551.577.37 (541.23)

DISASTROUS WEATHER EVENTS OF EXTREME HEAVY RAINFALL IN WEST BENGAL

1. Northern parts of West Bengal are situated at the foot-hills of the Himalayas. Most of the times, during southwest monsoon season these parts are affected by floods. Rainfall amount received during 24 hours may exceed 800 mm on some occasions. These are extreme disastrous weather events causing flood, landslides etc., which need to be studied in detail.

Karmakar and Khatun (1995) studied variability and probabilistic estimates of rainfall extremes in Bangladesh during southwest monsoon season. It revealed that mean rainfall and probabilistic rainfall estimates are maximum over the southeastern and northeastern parts of the country. Monsoon rainfall variability with comparative study in meteorological sub-divisions of West Bengal has been studied by Basu (2001). Extreme rainfall studies in various regions of the country have been made by many scientists. Stephenson and Rupkumar (1999) studied impact of extreme daily rainfall events on ensemble forecast of the Indian monsoon. Case studies of very heavy rainfall over Kolkata have been made by Banerjee *et al*. (1967) and Dhar and Ramachandran (1970). Heavy rainfall studies over Bombay and Kerala state have been made by Prasad and Agarwal (1996) and Saseendran *et al*. (1995) respectively. Desai *et al.* (1996) studied very heavy rainfall in the northern states like Punjab, Himachal Pradesh and Haryana. Study of depressions, cyclonic storms in the Bay of Bengal with very heavy rainfall have been made by Thapliyal *et al*. (2000) and Ganesan *et al*. (2000). Alam *et al*. (2003) has studied frequency of Bay of Bengal cyclonic storms and depressions crossing different coastal zones. It revealed that most of the monsoon depressions cross the Kolkata-Vishakhapatnam coast of India. Also, the frequency distribution of Bay of Bengal storms has 2 peaks – one in May and another in November, which is useful for seeing extreme rainfall events.

The purpose of this paper is to examine spatial and temporal variability of extreme heavy rainfall events in the West Bengal state during the period 1875 - 2000 and related climatology of rainfall in the state by considering rainfall normals during the period 1951 - 2000. The synoptic situations associated with heavy rainfall events in selected cases have also been examined.

2. Daily rainfall data from 1875 - 2000 have been utilized for computation of extreme heavy rainfall in 24 hours for about 137 stations of 19 districts in West Bengal. Daily rainfall data for the period 1951 - 2000 for 137 stations for 19 districts have been considered for computation of rainfall normals. Information on synoptic situations in case of some selected cases of extreme heavy rainfall have been collected from publication of Mausam.

