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551.553.21 : 551.577.3 (541.2)

# Variability of southwest monsoon rainfall over West Bengal

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सार–गंगेय और उप-हिमालयी पश्चिम बंगाल के जिलों में दक्षिण-पश्चिम मानसून के दौरान होने वाली वर्षा की मासिक और मौसमी परिवर्तिताओं का अध्ययन किया गया है तथा उनके बीच अंतर पर चर्चा की गई है। मानसूनी वर्षा की अक्षांशीय परिवर्तिताओं को स्पष्ट किया गया है। स्थल क्षेत्रों पर मौसमी वर्षा के दशकीय मानों की तुलना उत्तर अक्षांशों और उच्चतर क्षेत्रों के मानों के साथ की गई है। दीर्घावधि वर्षा की प्रवृत्तियों के अध्ययन का प्रयास भी किया गया है।

ABSTRACT. Monthly and seasonal variations of southwest monsoon rainfall over the districts of Gangetic and Sub-Himalayan West Bengal are presented and their differences discussed. Latitudinal variations of monsoon rainfall are brought out. Decadal means of seasonal rainfall over plains are compared with those at higher elevations and northern latitudes. An attempt is made to study long term rainfall trends.

**Key words** — Chances (in %), Position of monsoon trough, Average areal precipitation, Orographic effect, Latitudinal variation, Decadal variation, Recent trend.

## 1. Introduction

The State of West Bengal gets 71 to 84% of its annual rainfall in the southwest monsoon season (June-September). A normal distribution of this rainfall is highly beneficial to the agriculture based socio-economy of the State. An attempt has been made to examine certain aspects of the monsoon rainfall with reference to the associated synoptic situations and other meteorological factors. Chances (in %) of occurrence of appreciable amount of rainfall at few places over two meteorological sub-divisions, *viz.*, Gangetic West Bengal and Sub-Himalayan West Bengal in a particular month and during the season as a whole have been worked out. Spatial (latitudinal), diurnal variations with intensity of rainfall and decadal (one, three, five) variations of monthly and seasonal rainfall amounts with the recent trend etc have also been discussed.

## 2. Data used and methodology

Rainfall data recorded at all India Meteorological Department (IMD) observatories and at various raingauge stations maintained by the State of West Bengal and other organisations and also those situated in the adjoining areas of other States have been utilised for the purpose. Available data from 1901 to 1980 have been utilised for finding out the monthly and seasonal means, decadal, three-decadal and five-decadal variations etc.

