

Rainfall and Agriculture: Use of Routine Rainfall Reports for Crop Outlooks.

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ABSTRACT. The article gives a brief, popular and illustrated account of some of the main features of India's rainfall. The vagaries of the last 75 monsoons, in the 30 rainfall sub-divisions of India, their liability to FLOODS and DROUGHTS, are shown in a diagram. A simple method of presenting the progress of rainfall week by week in all the 30 sub-divisions, in a single chart for each year is next described. These diagrams show up the abnormalities of rainfall both weekly and seasonal in a striking manner. These are again presented sub-division-wise (each diagram showing the rainfall week by week for 40 years at a glance). Three interesting cases, *viz.* Gujarat, Central Provinces, West and Malabar are discussed with the aid of such diagrams. They show the variations in the seasonal distribution of rainfall in a series of years and to the frequency and duration of spells of FLOODS and DROUGHTS, in these areas. Finally, the use of the week by week rainfall charts for preparing All India Tentative Crop-Outlooks is also described.

1. Introduction.

The present writer reviewed in a recent article¹ the rainfall dependability of India, in connection with the following problem raised by Sir Frank Engledow, Draper Professor of Agriculture, Cambridge,—

“Plant breeders and others still go on trying to find varieties of crops and farming systems which will always give at any rate a reasonable result, but more and more I fear they are attempting the impossible and that the time has come to review the meteorological history and see what lessons must be accepted from it about future agricultural possibilities”.

Similarly, irrigation engineers in India often ask what are the possible variations in the rainfall over the catchments of the river basins, over a long series of years. Questions relating to rainfall trends and periodicities, etc. were asked recently by forest officials in Bihar.

The Ministry of Agriculture of the Government of India wants to have periodical All-

India Crop outlooks based on the rainfall distribution up to date during the current season; for, the “Food Problem” has become the most vital problem of the day.

These and many other similar questions demand prompt and ready attention. As such, the routine reports which are readily available must be pressed into service to provide the answers that the administrator, the engineer or the agricultural official needs so urgently.

The present note just gives a brief and popular account of some of the ways in which the routine rainfall records, both current and past, may be presented in a sufficiently condensed and pictorial manner so that one may see at a glance the essential major features without getting lost in minor detail.

2. How the S. W. Monsoon has behaved in India during the last 75 years: Frequency of FLOODS and DROUGHTS.*

As is well known, the success of Indian Agriculture depends mainly on the monsoon rains. For long term planning of agriculture, it will

*N.B. The terms FLOOD and DROUGHT are used in a special sense in this paper, having reference to variation of rainfall only.

(1) In Section 2 where the total monsoon rainfall is discussed,

FLOOD denotes an occasion when the actual monsoon rainfall exceeded the normal by more than twice the mean deviation.

DROUGHT denotes an occasion when actual

monsoon rainfall was deficient by more than twice the mean deviation.

(2) In Sections 3 and 4 where the rainfall week by week is discussed,

FLOOD denotes an occasion when the actual rainfall of the week was twice the normal or more.

DROUGHT denotes an occasion when the actual rainfall of the week was half the normal or less.

be of interest to know the history of the past 75 monsoons for which data are available, how many were beneficial, how many were total or partial failures, etc. For this purpose it will be sufficient to consider the total rainfall during the period June to September. If the deviation of the actual rainfall in a year in a sub-division (Fig. 1 shows the 30 sub-divisions of India) is

more than twice the mean deviation, that year may be defined as a year of FLOOD or DROUGHT according as the departure is positive or negative. Fig. 2 shows at a glance how the monsoon has behaved in the past 75 years in each of the 30 rainfall sub-divisions of India. In the figure the filled circle indicates a flood, the open circle a drought, and the blank

