

DROUGHTS AND FLOODS IN INDIA AND SOME OTHER COUNTRIES NEAR AND FAR FROM INDIA

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To bring out the major abnormalities of monsoon rainfall in the 30 rainfall sub-divisions of India, the author has considered the seasonal total rainfall in each year in each of the sub-divisions for the series of years from 1875 onwards for which actual recorded data are available. If ' M ' is the mean or normal seasonal rainfall and ' d ' the mean deviation from normal during the period of years considered, any particular year when the actual rainfall is less than $(M-2d)$ is defined as a 'Drought'. Again a year when the actual rainfall happens to be more than $(M+2d)$ is called a 'Flood'. A year when the actual rainfall lies between the above two limits is defined as 'Normal'. The occurrences of these abnormalities as well as the normal years are shown for the entire series of years as well as for all the 30 rainfall sub-divisions in a single diagram. For India the diagrams cover the period 1875 to 1970 for which actual recorded data are available, as well as the earlier period 1770 to 1875 for which no recorded data are available. The details for the earlier period 1770 to 1875 have been inferred from historical references to abnormalities of rainfall which were reported to have caused famines and floods. An examination of the diagrams for India reveal that there have been greater frequencies of 'Droughts' and 'Floods' during the period 1875 to 1920 than either before or after. The diagrams also show conspicuously the country-wide 'Droughts' in the years 1877, 1899 and 1918 as well as the country-wide 'Floods' in the years 1878, 1892 and 1917. Similar diagrams of 'Floods' and 'Droughts' have been prepared for a number of other countries near and far from India which show that calamities like these do occur in all countries. Happily, however, they do not seem to occur in the same year or simultaneously in all the countries considered.

INTRODUCTION

The recurring, severe and countrywide droughts and ensuing famines during the last quarter of the 19th century focussed the attention of the then British Government of India on the immediate need for setting up the India Meteorological Department. Systematic daily and instrumental observations according to a standard plan at a net-work of meteorological stations thus began in the year 1875. In other countries too, their weather services were organised about the same time and presumably for very similar reasons. Generally speaking, therefore, we have only about a century of regularly recorded data of important weather factors like rainfall, temperature, atmospheric pressure, winds, etc. For information regarding earlier centuries one has to fall back on vague information and cursory records and such indirect information on the weather sequences as may be provided by growth rings of old trees (Dendro-chronology).

INDIA, THE LAND OF THE MONSOONS*

India, favoured by the immense Himalayan barrier as her northern boundary, is the land of the monsoons, with the several river basins draining into the adjacent seas. Over most of the subcontinent the greater part of the annual precipitation occurs during the southwest monsoon season, June to September. Southeast peninsular India alone has its main precipitation during the retreating monsoon (or the North-East Monsoon) viz., from October to December.

The orographic rainfall along the Himalayan slopes and along the west coast of peninsular India favoured by the Western Ghats is the most dependable in quantity and distribution in time and space. The continental or interior tracts of north and central India as well as the northern tracts of peninsular India depend largely on the rainfall associated with (a) the westward to northwestward passage of the occasional monsoon depressions across the country and (b) the pre- and post-monsoon cyclones originating in the Bay of Bengal and the Arabian Sea, entering and passing through the subcontinent.

