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Incidence of droughts in Andhra Pradesh, Tamil Nadu and Mysore

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ABSTRACT. Drought spells in Andhra Pradesh, Tamil Nadu and Mysore during the last 60-65 years are studied by computing the monthly Palmer index values. For computing this index, a detailed hydrologic accounting of the area is carried out for a large number of years using data of rainfall, potential evapotranspiration and water-holding capacity of the soil. Several parameters are obtained from this accounting and these are used to compute the 'CAFEC' (Climatically Appropriate For Existing Conditions) precipitation of each month of the period. Anomaly of actual rainfall with respect to this 'CAFEC' precipitation is obtained for each month and this is used to compute Palmer index of the month.

Several drought spells occurred in these areas during the period studied. The longest drought spell experienced in each area was : (*i*) Interior Mysore North—70 months (August 1922 to May 1928), (*ii*) Coastal Andhra Pradesh—57 months (July 1904 to March 1909), (*iii*) Tamil Nadu—41 months (November 1949 to March 1953), (*iv*) Rayalaseema 36 months (March 1941 to February 1944), (*v*) Telangana—35 months (May 1911 to March 1914 and July 1918 to May 1921) and (*vi*) Interior Mysore South—27 months (December 1948 to February 1951).

1. Introduction

According to the American Meteorological Society (1959), drought is a prolonged and abnormal moisture deficiency. To the agriculturist it is lack of moisture in the root zone of crops, to the hydrologist it is below-average water-level in streams, lakes and reservoirs and to the economist it is water shortage which adversely affects the economy of the community. It is, therefore, difficult to define drought precisely. In many studies on drought, rainfall is used as the sole parameter. Although rainfall plays the most important role, there are other factors also which come into play in drought incidence. Potential evapotranspiration and water-holding capacity of the soil are some of these factors. For a realistic approach for the study of droughts, all these factors must be adequately accounted for. Such a technique has been developed by Palmer (1965) in the United States, based on the hydrologic accounting procedure. In this technique, moisture supply, moisture demand, current and antecedent weather and climate of the place are taken into account for obtaining a drought index. This approach has been followed in the study of droughts in Andhra Pradesh, Tamil Nadu and Mysore State during the last 60-65 years and the results are presented here. The areas are shown in Fig. 1.

2. Palmer's Technique

In Palmer's technique rainfall anomaly is the starting point. Instead of using the long-term mean rainfall ($\overline{P}$) for finding the anomaly, Palmer uses CAFEC (Climatically Appropriate For Existing Conditions) precipitation for obtaining the anomaly. This is an imaginary amount of precipitation that will maintain at normal level all the established human activities of a place. CAFEC precipitation ($\widehat{P}$) on the same analogy as that of natural precipitation is equal to CAFEC evapotranspiration ($\widehat{ET}$) *plus* CAFEC soil moisture recharge ($\widehat{R}$) *plus* CAFEC runoff ($\widehat{RO}$) *minus* CAFEC soil moisture loss ($\widehat{L}$). The CAFEC parameters indicated by circumflex are—

$$\widehat{ET} = \alpha \times (\mathrm{PE})$$
$$\widehat{R} = \beta \times (\mathrm{PR})$$
$$\widehat{RO} = \gamma \times (\mathrm{PRO})$$
$$\widehat{L} = \delta \times (\mathrm{PL})$$
$$\widehat{P} = \widehat{ET} + \widehat{R} + \widehat{RO} - \widehat{L}$$

where α, β, γ and δ are the climatic coefficients of evapotranspiration, soil moisture recharge, runoff and soil moisture loss respectively. PE, PR, PRO and PL are potential values of evapo-

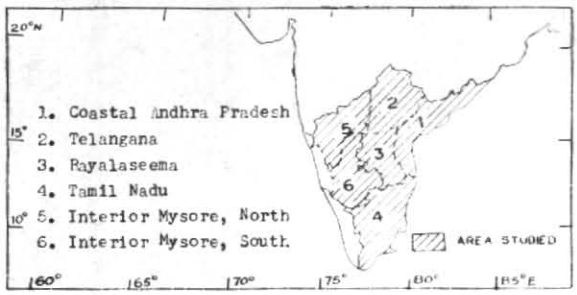

Fig. 1
Map showing areas studied

transpiration, soil moisture recharge, runoff and soil moisture loss, *i.e.*, the value of the parameter under optimum conditions. The climatic coefficients are given by—

$$\alpha = \frac{\overline{ET}}{\overline{PE}} \qquad \beta = \frac{\overline{R}}{\overline{PR}}$$

$$\gamma = \frac{\overline{RO}}{\overline{PRO}} \qquad \delta = \frac{\overline{L}}{\overline{PL}}$$

where, bar denotes long-term mean value.