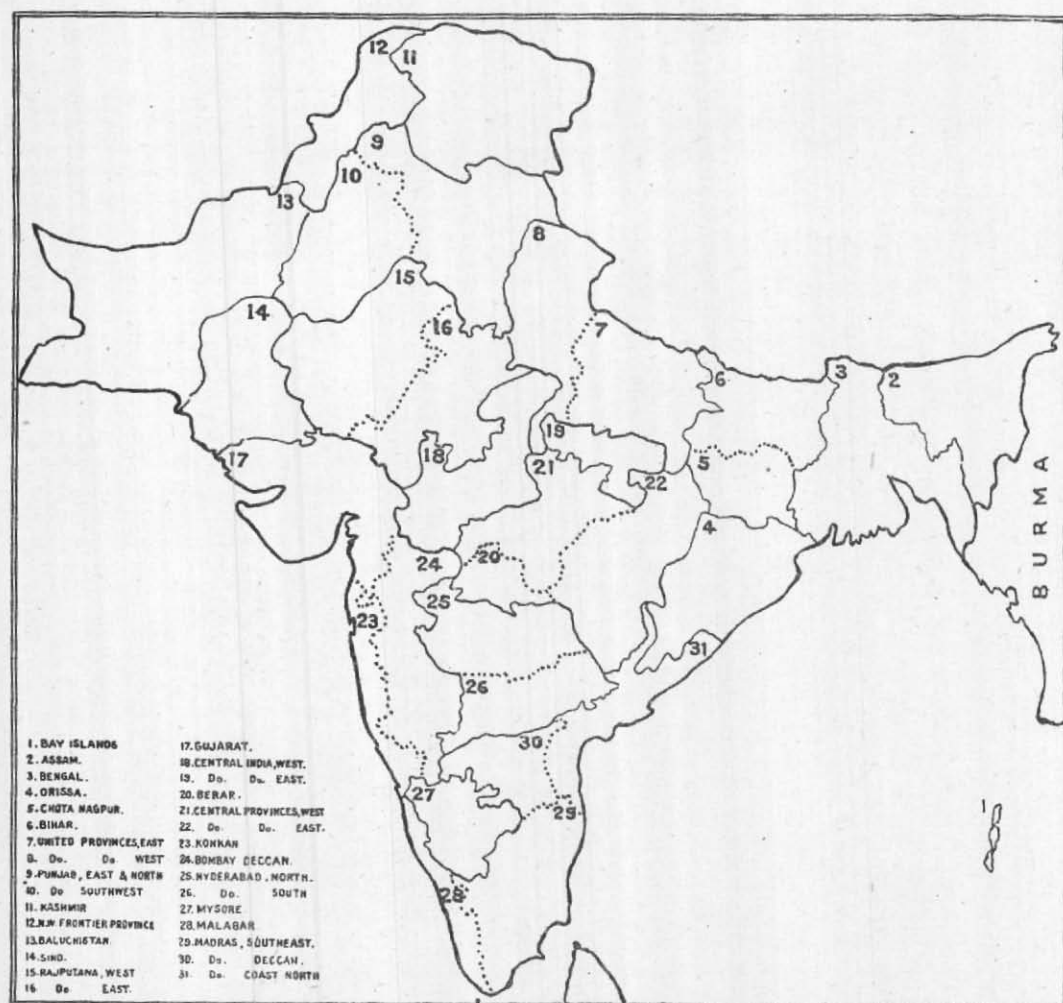


Fig. 1.

MAP OF INDIA SHOWING THE RAINFALL SUBDIVISIONS.

spaces are years and sub-divisions with more or less normal monsoon rainfall. At the bottom of the diagram are given for each sub-division,

- (a) the normal monsoon rainfall,
- (b) the mean deviation,
- (c) the limit for abnormality,
- (d) the total number of FLOODS during the period 1875-1949,
- (e) the total number of DROUGHTS during the period 1875-1949 and
- (f) the total number of abnormal years (*i.e.* floods plus droughts) during the same period.

This figure shows up all the major abnormalities at a glance. Generally speaking, when a large number of years is considered, the number of Floods and Droughts tends to equalise. It is the areas with very low rainfall (*e.g.* Baluchistan, Sind, Rajputana, etc.) which experience the greatest number of abnormalities; on the other hand, in areas like the Konkan, Malabar, Bengal, etc., where the monsoon rainfall is above 40", the number of abnormalities comes down very much.

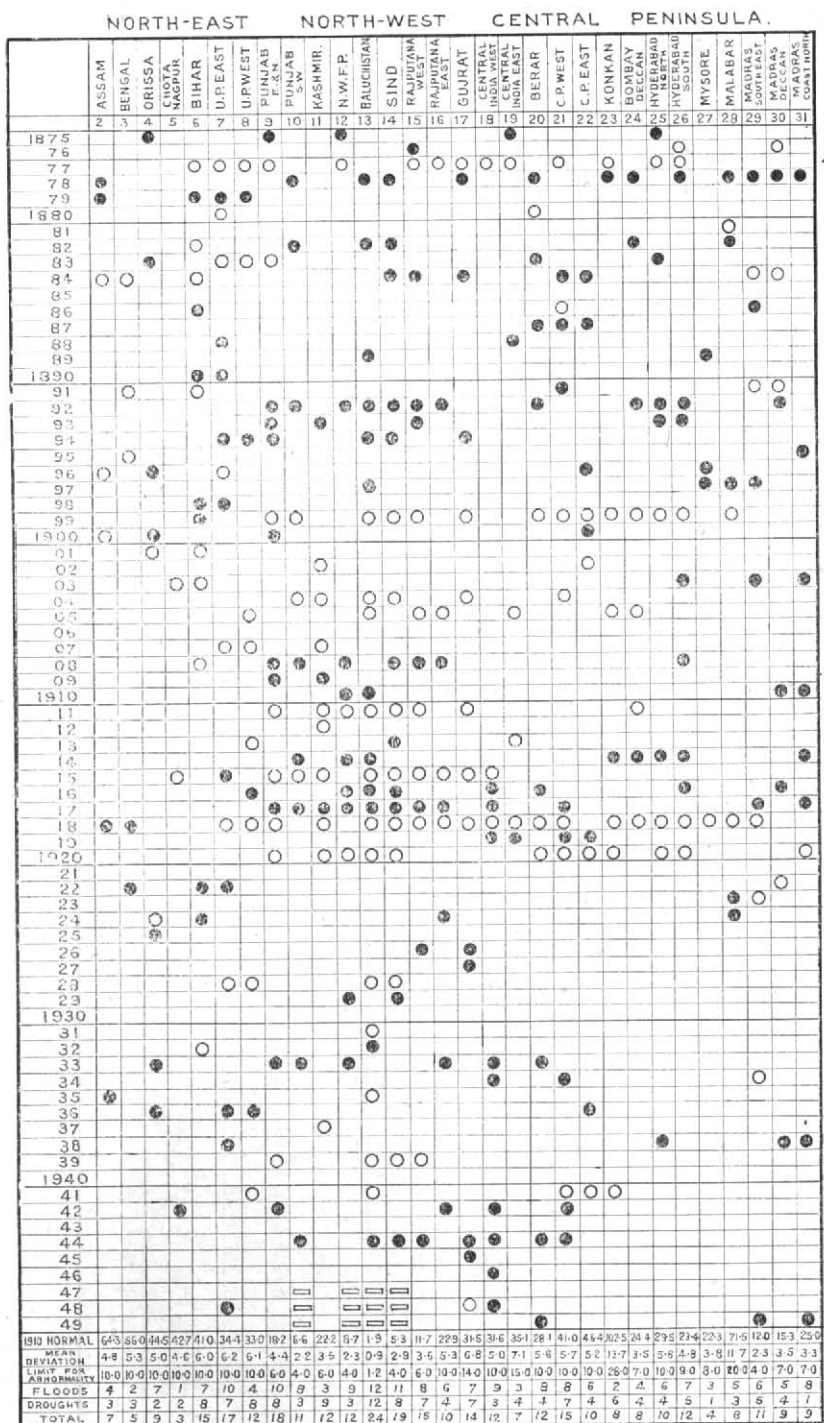
Considering the experience during each of the years 1875 to 1949 the years 1877, 1899 and 1918 stand out most prominently as years of general Drought. It will be recalled that these were actually years of great famine and distress. The year 1920 was one of partial Drought, only the North-West and the 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) Floods and Droughts occurred in adjacent years. There is no regularity in time in the distribution of Floods and Droughts. The chances of one Drought being succeeded by another or a Flood year being succeeded by another in any particular sub-division appear to be small. Areas of Drought and Flood, often tend to be associated with centres of defective or excessive rainfall in the years in which they do occur. Much useful information about the weather-risk due to incidence of Floods and Droughts in different parts of India can be obtained from Fig. 2. Such Diagrams are being prepared in respect of the *districts* of each rainfall sub-division in India. These when ready will be of very great interest to the local administrations, agricultural and irrigation officers, etc., while planning their long-term developments.

