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A note on the Statistical Assessment of Probability of Rainfall and its Agricultural Significance

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The value of rainfall to agriculture depends as much on its distribution and reliability as on its absolute amount. Farmers in regions with a long established agricultural tradition, are fortunate in having the heritage of the accumulated weather lore of centuries for their guidance. This enables them to assess their chances of successful crop production. In the absence of reliable weather lore, the enlightened farmer, has had perforce to use rainfall means as an indication of likely expectation of rain, his most important climatic factor. Such expectations without reference to variability may often be quite misleading. The failure to allow for this variability has led to disappointing results in some agricultural ventures, and may account in part for the fatalistic attitude adopted towards attempts at predicting rainfall expectation. Hence it is proposed to expound in this note that an efficient expression of rainfall variability, which is of fundamental importance to the better understanding of seasonal crop variation, is statistically practicable, with the annual rainfall data of Nagercoil – Kanyakumari District.

Nagercoil, situated as it is at 8° latitude to the north of the equator, is expected to experience occasional periods of convection storms, typical of tropical rainfall, which may distort the mean rainfall figure to such an extent as to destroy its value as a measure of central tendency. An examination of the past records would, of course, indicate the likely extremes, but without a measure of variability the frequency of occurrence of rainfall would remain uncertain. Expressions of rainfall variability and reliability have been devised by meteorologists, but the concept of 'confidence limits' introduced by Manning has, of late, found wider application in the field of agricultural meteorology[1,2,3]. The confidence limits estimate the chance or rather the risk of obtaining values that lie outside prescribed limits for a given statistic, like mean annual rainfall as in this study or, in other words, they may be said to define a range together with an associated probability, which expresses the confidence that a particular value lies within the range and consequently, the possibility of exceeding the limits set, will become obvious. The limits within which the rainfall may be expected to lie can be set according to need, that is, such limits can be calculated to any required level of probability. For example, with 9 : 1 confidence limits, an annual rainfall value outside these limits can be expected only once in ten years (i. e. 90% fiducial probability or $p=0{\cdot}1$) and of these deviations, half (i. e. once in twenty years) are to be expected below the lower limit and the other half above the upper limit. This indicates that only once in twenty years the rainfall can be expected to fall either below the lower limit or exceed the upper limit.

The calculation of confidence limits is illustrated from an analysis of the annual rainfall totals for the 36 year period (1921—1956) for Nagercoil. The mean and the standard deviation were calculated for the data. Given the standard deviation and the values for 't' for the required levels of probability, the computation of confidence limits for minimum and maximum rainfall expectation, is a simple statistical procedure. This, of course, assumes that the frequency distribution of annual rainfall of Nagercoil over a period of 36 years is normal in form. The calculation of the measures of skewness, g_1 and g_2 with their respective standard errors (vide table), proved the normality of the data under study.[4] The confidence limits for various levels of probability ranging from $p=0{\cdot}5$ to $p=0{\cdot}05$ were worked out and the comparisons of expectation and observation are given in the table appended.

It is obvious from the table that there is quite a good agreement between the expected and the actual observed deviations in annual rainfall even under a stringent level of probability like $p=0{\cdot}05$. Expressed in terms of confidence limits for $p=0{\cdot}05$, values outside the limits of 19·06 inches and 56·86 inches of rain, would be expected to occur nearly two times in 36 years and in fact it is noticed that these limits were exceeded three times in this period. As expected, these deviations tend to fall almost equally below and above the prescribed limits, under all levels of probability. Thus for $p=0{\cdot}5$, giving a minimum expectation for three years in four, the farmers in Nagercoil can be sure of receiving at least 31·61 inches of rain and in fact it is seen that they have received this amount of annual rainfall 28 times in a period of 36 years, the expectation for the period being only 27 times. If such an annual total rainfall is required for getting bumber crops, they can afford to run the risk of losing a crop about once in four years, the prospects for the other three years being definitely to their advantage. In considering the risk of crop loss through inadequate rainfall, it is more rational to think of the lower limit than the mean rainfall. Hence, while assessing the agricultural significance of an area a statement concerning the reliability of rainfall will be of great value and for this purpose information on the least amount and the greatest amount, likely to be received over a specified number of seasons would be more useful than the mean. This, in fact, would specify the crop risk either from too dry or too wet conditions. It is seen, therefore, that this study clearly demonstrates the value for the assessment of rainfall probability, of minimum and maximum rainfall expectations calculated from the statistical properties of the normal curve. Suitable transformations are available for rainfall data which are asymmetrically distributed.[1] So, this concept of rainfall expectation at selected levels of probability can be deemed a completely objective and reliable estimate of rainfall to be expected, and thus is bound to be of immense use in assessing long-term crop risk, which is not usually apparent when means alone are considered.

REFERENCES

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TABLE I.

Analysis of 36 years' (1921—1956) annual rainfall at Nagercoil (Data in inches).

Confidence limits for various levels of p.

S No.	Probability (p)	Confidence interval (years)	Chances of falling outside, either the lower limit or the upper limit, once in (years)	Confidence Limits of rainfall in inches		Deviation from limits				
				Lower	Upper	Expected + values —	Actual observed values: Below the lower limit	Actual observed values: Above the upper limit	Total expected	Total observed
1	0·5	1 in 2	4	31·61	44·31	9·0	8	7	18·0	15
2	0·2	4 in 5	10	25·80	50·12	3·6	4	4	7·2	8
3	0·1	9 in 10	20	22·23	53·69	1·8	2	2	3·6	4
4	0·05	19 in 20	40	19·06	56·86	0·9	1	2	1·8	3

Mean Annual Rainfall: 37·96 inches. Standard deviation=9·31 inches.

Measures of skewness of the distribution of annual rainfall: $g_1 = -0{\cdot}8011$, S. E. $g_1 = 0{\cdot}4008$. $g_2 = 0{\cdot}1770$, S. E. $g_2 = 0{\cdot}7681$.