Parameters ET, R, RO, L are computed from the hydrologic accounting procedure detailed by Palmer. From these are computed the potential values : PR as the amount of moisture required to bring the soil to field capacity, PRO as a function of the soil moisture available and PL as the amount of moisture that could be lost if there was no precipitation. From these the monthly CAFEC precipitation ($\hat{P}$) and the rainfall anomaly ($P-\hat{P}$) are computed. To make this anomaly comparable in space and time, it is multiplied by a weighting factor K which depends on average moisture demand and supply and mean of absolute values of anomaly of the place.

From physical and other considerations, Palmer has shown that intensity of drought in any month (X_i) is related to the weighted anomaly (Z_i) of the month and intensity of drought (X_{i-1}) of the previous month by the relation—

$$X_i = X_{i-1} + Z_i/3 - \cdot 103\ X_{i-1}$$

Or $$X_i = 0{\cdot}897\ X_{i-1} + Z_i/3 \qquad (1)$$

3. Determination of commencement and termination of Drought

Near normal conditions are taken to prevail when value of the index is between $-0{\cdot}5$ and $+0{\cdot}5$. The anomaly Z_e required to end the drought of any month i can be found out from the Eq. (1) by putting $X_i = -0{\cdot}5$.

$$\therefore \quad Z_e = -2{\cdot}691\ X_{i-1} - 1{\cdot}5$$

for ending of drought. Similarly, there is a certain minimum value of anomaly which can occur month after month and still maintain the index value at near normal category ($\cdot 5$ to $-\cdot 5$) and with no change in the value of index, *i.e.*, $X_i - X_{i-1} = 0$. Thus equation,

$$X_i = X_{i-1} + Z/3 - \cdot 103\ X_{i-1} \text{ becomes:}$$
$$0 = Z/3 - \cdot 103\ (-0{\cdot}5)$$
$$Z = -0{\cdot}15$$

The effective anomaly of the month therefore, will be the anomaly of the month *minus* 0·15.

Drought calculations are commenced when after a wet spell, the anomaly Z of a month becomes $\leqslant +0{\cdot}15$ for the first time. Effective dryness of the month is $Z - 0{\cdot}15$ and Z_e value required to end in one month the wet spell prevailing at the start of the month is $-2{\cdot}691 X_{i-1} + 1{\cdot}5$.

The ratio $\dfrac{Z - 0{\cdot}15}{-2{\cdot}691 \times X_{i-1} + 1{\cdot}5} \times 100$ gives the percentage probability of ending of the wet spell. If the wet spell has not ended in this month as seen from the probability percentage being less than 100 per cent, then the probability percentage is calculated for successive months by a process of integration till probability becomes either 100 per cent (wet spell has ended) or 0 per cent (wet spell has not ended). If the wet spell has ended, then from the first month of testing onwards drought has commenced and its index value from that month onwards gives the appropriate drought index. Once the index value becomes $-1{\cdot}0$ or less, drought is established and the index value is calculated using the relation $X_i = 0{\cdot}897\ X_{i-1} + Z_i/3$ till Z_i becomes greater than $-0{\cdot}15$. When Z_i becomes greater than $-0{\cdot}15$, testing for the commencement of wet spell is done in a similar manner. Drought is taken to end in the month previous to the one in which the wet spell commences. For details, references given at the end may be consulted.

4. Drought intensity classification

Based on the value of the index, Palmer gave the following criteria for describing the intensity of drought.

Index value	Class of drought
$-1{\cdot}00$ to $-1{\cdot}99$	Mild drought
$-2{\cdot}00$ to $-2{\cdot}99$	Moderate drought
$-3{\cdot}00$ to $-3{\cdot}99$	Severe drought
$\leqslant 4{\cdot}00$	Extreme drought

5. Period and areas studied

The monthly Palmer index values from 1901 to

TABLE 1

Percentage occurrences of various classes of drought
(Period studied : 60 years)

Class	Index value	Coastal Andhra Pradesh	Telangana	Rayalaseema	Tamil Nadu	Interior Mysore North	Interior Mysore South
Mild drought	—1·00 to —1·99	18	11	19	17	20	11
Moderate drought	—2·00 to —2·99	12	12	18	13	13	13
Severe drought	—3·00 to —3·99	7	10	9	9	7	10
Extreme drought	≤4·00	2	5	5	2	1	6

1969 were computed for the following meteorological sub-divisions of the country (Fig. 1):

(1) Coastal Andhra Pradesh
(2) Telangana
(3) Rayalaseema
(4) Tamil Nadu
(5) Interior Mysore South and
(6) Interior Mysore North.

