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# Some hydrometeorological studies over Teesta basin in north Bengal

S. K. PRASAD, A. K. DAS and I. SENGUPTA

*Flood Meteorological Office, Jalpaiguri*

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**सार** — उत्तरी बंगाल की तीस्ता द्रोणी तथा उसके आस-पास स्थित 40 वृष्टि केन्द्रों के 7–23 वर्षों के आंकड़ों के आधार पर वर्षा के मासिक स्थानिक वितरण की जल मौसम विज्ञान सूचनाएं, और तीस्ता द्रोणी के चरम वृष्टि वितरण निर्धारित किए गए हैं और मई से अक्तूबर महीनों के द्रोणी मानचित्रों में वर्षा के दिनों को चित्रित किया गया।

एक दिन के लिए औसत मासिक क्षेत्रीय वृष्टि की गहराई साथ ही साथ चरम क्षेत्रीय वृष्टि गहराई की चर्चा द्रोणी के 6 सक्टरों के लिए की गई। मई से अक्तूबर के दौरान जलग्रहण क्षेत्र में 22 चुनिंदा स्टेशनों के लिए पंचदिवसावधि वर्षा का मूल्यांकन व चर्चा की गई।

ABSTRACT. Based on data of 40 rainfall stations located within and in the neighbourhood of Teesta basin in north Bengal for period ranging between 7 & 23 years, hydrometeorological informations on the spatial distribution of monthly rainfall, number of rainy days and extreme rainfall distribution over Teesta basin have been determined and presented on basin maps for the months of May to October.

The average monthly areal precipitation depth as well as extreme areal precipitation depth for a day have been discussed for 6 sectors of the basin. The pentads rainfall for 22 selected stations in the catchment during May to October have also been evaluated and discussed.

**Key words** — Hydrometeorology, Rainfall distribution, Rainstorm, Precipitation depth.

## 1. Introduction

In the past, a few research workers have devoted their attentions to rainfall studies of river catchment of north Bengal and Sikkim. Dhar *et al.* (1966) made a study of rainfall over the Teesta basin based on 5 years of rainfall data. A detailed rainfall study of rainstorms over north Bengal as a whole has been carried out by Abbi *et al.* (1970). Gupta and Abbi (1972) have further studied in detail, the rainfall depth in various rivers catchments of north Bengal including the estimation of average catchment precipitation and computations of rainfall of different magnitudes for different return periods. Recently Biswas and Bhadram (1984) have studied rainfall distribution and major rainstorms and their associated synoptic conditions over the entire Teesta basin from its origin in north Sikkim up to Indo-Bangladesh border.

In the present study, entire Teesta basin has been divided into 6 sectors and presented on basin maps the spatial distribution of monthly rainfall and number of rainy days sectorwise. The average monthly areal precipitation depths have been presented in the form of tables for each sector. The pentad rainfall have been evaluated for 22 selected rainfall stations of the catchment during June to October months for 30 pentads only. The extreme rainfall isohyetal maps for a day have also been prepared and results are presented.

## 2. Raingauge network and contour heights of the catchment

The distribution and location of 40 raingauge stations in and around Teesta catchment have been shown in Fig. 3. The elevations (metres) for raingauge stations in the central and southern parts of the catchment are also shown except the stations located in the northern parts of the catchment where the elevations are not available.

## 3. Data

Due to non-availability of continuous daily rainfall data for the same period for all the stations, the rainfall data from 40 raingauge stations have been considered as follows :

(a) For 22 raingauge stations within the Teesta catchment, rainfall data for 23 years (1961-1983) have been used.

(b) For 8 stations within the catchment, rainfall data have been used for 7-8 years up to 1983 since their installations.

(c) For 10 stations in the neighbourhood of Teesta basin, rainfall data for 7-10 years up to 1983 have been used since their installations.

