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A study of major rainstorms of the Teesta basin

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सार— 1960 से 1981 तक के 22 वर्षों के वर्षा के आंकड़ों के आधार पर समवर्षण विधि से तीस्ता बेसिन की मासिक एवं वार्षिक वर्षा के औसत ज्ञात करके बेसिन पर की वर्षा बंटन के प्रमुख अभिलक्षणों का उल्लेख किया गया है। इस अवधि में 1 दिन से 3 दिन की अवधि वाली तूफानी वर्षा 53 बार हुई, जिसका यहां विश्लेषण किया गया है। देखा गया है कि तूफानी वर्षा सबसे ज्यादा जुलाई के महीने में हुई और उसकी अवधि अधिकतर एक दिन की रही। अध्ययन के लिए विवेच्य अवधि में 3 से 5 अक्तूबर 1968 की तूफानी वर्षा में हुई औसत वर्षा का योगदान 1, 2, 3 दिन की अवधि वाली में सबसे ज्यादा था। शोधपत्र में तूफानी वर्षा से संबद्ध सिनॉप्टिक परिस्थितिओं पर भी विस्तार से चर्चा की गई है।

ABSTRACT. The average monthly and annual rainfall of the Teesta basin have been worked out by isohyetal method based on 22 years (1960 - 81) rainfall data; and the salient features of rainfall distribution over the basin are discussed. 53 rainstorms occurred during the period, of durations 1-day to 3-day have been analysed. It is observed that rainstorms are most frequent during the month of July and are of 1-day duration. For the period under study, the rainstorm of 3 - 5 Oct 1968 has made maximum contribution of average depth of rainfall for 1, 2 and 3-day durations. The synoptic situations associated with the rainstorms are also discussed in detail.

1. Introduction

The river *Teesta* originates in the glaciers of north Sikkim at an elevation of 6400 metres above mean sea level. It is mainly formed by the union of two streams, namely, *Lachen Chu* and *Lachung Chu* near Chungthang in Sikkim. It flows through Sikkim State, and Darjeeling, Jalpaiguri and Cooch Behar districts of West Bengal and finally enters Bangladesh where it falls into the river *Brahmaputra*. During its course, the river *Teesta* is joined by many tributaries, *Great Rangit* is the main one. The total catchment area of *Teesta* is 12,650 sq. km of which roughly 9,350 sq. km lies in the hilly region. The upper and middle portions of the catchment are much wider compared to the lower one.

The major portion of the catchment being hilly with the river flowing down a steep gradient, heavy rainfall over the upper and middle catchments has an immediate effect of rendering the plains to flash floods. Floods in the past including the one of 1968 have caused much devastation in terms of property as well as human life.

In the past, a few authors devoted their attention to the studies related to river catchments of north Bengal & Sikkim. Considering the lower limit of the catchment upto Teesta Bridge, Dhar *et al.* (1966) have made a study of rainfall over the Teesta basin based on 5 years' (1958-62) rainfall data. Abbi *et al.* (1970) have made a detailed analysis of heavy rainstorms that occurred over north Bengal. The diurnal variation of rainfall during the monsoon season in the river catchments of Teesta, Jaldhaka, Torsa and Raidak of north Bengal was studied by Bhattacharyya and Bhattacharyya (1980). Recently, a study regarding statistical forecasting of heavy rain and floods in the river *Teesta* was made by Lahiri (1981).

An attempt has been made in this paper to study rainfall distribution and major rainstorms and their associated synoptic situations over this catchment, based on last 22 years (1960-81) available data. In the present study, we have considered the Teesta catchment extending from its origin in north Sikkim upto Indo-Bangladesh border as shown in Fig. 1. On the basis of rainfall distribution, the catchment has been divided into three sub-divisions, *viz.*, upper, middle and lower as indicated in Fig. 1.

2. Raingauge network

In Teesta basin, there are 42 raingauge stations functioning under India Meteorological Department and Central Water Commission; 24 of these are equipped with self-recording raingauges. The network density of raingauges in the basin works out to be one raingauge per 300 sq. km of the basin area. Neighbouring stations whose data have been considered are also shown in Fig. 1.