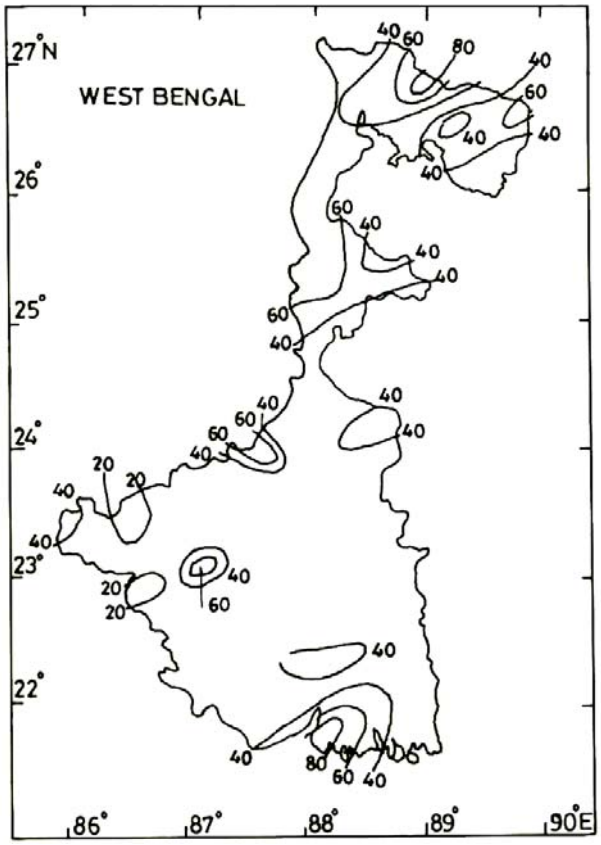

Fig. 1. Heaviest rainfall in 24 hrs (cm) for West Bengal

Climatological analysis of rainfall data has been made by considering daily rainfall data for the period 1951 - 2000. Monthly and annual rainfall normals for 137 stations of 19 districts in West Bengal have been computed. By considering data from 1875 - 2000 extreme heavy rainfall values during 24 hours have been extracted for the stations in West Bengal. Heaviest rainfall variability over different stations has been studied by frequency distribution of heaviest rainfall amount in different districts which has been depicted in Table 1. Continuous heavy rainfall for 2 or 3 successive days has been studied and shown in Table 2. For examining temporal distribution of heavy rainfall monthly frequency of extreme heavy rainfall in 24 hours for all districts in West Bengal have been examined and is shown in Table 3. Spatial variability of extreme heavy rainfall has been examined with the help of diagram (Fig. 1) showing

TABLE 1

Extreme heavy rainfall variability over West Bengal (Frequency during the period 1875-2000)

	Extreme rainfall amount (mm/day)							
Districts	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900
Bankura	3	8	4	1	1	-	-	-
Birbhum	-	2	3	-	-	1	-	-
Burdwan	1	2	5	-	-	-	-	-
Cooch Behar	-	-	2	3	-	-	-	1
Darjeeling	-	3	7	1	3	-	-	-
Dinajpur - North	-	-	-	-	-	1	-	-
Dinajpur - South	-	1	1	1	-	-	-	-
Hoogli	-	7	-	1	-	-	-	-
Howrah	-	-	1	1	-	-	-	-
Jalpaiguri	-	3	5	2	1	2	1	2
Kolkata	-	-	-	1	-	-	-	-
Malda	-	-	-	-	1	-	-	-
Midnapur-East	-	8	2	2	-	-	-	-
Midnapur-West	1	8	4	-	-	-	-	-
Murshidabad	-	3	1	1	-	-	-	-
Nadia	-	4	-	-	-	-	-	-
24 Parganas-North	-	3	3	-	-	-	-	-
24 Parganas-South	-	2	1	1	-	1	-	1
Purulia	2	5	1	-	-	-	-	-
Total	7	59	40	15	6	5	1	4

TABLE 2

Selected cases of heavy rainfall in 24 hours for 2 to 3 successive days in West Bengal

District	Stations	Rainfall in (mm/day)			
		Day 1	Day 2	Day 3	Period
Birbhum	Suri	673.1	539.8	450.9	01 – 03 Jul 1866
Cooch Behar	Mathabhanga (Hydro)	800.6	800.1	400.0	13 – 15 Aug 1990
Darjeeling	Darjeeling (Obsy)	500.5	500.1	504.4	29 – 31 Jul 1995
	Kurseong	501.7	464.1	-	11 – 12 Jun 1950
	Mongpoo	546.1	381.0	-	12 – 13 Jun 1950
Hooghly	Serampore	312.7	422.9	-	20 – 21 Sep 1900
Jalpaiguri	Chengmari/Diana (Hydro)	660.0	560.0	-	14 – 15 Feb 1990
	Hasimara (Hydro)	368.0	790.6	-	20 – 21 Jul 1993
	Kumargram (Hydro)	320.0	657.5	-	20 – 21 Jul 1993
	Nagarkata (Hydro)	805.3	404.4	-	06 – 07 Aug 1990
	Neora (Hydro)	802.4	600.0	-	26 – 27 May 1990
Midnapur-East	Tamluk	480.2	350.4	-	09 – 10 Jul 1964

TABLE 3

Monthly frequency of extreme heavy rainfall in 24 hours in West Bengal during southwest monsoon (1875-2000)

S. No.	District	Jun	Jul	Aug	Sep
1.	Bankura	3	2	6	5
2.	Birbhum	1	1	1	3
3.	Burdwan	2	1	-	5
4.	Cooch Behar	-	2	1	3
5.	Darjeeling	3	4	1	2
6.	Dinajpur-North	-	1	-	-
7.	Dinajpur-South	-	-	1	-
8.	Hoogly	1	-	1	5
9.	Howrah	-	-	1	1
10.	Jalpaiguri	1	10	2	1
11.	Kolkata	-	-	-	-
12.	Malda	-	-	-	1
13.	Midnapur-East	2	2	2	4
14.	Midnapur-West	4	-	4	3
15.	Murshidabad	3	-	1	-
16.	Nadia	-	2	-	2
17.	24 Parganas-North	1	-	1	3
18.	24 Parganas-South	1	2	-	2
19.	Purulia	1	1	1	4
	Total	23	28	23	44

isopleths for heaviest rainfall amount. Climatological charts for isopleths showing seasonal rainfall shown in (Fig. 2) have also been examined concerned with extreme heavy rainfall amount. Synoptic situations associated with selected extreme heavy rainfall events have been examined.

