THE PREDICTION OF RAINFALL INTENSITIES OF DIFFERENT DURATION AND RETURN PERIODS FROM DAILY RAINFALL DATA IN TANZANIA - PART II

J. Dumelow
Dept. of Agricultural Engineering and Land Planning,
University of Dar es Salaam.

The application of multiple regression to daily rainfall data to determine an equation for prediction of rainfall intensity

(The symbols used are those defined in part I).
Consider a return period of 2 years.

For a duration of 24 hours.

$$h = h_{24}$$

For a different duration

$$h = h_{24} \times f(t)$$

where f (t) = 1 when t = 24 hours

Various forms of f (t) were tried but the form that fitted the data best was found to be

$$f(t) = a + b\ln t$$

where a and b are constants

$$\therefore h = h_{24}(a + b\ln t)$$

$$\therefore \left(\frac{h}{h_{24}}\right) = b(\ln t) + a$$

$$\text{c.f. } y = mx + c$$

This equation is now of linear form and a linear regression computer programme can be applied to it. When the data for Tanzania, [Dar es Salaam (1942 - 1962), Dodoma (1942 - 1962), Kigoma (1939 - 1962), Mbeya (1932 - 1958)] was applied to the programme the values of the constants obtained were as follows:

$$a = 0.57$$

$$b = 0.14$$

Correlation coefficient r = 0.99

Now consider a modification for return periods other than two years:

$$h = h_{24} (0.57 + 0.14 \ln t) \times f(T)$$

where (fT) = 1 when T = 2 years.

Various forms of f (T) were tried but the form that fitted the data best was found to be

$$f(T) = c + d\ln T$$

where c and d are constants

$$\therefore h = h_{24} (0.57 + 0.14 \ln t)(c + d\ln T)$$

$$\therefore \left(\frac{h}{h_{24}(0.57 + 0.14 \ln t)}\right) = d(\ln T) + c$$

$$\text{c.f. } = mx + c$$

This equation is now of linear form and a linear regression computer programme can be applied to it. In this case the values of the constants were found to be as follows

$$c = 0.84$$

$$d = 0.25$$

Correlation coefficient r = 0.85.

$$\therefore h = h_{24} (0.84 + 0.25 \ln T)(0.57 + 0.14 \ln t)$$

It was observed that values of h calculated using this equation tended to be excessively high when applied to areas with high rainfalls. The following modification was therefore proposed.

$$h = h_{24}(e + fh_{24})\ (0.84 + 0.25\ \ln T)\ (0.57 + 0.14\ \ln t)$$

where e and f are constants

$$\therefore \left(\frac{h}{h_{24}(0.84 + 0.25\ \ln T)\ (0.57 + 0.14\ \ln t)}\right) = f(h_{24}) + e$$

$$\text{c.f.} \quad y = mx + c$$

The following values of the constants were found when linear regression was applied:

$e = 1.37$

$f = -0.0056$

$r = -0.39$

The correlation coefficient is rather poor but nevertheless this seemed to give better results overall

$$\therefore h = h_{24}\ (1.37 - 0.0056h_{24})\ (0.84 + 0.25\ \ln T)\ (0.57 + 0.14\ \ln t)$$

The values of the constants in the equation can now be improved by applying multiple regression as follows.

To improve the values of a and b apply linear regression to the equation

$$\left(\frac{h}{h_{24}\ (1.37 - 0.0056\ h_{24})\ (0.84 + 0.25\ \ln T)}\right) = b(\ln t) + a$$

This gives $a = 0.62$

$b = 0.20$

$r = 0.95$

To improve the values of c and d apply linear regression to the equation.

$$\left(\frac{h}{h_{24}(1.37-0.0056h_{24})\ (0.62 + 0.2\ \ln t)}\right) = d(\ln T) + c$$

This gives $c = 0.80$

$d = 0.26$

$r = 0.84$

To improve the values of e and f apply linear regression to the equation.

$$\left(\frac{h}{h_{24}(0.8 + 0.26\ \ln T)\ (0.62 + 0.2\ \ln\ t)}\right) = f\ (h_{24}) + e$$

This gives $e = 1.39$

$f = -0.0057$

$r = -0.52$ (c.f. -0.39 previously)

To improve the values of a and b further apply linear regression to the equation.

$$\left(\frac{h}{h_{24}\ (1.39 - 0.0057\ h_{24})\ (0.8 + 0.26\ \ln T)}\right) = b(\ln t) + a$$

This gives a = 0.62 (as before)

b = 0.20 (as before)

r = 0.95 (as before)

To improve the values of c and d further apply linear regression to the equation.

$$\left(\frac{h}{h_{24}\ (1.39 - 0.0057\ h_{24})\ (0.62 + 0.2\ \ln t)}\right) = d(\ln T) + c$$

This gives c = 0.83

d = 0.24

r = 0.93 (c.f. 0.84 previously)

To improve the values of e and f further apply linear regression to the equation.

$$\left(\frac{h}{h_{24}\ (0.83 + 0.24\ \ln T)\ (0.62 + 0.2\ \ln t)}\right) = f(h_{24}) + e$$

This gives e = 1.40

f = -0.0058

r = -0.52 (as before)

Further applications of linear regression result in no further changes in the constants or the correlation coefficients.
Therefore the final equation is:

$$h = h_{24}\ (1.4 - 0.0058\ h_{24})\ (0.83 + 0.24\ \ln T)\ (0.62 + 0.2\ \ln t)$$