these curves are given in Table 1(a).

6. Duration of heavy rain and total rainfall during past rainstorms in West Bengal

Analysis of rainfall during a few major rainstorm in Gangetic West Bengal in the past creating floods show that rainfall exceeding 2.5 cm in a day generally occurs on 3 or 4 consecutive days and only in a few cases for 5 days. During these rainstorms more concentrated rainfalls generally occur in the middle of the spell. A study of the rainfall during rainstorms in West Bengal indicated a total rainfall of 17.8 cm to 20.3 cm in a four-day storm in the coastal districts and interior districts of Murshidabad, Birbhum, Bankura, Burdwan and Nadia with an extreme maximum of 38.1 cm. In the western districts of Purulia adjoining the Chotanagpur plateau the rainfall is less and seldom exceeds 10.2 cm for a three day storm and 15.2 cm for a four day storm with extreme maximum of 17.8 cm (Report 1959).

7. Comparison with 1959 flood

The severe flood in Gangetic West Bengal during the period 30 September-3 October 1959 was caused by a depression which developed over the Bay of Bengal on 28 September, moved northwest and intensified into a severe cyclonic storm of small extent on 30 September. It crossed the coast near Balasore on the morning of

TABLE 1(a)

Average maximum depths of rainfall for different duration and areas for the period 27-30 September 1978

Area in 1000 sq km	Depth of rainfall (cm)			
	1-day	2-day	3-day	4-day
0.5	36.0	61.0	71.0	72.5
1.0	35.0	58.0	69.5	71.5
2.5	31.5	54.3	65.5	69.0
5.0	28.0	50.0	62.0	65.7
10.0	23.8	46.0	56.7	60.5
15.0	22.0	43.0	53.0	57.5
20.0	21.0	41.0	50.0	55.2
25.0	20.0	39.0	47.5	53.5
30.0	19.0	37.2	45.0	52.0
35.0	18.0	36.0	43.5	50.0
40.0	17.7	35.0	42.0	48.2
45.0	17.0	34.0	41.0	42.0

TABLE 1(b)

Average maximum depths of rainfall for different duration and areas for the period 30 September-3 October 1959

Area in 1000 sq km	Depth of rainfall (cm)			
	1-day	2-day	3-day	4-day
0.5	24.0	34.8	37.2	41.0
1.0	23.7	34.5	37.0	40.8
2.5	22.7	33.0	35.5	40.0
5.0	21.2	31.8	34.0	38.8
10.0	18.5	28.7	32.0	37.0
15.0	16.3	27.0	30.2	35.0
20.0	15.0	25.5	29.0	33.8
25.0	13.7	24.5	27.8	32.5
30.0	12.8	23.2	26.8	31.0
35.0	12.0	22.2	26.0	30.0
40.0	11.2	21.5	25.5	29.0
45.0	10.8	21.0	25.0	28.5

TABLE 2

Statement showing gauge records during September 1978 & October 1959 floods in West Bengal

River	Gauge station	Extreme danger level in feet	Max. water level attained in third spell of flood in 1978 (ft)	Max. water level attained in 1959 flood (ft)	Previous highest water level in feet on record
Damodar	Champadanga	44.29	48.29 (28-9-78)	—	46.50 (1956)
	Amta	20.50	26.50 (29-9-78)	23.24 (5-10-59)	—
Mundeswari	Harinkhola	42.00	45.85 (29-9-78)	44.80	—
Rupnarayan	Ranichak	18.40	29.99 (28-9-78)	27.20 (4-10-59)	—
	Gopiganj	—	27.59 (29-9-78)	21.78 (4-10-59)	—
Silabati	Bank	51.46	51.31 (29-9-78)	—	52.49 (1946)
	Goghat	31.49	32.97 (29-9-78)	—	33.79 (1946)
Darakeswar	Arambagh	58.50	62.80 (28-9-78)	—	60.20 (1970)
Hooghly	Kalna	27.50	30.97 (1-10-78)	27.89 (3-10-59)	29.23 (5-9-71)
Jalangi	Swarupganj	29.68	35.86 (1-10-78)	34.27 (8-10-59)	34.81 (5-9-71)
Ajoy	Satghania	174.50	181.90 (27-9-78)	178.50 (2-10-59)	180.25 (27-8-56)
	Budra	132.49	140.49 (27-9-78)	135.54 (2-10-59)	—
	Katwa	49.50	54.80 (28-9-78)	51.89 (4-10-59)	—
Mayurakshe	Tilpara	206.00	217.00 (27-9-78)	—	—

1 october, weakened and lay as a depression near Daltonganj on the morning of 2 October. It weakened further on 3rd & moved away as a low pressure area over Bihar and adjoining east Uttar Pradesh.

