Prediction of consecutive days rainfall from one day rainfall for Bundelkhand region during monsoon season

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ABSTRACT

Two to six consecutive day rainfall totals corresponding from 2 to 20 years and crop tolerance period in determining the drainage coefficient for agricultural fields. In the present study, 30 years daily rainfall data for the monsoon period of Jhansi in the Bundelkhand region was used to investigate the relationship between 1-day rainfall and 2-6 days consecutive day rainfall for return periods 1-20 years. For this purpose various statistical tools were used to test the agreement between the predicted and observed rainfall of various consecutive days. The equation developed in this study showed about 80 percent accuracy in predicting consecutive day rainfall total from known value of 1 day rainfall.

Key Words: Drainage coefficient, Rainfall, Consecutive days, Crop tolerance, Return period.

Agricultural production in India is very much dependent on the rainfall particularly in Bundelkhand region of central India. The production can be increased if rain water is efficiently utilized in predominantly rainfed regions. Prediction of rainfall, therefore, is dire necessity for the arid and semi-arid regions. Despite the erratic and random nature, rainfall can be predicted reasonably for certain return periods using probability analysis, as it is an important parameter for hydrological design of drainage system.

If one is interested in planning and evolving certain drainage criteria for different crops, study of rainfall duration and amount of maximum rainfall of various return period is required depending on crop tolerance period. For estimating the drainage coefficient for agricultural crops, one needs to know the total rainfall over duration of crop tolerance period (Bhattacharya *et al.* 1982). Normally, the tolerance period of crops vary from 1 day (for pulses) to 6 days (for rice). Upadhyay *et al.* (1998), estimated the one day as well as 2 to 6 days consecutive days rainfall using various probability distribution such as log normal, pearson type III, log pearson type III, Extreme value type I, log extreme value type I and gamma distribution.

This paper attempts to estimate 2 to 6 consecutive day rainfall from known value of one day rainfall during monsoon season with reasonable accuracy for desired recurrence interval for Jhansi district of

Bundelkhand region. The study area Jhansi is located at 78° 35'E long. 25° 27' N lat. and 271 m above msl in semi arid region of Bundelkhand. It receives an average annual rainfall of 909.0 mm.

MATERIALS AND METHOD

Daily rainfall data of 30 years (1971-2000) for Jhansi was collected and compiled from India Meteorological Department (IMD), Pune and Indian Grassland & Fodder Research Institute, Jhansi. Daily rainfall data during mid June to mid October i.e. during monsoon is used for this study. In order to analyze the rainfall data, Gringorten's plotting position was applied as Weibull's formula gives largest value of rainfall at too small return period (Chow et al., 1988). Probability of the rainfall exceeding a certain amount were computed using Gringorten's formula given below:

$$P(y \geq Yr) = \frac{m - b}{n + (1 - 2b)}$$

where, P (Y ≥ Yr) is the probability of rainfall greater than or equal to Yr, 'm' is the rank number when arranged in descending order, 'n' is the number of years and the value of 'b' is 0.44.

Since inverse of probability of exceedence gives return period, six series for various return periods and rainfall values were obtained. Investigation was done both graphically and statistically to find out the predictability of 2-6 consecutive day rainfall total from one day rainfall at recurrence interval (RI) using

SPSS base 11.0. Rainfall values were plotted against return periods and six logarithmic equations of best fit were obtained (Table 1). Using these equations rainfall for 1 day as well as 2,3,4,5 and 6 consecutive days corresponding to the return period varying from 1 to 20 years (1 to 10 years at an interval of 1 year and 15 & 20 years) were computed.

RESULTS AND DISCUSSION

The rainfall values of 1 day rainfall and 2,3,4,5 and 6 consecutive days rainfall total estimated using equations given in Table 1 were graphically represented in Fig. 1. As the figure shows linear relationship between 1 day and 2 to 6 consecutive day rainfall total over the range of recurrence interval from 1 to 20 years, the regression equations were also obtained. The relevant regression equations and parameters with respect to each of the lines of Fig. 1 are depicted in Table 2.

Statistical analysis revealed that all the regression parameters were significant at 5 percent probability level. Also the R^2 values for each regression equations indicated that over 99 percent variations in 2 to 6 consecutive days rainfall is accounted for by the variation in one day rainfall over the recurrence interval from 1 to 20 years. Both slope and intercept of regression equations are showing increasing trend with an increase in number of consecutive days.

Since use of large number of regression equations is not expeditious for prediction, it was investigated if the five equations of Table 2 could be combined.

Table 1: Regression equations of best fit

Variables	Equations	Coefficient of determination (R^2)
1 day Vs RI	$Y = 5.0 + 27.54 \log x$	0.968
2 day Vs RI	$Y = 22.62 + 53.31 \log x$	0.917
3 day Vs RI	$Y = 46.26 + 73.05 \log x$	0.898
4 day Vs RI	$Y = 82.47 + 70.76 \log x$	0.801
5 day Vs RI	$Y = 106.69 + 69.67 \log x$	0.806
6 day Vs RI	$Y = 129.43 + 77.21 \log x$	0.930

Table 2: Regression equations of 2,3,4,5 and 6 consecutive day rainfall as a function of one day rainfall.

