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RAINFALL OF INDIA: A BRIEF REVIEW *†

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A DETAILED discussion of Indian rainfall would fill volumes. In a short article like the present all one can attempt is to take a bird's-eye view of the subject. A history of Indian rainfall is really a history of the well-known south-west monsoon. We have reliable records for about 60 years. As judged by these records, what is the dependability of rainfall in different parts of this vast sub-continent, and what are the chances of success of agriculture in different parts of the country? How often in a century is the monsoon rainfall so conspicuously in excess (flood) or in defect (drought) as to cause widespread havoc and failure of crops? Which are the regions in India with minimum of weather-risk? Do such risks occur at random or is there any regularity or law governing the time and place of their occurrence? What are the large-scale and long-term measures which the State can undertake in order to reduce weather-risks? In what parts of India will such developments be practicable? These are some of the questions which deserve consideration. In what follows, resort will be had to self-explanatory diagrams and tables so as to secure brevity.

PHYSICAL AND CLIMATIC FEATURES

100 07 Figs. 1 and 2 show the distribution of the mountain and river-systems and of the normal annual rainfall of India. The areas of very heavy rainfall are to the windward side of the Western Ghats, the hills of Assam, and the great Himalayan barrier. These are the watersheds from which originate the major river-systems of the country. Elsewhere, in the plateau of the Deccan, the Gangetic plains of North India, and the plains of the Carnatic, the effects of orography are less pronounced or are completely absent and the rainfall is only moderate. In the north-west, the Punjab, N.W. Frontier Province, Sind, Baluchistan, and the desert of Rajputana constitute the driest area of the country.

Table I, gives the normal rainfall in different seasons of the year and during the year as a whole in the 30 subdivisions into which India may be divided (see Fig. 3). The four seasons are: winter, December to February; summer or pre-monsoon, March to May; monsoon, June to September; post-monsoon, October to November. In columns (2) to (5) the figures within brackets are the seasonal amounts expressed as percentages of the annual rainfall.

A study of these figures reveals at once that India is truly the land of the monsoons. With the exception of Kashmir, the N.W. Frontier Province, and Baluchistan in the north and SE. Madras in the south, a very large percentage of the annual rainfall over the country occurs during the south-west monsoon (June to September). In the extreme north a good proportion of the annual rainfall is contributed by winter precipitation, whilst in SE. Madras nearly half the annual rainfall occurs during the post- or retreating monsoon period (i.e., after September).

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† The article deals with undivided India.

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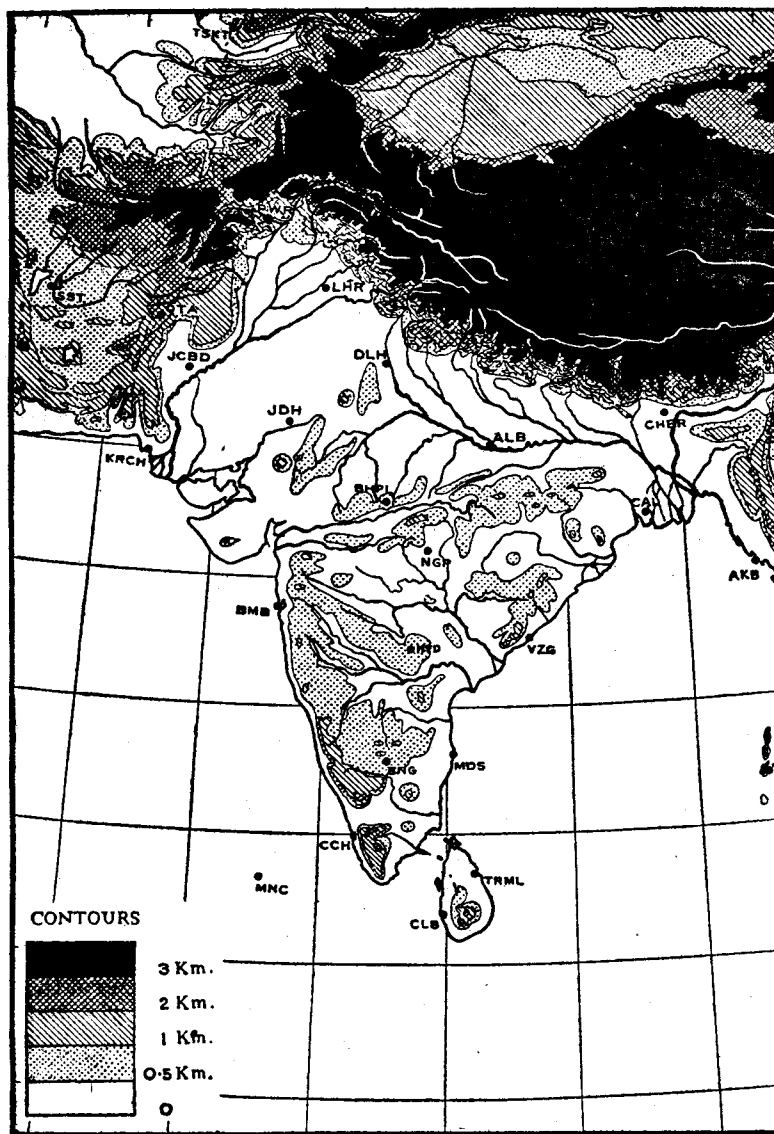


Fig. 1. Relief map of India

Besides the setting in of the monsoon early in June, its extension into India during June and July, and finally its retreat southwards in September and October, we have also to consider the other major phenomena like cyclonic storms and depressions.