3. Rainfall of India week by week for each year.

We may now turn to the problem of rainfall "distribution" week by week. For this purpose we use the rainfall data published regularly in the weekly weather reports of the India Meteorological Department. The method of presenting the actual and the normal weekly rainfall week by week for all the 30 sub-divisions of India in a single chart is illustrated by Fig. 3 which refers to the year 1946-47. Against each sub-division for each week two entries are made. The upper figure gives the 'actual' while the lower one gives the 'normal' weekly rainfall. For marking out the abnormalities, weeks with the actual rainfall equal to or less than *half the normal* have been defined as Droughts; weeks with the actual rainfall equal to or more than *twice the normal* have been defined as Floods. The incidence of Droughts and Floods as defined above is shown in Fig. 3 by under-lining the rainfall figures with *blank and black* bars respectively. The normal weeks when the rainfall was within the above limits (*i.e.*, more than half and less than twice the normal) are shown by hatched bars. The areas in the diagram where the normal weekly rainfall is less than 0.2" have been demarcated by continuous thin lines. These represent the dry season when Drought is the rule and only Floods, if any, need be indicated.

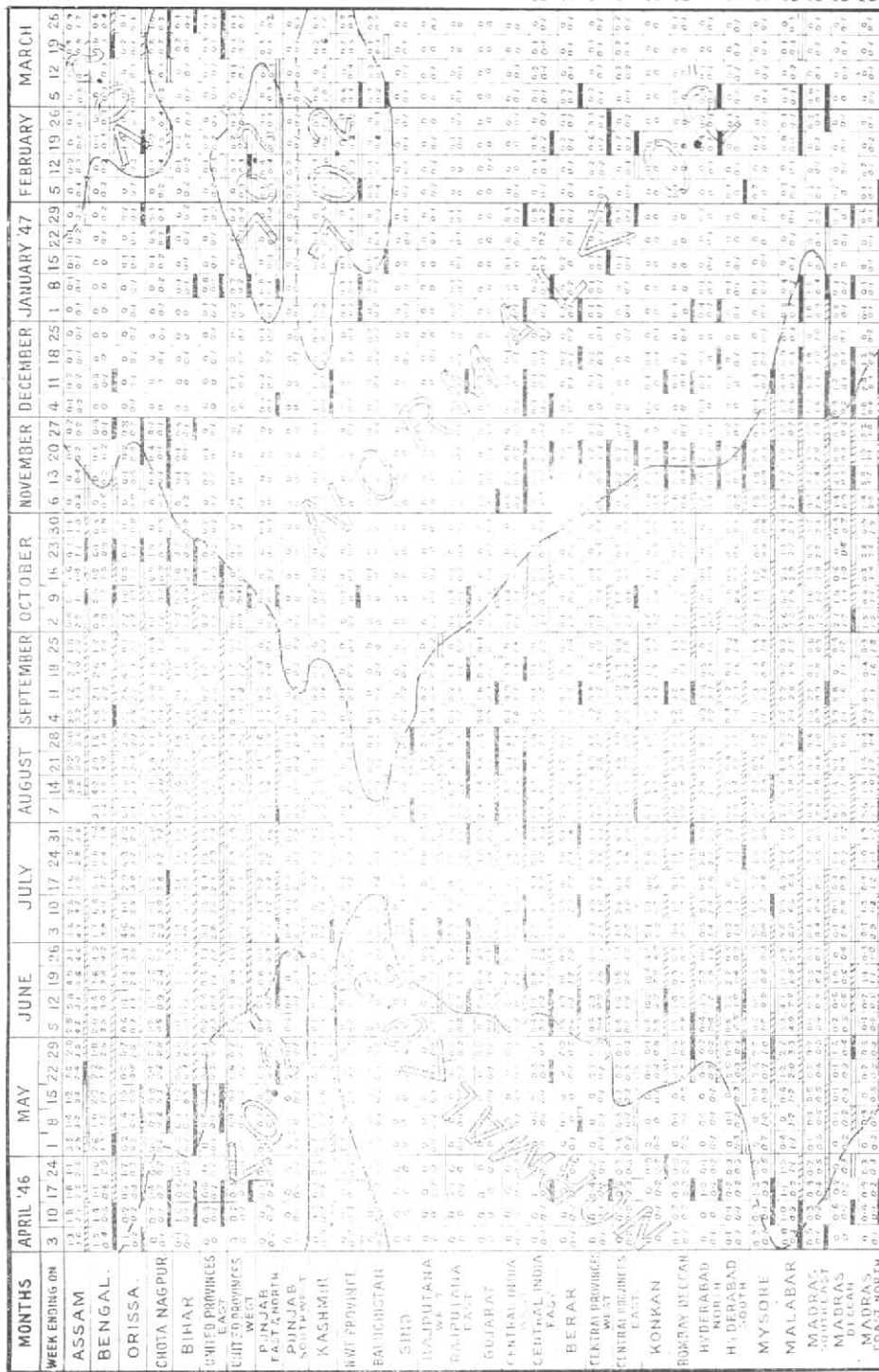
The ideal year will be one in which there are no Droughts or Floods. Successful crop production depends not only on the total seasonal rainfall, but also on the proper distribution of the rainfall in time and space. Even a sub-normal rainfall may, if well distributed, produce a good yield. The incidence of some spells of Drought and of Flood is expected in most years. In many years only short spells of Drought and Flood alternate without materially affecting the total rainfall of the season. Once in about 5, 10 or 20 years, however, depending on the area concerned, the Drought or Flood extends over a number of consecutive weeks; such prolonged spells, particularly at the critical stages of crops cause widespread damage.