Variables of regression	Equations	Coefficient of determination (R^2)
2 days Vs 1 day	$Y = 1.963 x + 12.931$	0.997
3 days Vs 1 day	$Y = 2.653 x + 32.973$	0.993
4 days Vs 1 day	$Y = 2.57 x + 69.611$	0.995
5 days Vs 1 day	$Y = 2.53 x + 94.022$	0.992
6 days Vs 1 day	$Y = 2.80 x + 115.395$	0.994

Table 3 : Regression of slope (m) and intercept (c) of the equations of Table 2 with duration (D) of consecutive day rainfall

| Relationship	Equations	Coefficient of determination (R^2)
Slope Vs days	$m = 0.161 D + 1.853$	0.59
Intercept Vs days	$c = 26.597 D - 41.404$	0.99

In this respect, finding an average regression would not be scientific as the variations of the slope and the intercept are not random but are directional. Further, the multiple regression approach could not be adopted because of unknown nature of relation between one day rain, consecutive days rain and the corresponding duration. Thus a simpler method as suggested by Singh et al. (1992) was adopted to investigate the predictability of the slope and intercept of the regressions as function of duration. Simple linear regressions were obtained between the slope and duration, and intercept and duration (Table 3).

It is evident from the table that these regressions are also significant and

Table 4 : Absolute difference between predicted and observed values of consecutive day rainfall

Return period (years)	Absolute difference (%)				
	2 day	3 day	4 day	5 day	6 day
1	10.20	18.25	16.06	11.69	12.20
2	15.32	11.79	15.36	10.55	11.97
3	16.48	10.51	15.18	10.15	11.78
4	17.44	11.51	14.89	10.26	11.81
5	17.98	12.18	14.72	10.53	11.81
6	18.00	12.91	14.79	10.56	11.65
7	18.41	13.19	14.62	10.77	11.71
8	18.59	13.52	14.56	10.88	11.69
9	18.71	13.80	14.54	10.95	11.65
10	18.65	14.15	14.60	10.94	11.55
15	19.20	14.81	14.38	11.28	11.56
20	19.34	15.34	14.36	11.40	11.47
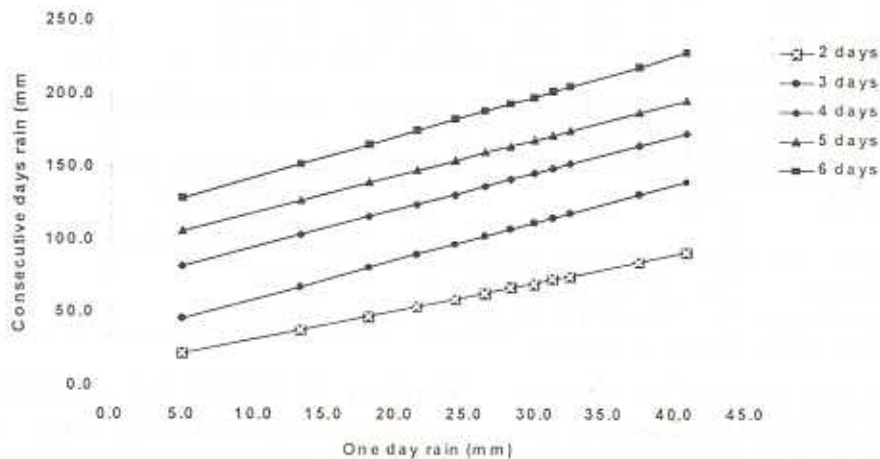
Fig. 1: Relationship between various consecutive day rain with one day rain over a range of recurrence interval

59 and 99 percent variations of the slope and intercept respectively could be accounted for by the variation in the duration of the consecutive day rainfall. Hence, these two equations can be combined to obtain a general prediction

equation as:

$$Y = (0.161\ D + 1.853)* X + 26.597\ D - 41.404 \qquad \ldots\ldots\ldots\ldots(1)$$

where, Y - rainfall total (mm) in D consecutive days; X - 1 day rainfall (mm).

This equation is valid for predicting consecutive day rainfall for 2-6 day over the recurrence interval of 2-20 years for the data used. The values of 2-6 consecutive day rains were predicted using equation (1) corresponding to 1 day rain for each of the chosen return period. These values were compared with observed values to evaluate the performance of the equation. The absolute difference between the observed and predicted values of consecutive day rainfall magnitude of return periods 1-20 years is given in Table 4.

It is clear from the table that absolute difference is not more than 20 percent in any case. Moreover, the prediction in case of 5 & 6 consecutive day rainfall magnitude are 85 percent accurate because absolute difference between predicted and observed values are well below 15 percent. Thus the equation (1) is expected to predict 2-6 consecutive day rainfall magnitude for return periods 2-20 years with 80 percent accuracy.

CONCLUSION

Usually, engineers and hydrologists consider 5 or 10 year recurrence interval hydrological events for designing of engineering measures in agricultural fields. Thus, regression equation (1) would be useful for predicting various consecutive day rainfall from the known value of 1-day rainfall with reasonable accuracy for the recurrence interval of 5 or 10 years though, the presently developed relationships are specific to the data used.

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