In the computations, meteorological data of the same stations in a sub-division are used for all the years so that the index values for the different years are comparable. PE values used in the computation are those estimated according to Thornthwaite's empirical relation (1948). The Palmer index of each month gives the drought or wet spell intensity expressed as a single number based on rainfall, potential evapotranspiration, water-holding capacity of the soil and the different coefficients which adjust appropriately for the climate of the place.

6. Drought frequency

Percentage of months in the total period with mild/moderate/severe and extreme droughts in the different sub-divisions are shown in Table 1. Mild drought months constitute 17 to 20 per cent of the total period except in Telangana and Interior Mysore South where it is only 11 per cent. Moderate drought is 12 to 13 per cent; only in Rayalaseema, it is more (18 per cent). Severe drought occurs 7 to 10 per cent of time in all the sub-divisions. Extreme drought months are 1 to 2 per cent in Coastal Andhra Pradesh, Tamil Nadu and Interior Mysore North and 5 to 6 per cent in the other three sub-divisions. Monthwise distribution of the different classes of droughts is detailed below.

(*i*) *Mild drought* (*index value —1.00 to —1.99*)

Occurrence of mild drought is 25 per cent or more in Interior Mysore South in July, November, December; in Coastal Andhra Pradesh in November; in Rayalaseema in December. It is 20 to 24 per cent in Coastal Andhra Pradesh from June to October; in Interior Mysore South in January and from August to October; in Rayalaseema from January to March, May, June and in November; in Tamil Nadu in June and November. It is only 5 per cent in Telangana in April and May and in Interior Mysore North in October.

The frequency of mild drought in the different areas is given in Table 2(a).

(*ii*) *Moderate drought* (*index value —2·00 to —2·99*)

Moderate drought has occurred on 20 per cent or more occasions in Rayalaseema in July, September November, December and February. It is 15 to 19 per cent in Rayalaseema in January, March to June, August and October; in Interior Mysore South from January to April, August and October; in Interior Mysore North in May, August and October. It is less than 10 per cent in Coastal Andhra Pradesh in April and May, in Telangana in June and July, and in Tamil Nadu in November.

The frequency of moderate droughts in the areas is given in Table 2(b).

(*iii*) *Severe drought* (*index value —3·00 to —3·99*)

Severe drought occurs highest (15 to 17 per cent in Telangana in March and June and in Coastal Andhra Pradesh in April. It occurs 10 to 14 per cent in Telangana from November to July; in Rayalaseema in August, October and January to May; in Tamil Nadu in January, February, April and August; in Interior Mysore North from November to March, June and September; in Interior Mysore South from November to March; in Coastal Andhra Pradesh from March to May. It is less than 5 per cent in Coastal Andhra Pradesh in June, July and September; in Telangana in August; in Interior Mysore South from July to October. It has not occurred in Coastal Andhra Pradesh in November.

The frequency of severe drought in these areas is given in Table 2(c)

TABLE 2

Sub-Division	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(a) Percentage occurrences of mild drought (Index value —1·00 to —1·99)												
Coastal Andhra Pradesh	15	13	10	12	12	23	23	23	22	22	25	15
Telangana	8	12	7	5	5	15	13	17	15	12	12	15
Rayalaseema	23	20	20	15	23	23	12	13	15	18	22	27
Tamil Nadu	13	13	15	17	18	22	18	15	15	15	23	18
Interior Mysore North	7	12	10	12	15	17	17	8	8	5	8	12
Interior Mysore South	20	18	17	8	12	18	25	23	23	22	25	25
(b) Percentage occurrences of moderate drought (Index value —2·00 to —2·99)												
Coastal Andhra Pradesh	15	13	13	8	8	10	13	17	10	12	10	17
Telangana	15	13	12	10	10	5	5	13	12	17	17	12
Rayalaseema	17	20	18	18	15	17	20	18	22	17	20	20
Tamil Nadu	12	12	12	13	13	12	17	13	18	12	8	10
Interior Mysore North	13	12	12	13	17	10	13	15	10	17	13	10
Interior Mysore South	15	17	15	15	10	13	10	15	12	17	10	10
(c) Percentage occurrences of severe drought (Index value —3·00 to —3·99)												
Coastal Andhra Pradesh	8	8	12	17	10	3	3	7	3	7	0	5
Telangana	12	10	15	12	12	15	12	3	7	8	10	12
Rayalaseema	13	12	12	13	10	5	8	12	5	10	7	8
Tamil Nadu	12	12	8	12	8	8	5	10	5	7	7	8
Interior Mysore North	12	13	12	8	8	12	7	7	13	8	13	12
Interior Mysore South	10	10	12	7	8	5	3	2	3	3	10	10
(d) Percentage occurrences of extreme drought (Index value $\leq$4·00)												
Coastal Andhra Pradesh	2	3	5	2	3	5	0	0	2	0	3	2
Telangana	7	8	8	8	7	2	0	3	3	5	3	5
Rayalaseema	2	2	2	0	0	2	0	0	0	0	0	0
Tamil Nadu	3	5	8	2	2	0	0	0	0	2	2	2
Interior Mysore North	8	7	8	8	7	3	3	7	3	5	3	7
Interior Mysore South	3	2	0	2	2	2	2	2	0	3	0	2