TABLE I

Normal seasonal rainfall in the 30 rainfall subdivisions of India in inches

Subdivision (1)	Winter December to February (2)	Summer or Pre-monsoon March to May (3)	Monsoon June to September (4)	Post-monsoon October to November (5)	Year (6)
1. Assam	2.38 (2.4) per cent	25.06 (25.7) per cent	64.26 (65.8) per cent	5.96 (6.1) per cent	97.66
2. Bengal	1.53 (2.0)	12.42 (16.5)	56.01 (74.5)	5.17 (6.9)	75.13
3. Orissa	1.82 (3.2)	5.62 (9.9)	44.49 (78.2)	4.98 (8.8)	56.91
4. Chota Nagpur	2.57 (5.0)	3.64 (7.1)	42.71 (83.4)	2.26 (4.4)	51.18
5. Bihar	1.41 (2.9)	3.30 (6.8)	40.96 (85.0)	2.54 (5.3)	48.21
6. U. P. East	1.53 (3.9)	1.12 (2.9)	34.44 (88.0)	2.04 (5.2)	39.13
7. U. P. West	2.27 (6.0)	1.36 (3.6)	32.98 (87.8)	0.97 (2.6)	37.58
8. Punjab, E. & N.	2.76 (11.9)	1.89 (8.1)	18.23 (78.4)	0.37 (1.6)	23.25
9. Punjab, SW.	1.28 (13.7)	1.36 (14.5)	6.58 (70.4)	0.13 (1.4)	9.35
10. Kashmir	9.12 (22.1)	9.09 (22.0)	22.19 (53.7)	0.94 (2.3)	41.34
11. N. W. F. P.	3.36 (20.0)	4.18 (24.9)	8.65 (51.5)	0.62 (3.7)	16.81
12. Baluchistan	3.50 (45.6)	2.03 (26.4)	1.89 (24.6)	0.26 (3.4)	7.68
13. Sind	0.67 (10.4)	0.41 (6.4)	5.28 (82.4)	0.08 (1.2)	6.44
14. Rajputana, W.	0.62 (4.8)	0.56 (4.3)	11.74 (90.0)	0.12 (0.9)	13.04
15. Rajputana, E.	0.96 (3.8)	0.78 (3.1)	22.91 (90.9)	0.55 (2.2)	25.20
16. Gujerat	0.22 (0.7)	0.24 (0.7)	31.46 (96.2)	0.71 (2.4)	32.69
17. C. India, West	0.85 (2.5)	0.47 (1.4)	31.56 (93.8)	0.75 (2.2)	33.63
18. C. India, East	1.44 (3.7)	0.79 (2.0)	35.05 (90.9)	1.30 (3.4)	38.58
19. Berar	1.01 (3.1)	0.86 (3.0)	28.10 (87.4)	2.07 (6.4)	32.14
20. C. P. West	1.47 (3.2)	1.14 (2.5)	41.04 (90.4)	1.76 (3.9)	45.41
21. C. P. East	1.58 (3.0)	2.10 (4.0)	46.37 (89.1)	1.99 (3.8)	52.04

TABLE I—*contd.**Normal seasonal rainfall in the 30 rainfall subdivisions of India in inches—contd.*

Subdivision (1)	Winter December to February (2)	Summer or Pre-monsoon March to May (3)	Monsoon June to September (4)	Post-monsoon October to November (5)	Year (6)
22. Konkan	0.28 (0.3)	1.85 (1.7)	102.45 (93.7)	4.75 (4.3)	109.33
23. Bombay Deccan	0.51 (1.7)	2.13 (6.9)	24.41 (79.1)	3.82 (12.4)	30.87
24. Hyderabad, N.	0.67 (1.9)	1.53 (4.4)	29.51 (84.5)	3.20 (9.2)	34.91
25. Hyderabad, S.	0.57 (1.9)	2.10 (7.0)	23.38 (78.1)	3.88 (13.0)	29.93
26. Mysore	0.73 (2.0)	5.47 (15.2)	22.27 (61.8)	7.54 (20.9)	36.01
27. Malabar	2.73 (2.6)	12.81 (12.2)	71.47 (68.9)	16.93 (16.3)	103.74
28. Madras, SE.	4.76 (13.6)	4.53 (12.9)	12.01 (34.2)	13.80 (39.3)	35.10
29. Madras, Deccan	0.74 (3.0)	2.42 (9.9)	15.27 (62.3)	0.09 (24.8)	24.52
30. Madras, Coast N.	1.69 (4.2)	3.44 (8.9)	25.03 (62.3)	10.00 (24.9)	40.16

Eastern depressions

The fluctuations in the intensity of the monsoon itself are to a large extent associated with a series of depressions which mostly originate (or, when they are coming from farther east, strengthen) at the head of the Bay of Bengal and travel in a north-westerly direction across the country towards NW. India, causing heavy rainfall along their track. The frequency of such depressions is three or four per month during the monsoon months (June to September).

Western depressions

During the period November to May a series of western depressions enter India through Baluchistan and the NW. frontier and move eastwards across North India towards NE. India (Assam-Bengal). These depressions cause cloudy weather and light rains in the plains with snowfall in the Himalayas and are followed by cold waves. Their frequency is, on the average, two in November, four to five per month during December to April, and about two in May.

(3) *Cyclonic storms*

The more severe cyclonic storms usually form in the Bay of Bengal and in the Arabian Sea in the transition periods April to June and October to December. They enter inland and cause considerable precipitation and damage due to high winds and, occasionally, tidal waves, in the coastal tracts. The mode of occurrence of these storms and their favourite tracts have been discussed in the publications of the India Meteorological Department. On an average one or two severe cyclones may be expected in the pre-monsoon period and two or three in the post-monsoon period.