Looking at Fig. 3 it will be seen that on the whole, the year 1946-47 has not been quite favourable. The number of abnormal spells *i.e.* Floods and Droughts, indicates that the distribution of the monsoon rainfall was far from ideal although there was no prolonged spell of Flood or Drought over any large part of the country. But an out-



FLOODS ● AND DROUGHTS ○ IN INDIA.
 THE FAMINE YEARS OF 1877, 1899 AND 1918 ARE CONSPICUOUS.
 DATA NOT AVAILABLE.

FIG. 2.



A - Actual Rainfall. N - Normal Rainfall.

RAINFALL OF INDIA WEEK BY WEEK - 1946-47.

FIG. 3.

standing feature of this year was the unseasonable rain during winter (November 1946 to February 1947) in the Central parts of the country. In these parts consisting of Central India, the Central Provinces and Berar, Bombay and Hyderabad, there was absence of the seasonal cold weather during the winter and the incidence of wet and cloudy weather, as will be seen from the large number of floods. This comparatively warm and cloudy wet weather provided conditions most favourable for the incidence of "rust" disease of wheat.

Charts like Fig. 3 have been prepared for a series of 40 years (1908-1948). These charts reveal that the method of presentation of the weekly rainfall data brings out satisfactorily all the major abnormalities which are likely to affect agricultural or other activities adversely. A further discussion of these charts is being made in a forthcoming paper by Mr. T. S. Govindaswamy, but three typical diagrams are given in Fig. 4(a), 4(b) and 4(c). For the sake of simplicity, the values of actual and normal rainfall are omitted and only the bars showing the abnormalities are reproduced. In these diagrams the Floods are indicated by the *black* bars, Droughts by the *blank* bars and normal weeks by the *light hatched* bars.

Fig. 4(a) gives the weekly distribution of rainfall during the famine year 1918-19, when the South-West monsoon commenced a month too early and practically faded out early in July. The presence of many long *blank* bars with very few *black* bars during the monsoon season brings this out in a very striking manner.

Fig. 4(b) refers to 1944-45, a more or less normal year, while Fig. 4(c) shows the rainfall abnormalities during 1946-47, already referred to in detail in Fig. 3. This type of distribution with unseasonable rainfall during the clear season occurs once in 4 or 5 years in parts of the country, leading to the incidence of insect pests and plant diseases in the affected areas.

4. Diagrams showing abnormalities of rainfall week by week, in each rainfall sub division for all the years 1908-1948.

In the previous section reference was made to a series of 40 charts for the years 1908-48, which have been prepared. A chart of this type (*vide* Figs. 3 and 4) gives information for all the weeks and all the sub-divisions for a single year. When we wish to see at a glance the rainfall abnormalities of a particular sub-division for all the 40 years, the information

available in the above 40 charts, can be presented in the manner shown in Fig. 5.

In Fig. 5(a), 5(b) and 5(c) the information for 40 years is presented in respect of three typical areas, *viz* (a) Gujarat, (b) the Central Provinces (West) and (c) Malabar. The rainfall abnormalities are indicated in these figures exactly as in Fig. 4.

Fig. 5(a) shows how liable Gujarat is to long spells of abnormality in rainfall. Years in which abnormally long spells of Flood had occurred for 3 week spells more than twice in the same season or for 4 week spells continuously are 1917, 1926 and 1932. Coming to Droughts, there have been many years in which Droughts had continued for 7 weeks or more—such are 1910, 1911, 1915, 1918, 1925, 1941 and 1948 (once in five years on an average).

Fig. 5 (b). shows similar information for Central Provinces, (West). As compared to Gujarat, this sub-division has a wet season of 23 weeks and climatically is a more dependable area. Although Droughts of more than 5 weeks' duration have occurred 9 times in 40 years, spells of Drought exceeding 6 weeks in duration have occurred only twice (1912 and 1939) in the same period. Floods lasting for 4 weeks continuously have also occurred only in 3 years *viz*. 1917, 1931 and 1936. Long spells of 'normal' rainfall are more frequent in this area.

Fig. 5 (c) refers to Malabar. Here the wet season extends from April to December and includes both the South-West monsoon as well as the significant part of the North-East monsoon. The wet season so defined consists of 39 weeks as compared to the 17 weeks in the case of Gujarat. We may, therefore, be led to expect a larger proportion of abnormal spells. This, however, is far from being the case. The occurrence of a large number of prolonged spells of normal weather is even more pronounced than in the case of the Central Provinces (West). Flood spells lasting 4 weeks continuously have occurred in 1911, 1919 and 1931 only and once only in 1944 for 5 weeks continuously.