TABLE 3

(a) Percentage occurrences of droughts in kharif season

Month	Coastal A. P.	Telangana	Rayalaseema	Tamil Nadu	Interior Mysore	
					North	South
	(a) Class moderate and above					
Jun	18	22	24	20	25	20
Jul	16	17	28	22	23	15
Aug	24	19	30	23	29	19
Sep	15	22	27	23	26	15
Oct	19	30	27	21	30	23
Nov	13	30	27	17	29	20
	(b) Class severe and above					
Jun	8	17	7	8	15	7
Jul	3	12	8	5	10	5
Aug	7	6	12	10	14	4
Sep	5	10	5	5	16	3
Oct	7	13	10	9	13	6
Nov	3	13	7	9	16	10

(iv) Extreme drought (index value ≤ -4.00)

Extreme drought has occurred in all the months in Interior Mysore North (3 to 8 per cent). In Telangana also it has occurred (2 to 8 per cent) in all the months except July. This drought has not occurred in Coastal Andhra Pradesh in July, August and October; in Rayalaseema in April, May and from July to December; in Tamil Nadu from June to September; in Interior Mysore South in March, September and November.

The frequency of extreme droughts in the areas studied is given in Table 2(d)

7. Effective droughts of the kharif season

Droughts of intensity moderate and above are supposed to affect crop yields adversely. The extent of damage due to drought will depend on the type of crop and its stage of growth. Taking broadly the *kharif* season as June to November, percentage occurrences of droughts of intensity moderate and above (index value less than -2.0) in each of the months are given in Table 3(a). Such droughts occur 18 to 25 per cent generally in these sub-divisions.

Similarly, percentage occurrence of droughts of intensity severe and above (index value less than -3.0) are given in Table 3(b). These classes of droughts occur 8 to 12 per cent of time in these sub-divisions.

8. Drought spells

The drought periods, when the value of the index fell below -1.00, together with the number of such months, the maximum value of drought intensity and the number of months in different drought classes are given in Appendix for the different sub-divisions.

The longest drought spell experienced in the period studied was in Interior Mysore North for a period of 70 months from August 1922 to May 1928. The intensity reached was only class severe. During this period, all the other sub-divisions also experienced droughts although for smaller periods : Interior Mysore South (42 months), Tamil Nadu (34 months), Telangana (35 months), Rayalaseema (30 months) and Coastal Andhra Pradesh (17 months).

Tamil Nadu had the longest drought spell of 41 months from November 1949 to March 1953. From 'Season and Crop Reports' of the Madras State are given below the land revenue remission sanctioned by the Government of Madras. This gives an idea of the extent of crop damage in this period.

Year	Land revenue remission in Lakhs of Rupees
1948-49	48·41
1949-50	56·31
1950-51	84·89
1951-52	61·63
1952-53	Seasonal condition continued to be unsatisfactory and special land revenue remission was granted on large scale but the actual amount was not given in the report.
1953-54	6·19
1954-55	8·69

Fig. 2 shows the drought spells of the decade 1905-1914 experienced in all the sub-divisions. Coastal Andhra Pradesh experienced the longest drought spell in this period for 57 months from July 1904 to March 1909, when 11 months had extreme drought with the highest intensity of -4.97. In this period, droughts were experienced in all the other sub-divisions also. However, the intensity reached in Telangana and Rayalaseema was only severe while in other sub-divisions, it reached class extreme.