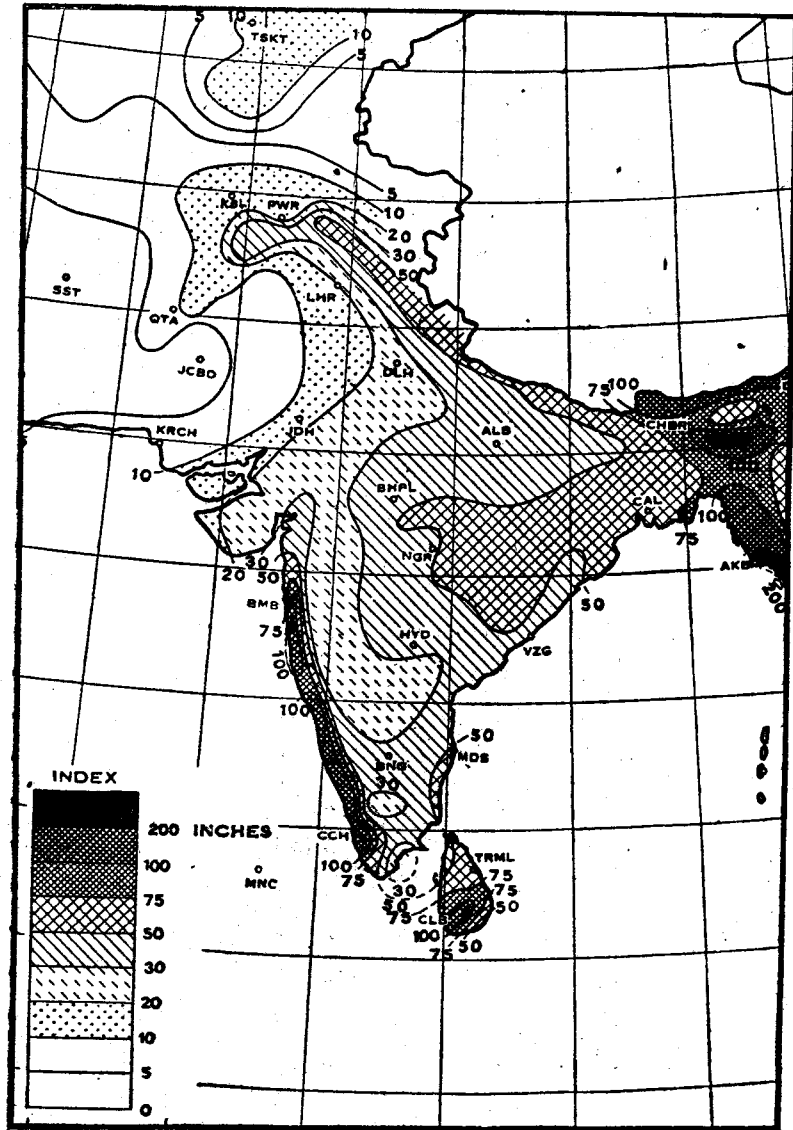


FIG. 2. Annual rainfall in India

TABLE II

Date of establishment of the S.W. monsoon along the West Coast of India

Year	Travancore-Cochin	S. Kanara	Ratanagiri	Kolaba
1891	May 27	June 3	June 19	June 21
1892	" 22	May 24	May 29	May 31
1893	" 22	June 4	June 10	June 10
1894	June 1	" 2	" 7	" 7
1895	" 8	" 12	" 14	" 15
1896	May 30	May 31	" 1	" 1
1897	" 30	June 5	" 7	" 7
1898	June 2	" 3	" 8	" 8
1899	May 23	" 7	" 9	" 10
1900	June 6	" 8	" 9	" 9
1901	" 1	" 4	" 7	" 7
1902	May 31	" 6	" 7	" 12
1903	June 8	" 11	" 12	" 12
1904	May 29	" 1	" 7	" 8
1905	June 6	" 8	" 9	" 10
1906	" 3	" 6	" 7	" 8
1907	May 31	" 5	" 11	" 11
1908	June 8	" 10	" 11	" 11
1909	" 1	" 2	" 3	" 3
1910	May 23	" 2	" 3	" 3
1911	June 1	" 2	" 4	" 4
1912	" 4	" 6	" 12	" 12
1913	May 24	" 1	" 6	" 7
1914	" 28	" 5	" 13	" 13
1915	June 3	" 12	" 17	" 18
1916	May 26	May 27	May 31	" 1
1917	" 26	" 29	June 4	" 5

TABLE II—contd.

Date of establishment of the S.W. monsoon along the West Coast of India—contd.

Year	Travancore-Cochin	S. Kanara	Ratnagari	Kolaba
1918	May 7	May 15	May 22	May 25
1919	„ 16	„ 26	June 4	June 6
1920	„ 27	June 2	„ 6	„ 6
1921	June 1	„ 3	„ 10	„ 12
1922	May 25	May 31	„ 10	„ 12
1923	June 4	June 11	„ 12	„ 13
1924	May 31	„ 3	„ 10	„ 12
1925	„ 27	May 28	May 29	May 29
1926	„ 28	June 5	June 9	June 10
1927	„ 23	May 27	„ 10	„ 10
1928	„ 31	„ 31	„ 5	„ 7
1929	„ 29	„ 30	„ 1	„ 6
1930	„ 21	June 7	„ 8	„ 9
1931	„ 23	May 29	„ 14	„ 14
1932	„ 14	June 2	„ 3	„ 3
1933	„ 22	May 28	„ 1	„ 1
1934	June 6	June 6	„ 10	„ 10
1935	„ 10	„ 10	„ 12	„ 14
1936	May 20	May 22	May 29	„ 1
1937	June 3	June 10	June 11	„ 12
1938	„ 1	„ 2	„ 2	„ 4
1939	„ 6	„ 6	„ 7	„ 9
1940	„ 7	„ 13	„ 16	„ 18
1941	† May 23	„ 3	„ 14	„ 16
1942	June 4	„ 8	„ 12	„ 13
1943	May 12	May 14	May 21	May 21

THE SW. MONSOON

Date of establishment

As is well known, the success of Indian agriculture depends mainly on the monsoon rains ; the farmer looks forward to the onset of the monsoon with great anxiety and prays for a timely and suitable distribution of rainfall during the season. The monsoon has been described in various publications of the India Meteorological Department. Figs. 4 and 5 show the *normal* dates of *onset* and of *withdrawal* of this monsoon in different parts of India. The actual dates of onset as well as the intensity and distribution in time and space of the monsoon precipitation vary from year to year. Table II gives the actual dates of establishment of the SW. monsoon in four areas along the west coast of the peninsula. It will be noticed that there is a considerable variation not only in the *dates* of establishment but also in the speed with which the monsoon current moves from the Travancore-Cochin area in the south towards Kolaba in the north (near Bombay). Table III below summarizes the information given in Table II.

