THE ANALYSIS OF RAINFALL RELIABILITY FOR PROBABILITY ESTIMATES OF CROP WATER DEFICITS

Rosemary Williams*

Rainfall reliability and distribution are much studied, but when change engenders questions which require answers in specific forms it may be desirable to develop new analytical techniques to provide them. Planned changes in agriculture, particularly new cropping systems and water control schemes, throw up the question: how far will rainfall meet crop water requirements under a given cropping regime; or, put another way, perhaps more relevant to the planning of irrigation schemes, what is the likelihood of a shortfall at important stages of growth, and how big is the probable deficit?

My research attempted to initiate the development of techniques which would be both simple enough to require only such information on rainfall and crop water requirements as might be readily available (e.g. daily rainfall records, open water evaporation records) and complex enough to give answers useful for policy making. Accordingly a method was outlined for measuring the range of rainfall to be expected with a known degree of probability for each of a series of short periods over the year. This is, of course, simply an extension of existing climatological analyses with important differences in the use of short periods and in the method of measuring expected rainfall to take account of the skewness of rainfall distributions so that the measures of variability are not dependent on the mean.

A standard length of ten days was used for the analysis. This question warrants more attention as, in principle, the period length could perhaps be related more closely to crop growth. Measures of probable expected rainfall were found by transforming the observed distributions of weekly rainfall for all years of available data to approximate normality, using either a logarithmic ($\log(x + c)$) transformation or one of the form x^{1-n} (where x is the observed weekly rainfall, c is a constant and $0 \langle\ n\ \rangle 1$). Periods for which the transformation was successful permitted the calculation of

---

* Rosemary Williams worked as a Research Assistant at IDS on a funded project from April 1969 to June 1971. The data came from Bihar, India.

confidence limits corresponding to three given probability levels using the mean and standard deviation of the transformed distribution and these defined the range of rainfall expected at that probability.

Here, too, there is much scope for improvement since these transformations were only used successfully for periods in the wet season. It may be that fitting known (e.g. Pearson) distributions to each period according to its characteristics would permit probabilities to be measured for all periods in the year. The analysis does not allow prediction of probable rainfall in any given year, nor does it tackle the question of interdependence between one period and another. Nevertheless, this form of presenting rainfall probabilities as a range of rainfall to be expected in *a* years out of *b* may be more useful to workers in agriculture than, for instance, measures of annual or monthly percentage variability.

The second possibility explored was a method for estimating probable water deficits for a crop in specific circumstances. For any farming system crop water requirements may be postulated in relation to predicted open water evaporation. For a crop planted on a particular date cumulative crop water requirement (or potential evapotranspiration) may be predicted and plotted over time for comparison with 'most probable' cumulative rainfall measured from the same date. This gives an estimate of the adequacy of rainfall to meet crop water needs. Accumulation of rainfall (which should be corrected for run-off and deep percolation) and crop water requirement takes place over periods defined by the estimated rate of depletion of soil water from field capacity to permanent wilting point.

Distributions of cumulative rainfall for each period over all years of available data are used to measure 'most probable' cumulative rainfall in that period. Again there is scope here for curve fitting to each distribution on its merits for accurate measures of probability. Distributions of differences between crop water requirement and cumulative rainfall for each period for each year of available data may be formed in the same way and curve fitting undertaken to find the most probable differences between supply and need. Even given the drawbacks involved in using potential evapotranspiration as a proxy for crop water requirement, and the drawbacks in the assumption that rainfall equals water available for plant use, it should be possible to see at what points in the growth cycle deficits may occur. The more accurate the figures for supply and need, of course, the more accurate will be any measures of most likely differences, so that there is plenty of scope for improving on these.

The farmer is more concerned with the problem of uncertainty – will there be enough rain this year? – than that of risk – in ten years how often will rainfall be deficient? The problem of predicting crop water stress at any given moment, possibly using soil water potential as an indicator of plant-soil-water conditions, was therefore touched upon as a logical development out of the work on risk.

The report, containing computer programmes of the two routines described, is very much in the nature of a working paper and has in fact been used as such at a seminar on rainfall reliability analysis at the Indian Agricultural Research Institute Division of Agricultural Economics in May 1972. It was also used as a background paper for the Indian Council of Agricultural Research – India Meteorological Department Joint Study Group on rainfall reliability analysis in October 1972, which met to consider the systematic study of rainfall reliability on an all-India basis and the publication of a periodical containing papers about applications of the analysis.

Paper

'The analysis of rainfall reliability for probability estimates of crop water deficits'. Report submitted to ODA, November 1973. Not yet available for dissemination.