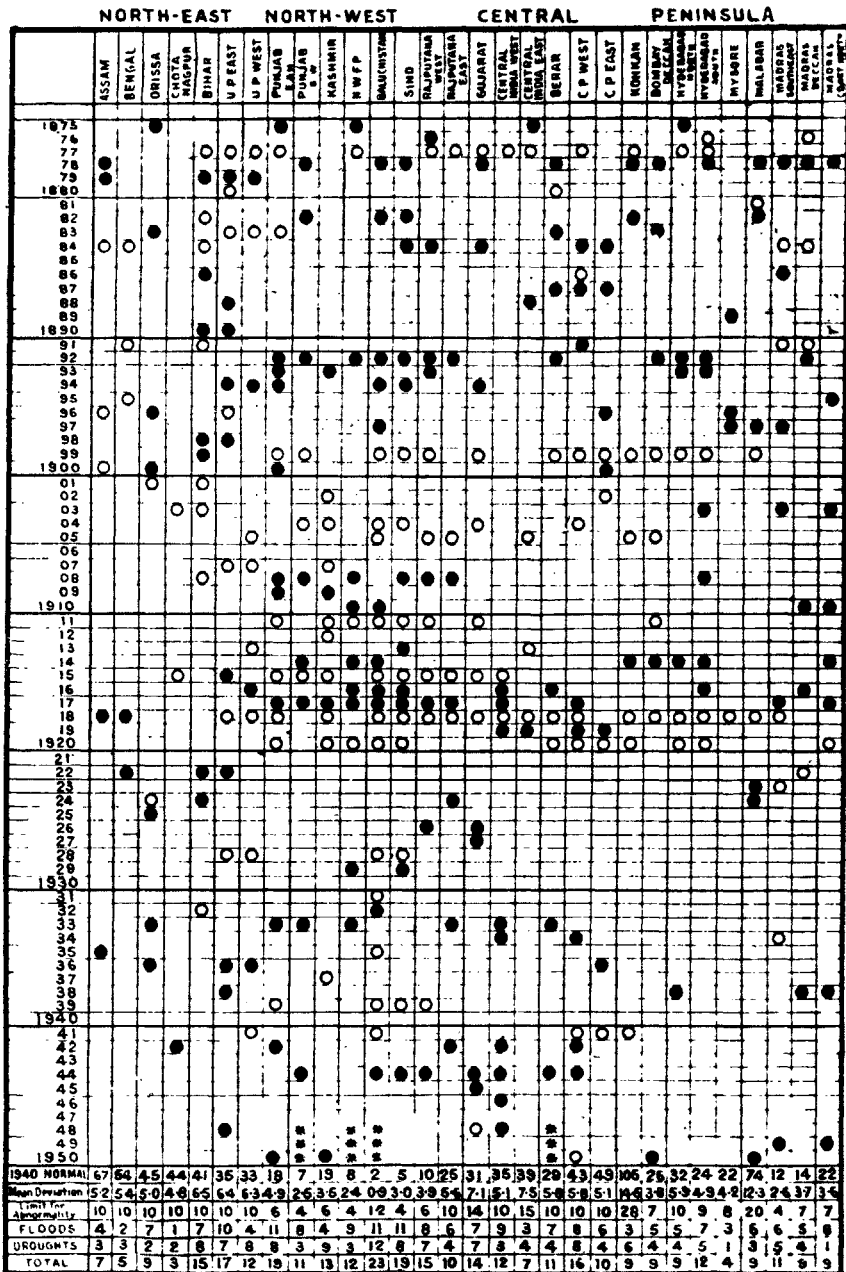
The data of commencement, duration and intensity, the date of termination as well as the fluctuation and occasional breaks of the monsoon during its seasonal course, reveal considerable variation from year to year. The question whether the Indian monsoons were getting weaker was raised urgently by the Bombay government in the nineteen forties and the present writer was asked by the then Director-General (Sir Charles Normand) to look into this problem.

Realising that in assessing the performance of the monsoon year by year in each of the 30 rainfall sub-divisions of the country, it is essential to take a bird's eye-view, as it were, of the season as a whole, so as to avoid getting hopelessly entangled in a bewildering maze of detail, after considerable thought, the actual procedure adopted by the present writer to compress the information provided by the enormous quantity of rainfall data over several decades for which instrumental data are available into a single diagram showing the major features, was as follows:—

A year in a sub-division was defined as a 'Drought' when the actual total rainfall of the monsoon season as a whole was less than $M - 2d$, where M is the normal or mean seasonal rainfall of the series of years considered. ' d ' is the mean deviation during the same period. On the other hand, a year in a sub-division was defined to be a 'Flood' if the total actual rainfall of the monsoon season was more than $M + 2d$. A year during which the actual seasonal rainfall lay between the above limits of abnormality was defined as more or less 'Normal'. Fig. 1 has been prepared accordingly. Here the open circles indicate the 'Droughts', while the filled circles show the 'Floods', during the series of years 1875 to 1950, and for the 30 rainfall sub-divisions. The blank spaces in this diagram are the years in sub-divisions when the monsoon rains were more or less normal.

Fig. 1 does show very effectively and in a single diagram the major rainfall abnormalities, viz., 'Droughts' and 'Floods', and their distribution in time and space (i.e., years and sub-divisions). Taking Fig. 1 as a whole, one finds that the largest number of abnormalities occurs in areas of scanty rainfall like NW India,

*Vide Ramdas (1946, 1950, 1958, 1960, 1968) and Ramdas *et al.* (1954).