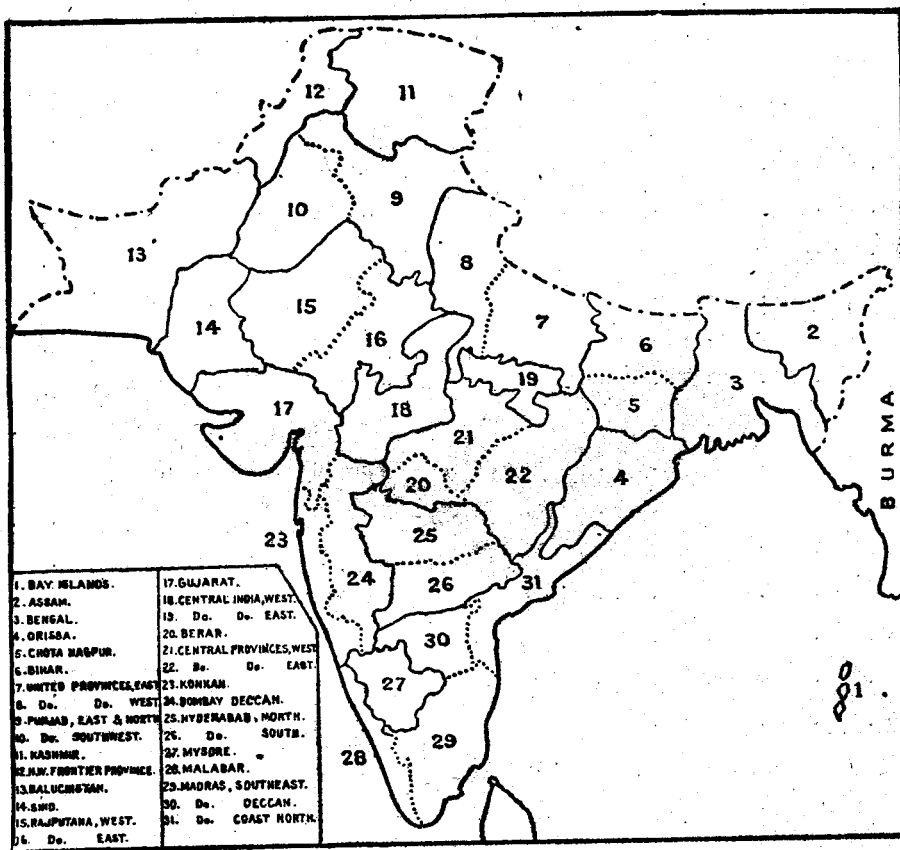


FIG. 3. Map of India showing the rainfall subdivisions

As the major agricultural operations have to synchronize with the monsoon rains, the importance of predicting the date of establishment of the monsoon in different parts of the country, the spells of rain and breaks which occur during the season, cannot be over-emphasized.

Survey of the past 70 monsoons (1875-1944). Frequency of drought and flood years

For this purpose the total rainfall during the period June to September is considered. If the deviation of the actual rainfall in a year is more than about twice the mean deviation, that year is defined as a year of flood or drought according as the departure is positive or negative.

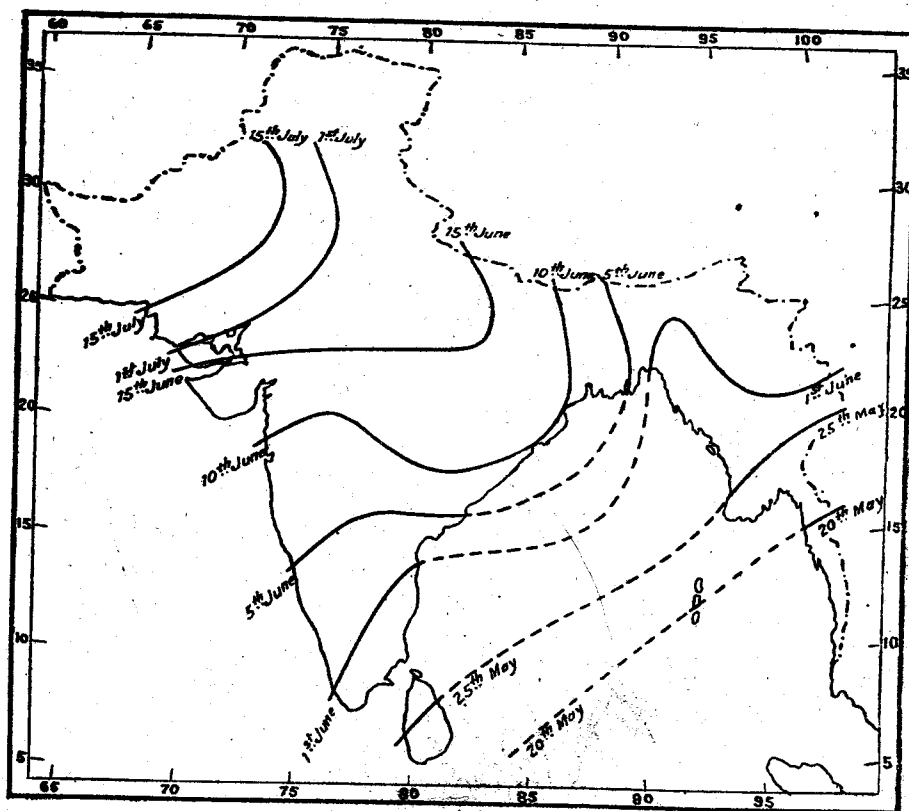


FIG. 4. Normal dates of onset of SW. monsoon

TABLE III

Dates of establishment of the SW. monsoon along the West Coast of India

Area	Mean date	Standard deviation (in days)	Earliest date	Latest date
Travancore-Cochin	May 29	7.0	May 7	June 10
South-Kanara	June 3	5.7	" 15	" 12
Batanagiri	" 7	5.4	" 22	" 19
Kolaba	" 8	5.2	" 25	" 21

