

# A STUDY OF INCIDENCE OF DROUGHTS IN THE GANGETIC WEST BENGAL

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Incidence of droughts in Gangetic West Bengal has been studied using the rainfall data of about 112 stations for the 70-year period from 1891 to 1960. This study has been made both for the individual districts of the Gangetic West Bengal as well as for the sub-division as a whole. Percentage departures of rainfall from the normal have been worked out for individual districts as well as for the entire sub-division to categorize droughts of different intensity for (i) individual rainy months from May to October and for (ii) different rainy periods. From this statistics, frequency of occurrence of droughts of different intensities has been worked out both in space and time. Years when the sub-divisions suffered worst droughts or excess of rainfall have also been indicated by way of information.

## INTRODUCTION

Droughts, like floods, have been experienced by mankind from the dawn of civilization. They rank among the worst natural tragedies that can befall mankind due to vagaries of weather. With all advances in science and technology man has not so far been able to fully control or forecast these, in spite of his best efforts.

Normally, by the term "drought" is meant a dry period caused by lack of rains. According to American Meteorological Society (Huschke 1959), drought is a period of abnormally dry weather of a prolonged duration which may cause severe hydrologic imbalance due to shortage of water. It may, therefore, be said that invariably droughts over a region are caused by the serious deficiency of rainfall. In this study, the incidence of rainfall over various districts of Gangetic West Bengal as well as over the region as a whole in different rainy months as well as during different rainy periods of the year have been examined fairly in detail using the rainfall data of about 112 stations for a period of 70 years from 1891 to 1960. An investigation of this type gives an insight into intensity, duration and probabilities of occurrence of droughts over this region as a whole as well as in its different districts during the principal rainy months during which important agricultural operations such as sowing, growing or harvesting of crops are carried out.

## MEAN MONTHLY AND ANNUAL RAINFALL AND ITS VARIABILITY

*Mean monthly and annual rainfall*—On the basis of various meteorological elements like rainfall, temperature, etc., the country has broadly been divided into 35 meteorologically homogeneous sub-divisions and Gangetic West Bengal happens

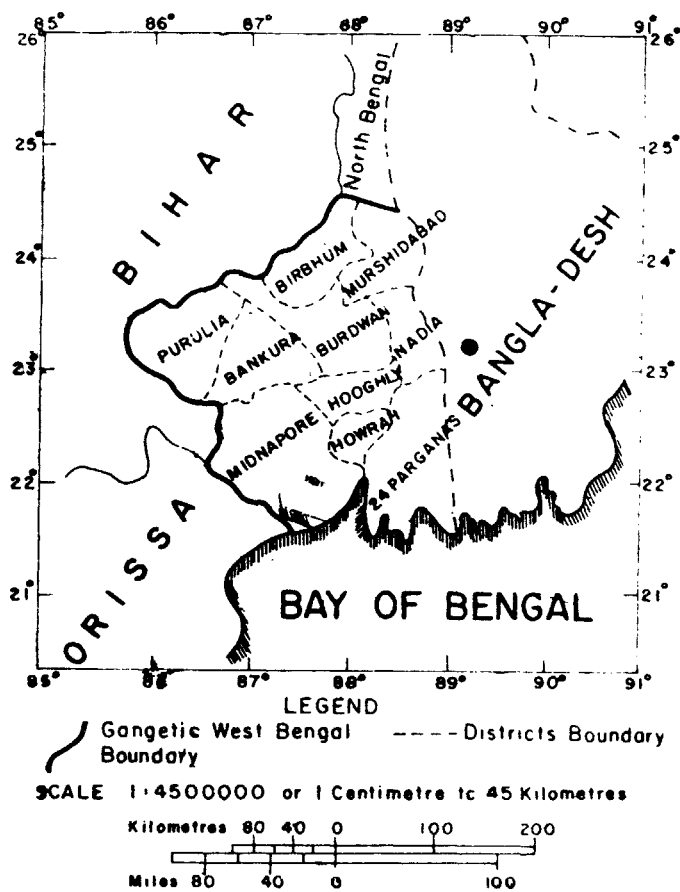


FIG. 1. Districts map of Gangetic West Bengal.