9. Concluding remarks

The methodology developed by Palmer is elaborate and presents a logical approach to the study of droughts in semi-arid and dry sub-humid regions. The index takes into account rainfall deficiency in meeting the requirements of (*i*) evapotranspiration, (*ii*) soil moisture recharge and (*iii*) runoff and

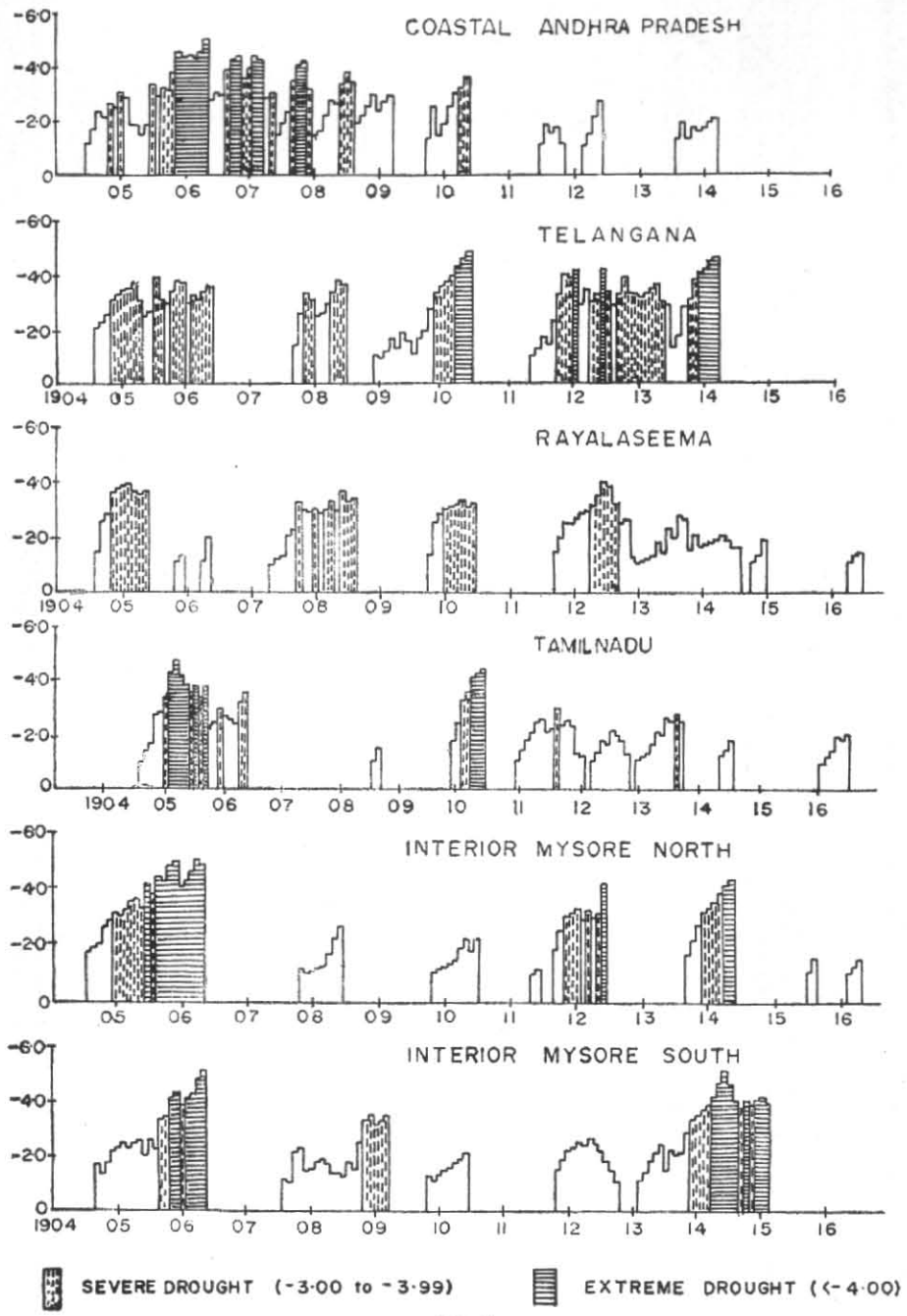

Fig. 2

Drought spells for the decade 1905-1914

as such is an index of meteorological drought. Of these, the first two are the factors that affect crop growth. The areas studied (Andhra Pradesh, Tamil Nadu and Mysore) are mainly semi-arid (1956, 1971), where the first two factors are the more important ones, for, runoff in the semi-arid regions is practically *nil*. In these areas, therefore, Palmer index represents in reality agricultural drought index.

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APPENDIX

Drought spells of duration 2 months or more (1904-1969)