## 3. Chances (in %) of occurrence of a certain amount of rainfal at different stations

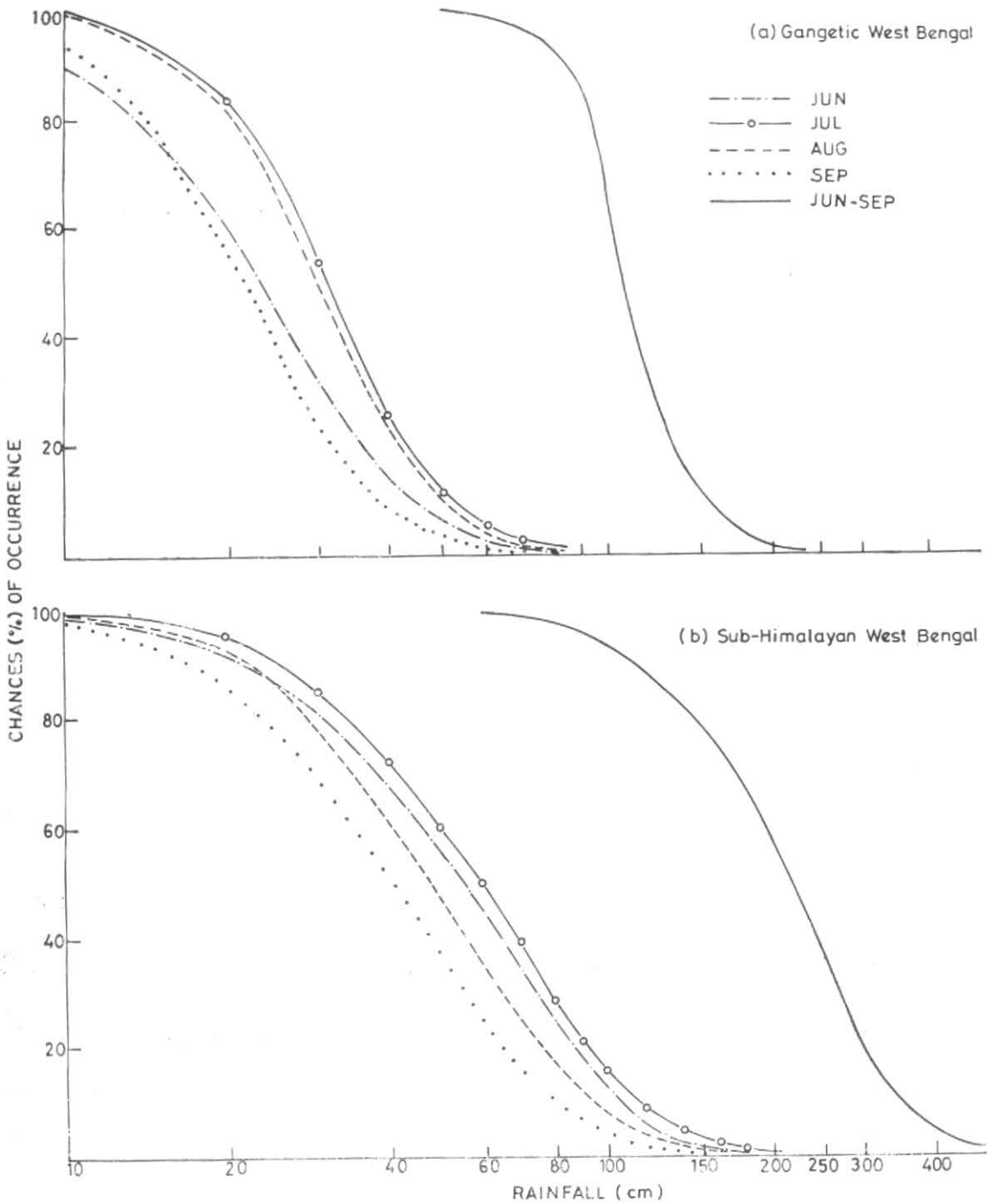
Theoretically, the amount of rainfall at a place over a specified time interval may vary from zero to a probable quantity. The chances (in %) hereafter called 'chances', of occurrence of 20, 40, 60 and 80 cm of rainfall in each of the months of June, July, August and September and that of 80, 120, 160, 200 and 300 cm of rainfall during the season (June-September) in respect of some important stations in West Bengal are computed using simple statistical methods and the results are presented in Table 1. The chances of getting at least 40 cm of rainfall in any of the four months is not appreciably high for stations situated in Gangetic West Bengal and in the southern part of Sub-Himalayan West Bengal. Other stations in Sub-Himalayan West Bengal region are having moderate to high chances of getting at least 60 cm of rainfall in each of these months.

Figs. 1 (a & b) show average chances of occurrence of rainfall amounts, sub-divisionwise for Gangetic West Bengal and Sub-Himalayan West Bengal, starting from 10 cm to the highest possible values. In Fig. 1 logarithmic scale along the abscissa and simple scale along the ordinate are taken for convenience. From Fig. 1 following inferences are drawn :

(*i*) For stations in Gangetic West Bengal :

(a) The chances of occurrence of a certain amount of rainfall is highest in July followed by August, June and September. This order may reverse in case of June and September foi years having rainfall less than 15 cm in each of these months.

(b) Average chances for a certain amount of rainfall in July and August are almost same and much higher than those for June and September.




Figs. 1(a&b). Average chances (in %) of occurrence of SW monsoon rainfall over : (a) Gangetic West Bengal, and (b) Sub-Himalayan West Bengal

(c) Average chances for occurring an amount of 40 cm or more rainfall in July and August are three times more than that in September and almost double to that in June.

(*ii*) For station in Sub-Himalayan West Bengal :

(a) July is the rainiest month followed by June, August and September. Here also, the order between August and June may change for years having rainfall less than 23 cm in each of these months.

(b) Average chances for having an amount of 50 cm in each of the months of June, July and August lie between 48% and 60%. However, the average chances for having rainfall 80 cm or more in June and July is about 3 times higher compared to the rainfall in September and almost double to that in August.

(*iii*) The average chances for having rainfall amount of 50 cm or more in a month in Sub-Himalayan West Bengal is much more than that in Gangetic West Bengal.