Similarly, Droughts lasting for 5 weeks continuously have occurred in 1908, 1918, 1921, 1926, 1939 and 1945 (6 occasions), for 6 weeks twice only in 1917 and 1923 and for 7 weeks once only in 1947. Most of these prolonged Droughts (except that in 1918)

have occurred only during the North-East monsoon. We can well imagine how dependable this area is for agricultural purposes, so far as surety of well distributed and sufficient rainfall is concerned.

5. *All-India Tentative Crop Out-looks based on the rain-fall sequence week by week.*

We may now consider the problem² of utilising the rainfall charts week by week up to date (as in Fig.3) during a current year for the purpose of assessing the crop out-look from a very general All-India point of view. In view of the highest priority that the *food problem* has assumed of late, the importance of making reliable estimates of "Crop out-look" over the country week by week and month by month for guiding the agricultural and food-distribution policies of Government can hardly be over emphasised.

The weekly crop reports prepared and telegraphed to the Central Government by the various Indian States have recently been considerably improved in point of detail, but they are still based on district reports which in turn depend on the subjective or mental impressions of the revenue and district officials concerned. These telegrams are also being received by the Director of Agricultural Meteorology at Poona.

Can a reasonable and comparatively more "objective" picture of the crop-outlook be based on the progress of the weather week by week during the growing season so as to serve as an objective check on the crop outlook telegrams of the States?

We may briefly indicate here how dependent crops are on the weather during the growing season. Once the crops are sown and till the produce is harvested and stored they are entirely at the mercy of the weather, particularly so during certain critical periods. Immediately after sowing, when the seeds begin to germinate, heavy rainfall is known to affect adversely the percentage of germination, a case of infantile mortality as it were. On the other hand, if a prolonged Drought sets in immediately after germination, the tender seedlings wither away. During the vegetative phase, the crop needs alternating spells of wet and clear weather. Heavy rainfall or high winds can lay a promising crop low, particularly during the later stages of growth. Another

critical phase is the flowering period. If the weather is clear during this period, there is good seed-setting and chances of good out-turn. On the other hand, cloudy and unfavourable weather, during this period can seriously reduce the yield. Again, at harvest time, the farmer is always anxious to reap his harvest before any untimely rains set in. Even at the threshing floor the harvested produce is liable to serious damage if exposed to rainfall. Besides the many direct effects of weather on crop-growth, there are many indirect effects caused by the influence of weather on the incidence and intensity of diseases and pests. It will be clear, therefore, that certain optimum weather conditions are essential for ensuring crop productions.

About two years ago the Director of Agricultural Meteorology at Poona began getting the weekly crop-reports telegraphed by the Indian States, as kindly arranged by the Economic and Statistical Adviser of the Ministry of Agriculture, Government of India. The information supplied in these weekly telegrams from all the Indian States was charted on a single chart so that the progress of crops in India week by week could be seen at a glance. Fig. 6 shows the simple scheme according to which the wealth of detail given in these reports may be condensed conveniently on the crop chart. Fig 7 shows a section of the crop chart so prepared for the year 1946-47.

The crop chart is studied with the corresponding rainfall chart (Fig.3) as well as similar temperature and humidity charts. Monthly tentative All-India crop outlooks based on such a study are being prepared and supplied to the Ministry of Agriculture, Government of India, for more than a year now. The above Ministry has asked that these outlooks should be continued as a permanent measure.

6. *Concluding remarks.*

It may be pointed out in conclusion that week by week weather and crop charts like those described above will be of immense value to meteorological forecasters in the issue of Farmers' Weather Bulletins with a knowledge of the actual state of crops in their area during a current season; but for this purpose the charts should be region-wise and should refer to the districts of each region instead of the comparatively large tracts constituting the

RAINFALL OF INDIA WEEK BY WEEK.
1918-1919

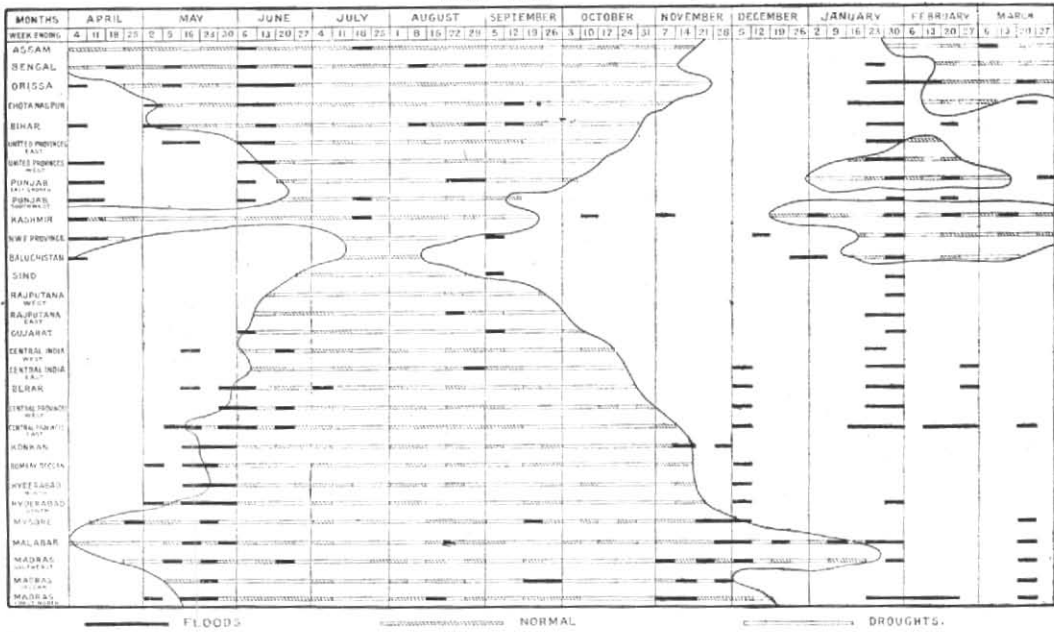


FIG. 4 (a).