Drought		Total number of months of drought	Lowest value of index	No. of months of drought of intensity			
Beginning	Ending			Mild (−1·00 to −1·99)	Moderate (−2·00 to −2·99)	Severe (−3·00 to −3·99)	Extreme (≤−4·00)
Coastal Andhra Pradesh							
Jul 1904	Mar 1909	57	−4·97	11	20	15	11
Oct 1909	May 1910	8	−3·61	3	3	2	0
Jul 1911	Nov 1911	5	−1·72	5	0	0	0
Mar 1912	Jun 1912	4	−2·77	2	2	0	0
Aug 1913	Mar 1914	8	−2·03	7	1	0	0
Oct 1914	Dec 1914	3	−2·59	2	1	0	0
Jul 1918	Oct 1918	4	−2·38	3	1	0	0
Jul 1920	Sep 1920	3	−2·59	1	2	0	0
May 1922	Oct 1922	6	−2·91	3	3	0	0
Jun 1923	Aug 1923	3	−3·46	1	1	1	0
Jun 1924	Aug 1924	3	−2·22	1	2	0	0
Oct 1926	May 1927	8	−4·32	1	2	0	0
Jun 1928	Aug 1928	3	−1·65	3	0	0	0
Dec 1928	May 1929	6	−2·07	5	1	0	0
Nov 1929	Apr 1930	6	−3·04	2	3	1	0
Aug 1932	Sep 1933	14	−2·40	11	3	0	0
Oct 1934	Jan 1936	16	−4·76	3	2	7	4
Jul 1937	Apr 1938	10	−3·72	5	1	4	0
Jun 1939	Sep 1939	4	−2·64	2	2	0	0
Mar 1941	May 1941	3	−1·84	3	0	0	0
Jul 1941	Aug 1941	2	−2·11	1	1	0	0
Jun 1942	Mar 1943	10	−3·41	2	7	1	0
Jun 1945	Oct 1946	17	−3·19	7	8	2	0
Mar 1948	Apr 1949	14	−2·29	10	4	0	0
Aug 1950	Feb 1951	7	−1·95	7	0	0	0
Oct 1951	Apr 1954	31	−4·31	6	14	9	2
Nov 1957	Jun 1958	8	−4·35	1	2	4	1
Nov 1959	Aug 1960	10	−3·72	1	3	6	0
Dec 1963	May 1964	6	−2·93	3	3	0	0
Jan 1965	Oct 1966	22	−4·68	8	6	4	4
Oct 1967	Apr 1969	19	−6·63	2	2	5	10

APPENDIX (*contd*)

Drought spells of duration 2 months or more (1904-1969)

Drought		Total number of months of drought	Lowest value of index	Number of months of drought of intensity			
Beginning	Ending			Mild (—1·00 to —1·99)	Moderate (— 2·00 to — 2·99)	Severe (— 3·00 to —3·99)	Extreme (≤— 4·0)
			Telangana				
Aug 1904	May 1906	22	—3·75	0	7	15	0
Sep 1907	Jun 1908	10	—3·73	1	4	5	0
Dec 1908	May 1910	18	—4·68	10	1	4	3
May 1911	Mar 1914	35	—4·63	6	5	18	6
Jul 1918	May 1921	35	—6·76	1	6	8	20
Aug 1922	Jul 1924	24	—3·82	7	12	5	0
Jun 1926	Jul 1926	2	—1·66	2	0	0	0
Sep 1926	May 1927	9	—4·03	1	2	5	1
Jul 1929	Jun 1931	24	—4·12	2	8	13	1
Aug 1935	Jan 1936	6	—2·11	5	1	0	0
Aug 1937	Apr 1938	9	—3·17	1	7	1	0
May 1939	Mar 1940	11	—3·34	2	7	2	0
Jul 1941	Mar 1942	9	—3·55	0	6	3	0
Oct 1942	Dec 1942	3	—1·19	3	0	0	0
Feb 1943	Mar 1943	2	—1·12	2	0	0	0
Sep 1946	Jun 1947	10	—3·69	4	4	2	0
Feb 1949	Apr 1949	3	—1·61	3	0	0	0
Sep 1951	Jan 1952	5	—1·74	5	0	0	0
Jun 1952	May 1953	12	—4·92	2	1	5	4
Oct 1957	Jun 1958	9	—3·05	3	5	1	0
Aug 1960	Apr 1961	9	—3·12	3	4	2	0
Jan 1964	Aug 1964	8	—2·76	4	4	0	0
Oct 1965	Jun 1967	21	—3·61	8	11	2	0
Sep 1967	Apr 1969	20	—4·81	1	13	5	1
			Rayalaseema				
Aug 1904	May 1905	10	—3·88	1	2	7	0
Nov 1905	Dec 1905	2	—1·35	2	0	0	0
Apr 1906	May 1906	2	—1·96	2	0	0	0
May 1907	Aug 1908	16	—3·66	3	6	7	0
Oct 1909	Jun 1910	9	—3·21	1	2	6	0
Sep 1911	Jul 1914	35	—3·96	18	12	5	0
Oct 1914	Dec 1914	3	—1·88	3	0	0	0
Apr 1916	Jun 1916	3	—1·44	3	0	0	0
Jul 1918	Oct 1918	4	—2·91	3	1	0	0
Jun 1920	Sep 1921	16	—3·32	3	9	4	0
Jun 1922	Jan 1923	8	—3·63	4	2	2	0
May 1923	Aug 1924	16	—4·08	2	4	9	1
Oct 1926	May 1927	8	—3·32	2	4	2	0
Nov 1928	Aug 1929	10	—3·35	5	4	1	0
Aug 1931	Jul 1933	24	—3·31	3	16	5	0
Sep 1933	Jun 1934	10	—1·92	10	0	0	0
Aug 1934	May 1935	10	—3·61	1	1	8	0
Nov 1935	Mar 1937	17	—3·94	7	3	7	0
Aug 1937	Sep 1937	2	—1·71	2	0	0	0
Dec 1937	May 1938	6	—1·89	6	0	0	0
Dec 1938	Feb 1939	3	—1·12	3	0	0	0
May 1939	Mar 1940	11	—2·16	8	3	0	0
Mar 1941	Feb 1944	36	—4·11	8	19	6	3
Aug 1944	Sep 1946	26	—3·03	4	20	2	0
Jun 1947	Jul 1947	2	—1·26	2	0	0	0
Jan 1948	Jul 1948	7	—1·58	7	0	0	0
Mar 1949	Apr 1949	2	—1·22	2	0	0	0
Nov 1950	Feb 1951	4	—2·10	3	1	0	0
Sep 1951	Apr 1952	8	—3·21	1	3	4	0
Aug 1952	Jun 1953	11	—2·95	3	8	0	0
Oct 1957	Mar 1958	6	—2·48	2	4	0	0
Nov 1959	Aug 1960	10	—3·01	7	2	1	0
Dec 1961	Mar 1962	4	—1·74	4	0	0	0
Dec 1963	May 1964	6	—2·71	4	2	0	0
Oct 1965	Apr 1966	7	—2·74	0	7	0	0
Jan 1968	Feb 1968	2	—1·26	2	0	0	0