TABLE 1

**Chances (in %) of occurrence of rainfall (mm) in West Bengal during the months of June-September**

| Name of the station | Location Lat./Long. (° ′ N/° ′ E) | Rainfall amount (cm) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jun | | | | Jul | | | | Aug | | | | Sep | | | | Jun-Sep | | | | | |
| | | 20 | 40 | 60 | 80 | 20 | 40 | 60 | 80 | 20 | 40 | 60 | 80 | 20 | 40 | 60 | 80 | 80 | 120 | 160 | 200 | 300 | 400 |
| **Gangetic West Bengal** | | | | | | | | | | | | | | | | | | | | | | | |
| Calcutta (Alipore) | 22 32/88 20 | 69 | 20 | 3 | — | 86 | 24 | 5 | — | 90 | 24 | 1 | — | 68 | 11 | — | — | 98 | 44 | 13 | — | — | — |
| Sagar Island | 21 39/88 03 | 70 | 24 | 2 | — | 90 | 39 | 8 | — | 91 | 40 | 6 | — | 75 | 14 | 6 | 1 | 98 | 67 | 0 | — | | |
| Gosaba | 22 11/88 48 | 72 | 14 | — | — | 97 | 43 | 6 | 3 | 97 | 42 | 3 | — | 67 | 6 | — | | 97 | 31 | 20 | 3 | — | |
| Bongaon | 23 04/88 49 | 69 | 20 | 2 | — | 82 | 22 | | | 80 | 31 | 6 | 2 | 59 | 4 | | | 92 | 41 | 6 | — | | |
| Krishnagar | 23 24/88 31 | 60 | 19 | | | 81 | 18 | 5 | | 73 | 8 | 1 | | 48 | 1 | | | 89 | 20 | — | | | |
| Berhampur | 24 08/88 16 | 56 | 6 | | | 74 | 19 | 3 | | 74 | 13 | 3 | | 59 | 6 | | | 88 | 24 | 1 | | | |
| Uluberia | 22 28/88 07 | 67 | 21 | 3 | | 89 | 32 | 8 | | 94 | 31 | 11 | | 48 | 9 | | | 89 | 50 | 17 | — | | |
| Arambagh | 22 53/87 47 | 54 | 10 | 2 | | 82 | 18 | 6 | 2 | 84 | 16 | 6 | | 42 | 10 | | | 82 | 31 | 2 | | | |
| Contai | 21 47/87 45 | 55 | 14 | | | 83 | 18 | 4 | 1 | 67 | 33 | 5 | 3 | 74 | 19 | 1 | — | 96 | 45 | 11 | | | |
| Midnapur | 22 25/87 19 | 54 | 13 | | | 91 | 24 | 1 | | 85 | 23 | 5 | | 59 | 8 | 1 | | 95 | 36 | 5 | — | | |
| Bankura | 23 14/87 04 | 48 | 12 | | | 85 | 23 | — | — | 87 | 18 | 1 | | 47 | 5 | | | 88 | 25 | 3 | | | |
| Purulia | 23 20/86 23 | 42 | 9 | 2 | 1 | 83 | 23 | 1 | | 96 | 26 | 1 | | 60 | 12 | 1 | | 91 | 23 | 3 | | | |
| Asansol | 23 41/86 59 | 46 | 8 | 3 | | 90 | 28 | 5 | 2 | 90 | 21 | | | 49 | 8 | | | 93 | 34 | 5 | — | | |
| Burdwan | 23 14/87 51 | 53 | 8 | 5 | 1 | 84 | 24 | 8 | 1 | 78 | 25 | 4 | 1 | 53 | 6 | 1 | | 88 | 31 | 1 | — | | |
| Bolpur | 23 40/87 42 | 45 | 11 | | | 79 | 14 | 3 | | 71 | 14 | 1 | | 40 | 5 | | | 82 | 15 | 3 | — | — | — |
| **Sub-Himalayan West Bengal** | | | | | | | | | | | | | | | | | | | | | | | |
| Malda | 25 02/88 08 | 53 | 13 | 1 | | 75 | 20 | 1 | | 70 | 13 | 1 | 1 | 64 | 15 | 4 | | 88 | 25 | 4 | — | — | — |
| Balurghat | 25 13/88 46 | 76 | 39 | 11 | 3 | 89 | 34 | 13 | 4 | 82 | 31 | 7 | 3 | 70 | 18 | 6 | | 94 | 65 | 24 | 8 | 1 | — |
| Raiganj | 25 37/88 08 | 67 | 20 | 6 | 4 | 89 | 28 | 4 | — | 85 | 28 | 6 | 2 | 64 | 15 | 2 | — | 92 | 55 | 19 | 2 | — | — |
| Bagdogra | 26 38/88 19 | 97 | 63 | 32 | 15 | 92 | 63 | 44 | 21 | 89 | 55 | 22 | 11 | 71 | 40 | 15 | 1 | 99 | 89 | 64 | 42 | 8 | — |
| Darjeeling | 27 03/88 16 | 97 | 68 | 30 | 12 | 100 | 96 | 79 | 42 | 97 | 88 | 44 | 9 | 93 | 43 | 12 | 1 | — | 100 | 99 | 76 | — | — |
| Jalpaiguri | 26 32/88 43 | 100 | 85 | 56 | 32 | 100 | 94 | 79 | 44 | 96 | 78 | 55 | 28 | 96 | 66 | 30 | 9 | — | — | 100 | 90 | 18 | — |
| Buxa | 26 46/89 35 | 100 | 98 | 91 | 72 | | 100 | 91 | 78 | 98 | 95 | 91 | 76 | 100 | 95 | 71 | 47 | | | | 100 | 94 | 52 |
| Cooch Behar | 26 20/89 27 | 97 | 84 | 63 | 38 | 99 | 88 | 61 | 37 | 92 | 69 | 41 | 23 | 92 | 65 | 31 | 16 | | 100 | 99 | 86 | 27 | 5 |
| Mathabhanga | 26 21/89 13 | 98 | 81 | 60 | 44 | 100 | 82 | 60 | 33 | 96 | 67 | 33 | 12 | 98 | 61 | 23 | 7 | — | 100 | 93 | 70 | 16 | — |