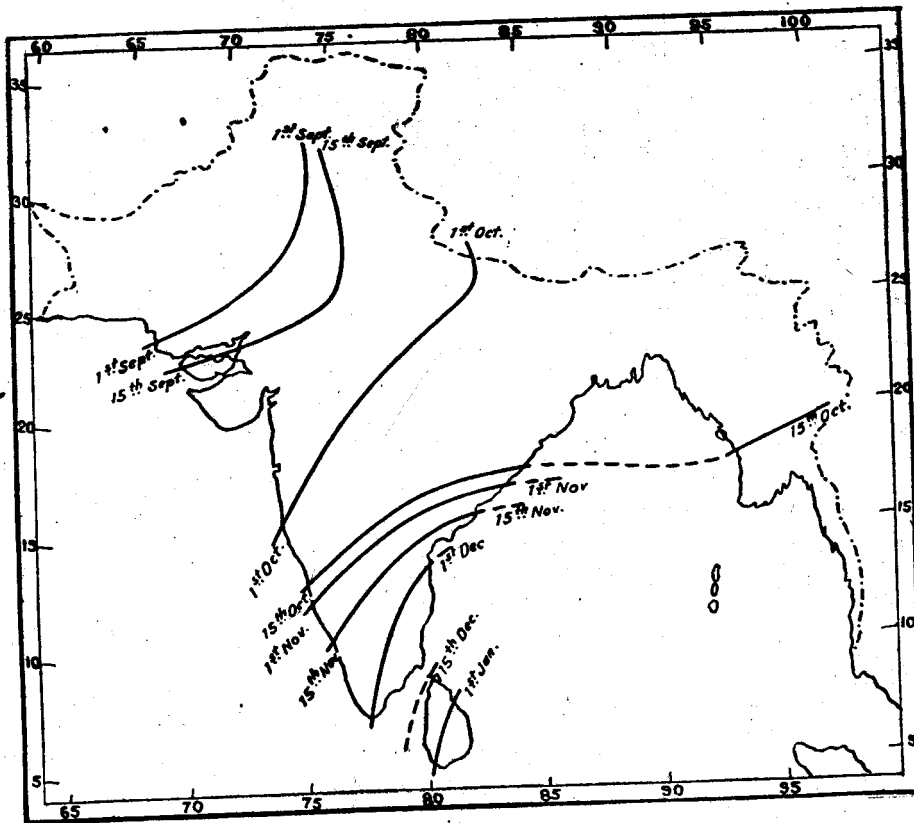


Fig. 5. Normal dates of withdrawal of SW. monsoon

Fig. 6 shows at a glance how the monsoon has behaved in the past 70 years in each of the 30 rainfall subdivisions of India. In the figure the filled circle indicates a flood, the open circle a drought, and the spaces which are blank are years and subdivisions with more or less normal monsoon rainfall. At the bottom of this diagram are given, for each subdivision, (1) the normal monsoon rainfall, (2) the means deviation, (3) the limit for abnormality, i.e., the amount by which the actual rainfall should be in excess or defect if it is to be labelled as 'abnormal' (flood or drought, as the case may be), (4) the total number of floods during the period 1875 to 1944, (5) the total number of droughts during the period 1875 to 1944 and (6) the total number of abnormal years (i.e. floods plus droughts) during the period 1875 to 1944.

These figures show that when we consider a sufficiently large number of years the frequencies of floods and droughts tend to equalize ; also, areas with a very low rainfall, e.g. Baluchistan, Sind, Rajputana, etc., are those where the total number of abnormalities is maximum ; in areas like the Konkan, Malabar, Bengal, etc., where the monsoon rainfall is above 40 in., the frequency of abnormal years comes down very much.

It is still more interesting to study the distribution of floods and droughts in the various subdivisions in each year. The years 1877, 1899, and 1918 stand out very prominently as years of general drought. It will be recalled that these were actually years of great famine and distress. The year 1920 was one of partial drought, only the north-west and the central parts of the country being affected. The years of general flood are 1878, 1892, and 1917. In two instances at least (1877, 1878, and 1917, 1918) droughts and floods occurred in adjacent years, but there is usually no regularity in time in the distribution of droughts and floods. The chances of one drought year being succeeded by another or a flood year being succeeded by another in a particular subdivision appear to be small. Areas of drought and floods are, however, associated into centres of defective or excessive rainfall in the years in which they do occur. For the rest, the reader can judge for himself from Fig. 6 how liable India is to the incidence of abnormal monsoons.

Before leaving this topic it will be interesting to compare the actual distributions of *weekly* rainfall during the monsoon season of the years 1917 and 1918, as they are likely to show up the contrast, not only in the total rainfall, but also in the distribution thereof. Fig. 7 shows the rainfall distribution in 1917 and 1918, for each of the main divisions : (1) NE. India ; (2) the United Provinces ; (3) NW. India ; (4) Central Provinces and Central India ; (5) North Peninsula ; (6) South Peninsula.

The dotted curves represent the normal weekly rainfall and the hatched area shows the actual rainfall. There is little contrast between 1917 and 1918 in NE. India as the rainfall was more or less normal in both the years. Over the other five divisions of the country, however, the contrast between the excess and the defect in 1917 and 1918 respectively was very marked.