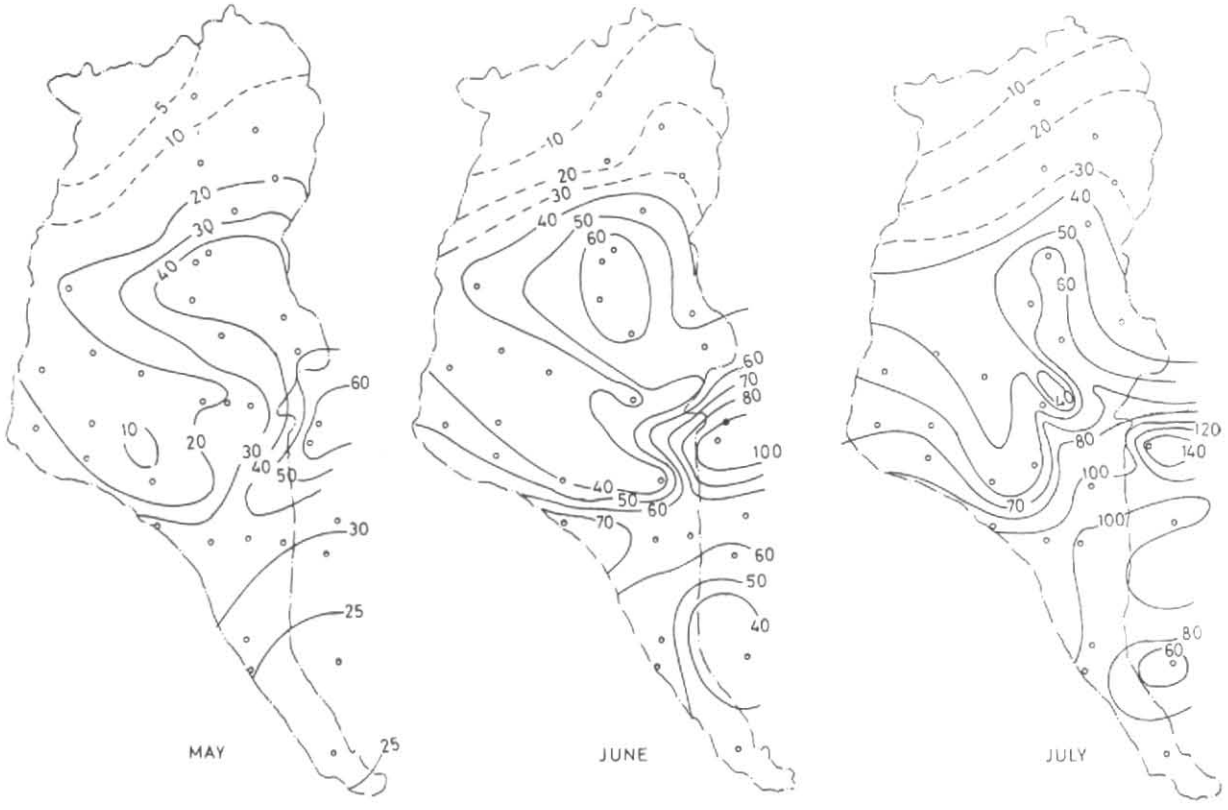


Fig. 1. Monthly isohyetal maps (May-July)

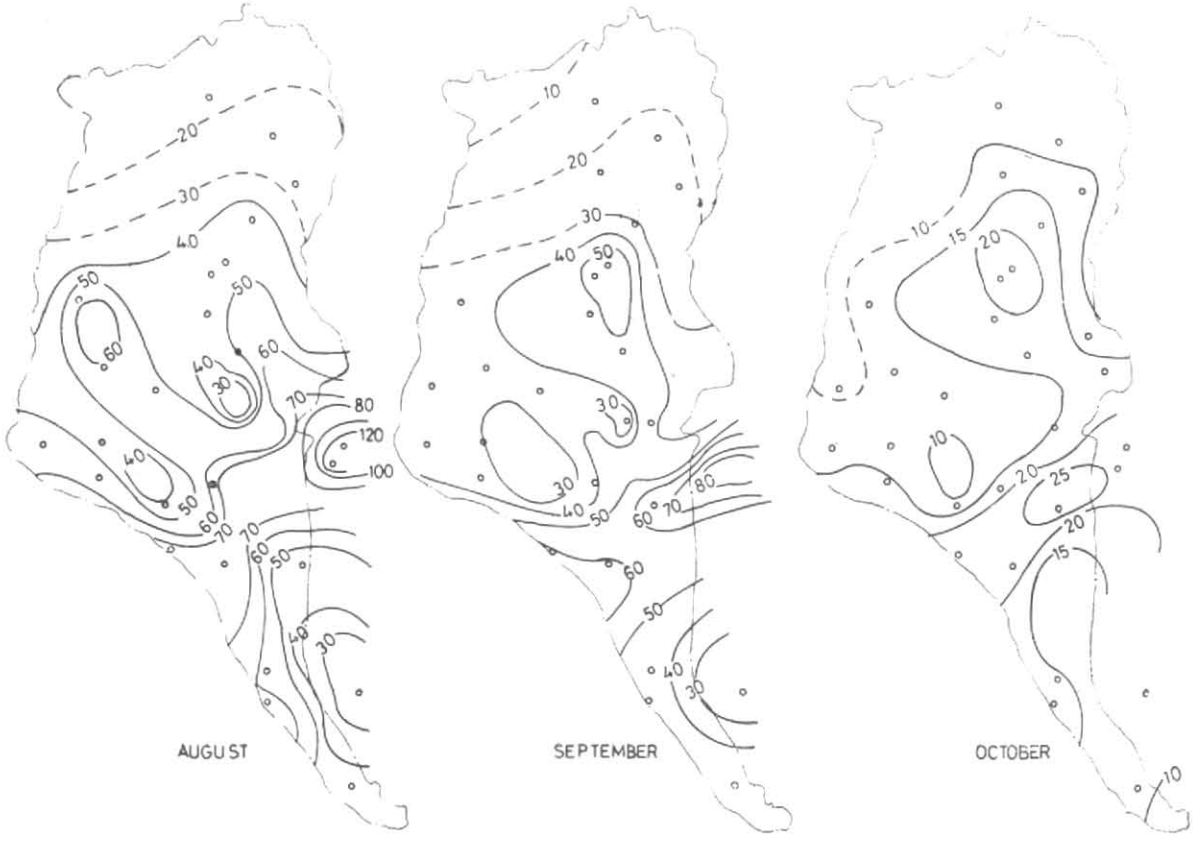


Fig. 2. Monthly isohyetal maps (August-October)