RAINFALL OF INDIA WEEK BY WEEK.
1944-1945

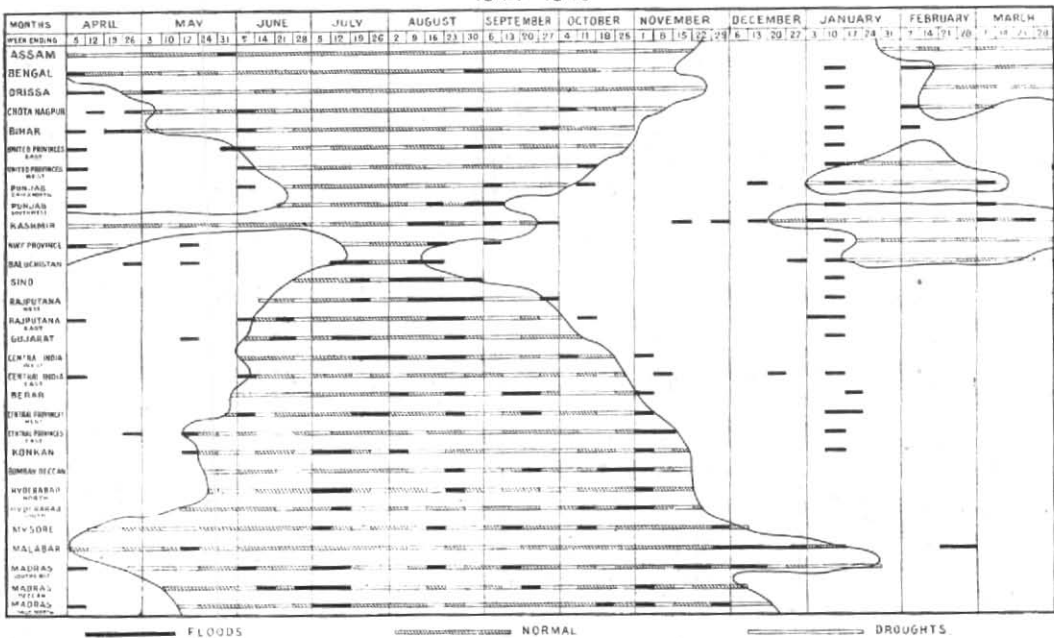


FIG. 4 (b)

RAINFALL OF INDIA WEEK BY WEEK
1946-1947

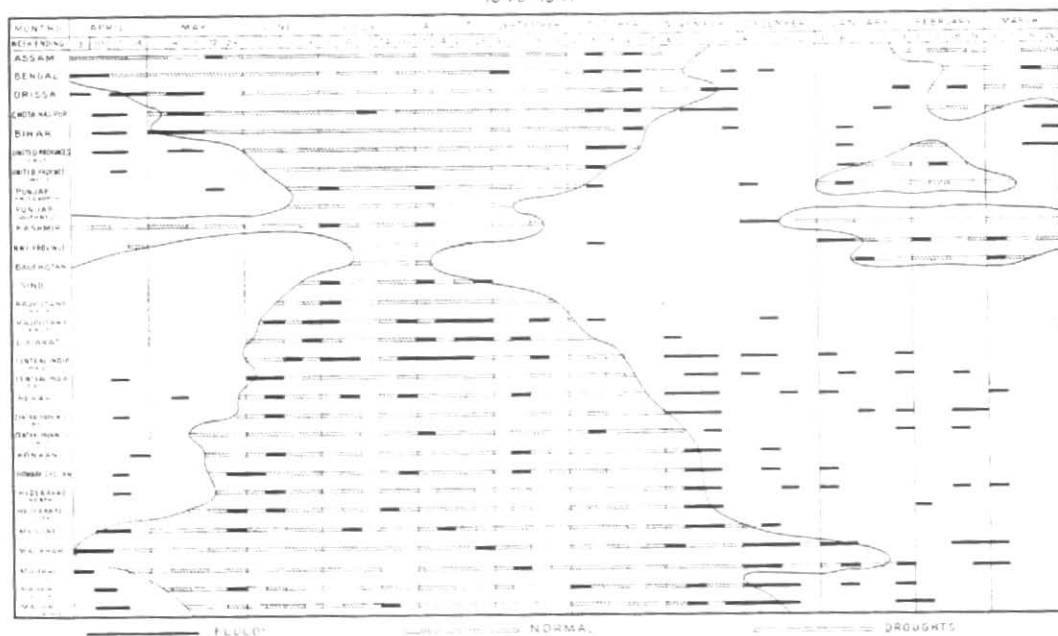


FIG 4(c)

RAINFALL OF GUJARAT WEEK BY WEEK.