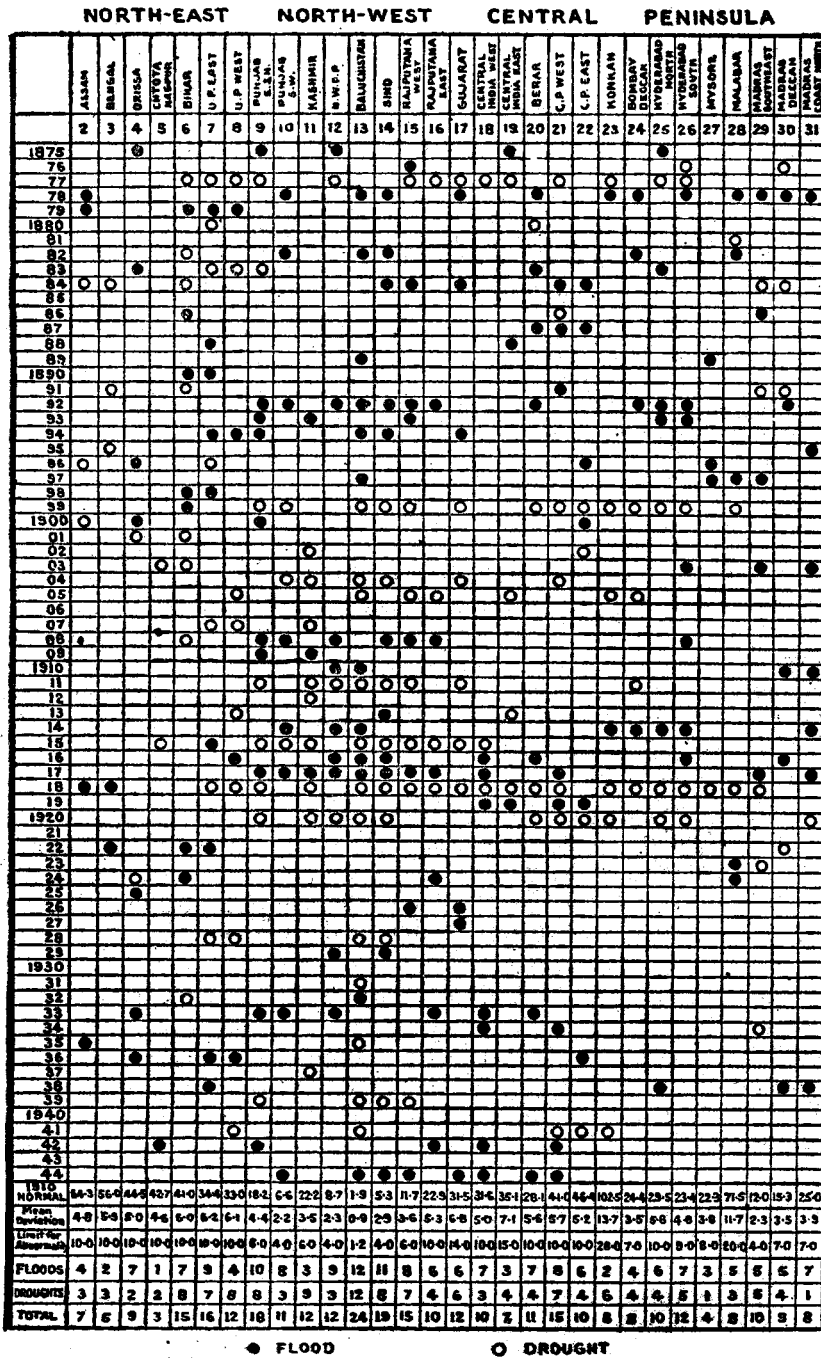


Fig. 6. Floods and droughts in India. Years of floods and droughts have for this purpose been defined as years with abnormality greater than twice the mean deviation.

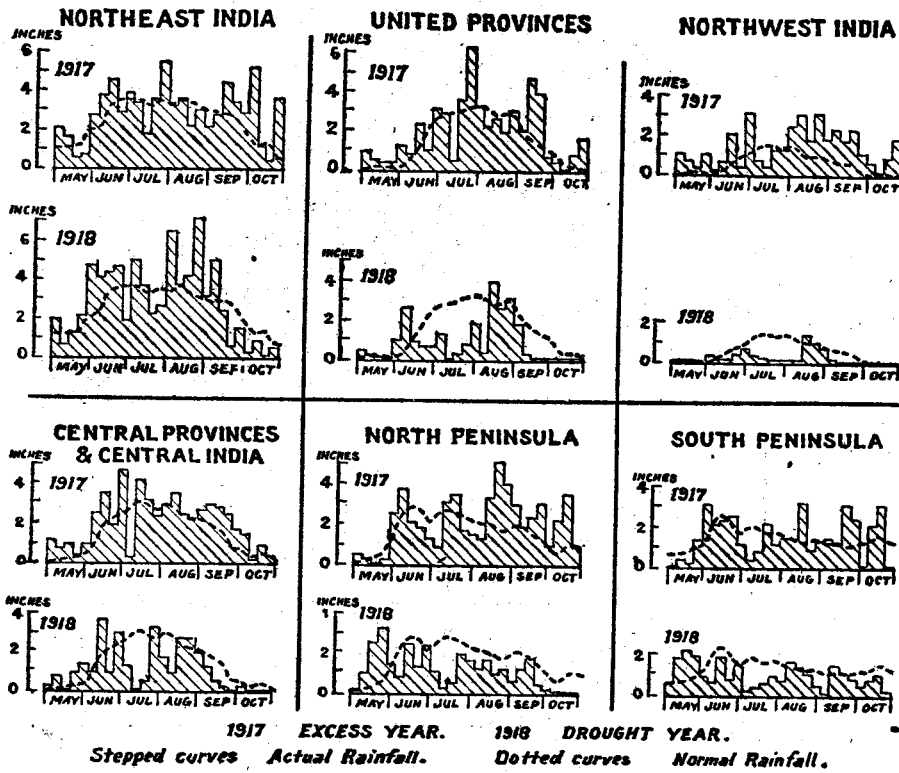


FIG. 7. Progress of the monsoon week by week

CONTEMPORARY RELATIONSHIPS OF MONSOON RAINFALL IN FIFTEEN DIVISIONS

We have just seen that the monsoon rainfall varies from year to year both as regards the total rainfall as well as its distribution during the season. Administrators and others interested in the country as a whole may naturally inquire whether the effects of a deficiency in the monsoon rainfall in one part of the country is likely to be compensated by the effects of excess in some other part or parts.