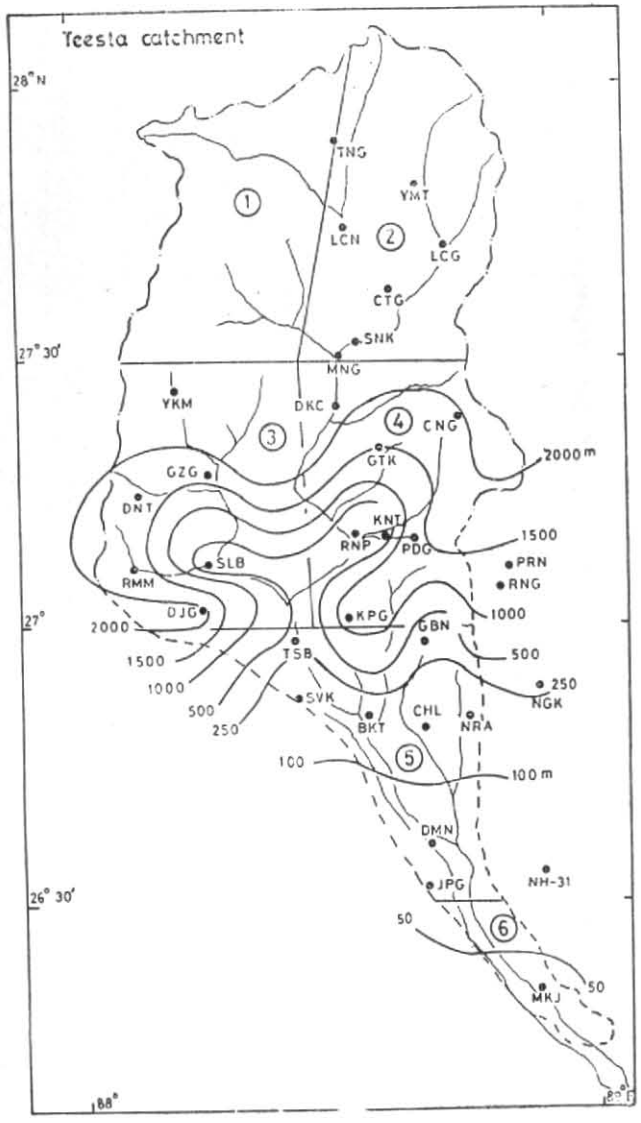


Fig. 3. Division of Teesta catchment into different sectors and contours (in metres)

#### 4. Method of analysis

Monthly precipitation amounts and number of rainy days were plotted on maps and isolines of rainfall and number of rainy days were drawn for the month of May to October. In regions of physiographic influence, isohyetal contours as well as number of rainy days were drawn by interpolation and extrapolation methods. The isohyetal method, which employs the areas encompassed between isohyetal contours as weights has been used for computing average precipitations depths and average number of rainy days. The areas have been determined by graphical method.

#### 5. Analysis and discussion

##### 5.1. *Monthly isohyetal maps of Teesta basin*

The spatial distributions of mean monthly rainfall over Teesta catchment for 6 months, *viz.*, May to October are shown in Fig. 1 and 2. The chief features as seen from these maps are given below :

(a) During May to October, highest monthly rainfall of 100 cm or more occurs in July over central region of sector 5.

(b) The secondary high rainfall belt occurs over northern region of sector 4 and adjoining sector 2 during all months.

(c) In each of the 6 months from May to October the rainfall is seen to have a steep decrease to the north over sectors 1 and 2, the monthly rainfall over sector 1 being 20 cm or less in the months of July, August and September and of the order of 10 cm in May and October.

(d) Another rainfall belt of low precipitation of about 10 cm is seen in sector 3 over a small area during May and October months.

(e) Outside the Teesta catchment in its close neighbourhood, a rainfall maxima of more than 140 cm is seen around Rango rainfall observatory during July in the Jaldhaka catchment.

##### 5.2. *Average monthly precipitation depth sectorwise*

In Table 1, sectorwise distribution of average monthly precipitation depth is given alongwith the precipitation depth of the entire Teesta basin. The highest monthly precipitation depth of about 53 cm occurs during July followed by August when 42 cm of rain occurs over entire Teesta basin. During May and June, the precipitation depth is highest in sector 4 followed by sector 5. During July to October, the highest rainfall occurs over sector 5.

##### 5.3. *Spatial distribution of mean monthly number of rainy days*

The spatial distribution of mean monthly number of rainy days on the basin are shown in Figs. 4 and 5 for the months of May to October. From spatial distribution of monthly rainy days, mean monthly number of rainy days were further evaluated for each sector of the catchment and same are presented in Table 2. The main features of Table 2 and Figs. 4 & 5 are given below:

(*i*) From Table 2 it is seen that during May to October, highest average number of rainy days is about 23 in July while minimum is 5 during October. The number of rainy days falls slowly from July to September and rapidly there after obviously due to withdrawal of southwest monsoon from the region in mid-October.

(*ii*) During July each sector records its highest number of rainy days in comparison to other months. The highest average number of rainy days is about 24 to 25 in sectors 2, 4 and 5 during July.

(*iii*) The number of rainy days during October in each sector is minimum in comparison to other months under study.

**TABLE 1**

**Average monthly precipitation depths (cm) — sectorwise**

| Month | Sectors | | | | | | Entire Teesta basin | Precipitation depths* |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| May | 8.6 | 19.9 | 18.1 | 35.1 | 28.6 | 25.4 | 22.1 | 22.6 |
| Jun | 17.2 | 28.9 | 42.9 | 53.9 | 51.6 | 46.0 | 39.6 | 38.8 |
| Jul | 21.4 | 30.0 | 53.9 | 59.0 | 89.0 | 78.6 | 52.9 | 51.2 |
| Aug | 18.9 | 27.6 | 49.9 | 53.2 | 57.1 | 44.0 | 42.2 | 41.7 |
| Sep | 20.4 | 25.3 | 35.5 | 41.5 | 50.0 | 40.3 | 35.2 | 30.4 |
| Oct | 6.7 | 10.2 | 12.2 | 15.2 | 16.2 | 12.3 | 12.0 | 11.7 |

*Biswas and Bhadram (1984)

**TABLE 2**

**Average number of rainy days—sectorwise**

| Month | Sectors | | | | | | Entire Teesta basin | No. of rainy days* |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| May | 9.2 | 16.0 | 16.1 | 16.8 | 12.4 | 11.0 | 14.2 | 14.7 |
| Jun | 14.7 | 19.5 | 19.4 | 21.1 | 17.0 | 16.1 | 18.6 | 19.8 |
| Jul | 16.9 | 23.6 | 22.6 | 24.7 | 24.3 | 20.3 | 22.8 | 21.5 |
| Aug | 16.2 | 22.2 | 21.0 | 22.6 | 19.3 | 9.6 | 19.9 | 20.2 |
| Sep | 10.9 | 18.6 | 15.2 | 18.4 | 14.1 | 10.8 | 15.2 | 16.5 |
| Oct | 3.7 | 6.7 | 4.7 | 7.8 | 3.8 | 4.1 | 5.1 | 5.9 |

*Number of rainy days as given by Abbi *et al.* (1970) over north Bengal region


Fig. 4. Monthly numbers of rainy days (May-July)