to be one of them. It consists of ten districts which are shown in Fig. 1. There are at present about 112 long-period rainfall stations located in this sub-division whose rainfall data are available from 1891 in printed rainfall tables. On the basis of this data, mean monthly and annual rainfall values have been worked out for each of these ten districts as well as for the subdivision as a whole and this statistics are shown in Table I. It is evident from this Table that the principal rainy months over the sub-division are the six months from May to October. The mean annual rainfall of the different districts in the sub-division varies from about 52 to 64 inches. The highest mean annual district rainfall of 64 inches was experienced in the two adjacent districts of Howrah and 24-Parganas which are located in the southeast. The lowest mean annual district rainfall is of the order of 52 inches and this was experienced in the four contiguous districts of Birbhum, Burdwan, Bankura and Purulia which are located in the west and northwest of the sub-division.

It is observed from Table I that the sub-division as a whole receives about 56 inches of rainfall annually and 76 per cent of mean annual rainfall occurs during the four monsoon months of June to September. Nearly 91 per cent of the mean annual

TABLE I  
*Mean monthly and annual rainfall (1891-1960) for different districts of Gangetic West Bengal*

District	No. of rain-gauge stations as in 1956	Rainfall (inches) in different months of the year												Annual (inches) to October	June to September as per cent of annual	May to October as per cent of annual	June to September as per cent of annual	
		Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.					
24-Parganas	11	0.5	1.0	1.2	1.9	5.0	11.1	13.8	13.0	9.8	5.2	1.0	0.2	57.9	47.7	63.7	91	75
Howrah	3	0.5	1.1	1.3	2.1	5.4	12.0	13.3	13.3	9.0	4.8	0.9	0.1	57.8	47.6	63.8	91	75
Midnapore	28	0.5	1.1	1.4	1.7	4.5	9.7	12.6	12.3	9.3	4.8	1.1	0.1	53.2	43.9	59.1	90	74
Hooghly	8	0.5	1.1	1.2	2.2	5.2	9.4	11.7	11.5	9.0	4.1	0.9	0.1	50.9	41.6	56.9	89	73
Purulia	9	0.6	1.0	0.9	0.9	2.3	8.2	13.1	12.2	8.7	3.2	0.5	0.1	47.7	42.2	51.7	92	82
Bankura	24	0.5	1.0	1.0	1.4	3.6	8.9	11.8	11.5	8.0	3.4	0.7	0.1	47.2	40.2	51.9	91	77
Burdwan	8	0.5	0.9	1.1	1.6	4.4	9.1	11.4	10.9	7.8	3.4	0.6	0.1	47.0	39.2	51.8	91	76
Nadia	3	0.4	0.9	1.3	2.6	5.9	10.1	10.5	10.4	8.3	4.3	0.8	0.1	49.5	39.3	55.6	89	71
Murshidabad	10	0.5	0.7	0.9	1.6	4.9	9.9	11.4	10.7	8.7	4.2	0.6	0.1	49.8	40.7	54.2	92	75
Birbhum	8	0.5	0.7	0.9	1.1	3.9	8.8	12.0	11.5	8.4	3.7	0.5	0.1	48.3	40.7	52.1	93	78
Gangetic West Bengal Sub-division	112	0.5	1.0	1.1	1.6	4.3	9.5	12.2	11.7	8.7	4.1	0.9	0.1	50.5	42.1	55.7	91	76

rainfall occurs during the six months from May to October. The total rainfall obtained over the sub-division during the two transitional months of May and October is about 15 per cent of the mean annual rainfall. The rainfall in the month of May is mostly associated with pre-monsoon thunder storms while the rainfall of the October month is mainly associated with the retreating southwest monsoon. Normally monsoon sets in over this region by the end of the first week of June and withdraws towards the end of the first week of October.

*Co-efficients of variability*—The co-efficients of variability of rainfall for each of the districts have been worked out for (i) the six individual rainy months, from May to October, (ii) for the period May to October, (iii) monsoon period (June to September) and (iv) the year as a whole and this statistics are shown in Table II. It is observed that co-efficients of variability from district to district do not differ much when the three rainy periods, mentioned above, are considered. The variability is of the order of 15 to 23 per cent during these rainy periods.