*Data not available

● Floods and ○ Droughts in India

FIG. 1.

Rajasthan and Gujarat. Areas of usually heavy rainfall like Malabar, Konkan, Bengal and Assam have the least frequency of abnormalities. Looking at the scores of each sub-division over the years, the occurrence of 'Drought' or

'Flood' appears to be more or less at random, but looking at the scores of all sub-divisions year by year, one is struck by the tendency in some (a few) years for most of the sub-divisions to experience the same type of abnormality. Thus, almost the entire Indian Subcontinent was in the grip of 'Drought' in the years 1877, 1899 and 1918. These three years are indeed remembered for the severe countrywide famines that devastated the subcontinent causing untold misery and starvation; thus, the method adopted for defining 'Drought' on the basis of rainfall alone does bear out actual experience. The above 3 abnormal years had 'Drought' over 50 per cent or more of the total number of sub-divisions in the Indian Subcontinent.

On the basis of Fig. 1, one may conclude that such countrywide failure of the monsoon may occur once in 20 years or five times in a century, while failures affecting only large parts of the country may occur in 3 to 4 out of twenty years (i.e., 15 to 20 years in a century). Thus about 15 out of 20 or 75 years in a century may be expected to be reasonably satisfactory to good.

As regards 'Floods', almost countrywide 'Floods' occurred in 1878, 1892 and 1917. Here again, nation-wide 'Floods' may be expected on an average only once in 20 years. There may be 6 to 7 years out of 20 when only large parts of the country may be affected by excessive rains.

Judging from Fig. 1 there is no suggestion of any regular periodicity in the incidence of these abnormalities. Sometimes adjacent years may be affected by 'Floods' and 'Droughts' on a countrywide scale. 1878 (Flood) and 1877 (Drought) and 1917 (Flood) and 1918 (Drought) are two such conspicuous instances. In many years, while some parts of the country have been suffering from 'Droughts', some other areas have had 'Floods'. There have been a few years when the entire subcontinent was Normal (as defined earlier). Such years are 1885, 1906, 1921, 1930, 1943 and 1947, i.e., 7 times in a series of 75 years considered in Fig. 1.

A MORE EXTENDED STUDY OF FLOODS AND DROUGHTS IN INDIA DURING THE TWO CENTURIES 1770 TO 1970

The present writer recently undertook to prepare a review of the "Changes in Climatic conditions as they affect Economic Conditions during the period 1770 to 1970 in the Indian Subcontinent" which will appear elsewhere. In this connection he not only brought Fig. 1, which deals with the period of scientific recording of meteorological data, up to the year 1970, but also attempted to extend the diagram backwards into the pre-scientific period 1770 to 1875, depending upon such records of major calamities like famines due to incidence of adverse weather like extremely deficient or very excessive rains as may be gathered from published literature (cf. Bhatia 1961; Cornelius Walford 1879; Dutt 1900, 1960; and Loveday 1914). A careful study of these references to weather abnormalities during the period 1770 to 1875 enabled one to decide whether a particular year may be classified as a 'Drought', 'Flood' or 'Normal' year in respect of the different parts of the country. We thus have in Fig. 2 as complete a picture as possible of the entire period 1770 to 1970, of which only the period 1875 to 1970 is based on accurate recorded rainfall data. In Fig. 2 the 'Floods' are indicated by filled in rectangles, 'Droughts' by hatched rectangles and 'Normal' years by the blank spaces. It will immediately

