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# Improving a drought early warning model for an arid region using a soil-moisture index

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A B S T R A C T

This study modifies a drought early warning model for Jodhpur district of Rajasthan State in India. The model had employed only two variables derived from the daily rainfall data and estimated pearl millet yield in order to issue a drought early warning. In this study, the model is modified by including an additional variable derived from a soil-moisture index. The modified model explained up to 77.3 percent of the yield variation. When tested, the mean absolute percent error in the estimated yield was 13.7 percent in the case of the modified model as opposed to 18.5% in the case of the existing model. The soil-moisture index and other variables derived from the rainfall data could be potential candidates for developing drought early warning models for other arid regions.



## Introduction

Arid regions are important parts of the world's farming systems. About 15 percent of the world's population live on arid lands which cover about one-third of the earth's land surface (Noin & Clarke, 1998, chap. 1). Droughts occur frequently in these regions and, as a result, crop yields are reduced significantly causing shortages of foodgrain as well as forage production. To handle such shortage-related situations, drought managers develop plans to import foodgrains for human population and forage for the livestock. Success of the drought planning depends on both the timing and the accuracy of drought early warning. The earlier the drought warning is available, the more effective and successful the drought planning will be. Considering the significance of a drought early warning, researchers have attempted to develop early warning models for different parts of the world, often including complex variables (Biatwright & Whitehead, 1986; Lohani & Loganathan, 1997; Morgan, 1985). In the case of arid regions, however, it is more appropriate to develop models using variables that can be derived from limited data available in these regions.

Present study is an attempt to improve a drought early warning model (Kumar, 1998) for Jodhpur district of Rajasthan State in India (Fig. 1). More than 60 percent of the total arid area in India lies in Rajasthan. Current system of providing drought early warning in India is subjective and not precise or objective as explained in the following section. Lately, Kumar (1998) developed an early warning model by predicting yield (production per unit area) of pearl millet, a single major crop of the Indian arid zone.

The present study was conducted to improve the drought early warning model. The decision to develop a drought early warning model for an arid district, and for not the entire Rajasthan, was based on the fact that there exists a significant spatial variation across state in soil types, average rainfall, crop varieties, and sowing dates. Crop varieties range from local to hybrids, from low to high tillering, and from early- to medium-duration cultivar (Bidinger, Weltzian, Mahalakshmi, Singh, & Rao, 1994).

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**Fig. 1.** A map showing the location of Jodhpur district (shaded) of Rajasthan State in India.

There is a large variation in soil types across Rajasthan. While loamy to fine sand (Typic Torripsamments) dominates western and northern parts of the state, loam (Lithic Haplocambids) to sandy loam (Typic Haplocambids) dominate central and mid-eastern parts of the state. Annual rainfall too varies significantly across state. While western parts may experience rainfall as low as less than 100 mm, rainfall may exceed 400 mm in south-eastern parts of Rajasthan. Therefore, a single model for the entire state is less likely to be effective in predicting pearl millet yield.

The drought model selected for this study was based on the variables derived primarily from the daily rainfall data. The objective of this study was to develop a soil-moisture index to improve the predictive power of this model and hence improve drought early warning.

## Study area

The study area includes Jodhpur district which is one of the 33 administrative districts of Rajasthan located in north-western part of India. Its latitude ranges from 25° 99′ to 27° 29′ N and longitude varies from 71° 59′ to 73° 46′ E. Agriculture is the main livelihood of the rural population living in this district. Farmers grow various crops including pearl millet, beans, and seasamum, but pearl millet is the main staple crop of the district and is predominantly sown not only in this district but also in the entire arid region of India. The majority of the Indian arid zone falls within Rajasthan and in parts of the adjoining states of Gujarat and Haryana. Less than 10 percent of agricultural land is irrigated in the study area and hence crops rely mainly on rains brought in by the Indian monsoon. Crops are sown during June–July, soon after the arrival of the monsoon and are harvested during September–October. The period from July through September receives about 90% of the total annual rainfall, about 300 mm, that occurs with a coefficient of variation exceeding 100 percent.

The Indian monsoon first develops in May at the southwest coast of India and progresses northward through the central part of India. As per the India Meteorological Department (IMD), the monsoon is scheduled to enter the study area on July 1 if the development and progression of the monsoon remains normal. Any delay, failure, or erratic behavior of monsoon causes droughts.

The state officials in Rajasthan monitor drought situations on the basis of the rainfall data and the reports on crop conditions prepared after field visits by government staff. If drought appears to be developing due to inadequate rains or their uneven distribution, the drought planners communicate with the federal government and other agencies such as Food Corporation of India, and may begin planning to import foodgrains and forage in order to make these commodities available in time to prevent any sufferings to human population or the livestock. If the severity of drought happens to be high, foreign agencies or governments may also be approached by the federal government to import these commodities.