TABLE II  
*Co-efficient of variability (%) of rainfall during different rainy months from May to October and year as a whole*

Districts	Rainy Months						Rainy periods		
	May (%)	June (%)	July (%)	Aug. (%)	Sept. (%)	Oct. (%)	May to Oct. (%)	June to Sept. (%)	Annual (%)
24-Parganas	61	43	31	28	49	65	19	19	18
Howrah	59	47	45	38	48	68	22	23	21
Midnapore	55	42	33	26	39	72	17	17	16
Hooghly	53	46	39	34	49	71	21	22	20
Purulia	62	45	30	29	35	87	16	16	15
Bankura	62	48	28	31	39	73	18	17	17
Burdwan	53	44	35	33	39	78	18	19	18
Nadia	47	40	36	36	45	67	20	23	19
Murshidabad	51	39	34	42	35	92	23	22	21
Birbhum	58	45	31	34	41	79	20	20	18

Co-efficients of variability have also been worked out for individual rainy months from May to October for all the ten districts of the sub-division and their values have been given in Table II. As expected, in the case of all the districts in the sub-division, the maximum values of co-efficients of variability are found in the two transitional months of May and October. The highest values of the co-efficients of variability was found to be of the order of 92 per cent in the month of October in respected of Murshidabad district which is located towards the north of the sub-division. In the individual monsoon months of June to September, the co-efficients of variability are rather low in magnitude and do not differ much from district to district. During the principal monsoon months of July and August all the districts have the lowest co-efficients of variability.

## YEARS OF THE LOWEST AND THE HIGHEST DISTRICT AND SUB-DIVISIONAL RAINFALL

The lowest and the highest values of rainfall experienced by each of the districts of the sub-division during the years from 1891 to 1960 are given in Table III. It is observed from this Table that in each of the years 1895, 1935 and 1957, two out of ten districts experienced the lowest rainfall amounts. During the worst years of deficient rainfall in the districts, it has been observed that the deficiencies have been of the order of 50 to 72 per cent of the mean annual rainfall of the respective districts. In the year 1960, Nadia district got just 50 per cent of its mean annual rainfall.

TABLE III  
*Years of the lowest and highest district and sub-divisional rainfall*

Districts	Lowest Rainfall			Highest Rainfall			10 worst years of deficient/excess sub-divisional rainfall			
	Years	Rainfall (inches)	Percent of mean annual (%)	Years	Rainfall (inches)	Percent of mean annual (%)	Deficient rainfall		Excess rainfall	
							Year	Percent of mean annual (%)	Year	Percent of mean annual (%)
24-Parganas	1935	40.2	63	1941	94.7	148	1892	81	1893	136
Howrah	1895	36.0	56	1933	91.2	143	1895	73	1909	118
Midnapore	1954	39.5	67	1913	79.7	135	1925	87	1913	131
Hooghly	1935	33.0	58	1959	88.4	155	1927	81	1917	125
Purulia	1915	36.9	72	1917	72.3	140	1934	77	1933	127
Bankura	1957	36.1	70	1893	79.7	154	1935	70	1939	118
Burdwan	1957	33.4	64	1909	72.1	139	1951	83	1941	125
Nadia	1960	27.9	50	1959	84.6	159	1954	74	1946	117
Murshidabad	1895	31.6	58	1959	98.9	183	1955	85	1956	119
Birbhum	1951	31.2	60	1917	71.9	138	1957	76	1959	126

As regards the highest rainfall experienced by different districts, it is seen from Table III, that in the year 1959 three contiguous districts, viz., Nadia, Murshidabad and Hooghly received the highest rainfall amounts which were 59, 83 and 55 per cent respectively in excess of their respective district annual averages. In the years when the individual districts received the highest rainfall amounts, the percentage departures were in excess by about 35 to 83 per cent of their respective district normals.

