

Studies on the incidence of droughts through seasonal aridity index

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सारा — वर्तमान अध्ययन में जल संतुलन संकल्पना द्वारा दक्षिण-पश्चिमी मानसूनी ऋतु के लिए शुष्कता सूचकांक (I_{sa}) को विकसित करने की कोशिश की गई है। 1901 से 1975 तक की अवधि के दौरान सूखे की घटनाओं का अध्ययन करने के लिए मद्रास और मसूलिपट्टनम का चयन किया गया है। सूखे के वर्गीकरण के लिए एक योजना का सुझाव दिया गया है। वार्षिक शुष्कता सूचकांक की तुलना में मौसमी शुष्कता सूचकांक के चयन का विवेचनात्मक निर्धारण किया गया है।

ABSTRACT. An attempt has been made in the present study to evolve the aridity index (I_{sa}) for the southwest monsoon season through water balance concept. Madras and Masulipatnam have been selected to study the occurrence of droughts during the period 1901-1975. A scheme is suggested for drought categorization. A critical appraisal is made in choosing the seasonal aridity index compared to annuals.

1. Introduction

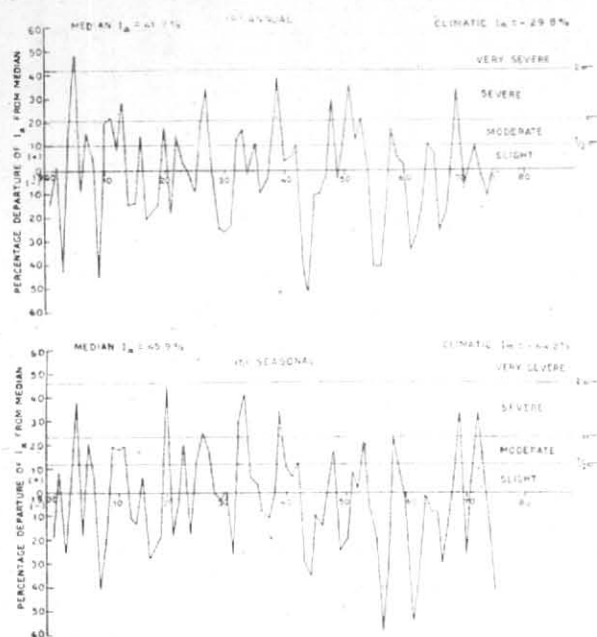
It is in the dry climatic province of the world that the frequency of droughts is highest with varied intensity and duration as a consequence of failure of seasonal rains. A detailed investigation of the problem of droughts and aridity is essential to understand the effects of these on the agricultural output and human settlement. The main problem with "drought" is, its quantification. Numerous research schemes have been suggested to quantify drought which are inherently having a demerit. Out of all the schemes proposed, the method of water balance approach developed by Thornthwaite (1948) claimed world recognition, in obtaining water deficit — the sole cause of famines. The water deficit which is obtained from the book-keeping procedure of water balance technique is highly useful in assessing the severity of droughts. The water deficit thus obtained alone cannot be used as a parameter by itself for drought studies. The most pertinent parameter for such studies is the aridity index, I_a of Thornthwaite (1948) which is on an annual basis and was used by Subrahmanyam and his associates Subrahmanyam and Sastry 1969; Subrahmanyam and Sarma 1973; Subrahmanyam and Sarma 1975) as the main parameter for drought analysis. George and Ramasastri (1975) made use of weekly aridity index to identify drought incidence over India during 1972 kharif season.

The aridity index, I_a , obtained from water budget method is capable of yielding objective results in finding

