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Qualitative agroclimatic assessment of rainfed crops

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सार – मौसम विज्ञान सम्बन्धी सूखा एक प्राकृतिक विपत्ति है एवं इससे किसी राष्ट्र की अर्थव्यवस्था दुष्प्रभावित हो सकती है। प्रस्तुत शोधपत्र में, सूखा के आकलन हेतु सामान्यकृत मानसून सूचकांक (जनरैलाइज्ड मानसून इंडैक्स, जी. एम. आई.) और उपज नमी सूचकांक (यील्ड मॉयश्चर इंडैक्स, वाई.एम.आई.) के विषय में चर्चा की गई है। उदाहरण के रूप में, महाराष्ट्र राज्य के शुष्क खेती क्षेत्र (डी.एफ.आर.) में, खरीफ ज्वार की उपज के आकलन हेतु इन सूचकांकों का अनुप्रयोग प्रस्तुत किया है। यह देखा गया है कि वाई. एम. आई. सूखा के प्रभाव की ओर संकेत करने वाला श्रेष्ठतर सूचकांक है। मानसूनी वर्षा ऋतु की आरम्भिक उत्तरोत्तर संचयी अवधियों के दौरान वाई. एम. आई. कृषि-जलवायुविक सूचकांक के शततमेकों के न्यून मानों को फसल पर सूखा के दुष्प्रभाव एवं उसके फलस्वरूप फसल उपज में संभावित कमी को पूर्व चेतावनी के रूप में लिया जा सकता है।

ABSTRACT. Meteorological drought is a natural disaster and it can adversely affect economy of a nation. In the present paper, two indices for drought assessment, namely, the Generalised Monsoon Index (GMI) and the Yield Moisture Index (YMI), have been discussed and as an example, their application to the assessment of kharif sorghum yields in the Dry Farming Region (DFR) of Maharashtra State has been presented. It is seen that YMI is a better indicator for assessing the drought impact. The low magnitudes of the percentiles of the YMI agroclimatic index occurring over the early successive cumulative periods of the monsoon rainfall season can be taken as an early warning of the adverse effect of drought on the crop and the consequent likely decrease in crop yield.

1. Introduction

Agricultural production, in many parts of India, continues to be largely dependent on weather and climatic fluctuations despite several impressive advances made in the field of agricultural technology over the last few decades. In India, the occurrence of two consecutive droughts, during 1965 and 1966, had caused much concern and interest in studying and evaluating the impact of weather and climate on crop production. Similarly, the severe drought associated with the failure of southwest monsoon during 1979 resulted in large scale crop failures. The occurrence of widespread drought conditions during successive three years, *viz.*, 1985, 1986 and 1987 has posed serious problems.

Agroclimatic assessments are based on a combination of short period weather assessments and climate/crop yield forecast models, both of which need to be determined for various agroclimatic regions. Qualitative agroclimatic assessment, on the other hand, provides reliable information on the potential abnormal food shortages likely to arise as a result of drought situations. For this purpose, in this paper, agroclimatic indices are employed to identify drought situations.

2. Methodology

Steyaert *et al.* (1981) and Achutuni *et al.* (1982) proposed agroclimatic assessment methods for early warning of drought/food shortages in south and southeast Asia. This approach involves the development of an agroclimatic crop index from long term records of climatic data and a predictable variable in the form of crop yield. The crop condition indices are related to the crop water demand and based mainly on monthly rainfall data.

Two of the indices for providing the monthly crop condition assessments proposed by Steyaert *et al.* are (1) Generalised Monsoon Index (GMI) and (2) Yield Moisture Index (YMI). The former is related to the rainfall during monsoon season (June to September), whereas YMI pertains to the specific crop under agroclimatic assessment.

2.1. *Generalised Monsoon Index (GMI)*

GMI for southwest monsoon areas has been defined as follows :

$$\mathrm{GMI} = \sum_i W_i P_i \qquad (1)$$

where,

P_i is the actual rainfall for the i^{th} month and $i=1$ for June, $i=2$ for July, $i=3$ for August and $i=4$ for September.