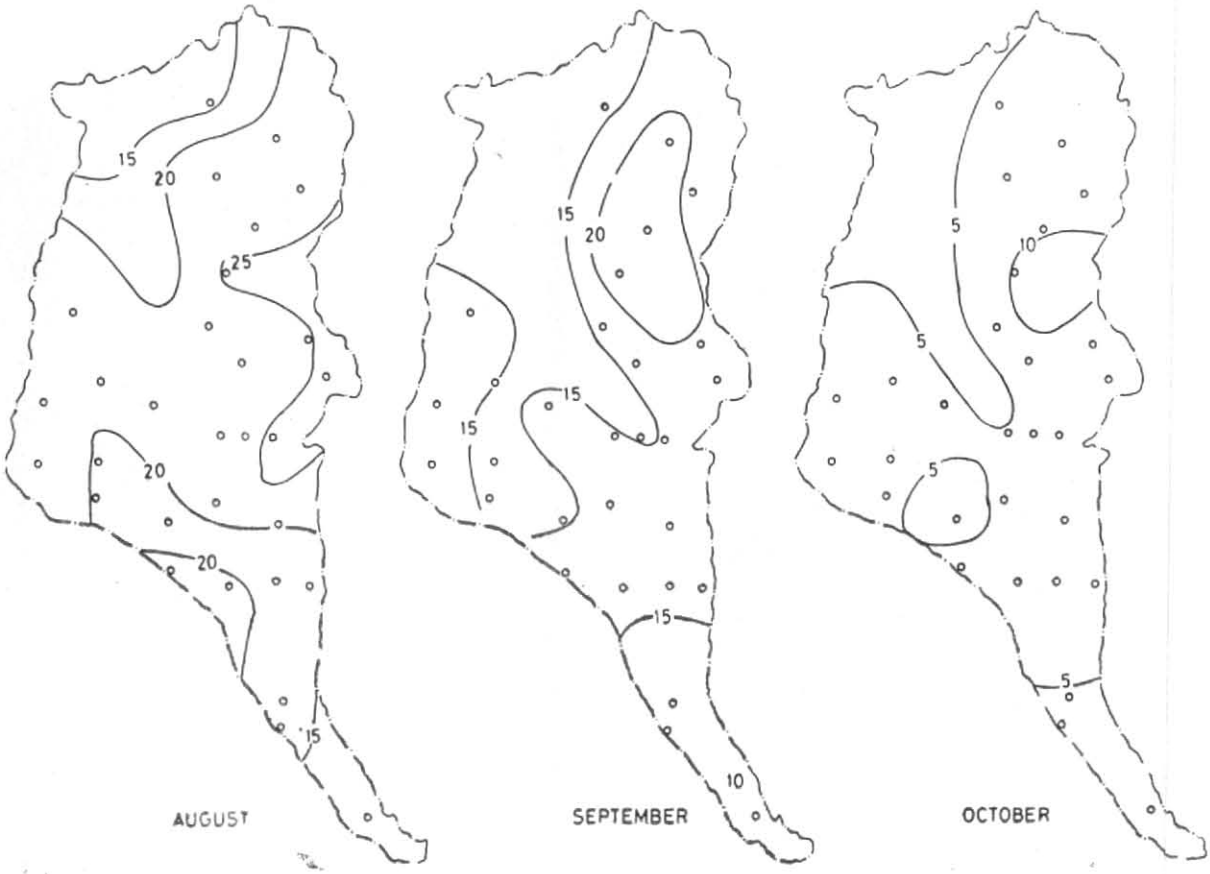


Fig. 5. Monthly number of rainy days (August-October)

TABLE 3
**Extreme rainfall (cm) for a day – sectorwise**

| Month | Sectors | | | | | | Entire Teesta basin |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| May | 3.8 | 9.1 | 7.6 | 13.4 | 14.1 | 11.1 | 9.4 |
| Jun | 4.1 | 4.6 | 16.8 | 14.9 | 16.4 | 20.0 | 12.2 |
| Jul | 5.5 | 5.3 | 23.8 | 15.6 | 23.1 | 23.4 | 15.6 |
| Aug | 8.7 | 7.3 | 21.7 | 19.9 | 16.6 | 17.7 | 15.3 |
| Sep | 4.7 | 6.0 | 15.3 | 15.0 | 16.9 | 18.3 | 12.1 |
| Oct | 6.0 | 8.4 | 17.7 | 20.9 | 15.2 | 9.0 | 13.8 |

(*iv*) The highest, 25-27 days of rain is seen to occur during July over eastern parts of sector 2 and most parts of sector 4 and 5 (Fig. 5).

5.4. *Extreme rainfall analysis*

Rainstorms of 1-day, 2-day and 3-day durations have been discussed by Dhar (1966), Abbi *et al.* (1970), Gupta and Abbi (1972) and recently by Biswas and Bhadram (1984) for the Teesta catchment. The rainfall precipitation depths in these studies have been made from a particular synoptic condition which was responsible for the heavy precipitation during the period. In order to evaluate for extreme rainfall and probable maximum flood (PMF) over a catchment or its subcatchments, it is desireable to study the most critical combination of meteorological and hydrological conditions. The precipitation depths evaluated from extreme rainfall data for each raingauge station over the Teesta basin and its 6 sectors will have useful applications for hydraulic designs within the catchment.

The isohyetal maps (extreme) for the months of May to October have been prepared from the observed extreme rainfall in a day during 1960 to 1983 and same are shown in Figs. 6 (a & b). The average extreme precipitation depths from extreme rainfall for a day for Teesta basin and its sectors have been evaluated and presented in Table 3. The chief features of the table are given below :

(*i*) Over the entire Teesta basin, the average extreme precipitation depth for a day varies between 9 and 16 cm during May to October, having highest magnitude of 15-16 cm during July and August (Table 3).

(*ii*) Extreme precipitation depths of 20 cm or more were seen in sector 3 during July and August, in sector 4 during August and October, in sector 5 during July and in sector 6 during June and July only.