(*iv*) Similarly for the seasonal rainfall chances for an amount of 160 cm over Sub-Himalayan West Bengal is nearly 10 times more than that over Gangetic West Bengal.

As the distribution of rainfall over West Bengal depends highly on the position of the eastern end of monsoon trough, the reason for occurrence of greater amount of rainfall over Sub-Himalayan West Bengal during the season may be attributed to the following observations in respect of the different positions of the monsoon trough during July-September.

The Average Areal Precipitation (AAP) per day over Sub-Himalayan West Bengal as compared to Gangetic West Bengal is :

(*i*) More than 5 times when the trough remains along Lat. 25° N or north of it (position A),

(*ii*) 50% more when the trough lies between Lat. 25° N and Lat. 22° N (position B),

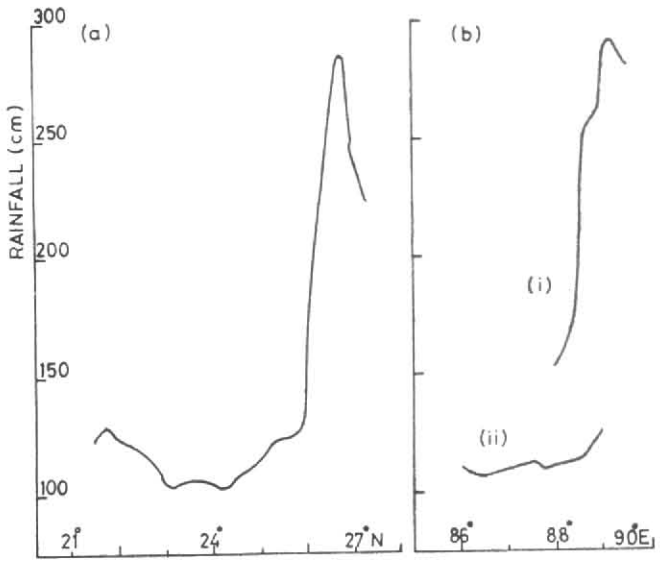
(*iii*) Almost the same when the trough lies along Lat. 22° N or south of it (position C), and

(*iv*) Nearly double when the trough remains west of Long. 88° E (position D).

Mean frequencies in days in respect of trough positions A, B, C and D are 20.3, 26.6, 37.7 and 7.4 (Biswas 1988) respectively. Hence, the total amount of mean rainfall over Sub-Himalayan West Bengal is almost double to that over Gangetic West Bengal during the months of July-September (Table 2). This ratio (2 : 1) does not decrease if we consider the rainfall in June also. It is obvious that the probability of occurrence of higher rainfall over Sub-Himalayan West Bengal increases appreciably during the years of prolonged 'break' in the monsoon when the trough remains closer to the foothills of the Himalayas (*refer* position A).