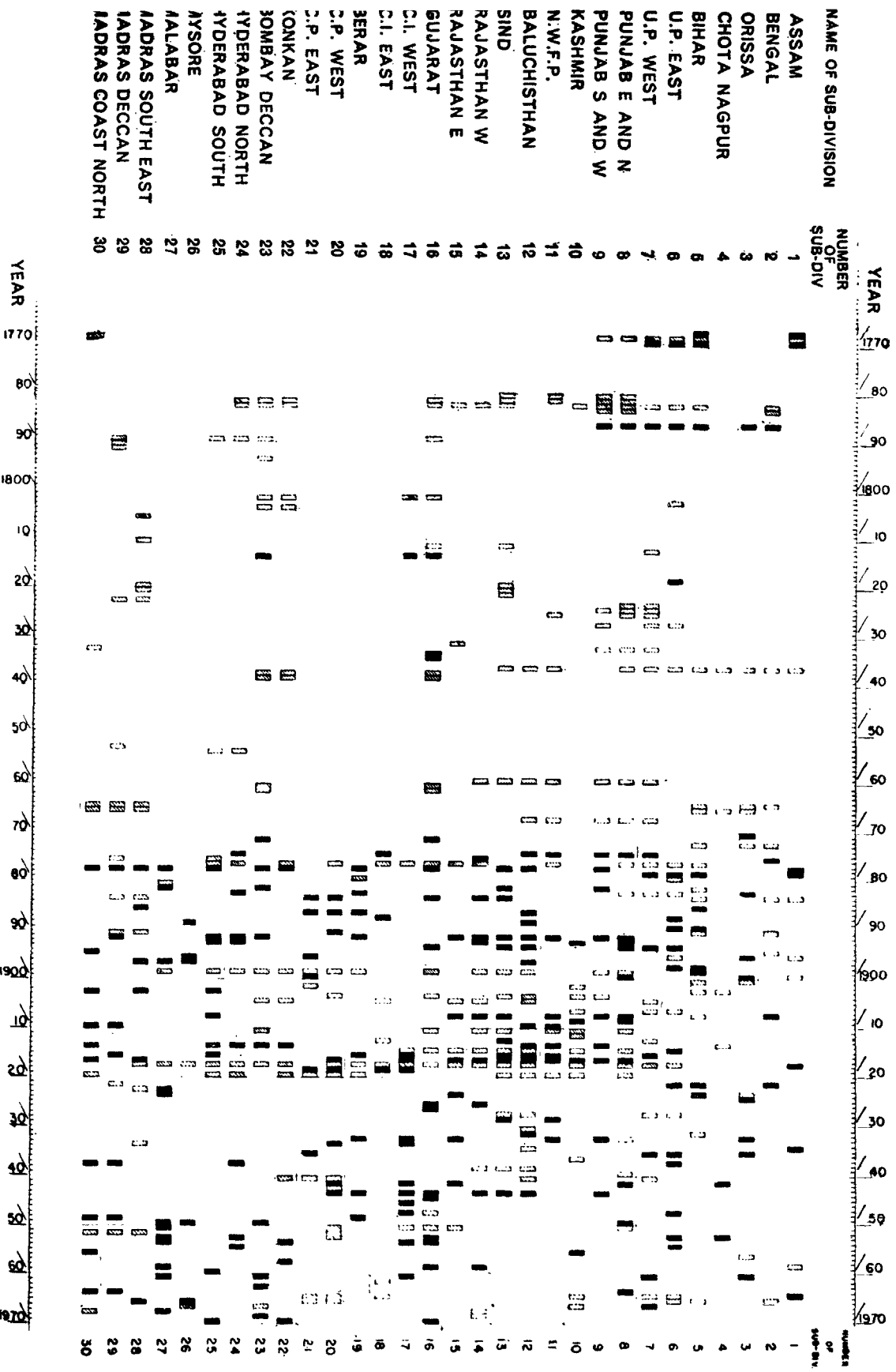


Fig. 2. 'Floods' (solid rectangle) and 'Droughts' (shaded rectangle) in the 30 rainfall sub-divisions of the Indian Subcontinent.

be observed from this extended diagram that during the earlier period 1770 to 1875 the years which had almost countrywide 'Drought' are 1782, 1837 and 1860. The years 1770 and 1787 seem to have had 'Flood' conditions in north India. Some of the other years appear to have had only localised spells of 'Drought' or 'Flood'. In the period 1950 to 1970, when we have fully recorded data on the same basis as during 1875 to 1950 (*vide* Fig. 1), there have been no country-wide abnormalities except partially in some of the sub-divisions in north and central India in the years 1965-1966. The most striking feature of Fig. 2 as a whole is that the period 1870 to 1920 has been afflicted by a higher frequency of both 'Floods' and 'Droughts' than either the earlier period 1770 to 1870 or the later period 1920 to 1970. *The period of maximum abnormality, viz., 1870 to 1920 appears to be sandwiched between two spells of considerably less abnormality.*

While this may suggest that over the centuries the rainfall abnormalities tend to concentrate, as it were, in certain intervals like 1870 to 1920, it has to be remembered that for the earlier period 1770 to 1870 we may not have succeeded in listing all the abnormalities that may have occurred. There is no doubt, however, that after the last general or countrywide 'Drought' of 1918 and the less extensive 'Droughts' of 1920, the Indian Subcontinent has luckily been spared from such disastrous 'Droughts' or countrywide failures of the Monsoon.