(*iii*) The sectorwise extreme precipitation depth during June to October is highest during August in sector 1, during October in sector 2 and 4 while in sectors 3, 5 and 6, it is highest during July.

5.5. *Pentad rainfall*

From the monthly precipitation depth analysis it has been understood that July is the only month with heaviest precipitation followed by August and June over the Teesta catchment. The pentads rainfall starting from first June for 30 pentads have been evaluated

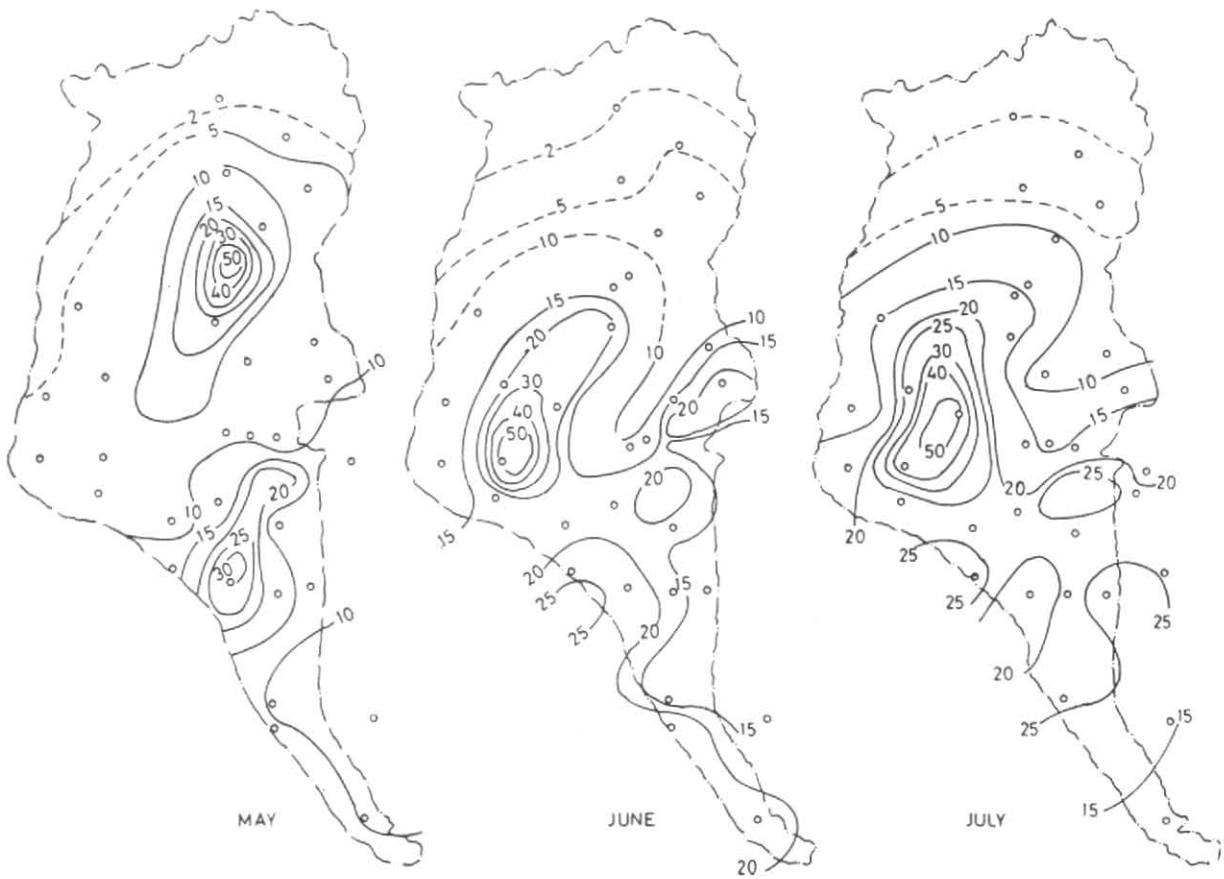


Fig. 6(a). Monthly isohyetal maps for one day extreme rainfall (May-July)

