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Studies on droughts of Tamil Nadu with special reference to their spread and severity

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सार — सूखा या अनावृष्टि सामान्यतया वर्षा की कमी के कारण सूखे मौसम की अवधि को कहा जाता है। लेकिन इसे उस क्षेत्र की जलवायु की सामान्य दशाओं, उपलब्ध जल स्रोतों, कृषि-क्रियाओं एवं आर्थिक गतिविधियों के आधार पर भी व्याख्यायित किया जाता है। किसी अध्ययन के उद्देश्य एवं चुनी हुई कसौटी के आधार पर सूखे से संबंधित सभी परिभाषाओं एवं संकल्पनाओं को वर्षण सूखा, वायुमंडलीय सूखा, कृषि संबंधी सूखा एवं जलीय सूखा के रूप में वर्गीकृत किया जा सकता है।

सूखे का अधिकांश साहित्य वर्षण एवं तापमान के अभिलेखों पर आधारित है। सांख्यिकीय विधियां संख्यात्मक होती हैं और उनमें अधिकांशत: गुणात्मक आधार की कमी रहती है। दूसरी ओर गैर-सांख्यिकीय विधियां अनुभव पर आधारित होती है। थोर्नथ्वइते की जल बजट विधि ऐसी संख्यात्मक विधि है जिसमें एक संगत एवं उपयुक्त भौतिक गुणात्मक आभार भी मौजूद है। इसके अनुसार किसी क्षेत्र में जल की आवश्यकता और मृदानमी की भूमिका का हिसाब लगाए बगैर सूखे की परिभाषा केवल वर्षा की कमी के आधार पर नहीं दी जा सकती।

प्रस्तुत अध्ययन में 1901 से 1975 तक की अवधि में तमिलनाडु और उसके आस पास के क्षेत्र में सूखे को जल संतुलन विधि का अनुप्रयोग करके विश्लेषित किया गया है। सूखे को व्यापक स्तर फैलने के लिए यद्यपि लम्बी अवधि की आवश्यकता होती है, क्योंकि वह सामान्यतया मौसम संबंधी कई घटनाओं के समुच्चयों पर निर्भर होता है। इसलिए वार्षिक आधार पर शुष्कता विसंगति आरेख खींचे गए हैं, जो वायुमंडल के सामान्य परिसंचलन में बड़े पैमाने पर होने वाले परिवर्तनों के कारण शुष्कता में आने वाले वार्षिक उतार-चढावों को दर्शाते हैं। वार्षिक प्रतिरूप को आधार मानकर, क्रोड क्षेत्रों एवं अवधियों की पहचान के लिए माहवारी आधार पर सूखे के प्रकीर्णन आरेख खींचे गए हैं।

सूखे की तीव्रता एवं विस्तार संबंधी विविध दौरों की पहचान के बाद संचयी विचलन तकनीक का उपयोग करके शुष्क दौरों में जल की कमी के संचयी प्रभाव का आकलन किया गया है। यह विधि सूखे की विकरालता के वस्तुपरक अनुमान के अतिरिक्त सूखे के दौरों की शुरूआत, अवधि और अन्त, यानी उनके अस्तित्व के नियमित चक्र के अवयवों को भी दर्शाती है।

वर्तमान अन्वेषण अनावृष्टि विश्लेषण में जल संतुलन प्रक्रिया के उपयोग को दृष्टिगोचर करता है। अनावृष्टि के विस्तार एवं तीव्रीकरण का अध्ययन विशेष रूप से कृषि एवं जल योजनाओं के बनाने में अपनी प्रमुख भूमिका अदा करता है।

ABSTRACT. Droughts, generally understood as a period of dryness due to lack of rain is interpreted variously depending on the normal climatic conditions, available water resources, agricultural practices and economic activities of the region. Depending on the purpose of study and basic criteria chosen, all the concepts and definitions regarding droughts may be classified as precipitation droughts, atmospheric droughts, agricultural droughts and hydrologic droughts.

Most of the literature on droughts is based on the analysis of precipitation and temperature records — the statistical techniques are quantitative and often lack the physical basis while the non-statistical ones are empirical. On the other hand, Thornthwaite's water budget method is quantitative and based on a sound and rational physical approach. According to this, drought cannot be defined in terms of rainfall deficiency alone, without taking into account the water need of the region and the role of soil moisture.