For the purpose of comparison with the late September 1978 flood the depth-area duration curves for the 1959 storm for the period 30 September - 3 October were drawn and the average maximum depth of rainfall for different durations and areas were picked out. These are given in Table 1(b)

It is evident from Tables 1(a) and 1(b) that the average depth of rainfall for all areas and duration was much less during October 1959 flood than that in late September 1978 flood.

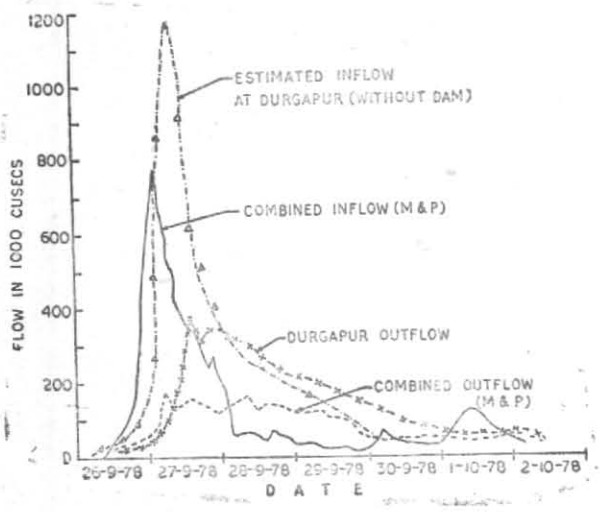

Fig. 3. Combined (M & P) and Durgapur inflow and outflow (3-hourly) hydrograph

TABLE 3

Annual maximum combined peak inflow (Maithon-Panchet)

Year of flood	Flood period	Peak inflow (1000 cusecs)	Volume of flood the period when inflow was more than 50,000 cusecs (million acre feet)
1913	5-12 Aug	650	3.24
1935	11-15 Aug	640	1.56
1939	31-7 Jul, Aug	282	1.75
1941	9-13 Oct	634	1.35
1942	7-13 Aug	382	1.73
1946	16-21 Sep	323	1.45
1950	16-22 Jul	338	2.20
1958	14-19 Sep	665	1.31
1959	30-3 Sept, Oct	810	2.10
1961	30-4 Sept, Oct	516	1.49
1978	2-7 Sept	159*	1.27**
	26-30 Sept, Oct	379* (3 hrly) 851* (Hourly)	3.73**

*Moderated peak flow at Durgapur Barrage.
**Approx. volume of moderated flood at Durgapur barrage.

The gauge records of various important gauge sites in the above two spells of floods have been shown in Table 2. It will be seen that in almost all the rivers the gauges in the late September 1978 exceeded the 1959 level.

8. Inflow of rain-water in Damodar basin

Most of the large-scale flood damage in September 1978 was caused by Damodar flood in the third spell. Originating from the hilly plateau of Chotanagpur the *Damodar* river straddles both the States of Bihar and West Bengal. On reaching the deltaic plains of West Bengal it moves southward towards Bay of Bengal, through the western districts of Gangetic West Bengal, Burdwan, Hooghly and Howrah.

Near Begua Hana the *Damodar* bifurcates into two channel, *viz*, *Amta* and *Mundeswari*. It finally reaches the *Hooghly* river at Falta, 48 km south of Calcutta (Fig. 1).

Flooding in the Damodar valley is limited to the lower reaches and is caused by the extremely poor drainage conditions.

To moderate the flood in tne Damodar, four major dams have been constructed by the Damodar valley corporation with a total cushion of one million acre-feet, the designed capacity of the four dams being 6,50,000 cusecs.