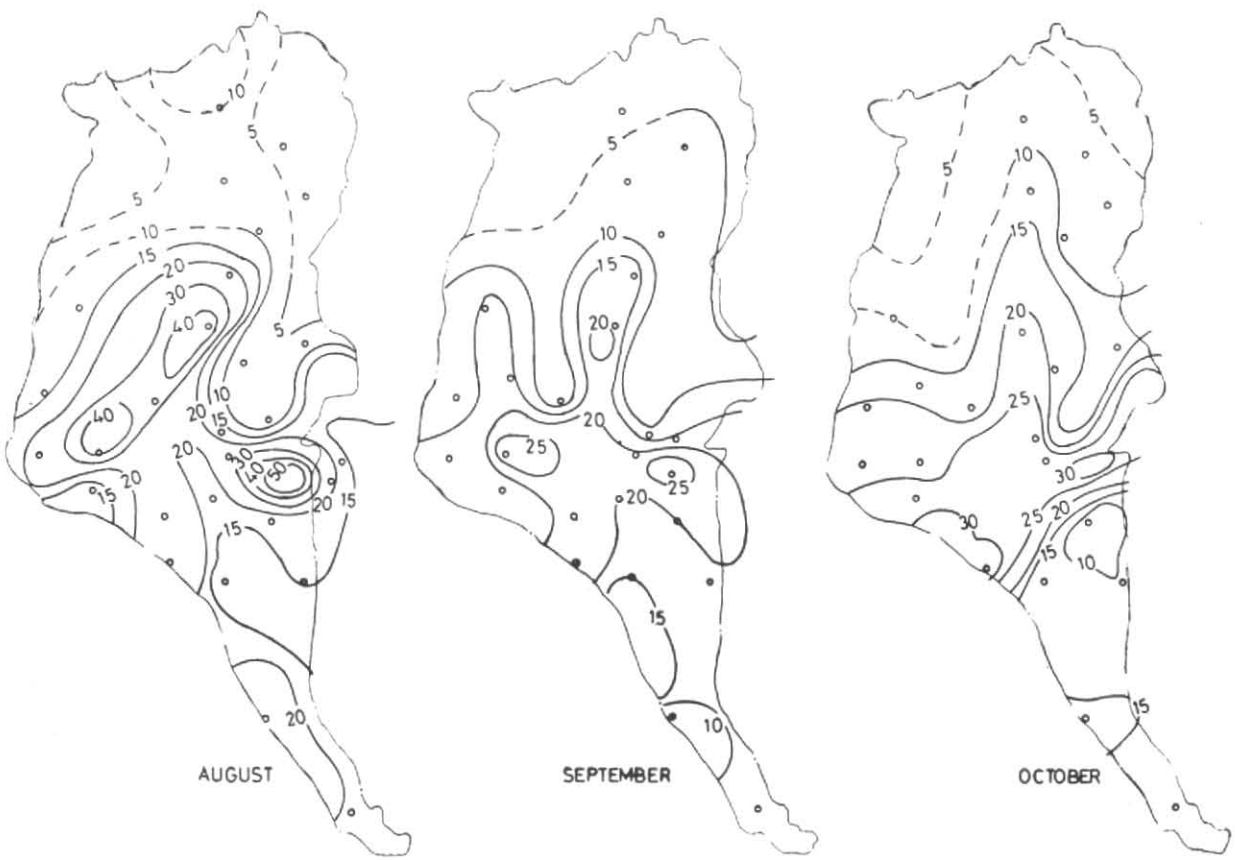


Fig. 6(b). Monthly isohyetal maps for one day extreme rainfall (August-October)

**TABLE 4**

**Pentad rainfall for selected stations within Teesta basin (June-October)**

| Pentad stations | Pentads | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| (1) Thanggu | 18.0 | 8.8 | 14.6 | 24.2 | 11.9 | 18.0 | 16.9 | 17.6 | 21.7 | 22.8 | 22.4 | 21.4 | 26.5 | 20.2 | 17.5 |
| (2) Yumthang | 23.8 | 29.8 | 44.5 | 67.8 | 44.1 | 52.5 | 43.4 | 40.3 | 42.6 | 47.9 | 48.2 | 44.1 | 49.9 | 42.9 | 43.4 |
| (3) Lachen | 38.2 | 28.0 | 29.4 | 42.1 | 35.7 | 36.1 | 34.1 | 33.5 | 36.1 | 41.4 | 49.4 | 43.3 | 47.0 | 30.9 | 41.1 |
| (4) Lachung | 36.0 | 39.3 | 47.7 | 80.4 | 60.2 | 49.9 | 43.9 | 38.7 | 51.1 | 46.2 | 55.9 | 50.8 | 64.4 | 45.7 | 42.5 |
| (5) Chungthang | 57.9 | 52.4 | 73.3 | 86.4 | 107.4 | 70.2 | 76.3 | 59.3 | 109.8 | 121.0 | 81.0 | 75.8 | 72.7 | 114.2 | 115.4 |
| (6) Singhik | 95.2 | 92.4 | 113.8 | 128.3 | 126.2 | 65.9 | 74.4 | 77.9 | 76.3 | 101.3 | 73.5 | 84.6 | 81.4 | 73.3 | 64.5 |
| (7) Dikchu | 109.6 | 92.4 | 140.3 | 96.7 | 109.6 | 74.1 | 77.8 | 82.8 | 72.0 | 101.8 | 103.6 | 99.0 | 65.0 | 124.3 | 58.2 |
| (8) Yuksum | 81.6 | 74.7 | 85.0 | 93.1 | 69.5 | 84.6 | 96.6 | 73.1 | 80.5 | 76.1 | 60.0 | 75.3 | 66.4 | 82.6 | 72.0 |
| (9) Chhangu | 89.2 | 74.9 | 101.4 | 73.2 | 78.8 | 61.6 | 68.4 | 75.9 | 74.4 | 93.3 | 91.5 | 70.0 | 92.1 | 95.9 | 87.9 |
| (10) Gnathang | 92.7 | 93.9 | 138.5 | 117.2 | 118.4 | 115.6 | 79.8 | 160.0 | 128.3 | 162.8 | 113.8 | 133.7 | 117.2 | 113.9 | 95.1 |
| (11) Damthang | 38.2 | 53.8 | 60.3 | 74.4 | 67.0 | 80.3 | 65.4 | 70.3 | 85.6 | 72.0 | 134.1 | 80.9 | 97.9 | 62.3 | 54.9 |
| (12) Dentum | 32.8 | 54.4 | 64.7 | 69.4 | 67.7 | 78.8 | 78.4 | 80.8 | 116.7 | 113.2 | 102.7 | 105.7 | 77.3 | 76.3 | 74.7 |
| (13) Rongli | 59.7 | 98.2 | 87.9 | 88.1 | 90.7 | 133.8 | 102.0 | 129.9 | 117.0 | 138.8 | 128.2 | 133.4 | 124.3 | 128.4 | 103.1 |
| (14) Raman | 56.4 | 53.8 | 74.2 | 78.1 | 72.7 | 123.9 | 104.7 | 94.3 | 96.6 | 121.6 | 108.1 | 119.1 | 109.8 | 94.3 | 88.0 |
| (15) Singlabazar | 23.3 | 46.9 | 68.1 | 88.6 | 52.7 | 94.5 | 101.3 | 66.1 | 98.6 | 137.4 | 112.9 | 158.2 | 122.1 | 96.0 | 90.9 |
| (16) Munsong | 34.5 | 73.5 | 68.5 | 57.2 | 65.1 | 90.0 | 92.6 | 88.5 | 101.4 | 123.8 | 93.2 | 84.8 | 91.6 | 85.9 | 79.0 |
| (17) Algarah | 47.4 | 71.6 | 70.7 | 75.3 | 95.4 | 120.1 | 123.2 | 120.4 | 111.9 | 141.4 | 126.0 | 138.2 | 105.1 | 111.6 | 108.0 |
| (18) Ressisum | 36.1 | 71.4 | 68.2 | 82.9 | 96.4 | 104.2 | 105.9 | 103.1 | 99.5 | 124.7 | 122.1 | 110.6 | 87.1 | 104.6 | 102.9 |
| (19) Pedong | 38.0 | 76.2 | 73.1 | 67.3 | 84.1 | 91.2 | 104.5 | 93.9 | 110.0 | 135.6 | 97.8 | 82.6 | 81.5 | 101.3 | 76.2 |
| (20) Teestabazar | 34.4 | 48.1 | 54.3 | 47.4 | 66.1 | 104.5 | 88.7 | 77.1 | 81.4 | 103.7 | 90.7 | 94.4 | 59.7 | 65.7 | 64.5 |
| (21) Labha | 54.9 | 75.6 | 117.9 | 107.2 | 124.3 | 120.6 | 148.2 | 145.2 | 152.9 | 141.3 | 171.2 | 141.1 | 143.4 | 135.7 | 131.0 |
| (22) Sevoke | 108.2 | 106.5 | 131.5 | 147.7 | 182.5 | 170.4 | 176.8 | 161.1 | 159.1 | 163.1 | 165.8 | 173.5 | 135.6 | 119.9 | 118.3 |