#### 4. Latitudinal and longitudinal variations of rainfall over West Bengal

The mean latitude (23.6° N) of the rainfall minimum zone coincides with the axis of the monsoon trough [Figs. 2(a & b)]. This agrees with Sadler's (1969) observation of minimum cloudiness along trough axis, as observed on satellite mosaics over oceanic areas. So, rainfall is minimum along this mean position of the monsoon trough (Rao 1976). From Lat. 24° 15′N rainfall increases towards north and the increase is rapid from Lat. 25° 45′N to 26° 45′N. This is the area where




Figs. 2(a&b). (a) Latitudinal, and (b) longitudinal variation of average rainfall over West Bengal during SW monsoon season (Jun-Sep) : (*i*) Gangetic West Bengal, (*ii*) sub-Himalayan West Bengal

**TABLE 2**

**Average rainfall (mm) per day at various places in West Bengal in relation to the different positions of the monsoon trough during the months July-September**

| Station | Trough position with frequency (days) | | | | Total rainfall (mm) | Sub-divisionwise total rainfall (mm) |
|---|---|---|---|---|---|---|
| | A (20.3) | B (26.6) | C (37.7) | D (7.4) | | |
| Asansol | 6.8 | 11.6 | 9.3 | 5.0 | 834 | |
| Bankura | 4.6 | 14.8 | 8.7 | 3.9 | 844 | |
| Berhampur | 12.6 | 12.1 | 5.5 | 3.0 | 807 | |
| Burdwan | 8.0 | 11.8 | 9.1 | 4.7 | 854 | |
| Calcutta (Alipore) | 6.5 | 14.0 | 10.5 | 5.0 | 937 | 885 |
| Contai | 5.0 | 12.4 | 12.3 | 9.3 | 964 | |
| Krishnagar | 7.8 | 10.8 | 8.0 | 2.5 | 766 | |
| Midnapur | 5.8 | 13.8 | 10.3 | 6.0 | 918 | |
| Purulia | 5.2 | 13.5 | 10.2 | 5.5 | 890 | |
| Sagar island | 5.4 | 14.0 | 15.0 | 5.3 | 1087 | |
| Sriniketan | 6.3 | 11.5 | 8.0 | 4.7 | 770 | |
| Uluberia | 6.0 | 14.8 | 10.5 | 4.5 | 945 | |
| Gangetic W. B. | 6.7 | 12.9 | 9.8 | 4.9 | 885 | |
| Bagdogra | 41.0 | 22.5 | 10.8 | 6.2 | 1884 | |
| Balurghat | 19.2 | 13.5 | 5.9 | 6.0 | 1016 | |
| Cooch Behar | 41.4 | 21.5 | 11.0 | 8.0 | 1886 | |
| Darjeeling | 32.6 | 21.0 | 12.9 | 6.6 | 1756 | |
| Jalpaiguri | 40.5 | 22.5 | 11.8 | 10.0 | 1940 | 1717 |
| Kalimpong | 28.0 | 16.5 | 10.0 | 5.5 | 1425 | |
| Malda | 12.2 | 13.1 | 5.0 | 6.1 | 830 | |
| Buxa | 65.6 | 34.7 | 16.8 | 14.5 | 2995 | |
| S. H. W. B. | 35.1 | 20.7 | 10.5 | 7.9 | 1717 | |

orographic ascent of moist air takes place and since the average altitude along Lat. 26° 45′ N is about 600 to 900 m, rainfall reaches a maximum along this latitude (Murray 1948). North of Lat. 26° 45′N, rainfall gradually decreases. It is seen that the ratio between the maximum (129.0 cm) and the minimum (104.3 cm) amounts of latitudinal rainfall over Gangetic