Fig. 1. Teesta catchment showing rain-gauge network

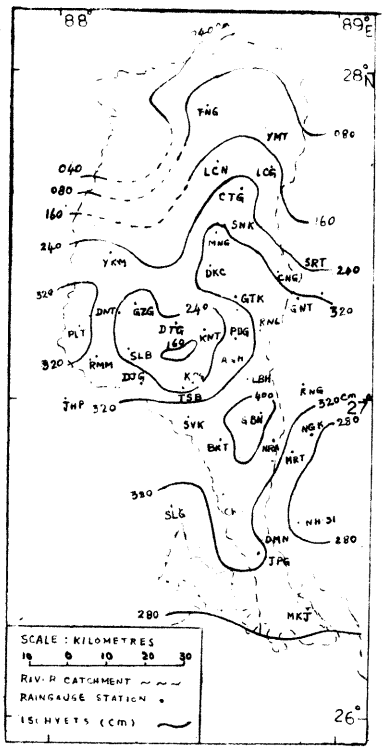

Fig. 2. Mean annual isohyetal map of Teesta basin

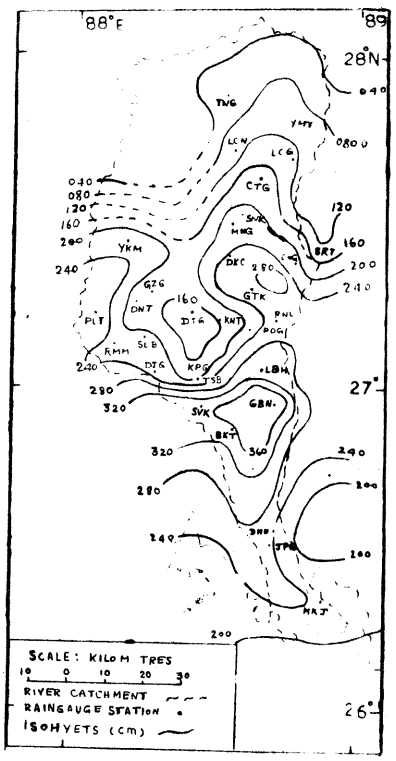

Fig. 3. Mean SW monsoon (Jun-Oct) isohyetal map

TABLE 1

Average monthly and annual rainfall (cm) of Teesta basin (1960-81)

Month	Catchment			Weighted mean for the whole catchment
	Upper	Middle	Lower	
Jan	2.1	2.3	0.6	1.8
Feb	4.1	3.2	1.6	3.2
Mar	7.3	6.6	3.0	6.0
Apr	7.2	14.7	14.4	11.3
May	14.2	27.4	31.5	22.6
Jun	24.5	46.3	54.7	38.8
Jul	23.6	62.1	86.6	51.2
Aug	22.2	51.2	64.5	41.7
Sep	17.1	33.8	49.5	30.4
Oct	7.7	11.2	19.1	11.7
Nov	1.5	1.9	2.1	1.8
Dec	1.3	1.2	1.3	1.3

Annual 221.8=222 cm
SW monsoon (June-Oct)=173.8 cm (78% of the annual)

3. Rainfall characteristics of Teesta basin

The southwest monsoon normally sets in over this region in the first week of June and withdraws in the second week of October. The average annual rainfall in the basin is 222 cm, of which 78 per cent is recorded during the southwest monsoon season. The monthly breakup of the annual rainfall of the basin is given in Table 1. From Table 1 it is clear that July is the wettest month followed by August & June. The mean annual and southwest monsoon (June to October) isohyetal patterns for Teesta catchment are presented in Figs. 2 & 3. The upper, middle and lower catchments receive 71.6 per cent, 78.1 per cent and 83.4 per cent of the annual rainfall respectively due to southwest monsoon. The upper catchment receives 21.6 per cent of the annual rainfall during the pre-monsoon, while 6.7 per cent of annual rainfall during the post-monsoon and winter seasons. The pre-monsoon rainfall in the upper catchment is due to local thunderstorm activities associated with moving troughs in westerlies.

From the rainfall pattern shown in Figs. 2 & 3 it is clear that the maximum rainfall regime of the catchment is around Sevoke, Garubathan and Bagrakote. There are two more pockets of heavy rainfall — one is situated north of Gangtok while the other is around Phalut. In between these two maxima, there is a minimum rainfall area south of Damthang. Then the rainfall gradually decreases towards north.