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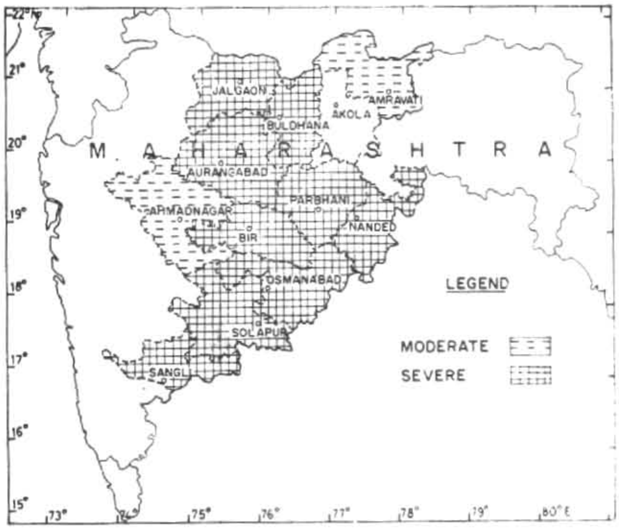

Fig. 1. Drought impact reflected by Yield Moisture Index (YMI) percentile ranks (July to October) in the dry farming region of Maharashtra State during 1985

TABLE 1

Monthly weights of Generalised Monsoon Index (GMI) and Yield Moisture Index (YMI) for kharif sorghum assessment in the dry farming region of Maharashtra State

Index weight	Jun	Jul	Aug	Sep	Oct
GMI (W_i)	0.21	0.29	0.22	0.28	—
YMI (C_{ij})	—	0.30	0.70	1.00	0.75
Phenophase	Sowing	Germination	Elongation	Flowering/ Grain formation	Maturity

W_i is the rainfall weight for the i^{th} month which is given by the ratio of the monthly normal rainfall for i^{th} month R_i to the normal seasonal rainfall $\sum_i R_i$ (June to September).

2.2. *Yield Moisture Index (YMI)*

The Yield Moisture Index (YMI) makes use of the crop coefficients to weight monthly rainfall during the crop growing season according to the relative water requirement between different crop stages.

For a particular crop, YMI, is defined as follows :

$$(\text{YMI})_j = \sum_i C_{ij} P_i' \qquad (2)$$

where, $(\text{YMI})_j$ is the Yield Moisture Index for the j^{th} crop (*e.g.*, rice, wheat, sorghum etc).

P_i' is the actual rainfall during the i^{th} crop stage (*e.g.*, $i=1$ for planting, $i=2$ for vegetative, $i=3$ for reproductive/flowering and $i=4$ for maturity).

C_{ij} is the appropriate crop coefficient for the j^{th} crop and i^{th} crop stage which is computed by the method given by Doorenbos and Pruitt (1977).

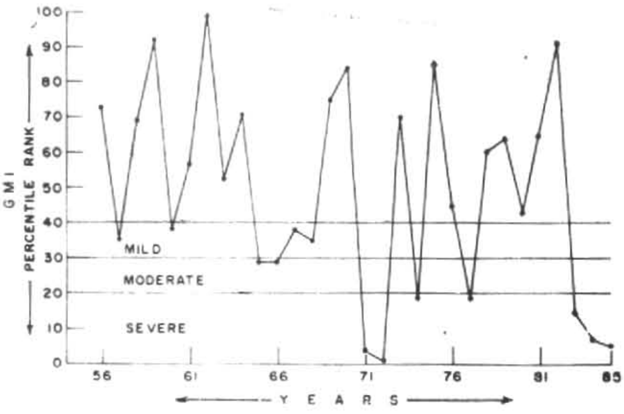

Fig. 2(a). Generalised Monsoon Index (GMI) for kharif sorghum assessment in the dry farming region of Maharashtra State

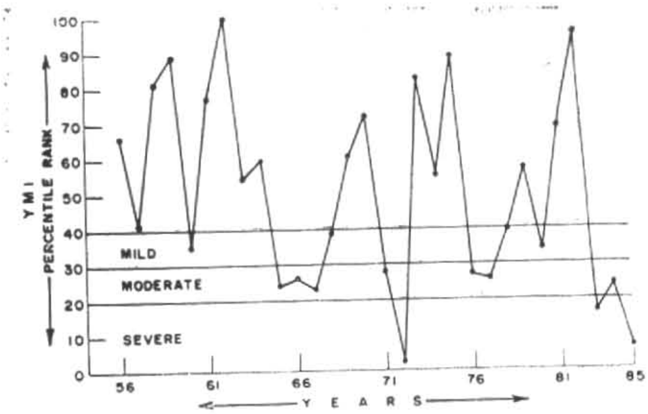

Fig. 2(b). Yield Moisture Index (YMI) for kharif sorghum assessment in the dry farming region of Maharashtra State

The crop coefficients for YMI were obtained by using,

(*a*) the Actual Evapotranspiration (AET) data for kharif sorghum available with the Agrimet Divison of India Meteorological Department at Pune and

(*b*) Potential Evapotranspiration (PET) values computed by Rao *et al.* (1971). AET data of Akola, Parbhani and Rahuri (Ahmednagar) were used for computing monthly YMI weights. At these stations, measurement of AET is carried out on a day-to-day basis with the help of gravimetric lysimeters installed in the midst of a large cropped field. The method involves the determination of the amount of moisture gained or lost by a suitably enclosed volume of natural soil.