**TABLE 4** (*Contd.*)

| Pentad stations | Pentads | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| (1) Thanggu | 23.1 | 21.4 | 21.0 | 12.4 | 18.3 | 20.1 | 19.8 | 19.6 | 31.4 | 30.4 | 22.8 | 22.4 | 12.1 | 8.3 | 0.9 |
| (2) Yumthang | 44.5 | 44.4 | 39.8 | 38.0 | 35.1 | 36.9 | 35.9 | 33.1 | 35.1 | 34.1 | 18.3 | 14.1 | 10.8 | 8.1 | 6.6 |
| (3) Lachen | 56.2 | 35.3 | 49.1 | 39.2 | 30.3 | 32.3 | 32.8 | 22.4 | 51.4 | 48.4 | 16.4 | 32.9 | 18.8 | 8.6 | 1.2 |
| (4) Lachung | 40.1 | 57.0 | 60.0 | 31.1 | 38.1 | 41.3 | 45.5 | 20.1 | 42.7 | 40.3 | 23.5 | 32.8 | 18.8 | 4.6 | 6.4 |
| (5) Chungthang | 60.6 | 84.5 | 59.4 | 53.1 | 55.6 | 57.9 | 56.7 | 36.4 | 57.9 | 57.9 | 39.9 | 24.6 | 16.0 | 12.7 | 7.6 |
| (6) Singhik | 72.7 | 85.9 | 67.4 | 71.0 | 58.3 | 64.9 | 80.4 | 51.2 | 58.5 | 72.5 | 47.2 | 48.5 | 18.7 | 23.3 | 28.6 |
| (7) Dikchu | 71.3 | 85.1 | 103.5 | 84.4 | 74.7 | 81.2 | 105.4 | 55.6 | 68.9 | 37.9 | 54.0 | 50.5 | 5.7 | 13.7 | 18.1 |
| (8) Yuksum | 103.3 | 110.1 | 100.1 | 86.8 | 89.3 | 42.9 | 97.2 | 63.1 | 63.6 | 52.7 | 84.3 | 53.3 | 19.8 | 28.4 | 3.1 |
| (9) Chhangu | 63.9 | 73.2 | 81.5 | 66.2 | 55.5 | 43.5 | 48.2 | 39.5 | 78.4 | 55.1 | 51.3 | 25.3 | 8.9 | 8.0 | 1.7 |
| (10) Gnathang | 137.9 | 122.8 | 104.5 | 91.9 | 60.7 | 61.0 | 95.1 | 44.2 | 94.9 | 69.9 | 93.2 | 10.2 | 7.4 | 8.9 | 3.1 |
| (11) Damthang | 61.7 | 43.1 | 52.9 | 34.5 | 33.9 | 32.2 | 41.5 | 36.4 | 25.6 | 37.3 | 19.0 | 21.9 | 5.1 | 4.9 | 3.4 |
| (12) Dentum | 75.6 | 62.3 | 81.4 | 86.8 | 59.9 | 50.5 | 68.3 | 35.2 | 57.9 | 41.8 | 36.2 | 13.3 | 7.9 | 5.8 | 5.5 |
| (13) Rongli | 130.5 | 97.8 | 98.4 | 81.6 | 81.5 | 77.3 | 81.7 | 53.5 | 55.8 | 36.4 | 19.7 | 41.3 | 11.1 | 13.9 | 2.8 |
| (14) Raman | 99.5 | 85.9 | 82.9 | 94.4 | 77.8 | 71.8 | 72.6 | 45.8 | 64.9 | 56.8 | 35.7 | 19.3 | 9.3 | 5.1 | 4.6 |
| (15) Singlabazar | 83.7 | 97.9 | 61.0 | 62.4 | 58.8 | 49.9 | 46.6 | 21.8 | 54.2 | 40.6 | 51.4 | 13.6 | 9.4 | 7.8 | 5.3 |
| (16) Munsong | 87.7 | 74.8 | 72.2 | 61.9 | 59.7 | 50.9 | 55.9 | 26.7 | 53.1 | 57.3 | 43.6 | 25.1 | 7.6 | 5.9 | 5.9 |
| (17) Algarah | 119.5 | 82.4 | 85.2 | 95.5 | 66.4 | 72.9 | 73.0 | 39.0 | 78.5 | 71.2 | 26.8 | 12.2 | 8.1 | 4.1 | 2.2 |
| (18) Ressisum | 104.4 | 87.1 | 60.2 | 79.4 | 72.2 | 61.8 | 64.9 | 44.4 | 99.7 | 55.0 | 43.3 | 27.6 | 7.6 | 3.7 | 1.6 |
| (19) Pedong | 94.1 | 74.0 | 78.2 | 63.2 | 60.2 | 51.2 | 57.2 | 35.2 | 54.3 | 52.6 | 33.3 | 27.2 | 6.6 | 9.5 | 8.8 |
| (20) Teestabazar | 68.1 | 68.8 | 76.8 | 58.8 | 53.7 | 37.9 | 62.9 | 30.1 | 49.2 | 44.4 | 39.2 | 22.1 | 8.2 | 6.2 | 3.1 |
| (21) Labha | 136.8 | 118.4 | 112.6 | 108.6 | 98.0 | 69.7 | 91.7 | 50.1 | 75.0 | 72.0 | 35.7 | 39.5 | 14.6 | 19.6 | 9.5 |
| (22) Sevoke | 134.8 | 138.7 | 102.3 | 117.3 | 113.9 | 124.7 | 154.5 | 88.5 | 103.7 | 111.5 | 58.1 | 48.7 | 7.4 | 14.1 | 9.6 |