TABLE IV
Monsoon rainfall June to September. Inter-correlations between pairs of divisions. Period 1875-1918
 (Vide Table E, Memoirs of the Ind. Met. Dept., Vol 25, Part ii, p. 23)

Division	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I Burma	-0.47	-0.14	-0.05	-0.01	-0.09	-0.21	-0.29	-0.07	-0.26	+0.01	-0.01	-0.32	-0.15	-0.33
II Assam	+0.45	+0.27	+0.01	-0.16	-0.10	-0.13	-0.17	-0.24	-0.27	-0.40	-0.01	-0.11	+0.14
III Bengal	+0.56	-0.07	-0.07	-0.05	+0.04	-0.24	-0.31	-0.22	-0.45	-0.18	-0.15	-0.12
IV Bihar and Orissa	+0.31	+0.13	+0.06	+0.06	+0.05	-0.10	+0.04	-0.27	-0.01	-0.07	-0.16
V United Provinces	+0.40	+0.31	+0.06	+0.55	+0.30	+0.68	+0.83	+0.37	+0.07	+0.22
VI Punjab	+0.82	+0.56	+0.87	+0.59	+0.79	+0.59	+0.61	+0.11	+0.35
VII N. W. P.	+0.65	+0.73	+0.59	+0.64	+0.46	+0.63	+0.22	+0.45
VIII Sind	+0.50	+0.65	+0.34	+0.34	+0.40	+0.24	+0.40
IX Rajputana	+0.57	+0.81	+0.54	+0.57	+0.21	+0.40
X Bombay	+0.46	+0.58	+0.72	+0.53	+0.66
XI Central India	+0.61	+0.40	+0.50	+0.21
XII Central Provinces	+0.55	+0.07	+0.18
XIII Hyderabad	+0.38	+0.61
XIV Mysore	+0.80
XV Madras

Table IV below expresses the relation between the monsoon rainfall in each of the 15 divisions and the remaining divisions in the form of contemporary correlation coefficients. A positive coefficient in the table indicates the two areas concerned are likely to be affected similarly (i.e. both may have heavy rains in some years and deficient rains in other years). A negative coefficient would indicate that a decrease in one is likely to be associated with an increase in the other area. Looking at the correlation coefficients in each row, one notices that a vigorous monsoon over Burma tends to be associated with a subnormal monsoon over India (and *vice versa*). To a smaller extent, excessive rainfall over NE. India tends to be associated with a defect elsewhere (and *vice versa*). Elsewhere, in India, i.e., NW. India, Central India, and the Peninsula, the correlation coefficients are generally positive, indicating that departures from normal are likely to be similar over the greater part of India, as indeed the dot-diagram (Fig. 6) does suggest in regard to even pronounced abnormalities like floods and droughts.

IS INDIA'S CLIMATE CHANGING ? ARE THERE SECULAR VARIATIONS OR PERIODICITIES IN INDIAN RAINFALL ?

The longest meteorological records in India are of rainfall at the cities of Madras (from 1813), Bombay (from 1847), and Calcutta (from 1829).

The rainfall data of the above stations as well as of shorter series in the case of some 10 stations in Bihar were examined for periodicity. In some cases there were significant periods, but considering that neighbouring stations do not indicate similar periods, not much importance can be attached to these results. It may be worth while to examine the question more extensively for a network of selected stations or selected areas in India, for settling this point conclusively. Evidence so far collected does not, however, support the possibility of any regular periodicity in Indian rainfall.

OCCASIONS OF UNUSUALLY HEAVY RAINFALL

The frequency of heavy rainfall over India has been discussed in a recent note by Doraiswamy and Mohamad Zafar (*Scientific Notes, Ind. Met. Dept.*, 7, No. 77). With reference to the heaviest fall in a day they find that :

- (i) Falls exceeding 5 in. in 24 hours have occurred over the whole of India excluding NE. Baluchistan and parts of the NW. Frontier.
- (ii) Falls have not exceeded 10 in. in 24 hours over most of the interior of the Peninsula and of Burma and in a few districts in the Central parts of the country.
- (iii) Falls of 15 to 20 in. in 24 hours have occurred all along the west coast including Gujerat and Kathiawar, on the south Coromandel coast on the north Burma coast, in south Assam, in Bengal, and the foot of the Himalayas.
- (iv) A few isolated falls of 20 in. and over have occurred in the plains.
- (v) The greatest fall of over 40 in. in 24 hours has occurred at Cherapunji in the Khasi hills.

When heavy rainfall occurs consecutively on a number of days and particularly over the catchment areas of rivers, the magnitude of the ensuing floods may well be imagined. Ramkrishnan (*Scientific Notes, Ind. Met. Dept.*, 7, No. 74) has estimated the total volume of water precipitated over certain areas in South India on days when they were under the grip of storms coming from the Bay of Bengal. The values given by him for one of these storms are quoted below :

Date	Area on land which had rain of 0.5 in. and more in sq. km.	Volume of water precipitated on land in cu. km.
21.10.30	60,150	1.0
22.10.30	53,730	1.6
23.10.30	71,540	4.9
24.10.30	103,660	8.0
25.10.30	133,740	6.5
26.10.30	141,620	7.1
27.10.30	342,520	11.9

Increasing forest-cover, checking erosion, delaying flood-peaks, and training the major rivers, etc., are problems which have begun to demand an increasing attention of the State.

REGIONAL PECULIARITIES IN DISTRIBUTION OF RAINFALL: CLIMATIC HOMOGENEITY

Even if we divide the country into climatically homogeneous tracts, judging from the normal rainfall there are still outstanding local peculiarities. This may be emphasized with the aid of a few examples.