4. Rainstorm studies

Selection of rainstorms was made on the basis of isohyetal analysis of daily rainfall values. Then, considering the rainfall distribution and size of the catchment an average depth of 4.0 cm or more was chosen for 1-day storm, while 8.0 cm or more and 12.0 cm or more were taken for 2-day and 3-day storms respectively.

On the basis of above criteria, 53 rainstorms of durations ranging from one to three days were selected for this study. The average isohyetal depths of these

TABLE 2

Average isohyetal depths (cm) of rainfall for different durations of rainstorms over Teesta catchment

S. No.	Storm period	1-day	2-day	3-day
1	28 Sep 1960	8.0		
2	8 Jul 1961	4.1		
3	19 Aug 1961	4.3		
4	27 Jun 1962	4.0		
5	29 Jul 1962	4.2		
6	2 Aug 1962	4.0		
7	18 Aug 1962	4.2		
8	9 Jul 1963	4.3		
9	20-21 Jul 1963	5.2	9.2	
10	7 Aug 1963	5.9		
11	12 Aug 1963	4.0		
12	15 Sep 1963	4.7		
13	29 Sep 1963	4.9		
14	6 Jul 1964	6.5		
15	24 Jul 1964	5.6		
16	29 Jul 1964	4.7		
17	4 Aug 1964	4.9		
18	19 Jun 1965	4.1		
19	19 Aug 1965	4.3		
20	30 Jun-1 Jul 1966	4.4	8.6	
21	23 Aug 1966	4.2		
22	13 Jul 1968	4.1		
23	3-5 Oct 1968	14.6	22.6	30.4
24	5 Jun 1969	4.0		
25	17 Jun 1970	4.0		
26	11 Jul 1970	4.0		
27	29 Sep 1970	4.3		
28	13 Jun 1971	4.3		
29	26 Jun 1971	4.1		
30	6 Jul 1971	4.0		
31	1-2 Oct 1971	4.6	8.3	
32	28 Jul 1972	5.1		
33	26 Sep 1972	7.8		
34	16-17 Jun 1973	4.8	8.2	
35	23 Jun 1973	4.0		
36	3 Aug 1973	4.1		
37	11 Aug 1973	5.3		
38	12-13 Oct 1973	10.9	19.2	
39	1-3 Jul 1974	5.0	8.7	12.9
40	27-28 Jul 1974	4.9	9.1	
41	13-14 Jun 1975	4.2	8.3	
42	2-3 Jul 1975	4.1	8.2	
43	26 Jul 1975	6.6		
44	2 Jul 1976	4.3		
45	4 Aug 1976	4.1		
46	17 Aug 1977	4.5		
47	29 Jul 1979	5.0		
48	21 Aug 1979	4.2		
49	4-5 Sep 1979	4.5	8.4	
50	6 Jul 1980	4.1		
51	16-17 Jul 1980	4.5	8.5	
52	3-4 Jul 1981	4.8	9.4	
53	28 Jul 1981	5.0		

TABLE 3

Monthwise distribution of rainstorms

Duration	Jun	Jul	Aug	Sep	Oct	Total
1-day	7	15	13	5	—	40
2-day	2	6	—	1	2	11
3-day	—	1	—	—	1	2
Total	9	22	13	6	3	53

rainstorms are given in Table 2. The monthwise distribution of rainstorms of different durations is presented in Table 3.

Out of 53 rainstorms, 40 are of one-day, 11 are of two-day while only 2 are of three-day duration. Evidently, rainstorms of one-day duration are most frequent. One possible cause for such maximum 1-day storms is the narrow width of the catchment for which the effect of any moving synoptic system lasts for a shorter duration. No storm of longer duration than 3-day is seen to occur. Majority of the storms have occurred during the months of July and August. The rainstorm of 3-5 October 1968 contributed the highest 1-day, 2-day as well as 3-day depths of rainfall over the basin during the period under study.