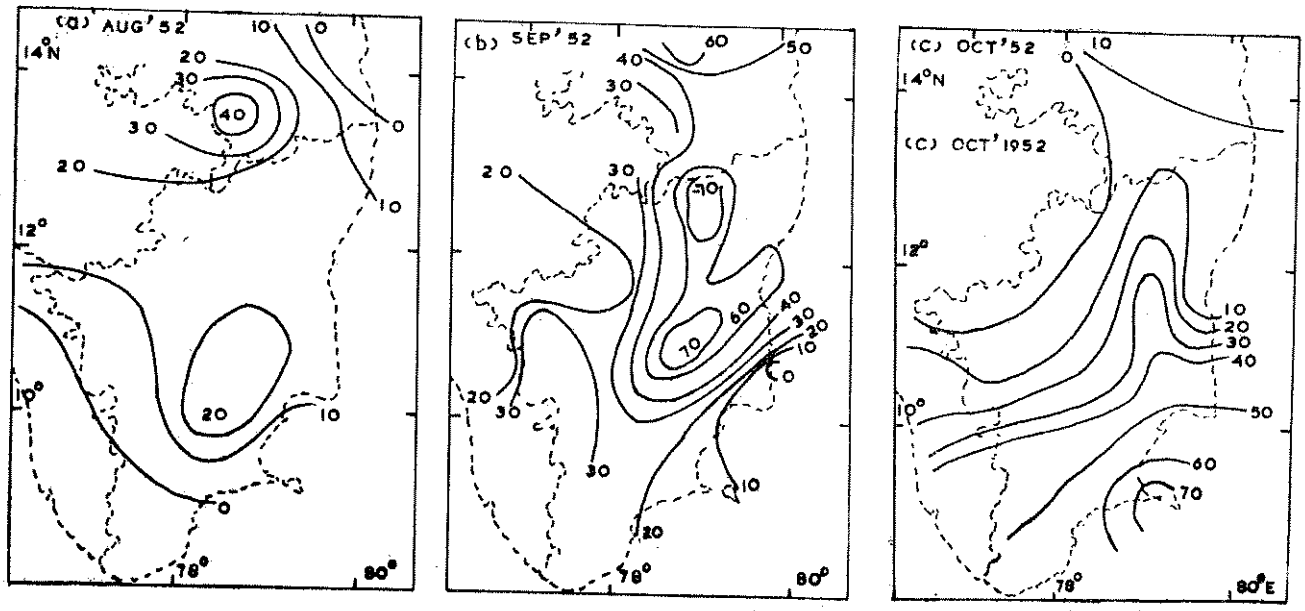
In the present study, droughts during the period 1901-1975 over Tamil Nadu and vicinity have been analysed by the application of the water balance approach. Droughts, however, require extended periods of time to develop as they are usually the culmination of a set of weather sequences. Aridity anomaly diagrams on a yearly basis have, therefore, been drawn which show annual fluctuation in aridity presumably caused by large-scale changes in general circulation of the atmosphere. With the annual patterns as a basis, drought spread diagrams on a monthly basis have been drawn to identify the 'core' areas and periods.

After identifying the drought spells of various intensities and their spread, the cumulative effect of these water deficiencies in dry spells were assessed by employing the cumulative deviation technique. This method besides giving an objective assessment of drought severity, also indicates the beginning, duration and end of a drought spell — the components of a regular life cycle.

The present investigation has brought forth the utility of the water balance procedure in drought analysis. The study of drought spread and intensification in particular is of great practical importance in agriculture and hydrological planning.

1. Introduction

In the present study, droughts over Tamil Nadu and vicinity, during the period 1901-1975 have been analysed by the application of the water balance approach. The scheme of classification of droughts is that suggested by Subrahmanyam and Subramaniam (1964, 1965) and Subrahmanyam and Sastry (1969). Accordingly, the departures of Thornthwaite's Aridity Index (I_a) values from the median have been employed as the central parameter for the drought study.



Figs. 1 (a-c). Spread of drought over Tamil Nadu : (a) August 1952, (b) September 1952 and (c) October 1952

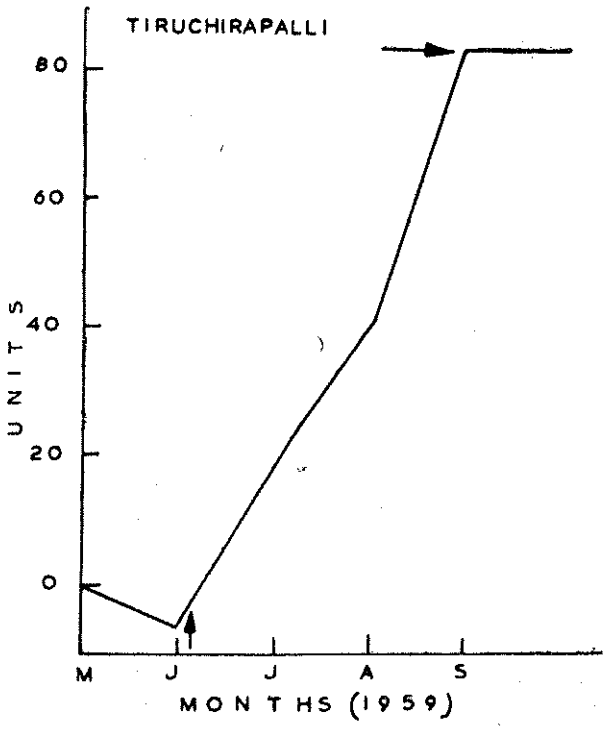


Fig. 2. Cumulative deviation curve

TABLE 1

Frequency of droughts over Tamil Nadu

Station	Period of study	Years of drought				
		Disas-trous	Severe	Large	Mod-erate	Total
Kodaikanal	1901-1975	4	7	10	17	38
Ootacamund	1903-1921, 1936-1975	3	11	7	9	30
Coonoor	1929-1960, 1968-1975	4	7	5	2	18
Madras	1901-1975	0	10	15	9	34
Nagapattinam	1901-1975	1	8	17	13	39
Cuddalore	1901-1975	2	6	9	24	41
Coimbatore	1901-1975	1	10	11	16	38
Madurai	1901-1975	3	14	7	16	40
Pamban	1901-1975	3	11	3	23	40
Salem	1901-1975	1	15	15	5	36
Tiruchirapalli	1901-1975	1	7	12	18	38
Vellore	1901-1975	2	8	16	8	34