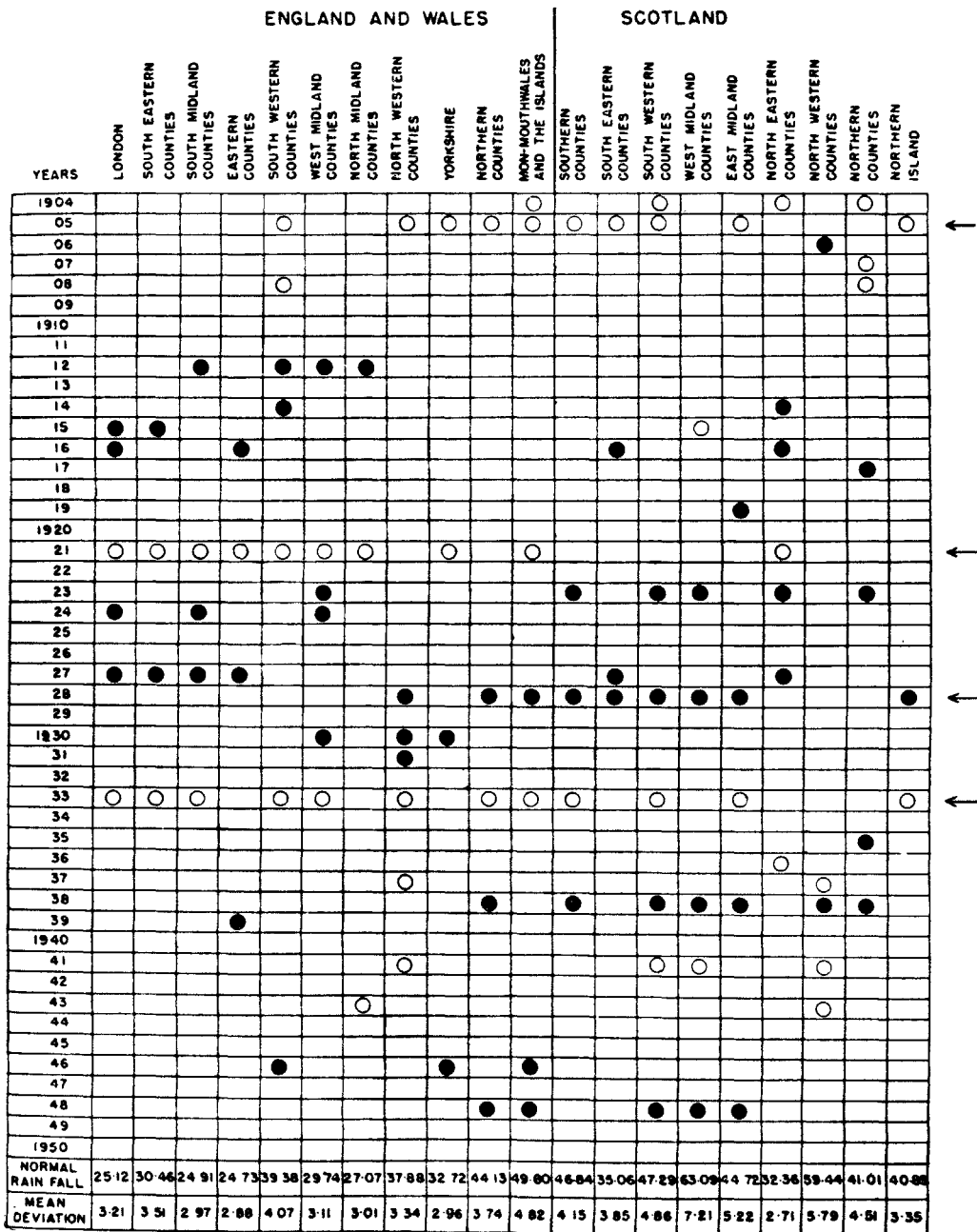
A further confirmation of the occurrences of spells of waxing and waning frequencies of rainfall abnormalities during the earlier centuries for which no recorded data are available may be sought from the behaviour of the annual growth rings of trees with long life whose sections reveal spells of years when the growth rings are more pronounced and further apart from each other when rainfall has been plenty than in spells of 'Drought'. The collection of tree sections with known history from different parts of our country and reading from them the vagaries of past climates is indeed a worthwhile major research project, already known as Dendrochronology. Such a project will need a body of competent meteorologists and botanists to work together for a sufficiently long period at what may be called a "Dendrochronological Institute". Such an endeavour on a worldwide basis may indeed be most rewarding.