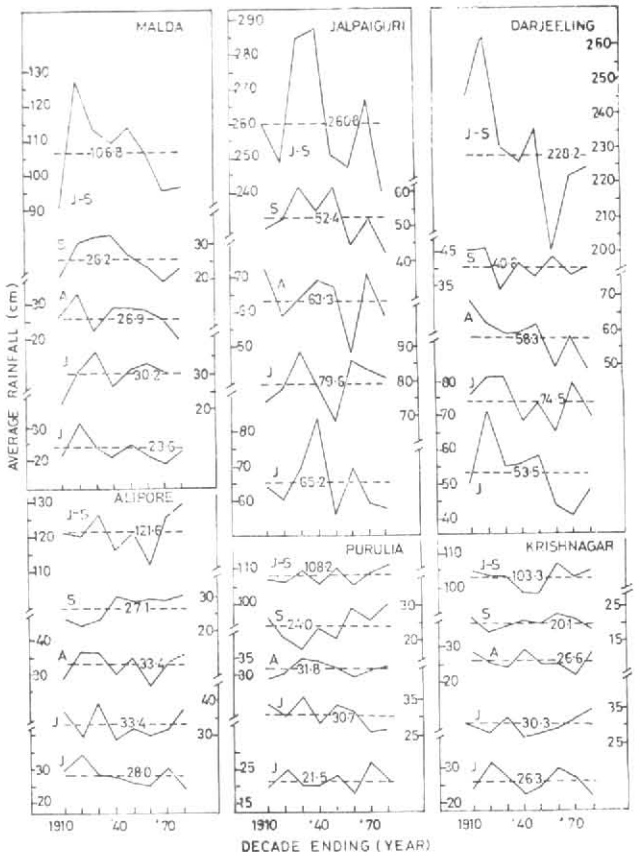



Fig. 3. Discrete decadal variation of monthly and seasonal rainfall during SW monsoon season at various places in West Bengal

West Bengal is of the order of 5 : 4, but the same in respect of Sub-Himalayan West Bengal is of the order of 13 : 5.

For Sub-Himalayan West Bengal average rainfall is minimum in the west as the major contribution to this area is made by Malda and south and north Dinajpur districts. It increases rapidly towards east from the longitude of Bagdogra (88° 19′E) and becomes maximum along 89° 35′E (Buxa). The location of Buxa is such that it is affected equally both by southerlies and easterlies and its altitude is 814 m, very favourable for maximum orographic effect causing rainfall (Murray 1948).

**5. Diurnal variations and intensity of rainfall**

During the southwest monsoon season Gangetic West Bengal receives about 35% of its rainfall within a period of six hours from 1100 to 1700 IST. About 8% of the total rainfall occurs from 2000 to 2300 IST.

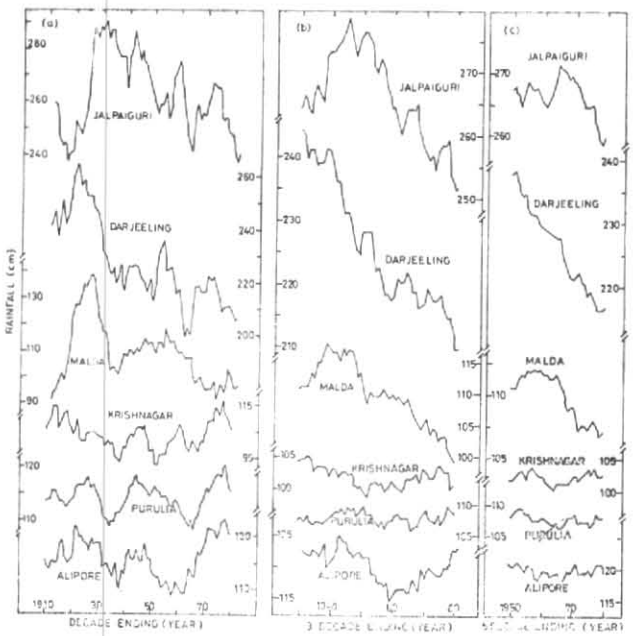
The rainfall during the monsoon season is mainly showery, occasionally accompanied by thunder, rainfall must be greater when convective activity is greater. The development of *Cb* clouds over Calcutta airport and 300 km around, *i.e.*, over Gangetic West Bengal during the monsoon months of June to September is maximum in the afternoon and evening hours (Biswas and Gupta 1989).

Near the hills, maximum rainfall occurs in the night and early morning hours, *i.e.*, between 1900 and 0500

TABLE 3

**Running decadal averages of highest, lowest and mean rainfall values (cm) of southwest monsoon season in West Bengal during 1901-1980**

| Station | Running decadal averages | | | | Running 3-decadal averages | | | | Running 5-decadal averages | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Highest | Lowest | Mean | C.V. | Highest | Lowest | Mean | C.V. | Highest | Lowest | Mean | C.V. |
| **Gangetic West Bengal** | | | | | | | | | | | | |
| Calcutta (Alipore) | 136.5 | 107.4 | 121.7 | 6.2 | 125.0 | 114.9 | 119.9 | 2.2 | 121.1 | 118.6 | 119.9 | 0.7 |
| Purulia | 121.3 | 96.1 | 108.4 | 5.1 | 109.8 | 105.8 | 107.9 | 0.9 | 109.7 | 106.5 | 107.9 | 0.8 |
| Krishnagar | 117.0 | 93.0 | 103.8 | 5.2 | 105.2 | 98.9 | 102.3 | 1.7 | 104.0 | 100.4 | 102.2 | 0.9 |
| **Sub-Himalayan West Bengal** | | | | | | | | | | | | |
| Malda | 139.1 | 90.9 | 108.4 | 15.3 | 118.0 | 99.5 | 110.1 | 4.5 | 114.5 | 103.9 | 110.0 | 3.4 |
| Darjeeling | 265.1 | 199.8 | 227.5 | 7.1 | 244.7 | 209.3 | 226.1 | 4.3 | 238.1 | 216.2 | 226.1 | 2.9 |
| Jalpaiguri | 290.8 | 237.4 | 263.0 | 5.6 | 278.9 | 251.7 | 266.7 | 2.7 | 271.7 | 258.8 | 266.4 | 1.2 |