From a perusal of Table III, it is seen that there is no one single year in which all the 10 districts together suffered either extreme deficiencies or extreme excesses of rainfall. This Table also shows the ten worst years of deficient and excess rainfall for the sub-division as a whole. During the last 70 years, the worst year of deficient rainfall was the year 1935, when the entire sub-division received only 70 per cent of the normal. Similarly the year of the highest sub-divisional rainfall was the year 1893. The rainfall received in this year was 136 per cent of the normal.

## DISTRICTWISE DROUGHT STUDIES OF THE GANGETIC WEST BENGAL

Districtwise drought studies were carried out for each of the principal rainy months from May to October. These studies were also carried out for the periods (i) May to October (ii) South west monsoon period (June to September) and (iii) Year as a whole. These are described in the succeeding sections.

*Districtwise drought study of individual rainy months of May to October*—It is evident from Table I that the chief rainy months during which the bulk of rainfall is received over the various districts of Gangetic West Bengal are the six months from May to October. Monthwise break up of mean annual rainfall over the sub-division as a whole for these six months is given below :

<i>Month</i>	<i>Percentage of mean annual rainfall over the Gangetic West Bengal during different rainy months</i>
May	8%
June	17%
July	22%
August	21%
September	16%
October	7%
Total rainy period [May to October]	91%

Percentage departures of rainfall for each district were worked out for the six rainy months for each year of the 70-year period. On the basis of this statistics the frequency of occasions when droughts of different categories were experienced in each district were worked out using the following criteria :

<i>Drought category</i>	<i>Percentage departure from the normal</i>
(a) Slight drought	11 to 25.9 %
(b) Moderate „	26 to 40.9 %
(c) Severe „	41 to 49.9 %
(d) Disastrous „	50% or more

The above criteria was used by Krishna Rao (1953) while studying the rainfall of the then Madras State. Recently, Banerjee and Chhabra (1963) also studied the incidence of droughts over the Telengana division of Andhra Pradesh using more or less the above criteria.

Table IV shows the frequency of droughts of different categories mentioned above, for the 10 districts of the Gangetic West Bengal for each of the rainy months. It is observed from this Table, that the following districts (*vide* p. 29) in the sub-division have experienced the highest number of droughts (of all categories) during the different rainy months of the 70-year period :



<i>Month</i>	<i>Districts which experienced max. number of droughts (of all categories) during 1891—1960</i>
May	24-Parganas [40]
June	Birbhum [34]
July	Hooghly [33]
August	Nadia [37]
September	Hooghly [37]
October	Murshidabad [43]

[Figures in brackets denote the frequency of droughts of all categories experienced during 70-years].

From the above it is obvious that the districts mentioned above can experience droughts (of different categories), on an average, once in two years in the months shown against them.

In case we consider only the two categories of droughts (*viz.*, serious and disastrous) experienced by the various districts in the sub-division, the following picture emerges from a study of Table IV :

<i>Month</i>	<i>Districts which experienced max. number of severe and disastrous droughts during 1891—1960</i>
May	Birbhum [18]
June	Purulia [14]
July	Howrah and Hooghly [11 each]
August	Burdwan and Nadia [7 each]
September	Nadia [11]
October	Murshidabad [31]

[Figures in brackets indicate the frequency of serious and disastrous droughts experienced during 70 years].

It is observed from the above that in the two transitional months of May and October, the maximum number of severe and disastrous droughts were experienced by the Birbhum and Murshidabad districts respectively. So far as individual monsoon months of June to September are concerned, it is seen from Table IV, that Purulia district experienced maximum number of severe and disastrous droughts in the month of June, Hooghly and Howrah districts in July, Burdwan and Nadia districts in August and Nadia district in September.

*Districtwise drought study during different rainy periods in a year*—A study of droughts has also been made for different districts of the sub-division using the total rainfall data of the following three rainy periods in a year.

(a) monsoon period—June to September; (b) rainy period—May to October and (c) year as a whole.