DROUGHTS AND FLOODS IN OTHER COUNTRIES OF THE WORLD

India, of course, is not the only country to be afflicted with natural calamities like 'Droughts' and 'Floods'. The present writer has been utilising his occasional leisure in attempting to make a world survey of the frequencies of 'Droughts' and 'Floods' which have occurred in different countries during recent decades for which instrumental meteorological records are available. This study is a time consuming one and will yet take some time to complete. However, diagrams like Fig. 1 have been prepared already for a number of countries, viz., U.K., U.S.A., Canada, Mexico, Brazil, Argentina, S. Africa, Thailand and Australia. Figs. 3, 4 and 5 are typical examples, referring to U.K., U.S.A. and Thailand respectively.

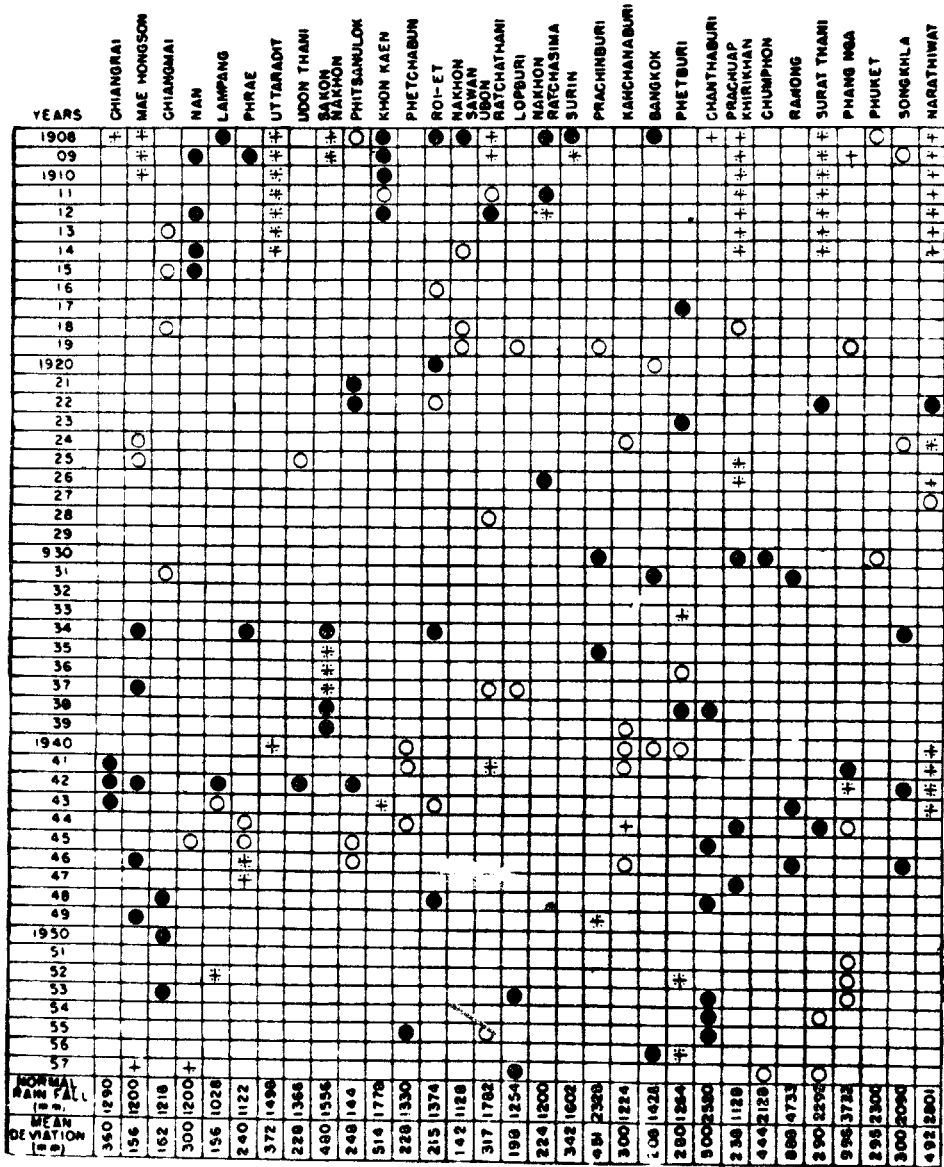
A general examination of the diagrams so far prepared reveals the following features:

- (1) In some countries, if one looks at the incidence of 'Drought' or 'Flood'



Floods ● and Droughts ○ in Britain

FIG. 3.



† DATA NOT AVAILABLE

FLOODS • AND DROUGHTS ○ IN THAILAND

Fig. 5.

in a district or a sub-division over a series of years, the abnormal years are seen to occur more or less at random. In a few years, however, there is a tendency for an abnormality like 'Drought' to occur simultaneously over all the districts or sub-divisions, thus bringing about a large-scale or countrywide disaster. We have already seen from Fig. 1 that India comes under this category (e.g., 1877, 1899, and 1918 were years of countrywide 'Drought' while 1878, 1892 and 1917 had countrywide 'Flood'). Countries that behave like India may be designated as coming under type "I".

(2) On the other hand, in many countries the occurrence of 'Floods' or 'Droughts' in each district or sub-division is at random, but otherwise there is no tendency for a particular calamity, say 'Drought,' to occur simultaneously in all or most sub-divisions. Such rather fortunate countries, where the calamity due to 'Drought' or 'Flood' is never widespread or nationwide, may be designated by the symbol "R".

Table I gives the list of countries so far examined, the period of years considered and the type (whether "I" or "R").

TABLE I

Name of Country	Period of years considered	Type of behaviour "I" or "R"
1. U.K.	1904 — 1950	I
2. U.S.A.	1888 — 1948	I
3. Canada	1890 — 1950	R
4. Mexico	1878 — 1950	R
5. Brazil	1876 — 1950	R
6. Argentina	1876 — 1950	I
7. S. Africa	1878 — 1946	I
8. Thailand	1908 — 1957	R
9. Australia	1885 — 1965	I
10. India	1875 — 1970	I

Thus out of the 10 countries so far examined, in 6 of them there is the tendency for widespread or nation-wide disaster to occur in some years. In countries like India where the rains are concentrated during a part of the year, during the monsoon, such countrywide abnormality causes acute distress. The rest are more fortunate in having only sporadic occurrence of 'Drought' or 'Flood' at random in a few of their districts or sub-divisions.

Let us now examine the worst years in each country as regards the most widespread occurrence of 'Drought' or 'Flood'. Table II gives the year of occurrence and the country affected. From Table II we see that countrywide or widespread Droughts or Floods occur only at random amongst the countries of the world and that there is little likelihood of entire continents or several countries together to be afflicted with a major abnormality like 'Drought' in the same year. It is reassuring, therefore, to note that there will always be large parts of the world which

can rush to the aid of a less fortunate country which is suffering from 'Drought' or 'Flood' in a particular year.

TABLE II
Years of major abnormality over maximum area of the country

Droughts		Floods	
Year of Occurrence	Country affected	Year of Occurrence	Country affected
1877	India	1878	India
1893	Argentina	1891	S. Africa
1897	Australia	1892	India
1899	India	1899	Brazil
1903	S. Africa	1904	Argentina
1904	Brazil	1909	S. Africa
1905	U.K.	1917	India
1914	Argentina	1919	Argentina
1918	India	1925	S. Africa
1921	U.K.	1927	Canada
1927	S. Africa	1928	U.K.
1930	U.S.A.	1945	U.S.A.
1933	U.K.	1955	Australia
1944	Australia	1956	Australia
1965	Australia		

CONCLUDING REMARKS

The present writer hopes to go into fuller detail on a future occasion when the task of the world survey of 'Flood' and 'Drought' is satisfactorily completed.

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