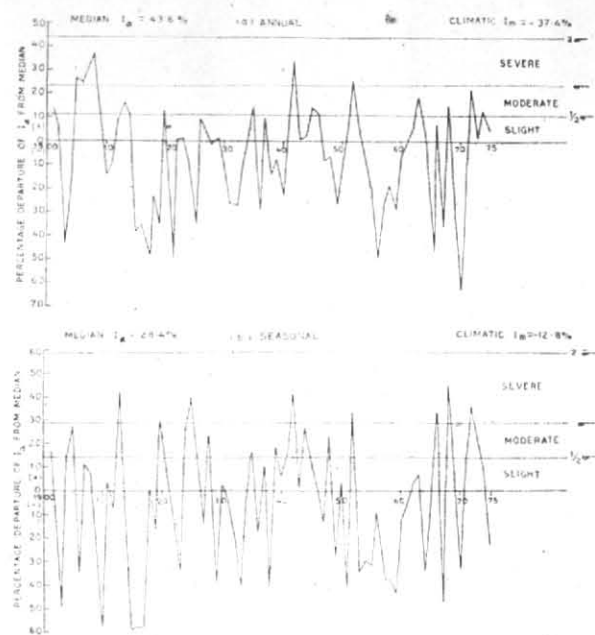
out the incidence of droughts and aridity at a station. The results that obtained by using I_a are no doubt encouraging but in understanding the magnitude of seasonal aridity, that too in the monsoon period (June-September), the annual values may not be helpful in assessing the nature of the monsoon. The aridity index which is on an annual basis reflects a comprehensive picture of seasonal as well as yearly and in such case the nature of the monsoon season is either overestimated or underestimated depending upon the magnitudes of water deficit and water need of the remaining seasons of the year. This in turn misinterprets the nature and impact of abnormality in the weather pattern on agriculture production. The authors in the present report made an attempt to consider the seasonal values of water deficit and water need of the monsoon period only in determining the magnitude of seasonal aridity index.

2. Materials and methods

The aridity index, I_a , of Thornthwaite (1948) is for the year as a whole but not for a season in the year. The Indian agriculture primarily depends upon the rainfall that pertains to the period June to September, and as such it will be more appropriate to have this index for the monsoon season alone. A knowledge of seasonal aridity together with its determination is highly beneficial for agricultural developments. The seasonal aridity index of the monsoon season, I_{sa} , is obtained by expressing the monsoon water deficiency as a percentage ratio of the water need of the monsoon season. This I_{sa} has been used in the present study for the incidence of droughts at the selected stations in meeting the water need of the place.



Figs. 1 (a & b). March of aridity index at Madras:
(a) Annual & (b) Seas



Figs. 2 (a & b). March of aridity index at Masulipatnam

Water balances of Madras and Masulipatnam have been computed for a period of 75 years according to the book-keeping procedure of Thornthwaite and Mather (1955). For each individual year for the selected stations, seasonal aridity indices have been computed as mentioned in the preceding paragraph. Departures of I_{sa} from the median are expressed as a percentage of the range of I_{sa} to indicate the severity of drought in the monsoon season. For an intercomparison of I_{sa} with I_a at the selected stations yearly aridity indices are also obtained for the same stations for the period of study and the departure of I_a from the median have been obtained and expressed as percentage ratios of the range of I_a . The categorization of droughts is according to standard deviation. The scheme of drought classification is as follows for both the approaches :

Departures of I_{sa} or I_a from the median expressed as % of the range of I_{sa} or I_a

$$< 1/2 \sigma$$

$$1/2 \sigma \text{ to } < \sigma$$

$$\sigma \text{ to } < 2 \sigma$$

$$\geq 2 \sigma$$

Drought intensity

Slight drought

Moderate drought

Severe drought

Very severe drought

TABLE I

Elements of water budget: Madras

	Water need (mm)	Rainfall (mm)	Water deficit (mm)	Water surplus (mm)	I_a (%)
Climatic (Annual)	1771	1243	637	109	35.9
1975 year (Annual)	1740	1493	723	383	41.5
Climatic (monsoon season)	709	366	314	0	44.2
1975 year (monsoon season)	686	659	115	0	16.7

are violent compared to annual values (Figs. 1a & 2a). The annual values simply overshadow the seasonal characters since the contribution of rainfall and water need other than in the season under question might increase or decrease the severity of the season in terms of water deficit.

3. Discussion and results

3.1. March of aridity index

Figs. 1 & 2 clearly show how the annual values of aridity mislead the magnitudes of the season. The departures of I_{sa} (Figs. 1b & 2b) from year to year

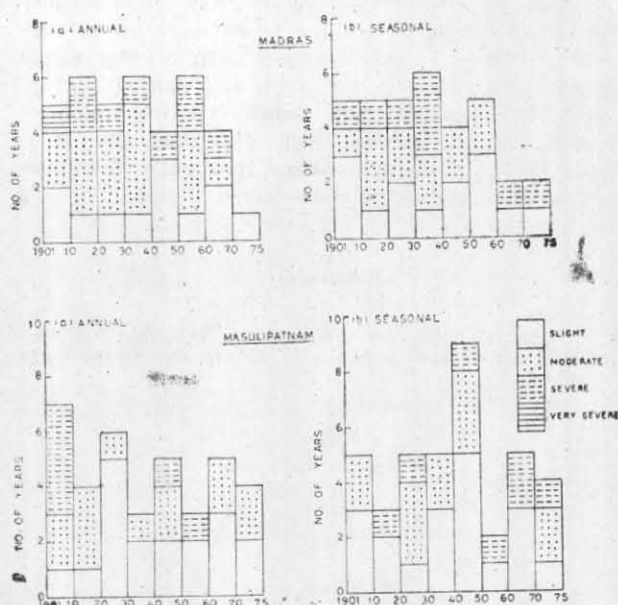
Madras (Fig. 1a), a coastal dry sub-humid station selected from Tamilnadu is benefitting by the southwest and northeast monsoons. It is the northeast monsoon that gives copious rainfall to Tamilnadu State. But inspite of it, Madras has been chosen for the present study to assess the magnitude of aridity and