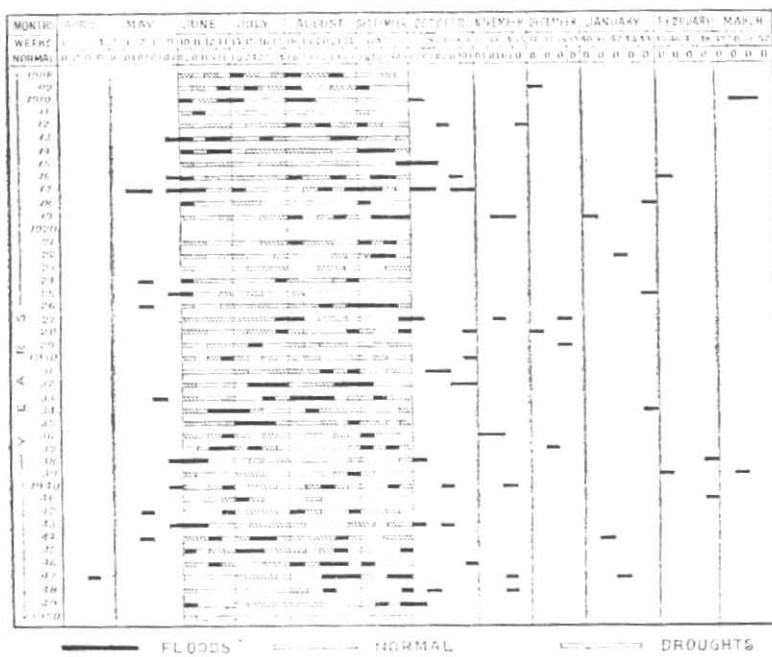


FIG 5(a)

RAINFALL OF CENTRAL PROVINCES (WEST) WEEK BY WEEK.

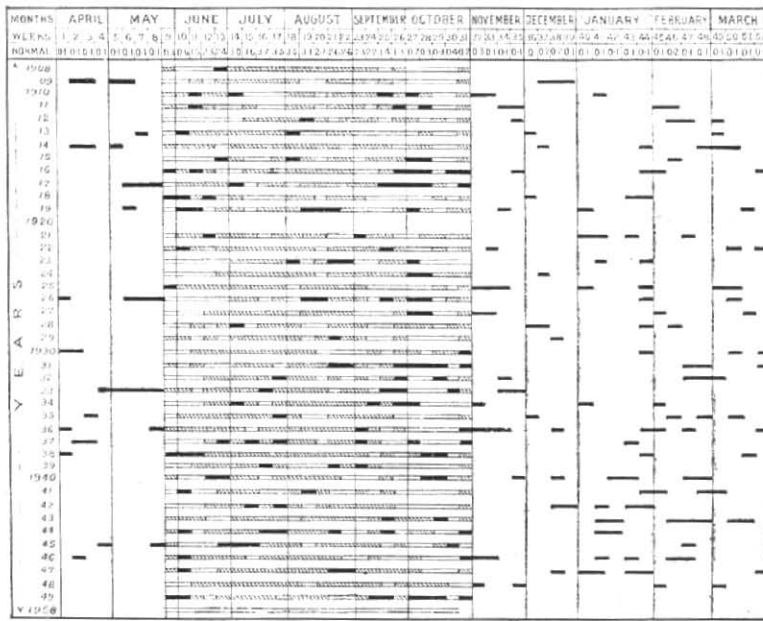


FIG 5 (b).

RAINFALL OF MALABAR WEEK BY WEEK.

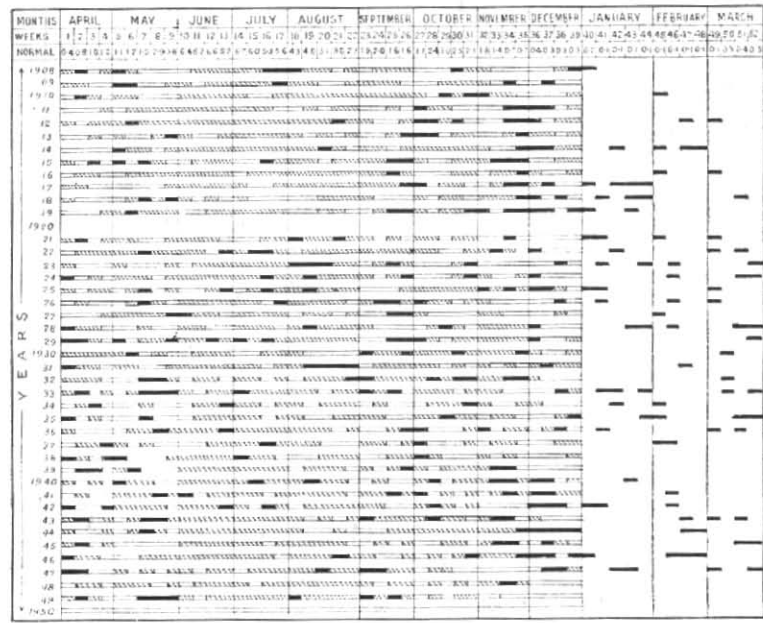


FIG 5 (c).