The weights of GMI were computed by using climatic normal values of monthly rainfall for the period 190–150.

A description of kharif sorghum crop assessment in the Dry Framing Region (DFR) of Maharashtra State comprising of 12 districts is presented by using monthly district average rainfall data series of 30 years from 1956 to 1985. The situation for 1985 has been

TABLE 2

Percentage departures of sorghum yields *vs.* drought occasions reflected by Generalised Monsoon Index (GMI) and Yield Moisture Index (YMI) during 1956-85

Percentage departures of yields	GMI			YMI			Both GMI and YMI		
	m	M	S	m	M	S	m	M	S
40 to 60	1	—	—	1	—	—	1	—	—
20 to 40	—	—	—	—	—	—	—	—	—
0 to 20	3	—	2	2	3	1	1	—	1
0 to —20	—	1	2	1	2	1	—	1	1
—20 to —40	—	1	1	—	2	—	—	1	—
—40 to —60	—	—	2	—	—	1	—	—	1
Total	4	2	7	4	7	3	2	2	3

Note — m, M and S represent mild, moderate and severe drought respectively

TABLE 3

Generalised Monsoon Index (GMI) and Yield Moisture Index (YMI) analysis for kharif sorghum assessment in the dry farming region of Maharashtra State for 1985

Index value	GMI				YMI			
	Jun	Jun-Jul	Jun-Aug	Jun-Sep	Jul	Jul-Aug	Jul-Sep	Jul-Oct
Actual	31	72	89	107	109	198	270	366
Normal	27	79	117	163	139	341	521	588
Percent normal	118	92	76	66	79	58	52	62
Percentile rank	77	33	19	5	29	4	4	7

discussed in particular in the light of the GMI and YMI agroclimatic indices and Fig. 1 shows the extent and intensity of drought over the area.

Agroclimatic indices, GMI and YMI, were computed by using their respective weights and actual monthly district average rainfall figures. Percentile ranks of GMI and YMI were then computed and classified to identify droughts of mild, moderate and severe intensity.

Following criterion has been adopted to classify drought intensity :

Drought intensity		*Rainfall/GMI/YMI Percentile ranks*
Mild	(m)	30-40
Moderate	(M)	20-30
Severe	(S)	0-20

3. Results

The weights of GMI and YMI are given in Table 1. GMI shows higher weights in July and September whereas YMI weights attach more importance to September and October rainfall. Large scale drought studies conducted by Bhalme and Mooley (1980) suggest the importance of August and September rainfall to crops in India.

Figs. 2 (a & b) show drought impact revealed by GMI and YMI in the DFR of Maharashtra State during 1956–85 on the basis of above classification. Both indices revealed moderate drought during 1965 and 1966 and severe drought during 1972, 1983 and 1985.

Table 2 shows the occasions of drought reflected by the agroclimatic indices GMI and YMI in various class intervals of the percentage departures of sorghum yield. In the higher class interval (40 to 60%) only mild drought occurred in 1960. The yield departures below 20% were generally associated with drought on more than 40 per cent occasions except in 1960 during 1956-85. The maximum frequency of drought emerged when yield departures were within 0 to 20 per cent and a secondary maximum appeared within 0 to —20 per cent.

The percentile ranks of cumulative rainfall and GMI were of the same order decreasing progressively with the advance of monsoon season during 1985. The lowest value in the seasonal period (June–September) dropped to 5th percentile. But all cumulative values of YMI were below 10th percentile as shown in Table 3. This suggests YMI as a better indicator of drought impact (Fig. 1) for qualitative agroclimatic assessment of kharif sorghum crop in the DFR of Maharashtra

State. Also, lower percentiles of progressive cumulative periods serve to provide an early warning of drought related food shortages.

4. Conclusion

A sample assessment of kharif sorghum crop in a dry farming region of India for the year 1985 revealed large scale drought conditions over Maharashtra State associated with the slow progress of monsoon. Yield Moisture Index (YMI) appeared as a better drought indicator. Lower values of percentile ranks for the progressive cumulative periods of crop condition indices serve to provide an early warning of drought related shortfalls in food production. The departures of sorghum yields below 20% were generally associated with drought conditions during 1956-85 except in 1960.

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