The frequency of occurrence of droughts of different categories was worked out for each of the districts of the sub-division and the total probability of their occurrence was also worked out for each of these periods. This statistics is given in Table V and it has been observed that there were no disastrous droughts in any of the districts during any of these rainy periods. However, it is seen from Table V, that severe droughts occurred in the monsoon period of 1925, 1927, 1945, 1951 and 1960 in the districts of Hooghly, Murshidabad, Howrah, Birbhum and Nadia respectively. If we consider the annual period, severe droughts occurred to Murshidabad and Howrah in the year 1895, in the Hooghly in 1935 and in Nadia in the year 1960. It is, however, evident from Table V, that in Nadia district severe droughts occurred in the year 1960 during all the three periods mentioned above. If Table V is examined carefully, it is obvious that during monsoon period alone, the maximum number of droughts of different categories occurred in Birbhum district and their frequency was of the order of 26 in 70 years. Next to this, are the districts of Nadia and Hooghly which experienced about 24 droughts. So far the year as a whole is concerned, the frequency of droughts has been of the order of 16 to 22 in the various districts. Probability of occurrence of droughts per year during the three periods is also indicated in Table V. In the monsoon period the highest probability of 37 per cent is experienced in respect of Birbhum district while the lowest probability of 27 per cent is obtained for the adjoining districts of Purulia and Bankura.

TABLE V

*Districtwise frequency of droughts of different categories during different rainy periods*

Period	24-Par- ganas	How- rah	Midna- pore	Hooghly	Purulia	Ban- kura	Burd- wan	Nadia	Murshida- bad	Bir- bhum
(i) <i>Slight drought</i> (—11% to 25.9%)										
Monsoon	17	12	16	17	16	17	20	17	13	20
May to Oct.	16	15	17	19	15	16	19	18	17	18
Annual	14	16	13	16	17	17	15	14	12	17
(ii) <i>Moderate drought</i> (—26% to 40.9%)										
Monsoon	4	6	4	6	3	2	3	6	8	5
May to Oct.	4	7	2	5	2	5	5	2	7	6
Annual	4	5	3	5	1	5	5	3	7	4
(iii) <i>Severe drought</i> (—41% to —49.9%)										
Monsoon	0	1(1945)	0	1(1925)	0	0	0	1(1960)	1(1927)	1(1951)
May to Oct.	0	0	0	1(1935)	0	0	0	1(1960)	1(1934)	0
Annual	0	1(1895)	0	1(1935)	0	0	0	1(1960)	1(1895)	0
(iv) <i>Probability (%) of occurrence of droughts of all categories</i>										
Monsoon	30	30	29	34	27	27	33	34	31	37
May to Oct.	29	34	27	34	24	30	34	30	36	34
Annual	26	34	23	31	26	31	29	26	29	30

(Figures in brackets denote the year of occurrence of droughts).

## DROUGHT STUDY OF THE ENTIRE SUB-DIVISION OF GANGETIC WEST BENGAL

Average monthly rainfall over the entire Gangetic West Bengal for each year of the 70-year period was worked out and percentage departures were calculated. As in the case of districtwise drought studies, the frequency of droughts was also worked out for the entire sub-division for the individual rainy months from May to October and the three rainy periods mentioned in the previous section.

The results of this study are summarized in Table VI [a and b].

TABLE VI (a)

*Frequency of occurrence of droughts of different categories in the sub-division of Gangetic West Bengal*

Category of droughts	Individual rainy months (May to October)						For the rainy period of		
	May	June	July	Aug.	Sept.	Oct.	June to Sept.	May to Oct.	Annual
Slight drought (- 11% to -25.9%)	11	17	12	19	18	8	19	17	14
Moderate drought (-26% to -40.9%)	9	12	10	7	11	10	0	1	3
Severe drought (-41% to -49.9%)	8	3	2	0	1	3	0	0	0
Disastrous drought (-50% and less)	6	4	1	0	1	16	0	0	0
Total	34	36	25	26	31	37	19	18	17

TABLE VI(b)

*Five instances of worst droughts in the Gangetic West Bengal during different periods*

Rank	Monsoon period			May to October period			Annual		
	Year	Rain-fall	Departure (%)	Year	Rain-fall	Departure (%)	Year	Rain-fall	Departure (%)
I	1895	31.4	-25	1935	34.8	-31	1935	38.8	-30
II	1945	31.7	-25	1895	37.7	-25	1895	40.8	-27
III	1925	31.9	-24	1934	39.0	-23	1954	41.1	-26
IV	1935	33.3	-21	1957			1957	42.3	-24
V	1954	33.4	-21	1954	39.1	-23	1957	42.3	-24
				1958	40.6	-20	1934	42.9	-23