Figs. 4(a-c). Running : (a) decadal, (b) 3-decadal, and (c) 5-decadal variations of SW monsoon seasonal rainfall at various stations in West Bengal

IST and the minimum between 0800 and 1200 IST. Here, nocturnal cooling over the hills and the associated katabatic wind flow might help in increasing vertical motion.

Very heavy rainfall amounting to 60 to 100 mm or more in an hour and 200 to 493 mm in 24 hours have been recorded by almost all stations in the State during the months from June to September

**6. Decadal, 3-decadal and 5-decadal variations of rainfall**

Decadal variations of rainfall for eight decades (1901-1980) is small and regular in Gangetic West Bengal. But in Sub-Himalayan West Bengal the variation from one decade to another is rather high and even irregular. The discrete decadal variations of monsoon seasonal rainfall in respect of observatories at Calcutta (Alipore), Purulia and Krishnagar situated in Gangetic West Bengal and at Malda, Darjeeling and Jalpaiguri in Sub-Himalayan West Bengal are shown in Fig. 3. The figure shows that the corresponding changes in respect of stations in Gangetic West Bengal are almost similar in nature but those in respect of Sub-Himalayan West Bengal vary from one station to another. Also, the magnitude of changes is very low in respect of Purulia and very high in respect of Darjeeling.

Fig. 4(a) shows the running decadal averages of rainfall in respect of the above stations. It is observed that the changes for stations in Gangetic West Bengal are more or less similar for corresponding decades with a few minor exceptions. It is also observed that the changes are wavy in nature, long period waves are superimposed by short period ones. The last decadal (1971-80) means are higher than the corresponding first decadal (1901-1910) ones. The Coefficient of Variation (C.V.) in respect of the running decadal averages are 6.2, 5.1 and 5.2 per cent for Calcutta (Alipore), Purulia and Krishnagar respectively (Table 3).

It is evident from Fig. 4(a) that the changes in running decadal averages of rainfall in respect of stations in Sub-Himalayan West Bengal are not in phase during the earlier decades under study. It increased highly for Malda, appreciably for Darjeeling but decreased for Jalpaiguri. The changes during the second half of the period are more or less similar in respect of all stations. It is interesting to note that the last decadal (1971-1980) average rainfall in respect of Malda is higher than the first decadal (1901-1910) one; it is appreciably less in respect of Jalpaiguri and remarkably less in respect of Darjeeling.

30-year running average values of rainfall for Calcutta (Alipore) vary between 114.9 and 125.0 cm, the first (1901-1930) and the last (1951-1980) values are nearly equal to 122.8 cm [Fig. 4(b)]. For Purulia these running average values lie between 105.8 and 109.8 cm and for Krishnagar between 98.9 and 105.2 cm. The last average value for Purulia is higher than its first one while the corresponding values are in a reverse order in case of Krishnagar. The changes in the running 3-decadal values are wavy in nature; longer waves are superimposed by shorter ones.

For Malda and Jalpaiguri the 30-year running average values of rainfall are more or less in the increasing phase during the first part of the period under study and subsequently in the falling phase. But for Darjeeling it decreased continuously from the beginning to the end of the period with occasional slight increase for shorter periods. The last 30-year average value being less than the corresponding first one in respect of stations in Sub-Himalayan West Bengal.

In Fig. 4(c), it is seen that the 50-year running avreage values of southwest monsoon seasonal rainfall in West Bengal follow nearly a similar relation to their corresponding values for 30-year running averages.

The highest, lowest and mean values (in cm) of running averages of southwest monsoon seasonal rainfall for different periods and the corresponding C.V. (%) in respect of the above stations are shown in Table 3. As it should be, C.V. decreases as the data length increases. The value of C.V. is less than 1 for running 5-decadal averages in case of all stations in Gangetic West Bengal and it lies between 1 and 3.5 for stations in Sub-Himalayan West Bengal.