TABLE 2

Drought spells over Tamil Nadu

No.	Drought spell	Duration (Years)
1	1904-1909	6
2	1910-1915	6
3	1916-1921	6
4	1924-1929	6
5	1934-1938	5
6	1947-1954	8
7	1956-1963	8
8	1963-1970	8
9	1971-1975	5

2. Frequency of droughts

Data from 12 representative stations have been analysed; of these, Kodaikanal has a perhumid climate, Ootacamund and Coonoor experience humid climates while Madras, Cuddalore and Nagapattinam belong to the dry sub-humid category. All the other six stations — Coimbatore, Madurai, Pamban, Salem, Tiruchirapalli and Vellore — belong to the semi-arid climatic type. The number of years if droughts of various categories of severity is shown in Table 1.

A general study of the decadal frequency of these droughts according to Ram Mohan (1978) reveals that in perhumid climate, during every decade, two moderate, one large and two severe droughts may be expected. In the humid regions, on an average one moderate, one large and two severe droughts are probable every decade. Disastrous droughts are more in number in these climates than in drier climates. In the case of dry sub-humid climates which cover a narrow strip along the Coromandal coast, two to three moderate, two large and one severe drought may be expected every decade while disastrous droughts are quite rare. In the semi-arid climates which cover a major portion of the State, two to three moderate, one to two large and severe droughts may be expected every decade. However, there is no specific or constant decennial frequency of droughts in their number or severity in any climatic category.

3. Aridity patterns

Unlike floods, droughts are not instantaneous phenomena but require extended periods to develop; a prolonged period of subnormal rains alone can give rise to a serious drought situation. The intensity of the drought depends on the nature and duration of the water deficiency responsible for the aridity. The study of aridity anomalies on an annual basis has been made to study this problem for Tamil Nadu. Percentage departures of annual aridity indices (I_a) from the respective median values were worked out for all stations in the region, plotted on a map and isolines drawn. This technique is somewhat similar to the rainfall decile method employed by Gibbs and Maher (1967).

Such charts drawn for all the years in the study period reveals broadly nine drought spells as detailed in Table 2.

In order to study the life-cycle of droughts, the nine drought sequences were examined in closer detail by preparing spread diagrams on a monthly basis by drawing isolines of departures of the monthly water deficiencies from the climatic median, expressed in units of thousandths of the annual water need.

One interesting feature of the spread diagram is that almost all the years exhibited water deficiency anomalies of noteworthy magnitudes only from July or August onwards. For example in August 1952, dry conditions prevailed all over the State with the cell of moderate intensity ($>$ 20) over the central districts (Fig. 1). Aridities increased all over the State in September with an intense dry region over north-eastern Tamil Nadu. Two dry-pockets were seen over Vellore and Tiruchirapalli ($>$ 70). This was the month of maximum drought intensities all over Tamil Nadu and neighbouring Andhra Pradesh. In October, there was a slight increase in aridity intensities and the two cells diffused considerably to form a north-south aridity gradient with a pocket around Pamban ($>$ 70).

After identifying the drought spells of various intensities and their spread, the cumulative effect of these water deficiencies were assessed by employing the cumulative deviation technique of Foley (1957). Cumulative mass diagram of the monthly deficiency from the median (expressed in units of thousandths of the mean annual water need) at selected stations for sequential drought situations were prepared and severity indices were calculated as gradients of the curves obtained. The severity indices for the four categories of droughts — moderate (M), large (L), severe (S) and disastrous (D) are respectively 0 to 10, 10 to 20, 20 to 40 and above 40, from the standpoint of cumulative categorization.

The diagram for Tiruchirapalli (Fig. 2) identifies the 4-month period from June to September 1959 as the actual dry spell with intensity of 30 units (severe drought). The severity of dry spells on a monthly basis is fairly consistent with the categorization on an annual basis except in perhumid and humid climates where even small monthly water deficiencies are reflected greatly in the annual I_a values.

An interesting result of the study is that in the coastal strips of dry sub-humid climates, the months October to December rarely experience drought spells perhaps due to the fairly dependable rainfall caused by Bay depressions and cyclonic storms. Severe droughts occur over the semi-arid zone between June and November. Most of the drought spells are short-lived — averaging about 2 months in the perhumid

and humid zones, 3 months in moist sub-humid zone and 4 months in the semi-arid zone.

The water balance approach to drought climatology is of great utility in the evaluation of realistic criteria for assessment of droughts as regards their duration, severity and spread — all important aspects in agricultural and hydrological planning.

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