3. Table 1 shows that frequency distribution for heavy rainfall cases is mostly distributed in 200 to 400 mm. Out of 137 cases, about 100 cases are within 200 to 400 mm with highest frequency of 59 in 200 to 300 mm. There are 4 cases in the range 801 to 900 mm and 5 to 15 cases in the range 601 to 700 mm, 501 to 600 mm and 401 to 500 mm respectively. The total cases of more than 400 mm are 31.

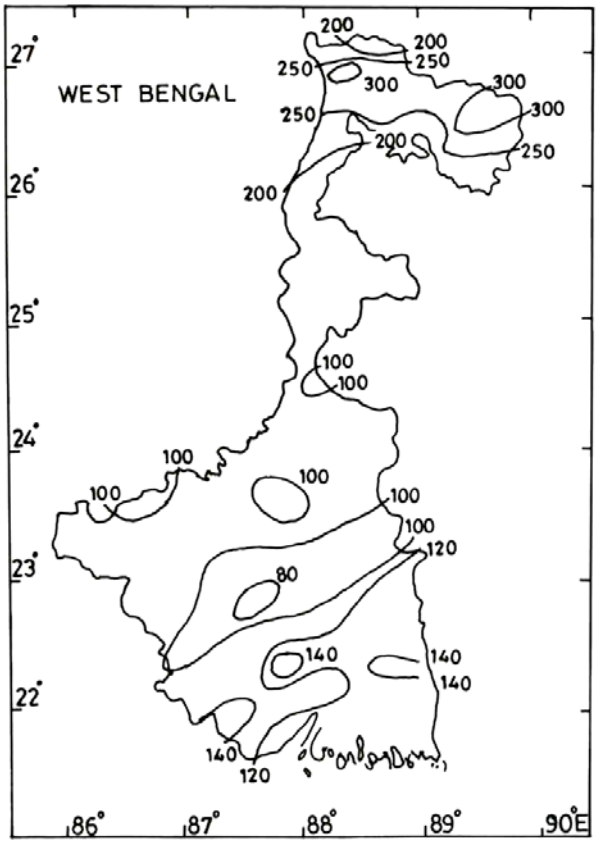

Fig. 2. Seasonal (June – September) rainfall (cm) for West Bengal

Table 2 shows selected cases of the occasions of heavy rainfall before or after the extreme heavy rainfall event. Occasions of at least 350 mm and above are considered. 12 occasions of successive heavy rainfall have been identified in districts of West Bengal during the period 1875-2000. Out of 12 occasions 8 occasions are during 1990 and onwards. Cooch Behar shows 2 successive occasions of 800 mm rainfall followed by 400 mm during 13 August to 15 August 1990. In Jalpaiguri and Darjeeling districts 5 and 3 occasions of successive 2 to 3 days heavy rainfall have been identified. In Darjeeling about 500 mm of rainfall occurred continuously for 3 days during 29 July to 31 July 1995. In Jalpaiguri district, at Chengmari/Diana (Hydro) 660 mm and 560 mm rainfall occurred on 14 and 15 February 1990 respectively. In the same district at Neora (Hydro) 802 mm and 600 mm rainfall occurred on 26 and 27 May 1990 respectively. These are few examples of successive days of heavy rainfall in different districts of West Bengal given in Table 2.