TABLE 2
Elements of water budget : Masulipatnam

	Water need (mm)	Rainfall (mm)	Water deficit (mm)	Water surplus (mm)	I_a (%)
Climatic (Annual)	1714	1074	640	0	37.3
1975 year (Annual)	1660	998	751	0	45.2
Climatic (monsoon season)	695	616	90	0	12.9
1975 year (monsoon season)	673	659	117	0	17.3

its fluctuations with time in the southwest monsoon season. The year 1905, is shown as a more severe drought year through seasonal approach (Fig. 1b) and is denoted as a very severe with annual value of aridity (Fig. 1a). The higher annual aridity value at Madras through annual approach, is on account of the accumulated water deficit other than in the southwest monsoon period. In the year 1975, the aridity index of Madras has gone below the median by a value of -42% with the seasonal analysis (Fig. 1b), while the same year is just below the median through annual value (Fig. 1a) — a situation which clearly indicates the role played by the water deficit and water need either in shooting up or lowering down the values of aridity index. In fact, in the year 1975 the seasonal water deficit of Madras has been diminished to 115 mm compared to a climatic value of 314 mm due to vigorous activity of southwest monsoon (Table 1). The magnitudes of the water budget elements both for the annual as well as for the southwest monsoon season for the year 1975 are given in Table 1. In the year 1920, Madras has experienced a severe drought with a maximum departure of 44% from the median (Fig. 1b).

In the year 1908, Masulipatnam has a 37% departure from the median and experienced a severe drought (Fig. 2a) condition on an annual basis, while the year comes out to be as slight drought year (Fig. 2b) through seasonal value. Even in a good monsoon year 1975, Masulipatnam experienced a slight drought condition with the annual approach (Fig. 2a). It is through seasonal analysis that the year 1975 is marked not only as a non-drought year but also as having a departure of -22.8% from the median (Fig. 2b). The magnitudes of annual and seasonal together with the climatic water budget elements at Masulipatnam are



Figs. 3 (a-b) & 4 (a-b) Decennial frequency of drought years at Madras (top figure) & Masulipatnam (bottom figure) respectively

presented in Table 2 for the year 1975. The slight increase in rainfall accompanied by a decrease in water need during 1975 monsoon season could not bring down the aridity index of the station from 17.3 to 12.9% (Table 2). And it is evident from this study that a slight increase in rainfall accompanied by a slight decrease in water need at a place might increase slightly the water deficit on account of the maldistribution of rainfall (Table 2).

4. Decennial frequency of droughts

At Madras, the severe order of droughts are completely absent in the 5th (1941 to 1950) and 6th (1951 to 1960) decades (Fig. 3b), while none of the decades are free from either severe or very severe through annual approach (Fig. 3a). The interesting drought frequency diagram of Madras shows an expectancy of 4 to 6 droughts per decade with at least one severe or more intense drought being more or less common (Fig. 3a). Starting with equal number of droughts in the first three decades the drought frequency diagram of Madras through seasonal concept of aridity shows a rise in number in the severe category of droughts in the 4th decade (Fig. 3b) where in maximum number of six droughts occurred of which 3 severe, 2 moderate and 1 slight.

It appears from Fig. 4(a) that the decade 1901-1910 is the severe one at Masulipatnam with four severe, two moderate and one slight drought years. But the severe category of droughts have altogether vanished through seasonal analysis (Fig. 4b). Very interestingly Masulipatnam in the 5th decade experienced a sudden increase of drought frequency to a maximum of nine drought years in which five slight, three moderate and one severe through seasonal approach (Fig. 3a) and can be considered as a severe one compared to

the first decade with annual values (Fig. 3a); because in this decade nine out of ten years were under sub-normal condition of monsoonish weather and might have adversely affected the crops and animal-husbandry of the Masulipatnam taluk. Though much of periodicity is not evident from the diagrams, it is obvious that the drought years frequently fluctuates from decade to decade at the selected stations.

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