5. Synoptic situations associated with rainstorms

It has been observed that rainstorms over this catchment occur in association with any of the following synoptic situations:

(*i*) Break monsoon conditions, *i.e.*, shifting of the axis of monsoon trough close to the foothills of the Himalayas;

(*ii*) Eastern end of monsoon trough lying north of Lat. 24 deg. N;

(*iii*) Movement of troughs in westerlies across the eastern Himalayas; and

(*iv*) Low pressure systems lying over or to the west of the catchment. These include depressions/storms originating in Bay of Bengal and breaking up over the Sub-Himalayan hills.

Many of the rainstorms under study were seen to occur due to either of the first two synoptic situations stated above during the months of July & August. A combination of the synoptic situations (*i*) or (*ii*) with (*iii*) is also a common feature over this area giving rise to heavy precipitation as in the case of a two-day storm of 4-5 September 1979. However, the rainstorms which occurred in the month of October yielding maximum precipitation were associated with the synoptic situation (*iv*).

Two rainstorms are discussed is the following paragraphs which occurred under different meteorological conditions:

(a) *Rainstorm of* 3-5 *October* 1968 — This occurred in association with a depression formed over central parts of Bay of Bengal on the morning of 29 September and continued to lie over there till 30th. It then moved in northwesterly direction and intensified into a cyclonic storm by the evening of 1 October and crossed north Andhra coast near Kalingapattanam on 2nd morning as a severe cyclonic storm. On the morning of 3rd, it was centred near Phulbani as a cyclonic storm. It weakened into a depression and lay near Daltonganj on 4th. On 5th morning it lay over Bihar plains as a low pressure area and broke up over the Himalayan region of north Bihar and north Bengal by the same evening.

The chief amounts of rainfall (cm) during the period are: 3 Oct: Sevoke 37, Labha 32, Singhik 18 and Jalpaiguri 12. 4 Oct: Sevoke 37, Kalimpong 26, Labha 23, Dikchu 22, Darjeeling & Teestabazar 21 each. Algarah & Singlabazar 20 each, Phalut 18 and Raman 16. 5 Oct : Kalimpong 42, Teestabazar 29, Darjeeling 27, Algarah 23, Singlabazar 22, Raman 21, Rongli, Dentam & Dikchu 20 each and Gangtok 18.

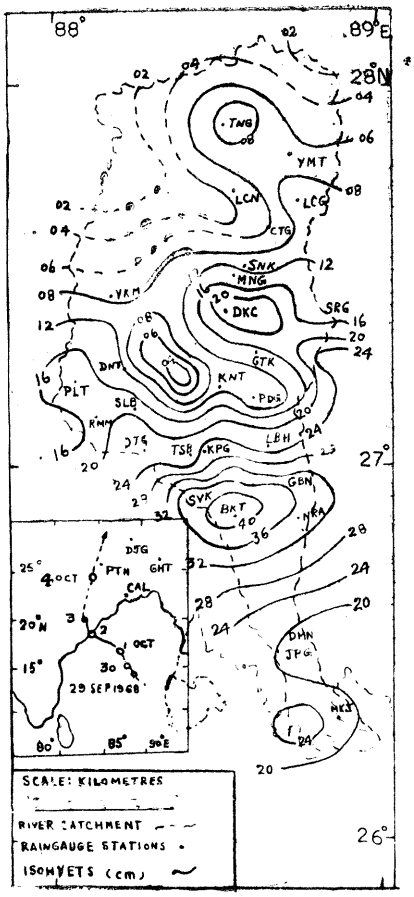

Fig. 4. 1-day rainstorm (4 Oct 1968) & track of Oct 1968 storm

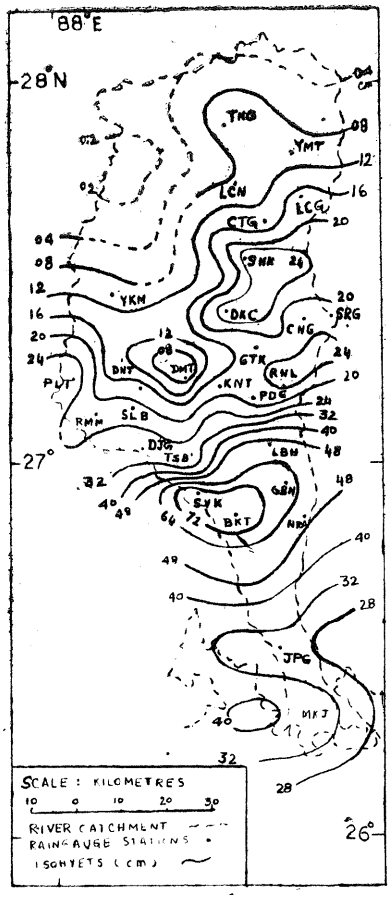

Fig. 5. 2-day rainstorm (3-4 Oct 1968)