with a view to obtain exact number of pentads responsible for heaviest rainfall and floods at an individual station. The pentad rainfall thus evaluated will be an useful tool in the hands of flood forecasters and climatologists engaged in the hydrometeorological services for the Teesta basin. The pentads rainfall have been evaluated from the daily rainfall figures starting from first June and for 30 pentads, only for the selected 22 raingauge stations. During evaluation of pentad rainfall, if any rainfall data is missing or not available for a day or so, the pentad rainfall for the same has been rejected. Thus after evaluating the pentad rainfall for each year, the mean pentad rainfall have been calculated and same are presented in Table 4. Chief features of Table 4 are given below :

(a) Out of 22 raingauge stations, 7 reported highest pentad rainfall in pentad 10 *i.e.*, during 16-20 July and 3 stations during pentad 4, *i.e.*, during 16-20 June.

(b) Thanggu, the northernmost raingauge station receives highest rainfall during pentad 24, *i.e.*, during 24-28 September.

(c) The highest pentad rainfall among 22 selected stations, occurs at Sevoke during pentad 5 and is about 182 cm and a minimum of about 31 cm occurs at Thanggu during pentad 24.

(d) The highest rainfall in a pentad at Thanggu, Yumthang, Lachen and Lachung is below 100 cm while for all other stations it lies between 100-200 cm.

5.6. *Comparison of results*

(a) Average monthly precipitation depths over the entire Teesta basin, as given by authors and Biswas and Bhadram (1984) are nearly same (Table 1).

(b) The number of rainy days exclusively over Teesta basin have not been evaluated by any other authors so far. Abbi *et al.* (1970) have given normal number of rainy days over north Bengal region and same are compared with number of rainy days evaluated for Teesta basin. It is seen that monthly number of rainy days of Teesta basin and of north Bengal have a very close relation (Table 2).

(c) The authors though have given extreme values of average precipitation depth for a day, it has not been possible to compare these all extreme values, as there are only a few events to compare during 1960-1984. Out of the 53 rainstorms studied by Biswas and Bhadram (1984) and those which occurred during 1982-1984, it is seen that one day rainstorm of 3-5 October 1968 and of 12-13 October 1973 have precipitation depths of 14.6 and 10.9 cm respectively. The extreme precipitation depth for the month of October is 13.8 cm over Teesta basin, which is very close to the observed highest one day rainstorm of 3-5 October 1968. For other extreme values of precipitation depth, it may be possible to compare them in future when such events occur.

**6. Conclusions**

(*i*) The highest monthly rainfall of about 53 cm occurs during July in the Teesta basin followed by August with 42 cm and June with 40 cm. A minimum rain of about 12 cm is observed during October.

(*ii*) The areal precipitation depth during July in each sector is highest in comparison to other sectors of different months. The highest precipitation in a sector occurs in sector 5 in July.

(*iii*) The minimum rainfall occurs in sector 1 of the Teesta basin during all the months from May to October.

(*iv*) The average monthly number of rainy days varies between 14 & 22 during May to September, the highest being 23 during July. The number of rainy days during October is only 5.

(*v*) The sectorwise monthly number of rainy days indicate that all the sectors during July record highest number of rainy days like highest average precipitation depths in the same month.

(*vi*) The extreme precipitation depths evaluated for entire Teesta basin and its sectors may be close to the maximum precipitation expected over an area on a day. These extreme values may find its application in design, construction of dams, reservoirs etc in future.

(*vii*) Out of 22 selected raingauge stations in Teesta basin, about 32 per cent stations report highest pentad rainfall in pentad 10, *i .e.*, during 16-20 July while about 14 per cent stations record highest rain in 4th pentad, *i. e.*, during 16-20 June.

(*viii*) The highest pentad rainfall at any individual station occurs at Sevoke during pentad 5 and is about 182 cm. The highest pentad rainfall at Thanggu occurs during pentad 24.

(*ix*) The average monthly precipitation depths and monthly number of rainy days evaluated by authors and Biswas and Bhadram (1984) and Abbi *et al.*(1970) are nearly same.

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**References**

Abbi, S.D.S., Gupta, D.K. and Jain, B.C., 1970, "A study of heavy rainstorms over North Bengal", *Indian J. Met. Geophys.*, **21**, pp. 195-210.

Biswas, B. and Bhadram, C.V.V., 1984, "A study of major rainstorms of the Teesta basin", *Mausam*, **35**, pp. 187-190.

Dhar, O.N., Mantan, D.C. and Jain, B.C., 1966, "A brief study of rainfall over the Teesta basin up to Teesta Bridge", *Indian J. Met. Geophys.*, **17**, Spl. No., pp. 59-66.

Gupta, D.K. and Abbi, S.D.S., 1972, "A study of storm rainfall over North Bengal river basins", India Met. Dep., Met. Monogr., Hydrology, No. 4.