APPENDIX (*contd*)

Drought spells of duration 2 months or more (1904-1969)

Drought		Total number of months of drought	Lowest value of index	Number of months of drought of intensity			
Beginning	Ending			Mild (—1·00 to —1·99)	Moderate (—2·00 to —2·99)	Severe (—3·00 to —3·99)	Extreme (≤—4·00)
			Tamil Nadu				
Aug 1904	May 1906	22	—5·09	3	7	6	6
Jul 1908	Aug 1908	2	—1·61	2	0	0	0
Nov 1909	May 1910	7	—4·77	1	1	2	3
Dec 1910	Jan 1912	14	—3·18	5	8	1	0
Mar 1912	Oct 1912	8	—2·29	6	2	0	0
Dec 1912	Sep 1913	10	—3·00	4	5	1	0
May 1914	Jul 1914	3	—1·95	3	0	0	0
Jan 1916	Jun 1916	6	—2·19	4	2	0	0
Feb 1917	May 1917	4	—1·90	4	0	0	0
Aug 1918	Oct 1918	3	—3·36	1	1	1	0
Jun 1923	Nov 1923	6	—2·59	3	3	0	0
Dec 1924	Feb 1925	3	—2·03	2	1	0	0
Sep 1925	Oct 1925	2	—1·73	2	0	0	0
Jun 1926	May 1927	12	—2·98	5	7	0	0
Jul 1927	Sep 1928	15	—3·92	3	2	10	0
Aug 1934	Sep 1934	2	—2·44	1	1	0	0
Nov 1934	Mar 1935	5	—1·74	5	0	0	0
May 1935	Jul 1935	3	—1·94	3	0	0	0
Oct 1936	Mar 1937	6	—1·36	6	0	0	0
May 1937	Mar 1940	35	—4·85	10	16	7	2
Jun 1942	Aug 1942	3	—1·76	3	0	0	0
Oct 1942	Nov 1942	2	—1·94	2	0	0	0
Jun 1945	Aug 1946	15	—2·74	5	10	0	0
Nov 1947	Apr 1949	18	—4·04	1	2	14	1
Nov 1949	Mar 1953	41	—5·59	1	11	20	9
Feb 1956	May 1956	4	—2·50	3	1	0	0
Apr 1957	Jun 1957	3	—1·10	3	1	0	0
Aug 1957	Sep 1957	2	—1·50	2	0	0	0
Dec 1958	Jun 1960	19	—3·07	10	8	1	0
Nov 1961	Apr 1962	6	—3·61	2	2	2	0
Apr 1964	Jun 1964	3	—1·43	3	0	0	0
May 1965	Jul 1965	3	—1·67	3	0	0	0
Oct 1965	Nov 1965	2	—1·64	2	0	0	0
Dec 1967	Sep 1969	22	—5·75	3	6	4	9
			Interior Mysore North				
Aug 1904	May 1906	22	—5·05	2	3	7	10
Nov 1907	Jun 1908	8	—2·61	6	2	0	0
Nov 1909	Jul 1910	9	—2·22	7	2	0	0
May 1911	Jun 1911	2	—1·15	2	0	0	0
Sep 1911	Jun 1912	10	—4·18	1	3	5	1
Sep 1913	May 1914	9	—4·28	1	2	4	2
Jul 1915	Aug 1915	2	—1·57	2	0	0	0
Feb 1916	Apr 1916	3	—1·58	3	0	0	0
Jun 1918	Sep 1921	40	—6·22	1	5	11	23
Aug 1922	May 1928	70	—3·99	16	27	27	0
Jul 1929	Aug 1931	26	—4·47	2	13	7	4
May 1934	Jun 1934	2	—1·33	2	0	0	0
Sep 1935	Feb 1938	30	—4·30	5	15	7	3