Suppose that a weather forecaster expects a particular subdivision in the country to come under the influence of disturbed weather and forecasts rainfall over the area. Can he expect all the rain-gauge stations to record more or less similar rainfall during a particular day? Or will the rainfall be very variable? This involves the question of rainfall variability in space and is very important from the weather forecaster's point of view.

We may also consider the point of view of an irrigation engineer faced by the problem of constructing reservoirs to serve the agriculturist's needs. Should he construct one big reservoir at a likely place or should he scatter a series of small reservoirs, casting his net wide as it were, so that one or the other of the reservoirs collects such rain as may fall over its neighbourhood? How would the variability between stations in a given area compare with the variability between days of a month and with that due to random chance?

In connexion with a recent inquiry, the variability of rainfall in the month of July 1942 was analyzed for a number of representative areas in India, taking 20 stations selected at random from each of these areas. Table V gives the analysis of variance between 'stations', days of the month, and 'residual' (due to random variability), for the Punjab, the United Provinces, the Central Provinces, Bengal, Rajputana, and Malabar. Column (5) gives the standard deviation of the variability 'between stations,' 'between days', and 'residual' or error. The next column gives the ratios of the variances, i.e.

$$\frac{\text{Variance between stations}}{\text{residual variance}} \quad \text{and} \quad \frac{\text{Variance between days}}{\text{residual variance}}$$

TABLE V
Analysis of variance of rainfall in July 1942

Due to	Degrees of freedom	Sum of squares	Mean square (variance)	Standard deviation	Variance ratio: 'F'	Rainfall per day	Coefficient of variability per cent.
1. The Punjab							
Stations	19	21.1334	1.1123	1.55	3.73*	0.228 in.	680
Days	30	19.8421	0.6614	0.81	2.22*	..	356
Residue	570	169.8981	0.2981	0.55	..	..	241
TOTAL	619	210.8736	0.3407	..	..	..	..
2. The United Provinces							
Stations	19	16.1105	0.8479	0.92	1.55	0.466 in.	197
Days	30	114.5280	3.8148	1.95	6.97*	..	418
Residue	570	312.1042	0.5475	0.74	..	..	159
TOTAL	619	442.7427	..	..	..	..	..
3. The Central Provinces							
Stations	19	45.5754	2.3987	1.55	1.35	0.697 in.	222
Days	30	279.4902	9.3165	3.02	5.16*	..	433
Residue	570	618.9352	1.07715	1.33	..	..	191
TOTAL	619	929.9901	1.5024	..	..	..	..

* Means significant at 1 per cent level.

TABLE V—*contd.*

Analysis of variance of rainfall in July 1942.

Due to	Degrees of freedom	Sum of squares	Mean square (variance)	Standard deviation	Variance ratio : 'F'	Rainfall per day	Coefficient of variability per cent.
4. Bengal							
Stations	19	41.4545	2.1818	1.48	3.62*	0.422 in.	350
Days	30	43.2902	1.4430	1.20	2.39*	..	284
Residue	570	343.4197	0.6025	0.78	..	..	185
TOTAL	619	428.1644	0.6917	..	..	..	..
5. Rajputana							
Stations	19	108.8973	5.7314	2.39	6.92*	0.417 in.	573
Days	30	46.2551	1.5418	1.24	1.86	..	297
Residue	570	471.9398	0.8280	0.91	..	..	218
TOTAL	619	627.0922	1.0131	..	..	..	..
6. Malabar							
Stations	19	85.4648	4.4981	2.12	5.53*	1.331 in.	159
Days	30	332.1749	12.7392	3.57	15.68*	..	238
Residue	570	463.1872	0.8126	0.90	..	..	68
TOTAL	619	930.8269	1.5038	..	..	..	..

* Means significant at 1 per cent level

If the variability 'between stations', 'between days', and 'residual' are all of the same order of magnitude the ratio *F* will not be significant.

In the Punjab, Bengal, and in particular Rajputana and Malabar, the variability between stations is very significantly larger than that caused by random chance. In Malabar this variability is due to orography, whilst in Rajputana it represents a real climatic non-homogeneity. The variability between days is significant in all cases. In places like Rajputana it is indeed difficult to indicate where exactly rain would fall during a wet spell. The engineer would be well advised to construct a wide network of tanks in preference to a single big tank in such tracts.

IRRIGATION WORKS AND LARGE-SCALE RESERVOIRS, BUNDS, ETC.

Wherever the precipitation falling over a very wide catchment is drained into large river-systems like the Indus and Ganges, it is obvious that irrigation projects will be successful, as has indeed happened in the Punjab and Sind. In the United Provinces, besides canal irrigation, tube-wells are also being sunk on a large scale.

It may be pointed out that the large dry tracts of Peninsular India which are not fed by rivers can get adequate supplies of water for agriculture if the necessary irrigation-projects are set up at suitable localities in the catchment areas of the Western Ghats *which receive sufficient rains for this purpose even in years with weak monsoons*. Much of this water is now drained by rapids flowing into the Arabian Sea. If large reservoirs are built up on the Ghats over elevated areas, taking advantage of natural facilities for impounding the rain-water, the water so collected can be fed into the plains to the east of the Ghats through canal systems. This is a problem which the State alone can tackle ; it is full of large potentiality for the future of the arid tracts of Peninsular India.

In concluding this all too brief a summary of India's rainfall as affecting its agricultural potentialities, it may be appropriate to state that the India Meteorological Department is undertaking, in the very near future, to broadcast special weather bulletins and forecasts for the farmer. Seven Regional Forecasting Centres have been started. These will cater for the special weather requirements of their respective regions. Warnings for heavy and untimely rainfall, heat waves, cold waves, droughts, hail-storms, high winds, etc. will be issued, keeping in view the needs of the important crops of each region. In this new undertaking the Agricultural Meteorologist will maintain a close liaison between agriculture and meteorology.