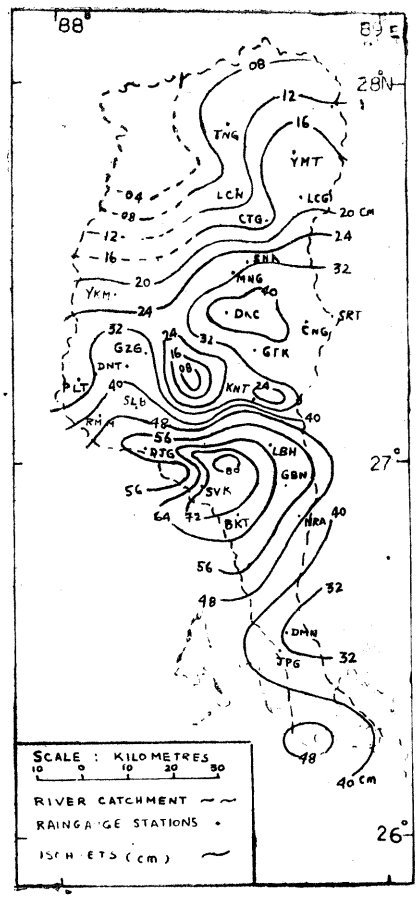

Fig. 6. 3-day rainstorm (3-5 Oct 1968)

(b) *Rainstorm of* 1-3 *July* 1974 — On 30 June : A trough line on sea level chart passed through Patna, Malda, Gauhati and Dibrugarh. A trough line at 900 metres above sea level also passed through Lucknow, Patna and Gauhati. On 1 July: Monsoon was vigorous over Sub-Himalayan West Bengal. Axis of seasonal trough on sea level chart was passing through Gorakhpur, Forbeshganj, Cooch Behar, Gauhati, Tezpur and Passighat. On 2 July : The trough line on sea level chart passed through Banaras, Patna, Cooch Behar, Gauhati and Passighat. Another trough line was roughly parallel to Long. 86 deg. E north of Lat. 20 deg. N between 1.5 km and 3.0 km above sea level. On 3 July: Axis of seasonal trough on sea level chart was passing through Bareilly, Lucknow, Patna, Dhubri, Tezpur and Khonsa.

The chief amounts of rainfall (cm) during the period are — 1 July: Jalpaiguri 28, Bagrakote & Garubathan 13 each, Pedong 7, Gangtok & Chungthang 6 each. 2 July: Garubathan 29, Sevoke 16, Teestabazar 8, Kalimpong, Algarah & Raman 7 each. 3 July: Garubathan 20, Bagrakote 18 and Sevoke 11.

During the period from 30 June 1974 to 3 July 1974, the eastern end of monsoon trough on sea level chart was fluctuating between Lat. 24 deg. N and Lat. 26 deg. N. The rainfall activity was accentuated due to a north-south trough prevailing parallel to 86 deg. E north of 20 deg. N between 1.5 km and 3.0 km above sea level on 2 July 1974.

6. Conclusions

(*i*) Rainstorms are most frequent in the month of July and are of one-day duration.

(*ii*) Rainstorms of Teesta basin generally do not exceed 3-day duration.

(*iii*) The general synoptic situation associated with the rainstorms is the prevalence of eastern end of monsoon trough to the north of Lat. 24 deg. N with or without general break in the monsoon.

(*iv*) For the period under study, the rainstorm of 3-5 October 1968 made maximum contribution of average depths of rainfall for 1-day, 2-day and 3-day duration. This heavy rainstorm, however, occurred in association with a cyclonic storm which originated in the Bay of Bengal and ultimately broke up over the Himalayan region of north Bihar as a low pressure area.

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