Table 3 shows monthwise frequency of heaviest rainfall in districts of West Bengal. Maximum frequency of extreme heavy rainfall events were noted in the month of September as 44 followed by July and August

TABLE 4

Synoptic situation for heavy rainfall in West Bengal for selected cases

District	Station	Rainfall (mm)	Date	Synoptic system
Cooch Behar	Mathabhanga	800.6	13 Aug 1990	Cyclonic circulation at lower level
Jalpaiguri	Jalpaiguri (Obsy)	474.0	10 Jul 1999	Low pressure area over Gangetic West Bengal
	Raiganj (Hydro)	680.0	11 Jul 1999	
	Hasimara (Hydro)	790.6	21 Jul 1993	Well marked low pressure area associated with cyclonic circulation during 14-21 July 1993
	Kumargram (Hydro)	657.5	21 Jul 1993	
	Nagarkatta (Hydro)	805.3	6 Aug 1990	Cyclonic circulation at lower level
	Neora (Hydro)	802.4	26 May 1990	Cyclonic circulation over west central Bay to south Orissa coast
24 Parganas - South	Sagar Island (Obsy)	884.5	22 Jul 1991	Well marked low pressure area in north Bay 21-27 July 1991

frequency as 28 and 23 respectively. Table 4 shows weekwise frequency of heaviest rainfall in districts of West Bengal. It shows maximum frequency in 2 weeks from 16 to 29 September followed by frequency from 8 to 15 July.

Fig. 1 shows extreme heavy rainfall in 24 hours in districts of West Bengal. In extreme northern parts of West Bengal extreme rainfall of 400 mm to 800 mm in 24 hours is noticed. In the central parts extreme rainfall of 300 to 700 mm in few cases are noticed. Towards south of the West Bengal state, the amount of extreme heavy rainfall in 24 hours is reduced and many cases are noticed in the range 200 to 300 mm. Some of the events of heavy rainfall of more than 400 mm are noticed in southeastern parts of the state. An occasional event of extreme heavy rainfall is noticed in extreme southeastern part of the state. In the extreme northern parts, the normal rainfall in southwest monsoon season is about 2000 to 3000 mm. In major parts it varies approximately from 900 to 1400 mm.

In extreme northern parts and extreme southeastern parts occasions of extreme heavy rainfall of 800 mm are noticed where normal seasonal rainfall in southwest monsoon is higher. The districts affected by extreme heavy rainfall more than 800 mm in 24 hours were Cooch Behar, Jalpaiguri and 24 Parganas which are situated in northern and southeastern parts respectively. Also, the districts Birbhum, North Dinajpur, Bankura, Darjeeling and Malda were affected by heavy rainfall more than 500 mm. These districts are situated in the Central parts of West Bengal.

Some of the cases of extreme heavy rainfall events were observed when low or well marked low pressure areas over West Bengal or adjoining areas were associated with cyclonic circulation extending upto mid-tropospheric levels. Some of the cases were associated with cyclonic storms or depressions starting from Head Bay upto Longitude 84° - 85° E. Some of the cases with cyclonic circulation over west central Bay of south Orissa coast lead to heavy rainfall more than 800 mm in Cooch Behar and Jalpaiguri districts. Well marked low pressure area in north Bay lead to more than 800 mm in south 24 Parganas during July 1991. Some selected cases of extreme heavy rainfall and associated synoptic situation are given in Table 4.

The study shows the important features as below :

(*i*) Frequency distribution of extreme heavy rainfall events in 24 hours in West Bengal is mostly in the range of 200 to 400 mm with highest frequency of 59 in 200 to 300 mm during 1875 - 2000.

(*ii*) There are 31 cases of extreme heavy rainfall in 24 hours more than 400 mm in West Bengal during 1875 - 2000.

(*iii*) More than 50% occasions of successive 2 or 3 days heavy rainfall are noticed during 1990 or onwards.

(*iv*) In Jalpaiguri and Darjeeling districts frequency of successive 2 or 3 days of heavy rainfall events is large and these districts are prone to continuous heavy rainfall.

(*v*) Monthwise temporal variability of extreme heavy rainfall in 24 hours over West Bengal during 1875 - 2000 shows maximum frequency during the month of September followed by July and August frequency.

(*vi*) Weekwise temporal variability of extreme heavy rainfall in 24 hours over West Bengal during 1875 - 2000 shows maximum frequency during 2 weeks from 16 to 29 September followed by the frequency from 8 to 15 July.

(*vii*) In extreme northern and southeastern parts of West Bengal extreme rainfall events more than 800 mm are noticed where normal seasonal rainfall is more than 2000 in northern parts and about 1400 mm in southeastern parts respectively.

(*viii*) Well marked low pressure areas associated with cyclonic circulation upto mid-tropospheric levels over West Central Bay lead to very heavy rainfall over West Bengal.

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