**7. Trend values of seasonal rainfall**

Trend values of the seasonal rainfall ($Y_c$) in respect of various stations are examined using the regression line :

$$Y_c = a + bX_i$$

where, $X_i$ corresponds to the $i$th year of which trend value ($Y_c$) for the year is to be determined. $a$ and $b$ are constants;

$$a = \frac{\Sigma Y_i}{N},\ b = \frac{\Sigma X_i Y_i}{\Sigma X_i^2}$$

where $Y_i$ is the seasonal rainfall amount in the $i$th year and $N$ is the total number of years considered. $i=0$ for the mid-year.

Now considering the monsoon seasonal rainfall amounts in respect of Darjeeling we find the following regression lines :

$Y_c = 227.26 - 0.6657X_i$ for 79 years (1902-1980),
$Y_c = 214.14 - 0.3476X_i$ for 41 years (1940-1980),
$Y_c = 214.98 - 1.9497X_i$ for 21 years (1960-1980).

All of the above three regression lines have falling tendency; the last one being most stiff.

Regression equations in respect of other stations have also been worked out. From these, it appears that the trend of southwest monsoon seasonal rainfall in respect of stations in Sub-Himalayan West Bengal has a falling tendency for periods ending in 1980. But in respect of most of the stations in Gangetic West Bengal rising tendency seems suggestive.

**8. Conclusions**

(*i*) July is the rainiest month in West Bengal. It is generally followed by August, June and September in Gangetic West Bengal and June, August and September in Sub-Himalayan West Bengal.

(*ii*) The chance of getting an amount of rainfall over 40 cm in a month or 160 cm in the season during the period from June to September is low (8 to 25%) for any station situated in Gangetic West Bengal and also in the southern part of Sub-Himalayan West Bengal whereas the same in respect of any other station in Sub-Himalayan West Bengal is high (50 to 100%).

(*iii*) Rainfall is minimum along Lat. 23° 37′N which coincides with the mean position of the monsoon trough and maximum along Lat. 26° 37′N having average altitude of 600 to 900 m. Buxa (26° 46′N, 89° 35′E) gets the highest amount of rainfall in West Bengal by virtue of its favourable location and altitude (814 m).

(*iv*) The average areal precipitation over Sub-Himalayan West Bengal is almost double to that over Gangetic West Bengal. But during the southwest monsoon season the chance for occurrence of an amount of 160 cm rainfall over Sub-Himalayan West Bengal is almost 10 times greater than that over Gangetic West Bengal.

(*v*) The latitudinal variation of rainfall is low over Gangetic West Bengal but is rather high over Sub-Himalayan West Bengal. The ratio between the maximum and the minimum amounts of average latitudinal rainfall over Gangetic West Bengal is of the order of 5 : 4 but the same over Sub-Himalayan West Bengal is about 13 : 5.

(*vi*) Over Gangetic West Bengal about 35% of the total rainfall during the southwest monsoon season occurs within a period of six hours from 1100 to 1700 IST and only 8% occurs between 2000 and 2300 IST.

(*vii*) Over and near the hills in Sub-Himalayan West Bengal, the maximum rainfall occurs between 1900 and 0500 IST and the minimum between 0800 and 1200 IST.

(*viii*) Very heavy rainfall amounting to 60-100 mm per hour or 200-493 mm per day have been recorded by most of the stations in West Bengal.

(*ix*) The corresponding changes in decadal averages of monthly and seasonal rainfall amounts during southwest monsoon season for stations in Gangetic West Bengal are generally low and almost similar in nature; but those in respect of stations in Sub-Himalayan West Bengal are very high and not similar in nature. Moreover, the magnitude of changes is very low in respect of Purulia and high in respect of Darjeeling.

(*x*) The changes in the running decadal average values of seasonal rainfall in respect of stations in Gangetic West Bengal conform to a sinusoidal pattern long period waves seem superimposed by short period ones. The last decadal (1971-80) means being higher than the respective first decadal (1901-10) ones. Such similarity is not observed in respect of stations in Sub-Himalayan West Bengal. Almost similar types of observations have been noticed in respect of 30-year as well as 50-year running averages of seasonal rainfall.

(*xi*) The trend, up to 1980, of southwest monsoon seasonal rainfall in respect of stations in Sub-Himalayan West Bengal seems to display falling tendency, but in respect of most of the stations in Gangetic West Bengal it seems to indicate a rising tendency.

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