MONTHS	NOVEMBER 1946																													
DATES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
ASSAM.	St ₂ except in flooded areas in Nalgong										St ₂					St ₂					St ₂									
BENGAL.	000p Rabi Aman St ₂					000 Aman Rabi St ₂					r in few districts Aman Rabi St ₂					r in some districts Aman Rabi St ₂					000 Am. Cultivate Rabi									
ORISSA.	000p Rabi Aman St ₂					000p Paddy Aman Paddy St ₂					000p Winter paddy Aman Paddy St ₂					000 Paddy Pulses St ₂					000 Paddy Pulses S									
CHOTA NAGPUR.	M St ₂					M Rabi St ₂					M Aman Rabi St ₂					M Aman Rabi St ₂					M Aman Rabi St ₂									
BIHAR.	M St ₂					M Rabi St ₂					M Aman Rabi St ₂					M Aman Rabi St ₂					M Aman Rabi St ₂									
UNITED PROVINCES EAST.	000 Rabi Aman St ₂					000 Rabi Aman St ₂					000 Rabi Aman St ₂					000 Rabi Aman St ₂					000 Rabi Aman St ₂									
UNITED PROVINCES WEST.	000 Rabi Aman St ₂					000 Rabi Aman St ₂					000 Rabi Aman St ₂					000 Rabi Aman St ₂					000 Rabi Aman St ₂									
PUNJAB EAST & NORTH.	r St ₂					r St ₂					r St ₂					r St ₂					r St ₂									
PUNJAB SOUTH-WEST.	r St ₂					r St ₂					r St ₂					r St ₂					r St ₂									
KASHMIR.																														
N.W.F. PROVINCE.																														
BALUCHISTAN.																														
SIND.	r Aman Rabi Aman St ₂					r Aman Rabi Aman St ₂					r Aman Rabi Aman St ₂					r Aman Rabi Aman St ₂					r Aman Rabi Aman St ₂									
RAJPUTANA WEST.																														
RAJPUTANA EAST.																														
GUJARAT.																														
CENTRAL INDIA WEST.																														
CENTRAL INDIA EAST.																														
BERAR.	000 Paddy Aman Rabi					Damage to Rabi & standing kh crops.					Rabi affected by rain					000, Juar St ₂														
CENTRAL PROVINCES WEST.	000 Paddy Aman Rabi					Damage to Rabi & standing kh crops					Standing crops Aman cotton harvested & damaged by rain					000, Juar Paddy cotton Y Rabi St ₂														
CENTRAL PROVINCES EAST.	000 Paddy Aman Rabi					000 Cotton Aman Rabi					Standing crops Aman cotton & harvested kh affected by rain					Y Rabi St ₂														
KONKAN.																														
BOMBAY DECCAN.																														
HYDERABAD NORTH.	000 Paddy Aman Rabi					000 Aman Rabi Aman St ₂					000 Aman Rabi Aman St ₂					000 Aman Rabi Aman St ₂					000 Aman Rabi Aman St ₂									
HYDERABAD SOUTH.	000 Paddy Aman Rabi					000 Aman Rabi Aman St ₂					000 Aman Rabi Aman St ₂					000 Aman Rabi Aman St ₂					000 Aman Rabi Aman St ₂									
MYSORE.																														
MALABAR.	000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂									
MADRAS SOUTH-EAST.	000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂									
MADRAS DECCAN.	000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂									
MADRAS COAST-NORTH.	000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂					000, T Paddy RR Aman St ₂									

Fig. 7.

SECTION OF THE CROP CHART WEEK BY WEEK 1946 - 1947.

CULTURAL AND CROP PHENOLOGICAL

EVENTS	SYMBOLS
1. PREPARATORY TILLAGE (Ploughing, Harrowing, Manuring, Planking, etc.)	〰〰〰
2. SOWING (Broadcasting, drilling, etc.)	〇〇〇
3. GERMINATION	Y
4. GROWTH (Vegetative phase)	Y
5. INTERCULTURE (Weeding, stirring up soil, earthing up, etc.)	xxx
6. TRANSPLANTING	T
7. IRRIGATION	I
8. FLOWERING	Y
9. GRAIN OR EAR FORMATION	Y
10. HARVEST	...
N.B.- (i) WILTING OF PLANTS TO BE SHOWN AS ACCORDING TO THE STAGE OF THE CROP	
(ii) LODGING TO BE SHOWN AS	Y Y Y
(iii) FLOODING TO BE SHOWN AS	Y Y Y
(iv) PESTS AND DISEASES TO BE MENTIONED VERBALLY.	
(v) STANDING CROPS	Poor, failure, etc. St ₁ Normal, good, etc. St ₂ Excellent St ₃

EACH RAINFALL DIVISION TO BE DIVIDED INTO FOUR QUADRANTS, VIZ, N.W., N.E., S.E., & S.W.



IF A PARTICULAR OPERATION OR PHENOMENON IS TAKING PLACE IN ALL QUADRANTS, THE WORD "ALL" SHOULD BE PLACED ABOVE THE SYMBOL. IF IT IS TAKING PLACE ONLY IN A PARTICULAR QUADRANT OR QUADRANTS, THEN S.W. OR N.E., ETC. SHOULD BE PLACED ABOVE THE SYMBOL. IF IN A QUADRANT THE EVENT OR PHENOMENON IS TAKING PLACE ONLY PARTIALLY, THE LETTER 'p' SHOULD BE ADDED AS A SUFFIX, e.g. S.W. (p).

RAINFALL.

r ₀	...	...	No rain.
r	...	...	(VERY LIGHT RAIN) MORE RAIN NEEDED. (LIGHT RAIN) INADEQUATE.
R	...	...	NORMAL RAIN. GOOD RAIN, SEASONABLE RAIN.
RR	...	...	HEAVY RAIN. EXCESSIVE, ETC.
r _{0D}	...	...	NO RAIN, DROUGHT CONTINUES.
r _N	...	...	RAIN NEEDED IN NORTHERN TRACTS, AND SO ON.
r _p	...	...	RAIN NEEDED IN PARTS.

Fig. 6. SYMBOLS USED FOR CROP-CHART WEEK BY WEEK.

rainfall sub-divisions. The maintenance of such charts will, however, involve extra work.

The present writer wishes to convey his grateful thanks to Mr. T. S. Govindaswamy for efficient assistance in the preparation of this paper. A very detailed discussion of rainfall variability in India will be

presented in separate papers by Messrs. T.S. Govindaswamy and P. V. Pimpalwadkar.

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1. Ramdas, L.A., *Empire Journal of Experimental Agriculture* (1946).
2. Ramdas, L. A. and Mallik, A. K., *Agricultural Situation in India* (1948).

“To be sure, when the number of factors coming into play in a phenomenological complex is too large, scientific method in most cases fails us. One need only think of weather, in which case prediction even for a few days ahead is impossible. Nevertheless, no one doubts that we are confronted with a causal connexion the causal components of which are in the main known to us. Occurrences in this domain are beyond the reach of exact prediction because of the variety of factors in operation, not because of any lack of order in Nature.”

—Einstein.