Considering only the disastrous droughts in the individuals months, it is seen from Table VI(a) that there were about 16 such droughts in the month of October during the last 70 years. In the month of August there were no such disastrous droughts or even severe droughts. Among the other monsoon months, the sub-division experienced one disastrous drought in July, 1916 and one in September, 1928. However, the maximum number of 4 disastrous droughts were experienced in June in the years

1905, 1926, 1958 and 1960. The five worst droughts experienced by the sub-division during the three different rainy periods are indicated in Table VI(b). It is evident from Table VI(a) that during the three rainy periods there were no severe or disastrous droughts in the sub-division during the 70-year period. However, during monsoon period, it was found that there were 19 occasions of slight droughts while in the case of May to October period there were 17 occasions of slight droughts and one occasion of moderate drought. If we consider the annual period, the sub-division experienced 14 droughts of slight intensity and 3 droughts of moderate intensity.

#### SUMMARY AND CONCLUSIONS

From the foregoing the following broad conclusions may be drawn :—

(a) The districts lying on the southern and eastern periphery of the Gangetic West Bengal receive rainfall of higher magnitudes than those districts which lie toward the northwest of the sub-division. The sub-division as a whole receives on an average 56 inches of rainfall and 91 per cent of this occurs during the six rainy months of May to October. During July and August months the sub-division receives about 43 per cent of the annual rainfall while in the transitional months of May and October, this percentage is of the order of 15 per cent. In the year 1935, the entire sub-division received the lowest amount of rainfall which was 70 per cent of the mean annual. In the year 1893, the highest amount of rainfall was received by the sub-division which was 136 per cent of the mean annual rainfall.

(b) The co-efficients of variability of the annual rainfall for individual districts reveals that the variability is high in the central districts of Hooghly, Howrah and northern district of Murshidabad. The magnitude of the co-efficients of variability was found lowest in the Purulia district during different rainy periods. Variability is maximum during the May and October months when only 8 and 7 per cent respectively of the mean annual rainfall are received over the sub-division. Compared to other months, co-efficients of variability are generally lowest in the month of August. The magnitude of the coefficients of variability is practically of the same order for each district whether we consider the monsoon period or the rainy period from May to October or the year as a whole.

(c) Drought analysis based on the rainy months of May to October reveals that practically all the districts experience drought conditions on an average once in two years for each month of this period but the frequency of severe and disastrous droughts (departure  $>$  41 per cent) decreases considerably from May to August and again increases from September to October.

Droughts of disastrous intensity (departure  $>$  50 per cent) in different districts are comparatively less in number in the months of July and August. Among the 10 districts in the sub-division, the districts of 24-Parganas, Midnapore, Bankura and Birbhum did not experience disastrous droughts in the month of August. In other months disastrous droughts were experienced by all the districts of the sub-division.

(e) Taking the three rainy periods viz., (i) monsoon, (ii) May to October and (iii) annual into consideration, no district in the sub-division suffered droughts of disastrous intensity. However, droughts of severe intensity did occur in these periods.

(f) Considering the sub-division as a whole it is seen that there were five

years (viz., 1895, 1934, 1935, 1954 and 1957) when the percentage departures from the normal were more than 20 per cent. If monsoon period alone is considered then the worst years of deficient rainfall for the sub-division were 1895, 1925, 1935, 1945 and 1954.

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#### REFERENCES

- Banerjee, S., and Chhabra, B. M. (1963). Drought conditions in the Telengana Division (Andhra Pradesh) during the southwest monsoon season. *Indian J. Met. Geophys.*, **14**, No. 4.
- Huschke, R. E. (1959). *Glossary of American Meteorology*. Am. met. Soc. Boston, Massachusetts, p. 180.
- Krishna Rao, P. R. (1953). Rainfall of Madras State with special reference to Tamil Nadu and Rayalaseema. *Mem. India met. Dept.*, **30**, Part-I.