In the third spell of 1978 flood, the Damodar basin received maximum rainfall on 26 and 27 September, *i.e.*, one day ahead of Gangetic West Bengal. Taking a threshold value of 2.5 cm per day as the average depth of precipitation for a rainstorm day, the rainspell over Damodar basin was a storm of two day duration only, *i.e.*, 26-27 September. The average depth of rain over the basin area (18,600 sq km) on these two days was 6.8 cm and 10.4 cm respectively. The heavy average rainfall of 10.4 cm in a day on 27th corresponds to an average rate of fall of rain water over Damodar basin of about 1.60 million acre feet. The highest mean rainfall that has occurred in a day over Damodar basin in the past was 12.4 cm on 12 August 1935 (Satakopan 1959) and 12.6 cm on 2 October 1959 (Das 1980).

From an analysis of the past rainstorms during the post-dam period from 1951 to 1977, it has been observed that the centres of heavy rainfall associated with all the major rainstorms during the above period were mostly confined to the central region of the basin and in a few cases only to the extreme northern upper reaches of the basin (Das 1980). The centre of one of the major rainstorm of 16-19 July 1975, the second heaviest 4-day rainstorm with weighted average rainfall over Damodar basin of 26.1 cm, was around Dumri, which recorded the highest ever one day point rainfall of 40.3 cm. The highest one day point rainfall in late September 1978 storm of 31.1 cm was recorded at Maithon on 27 September. The worst recorded storm in the Damodar basin during the pre-dam period occurred in 5-10 August 1913 giving a mean rainfall upto Raniganj of 30.1 cm on five consecutive days.

In the case of late September 1978 rainstorm the southern region of the basin around Maithon-Panchet was subjected to heavy rainfall amounts. The maximum intensity of rainfall around this region was of the order of 5 to 6 cm per hour compared to about 3 cm per hour around the central region of the basin during the July 1975 storm.

The location of intense heavy rainfall centre close to the Maithon-Panchet dam site, during the last spell of September 1978 storm, has significantly contributed to the rapid inflow into Maithon-Panchet reservoirs.

There was the all time record maximum combined inflow into Maithon-Panchet of 8.51 lac cusecs (hourly). The combined outflow could however, be limited to 1.63 lac cusecs in the same day. But the inflow from the uncontrolled catchment downstream was 2.20 lac cusecs for a few hours. Also the discharge below Durgapur was 1.50 lac cusecs for a very long period. The combined inflow and outflow hydrograph at Maithon-Panchet during this maximum flood is shown in Fig. 3.

An average rainfall of 3" (7.62 cm) in the upper Damodar catchment in the pre-dam period caused a peak discharge of more than 6 lac cusecs at Rhondia and still higher peak discharge further downstream. The incidence of such average rainfall due to rainstorm in Damodar basin is almost an annual recurrence, having been recorded even three times in a single year. The maximum frequency of such rainstorms in Damodar basin is in September followed by July and August.

The characteristics of high flood of the past in Damodar basin are given in Table 3. It will be evident from Table 3 that the total volume of flood is more important than the peak discharge as far as the lower trans — Damodar area is concerned. The total flood volume from Damodar basin during late September 1978 flood was unusually high.

9. Conclusion

After recurvature towards east and then towards south the late September 1978 depression slowly moved very close, parallel and practically in almost the same direction as the main channels of *Damodar* and *Kansabati* rivers. This directional movement of the depression contributed substantially to the rise of water in the river downstream and consequently the flood potential of such an event became enormous and progressively worse at the downstream channels and tributaries.

Heavy rainfall of high intensity close to Maithon-Panchet dam site contributed to the rapid inflow into Maithon-Panchet reservoir and the total flood volume from the Damodar basin during the late September 1978 flood was unusually high. There was also heavy rainfall in the lower trans — Damodar area giving rise to a very high inflow at the outfall of *Rupnarayan* river.

All these factors created severe drainage congestion in the north 24 Parganas district. The backwater effect of *Rupnarayan* river coupled with the favourable antecedent condition of soil moisture due to early September 1978 floods created a vast flood spill zone in the lower reaches of the rivers there.

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