APPENDIX *(contd)*

Drought spells of duration 2 months or more (1904-1969)

Drought		Total number of months of drought	Lowest value of index	Number of months of drought of intensity			
Beginning	Ending			Mild (—1·00 to —1·99)	Moderate (—2·00 to —2·99)	Severe (—3·00 to —3·99)	Extreme (≤—4·00)
			Interior Mysore North *(contd)*				
May 1939	Jul 1939	3	—1·55	3	0	0	0
Feb 1941	Mar 1943	26	—4·77	6	6	10	4
Aug 1944	Sep 1944	2	—1·63	2	0	0	0
Dec 1944	Jun 1945	7	—3·13	3	3	1	0
Apr 1947	Jul 1947	4	—1·44	4	0	0	0
Nov 1951	Apr 1952	6	—2·73	2	4	0	0
Jun 1952	May 1953	12	—4·96	2	2	3	5
Oct 1965	Aug 1966	11	—2·77	3	8	0	0
Aug 1968	Jun 1969	11	—2·48	8	3	0	0
			Interior Mysore South				
Sep 1904	May 1906	21	—5·12	3	9	3	6
Aug 1907	Mar 1909	20	—3·50	12	3	5	0
Nov 1909	Jun 1910	8	—2·09	7	1	0	0
Nov 1911	Oct 1912	12	—2·58	5	7	0	0
Feb 1913	Feb 1915	25	—5·16	4	6	6	9
Jun 1918	Aug 1918	3	—2·85	1	2	0	0
Jun 1920	Mar 1921	10	—2·43	6	4	0	0
May 1921	Sep 1921	5	—2·97	3	2	0	0
Sep 1922	Oct 1922	2	—1·61	2	0	0	0
Sep 1923	Apr 1925	20	—3·96	2	9	9	0
Jun 1925	Oct 1925	5	—2·84	3	2	0	0
Nov 1926	Jan 1928	15	—4·07	1	4	8	2
Jul 1929	Aug 1929	2	—1·67	2	0	0	0
Oct 1929	Apr 1930	7	—2·25	4	3	0	0
Jul 1930	Aug 1930	2	—2·18	1	1	0	0
Jan 1936	Feb 1936	2	—1·18	2	0	0	0
Apr 1936	May 1936	2	—1·32	2	0	0	0
Jul 1936	Aug 1936	2	—1·45	2	0	0	0
Oct 1936	Jan 1937	4	—1·87	4	0	0	0
Jul 1937	Jul 1938	13	—3·76	6	4	3	0
Feb 1942	Mar 1942	2	—1·52	2	0	0	0
Oct 1942	Mar 1943	6	—2·00	5	1	0	0
Jun 1943	Aug 1943	3	—1·81	3	0	0	0
Aug 1945	Oct 1946	15	—3·14	2	10	3	0
Jan 1948	Mar 1948	3	—1·60	3	0	0	0
Dec 1948	Feb 1951	27	—3·63	9	16	2	0
Jun 1952	Mar 1953	10	—2·80	6	4	0	0
May 1953	Jun 1953	2	—1·85	2	0	0	0
Sep 1957	Apr 1958	8	—1·78	8	0	0	0
Nov 1958	May 1959	7	—2·88	2	5	0	0
Oct 1959	Mar 1961	18	—3·82	3	10	5	0
Sep 1961	Mar 1962	7	—1·77	7	0	0	0
Jun 1963	Sep 1963	4	—1·63	4	0	0	0
Nov 1963	Apr 1964	6	—2·37	5	1	0	0
May 1965	Jun 1966	14	—3·89	5	0	9	0
Sep 1967	Aug 1968	12	—2·68	4	8	0	0