Determination of surface drainage coefficient - a case study of Doimukh (Arunachal Pradesh), India

P. P. Dabral*, Amardeep Kumar and Gymar Tana

(Department of Agricultural Engineering, North Eastern Regional Institute of Science and Technology (Deemed University), Nirjuli (Itanagar)-791109, Arunachal Pradesh)

Abstract: In this study, one day to 7 consecutive days annual maximum rainfall was predicted at various return periods using probability distribution functions for Doimukh (Arunachal Pradesh), India. Basic infiltration (Ib) rate value was estimated 10 mm h-1 for the agricultural field having sandy soil. The drainage coefficient was estimated for 5, 10, 20 and 25 years R.I. by subtracting basic infiltration rate from estimated consecutive day rainfall. For the study area, the maximum value of drainage coefficient at 25 years recurrence interval varied from 41.37 mm day-1 to 304.23 mm day-1 for 2 to 7 days consecutive rainfall. The minimum value of drainage coefficient at 5 years interval varied from 0 to 212.30 mm day-1 for 2 to 7 days consecutive rainfall. Study concluded that sandy soil of Doimukh (Arunachal Pradesh) having basic infiltration rate 10 mm h-1 had to be provided with agricultural drainage for its major crops grown in the area.

Keywords: consecutive days, annual maximum rainfall, probability distribution functions, basic infiltration rate, drainage coefficient

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1 Introduction

Drainage is the removal of excess water from an area. The source of excess water at a place is the rain falling over the place and the runoff flowing from the other places at higher elevation. Crops grow well and produce good yields under an aerated or well-drained root zone environment. Waterlogging suffocates the roots of the crop plants and they are then unable to absorb nutrient solutions from the soil. Hence, they become sick and their yields are reduced. If the waterlogging condition continues for a long time, the plants may even die.

The drainage need is expressed in terms of drainage coefficient. Drainage coefficient (DC) is expressed as the depth in centimeter of water drained off from a given area in 24 h. If the rate of drainage is not assessable by direct measurement, indirect method of its estimation such as analysis of rainfall will be used. The drainage coefficient for any region varies with the geographical locations, land use, sizes of area, rainfall intensity, frequency and duration and other climatic factors. Rainfall is the most important factor influencing the value of drainage coefficient and large number of rainfall data is required for its depth duration frequency analysis. Higher the rainfall less often it occurs. Higher the recurrence interval, higher the design rainfall is to implying more costly project with less risk of failure. An average failure of 5 to 10 years is generally accepted for agricultural land drainage since cropping pattern in a particular area changes fast. Particularly, for flat lands with slopes ranging between 0% - 0.05% the design rate of removal of excess surface water is decided by the interaction of crop loss due to water logging. The design drainage rate for surface drainage is commonly taken as approximately 9.3 mm day^{-1} of agricultural watersheds of various command areas of the country, irrespective of the agro meteorological conditions such as type of crops grown, soil or rainfall pattern. Bhattacharya et al. (1982) reported

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***Corresponding author: PARMENDRA PRASAD DABRAL,** Department of Agricultural Engineering, NERIST, Nirjuli-791109, Arunachal Pradesh, India. Email: ppdabral1962@ gmail.com

that for estimating drainage rate for agricultural crops one needs to know the total rainfall over duration of crop tolerance period. It is possible to allow excess water condition to the crops for few days in agricultural drainage depending upon sensitivity of crop to excess water condition.

Sharma et al. (1997) stated that soils of Tawa command having basic infiltration rate 1 to 3 mm h^{-1} required surface drainage system for its existing major crop sequence soybean followed by wheat. Patle et al. (2005) determined the surface drainage coefficient for agricultural watershed at Central Research Station of PDKV Akola (CRS), India. For this purpose 25 years daily rainfall data was used for its depth – duration – frequency analysis to get one to four consecutive days rainfall values for 2, 5, 10 and 20 years recurrence interval (R.I.).

Dabral and Baithuri (2008) estimated surface drainage coefficient for North Lakhimpur, (Assam), India using 24 years daily rainfall data (1981-2004). They determined the year wise one to 7 consecutive days maximum rainfall. Three commonly used distribution functions (Normal, Log normal and Gamma) were fitted. The drainage coefficients were calculated by subtracting basic infiltration rate from consecutive days maximum rainfall for R.I. of 2, 5, 10 and 20 years. They concluded that soil of North Lakhimpur (Assam), India having predominantly loamy to clay loam and having basic infiltration rate between one to 5 mm h^{-1} may necessarily have to be provided with agricultural land drainage for its major crops grown in the area.

"Rice is a major food crop over a larger part of asia. Drainage becomes important if some of the monsoon rainfall events are of such high and magnitude that they create large scale land and crop inundation. Rain falling over a region by itself may not cause such problems. But the accumulation of runoff from higher lands over the relatively low land cause excessive water congestion and standing water on the crop fields. Runoff water is usually silt laden and is translucent or opaque to light, depending on the sediment concentration in the runoff water. If a plant gets substantially submerged by such water, its photosynthesis activity is seriously affected. For most rice varieties plant inundation above a certain height and beyond a certain continuous days is injurious to the plant even if water is clear. This danger is more at the initial stages of the plant establishment, during mid-June to mid-July. Lysimetric studies on the effect of paddy plant submergence by different extent and for a varying number of days have shown that the seedling stage (June-July) is the most vulnerable stage. If a plant is submerged by 40 cm(i.e. 40 cm of water above the topmost leaf of the plant), and if the drainage rate is so adjusted as to remove this water in 12 days, the loss of yield will be 72% of the normal production"(Maity and Singh.1989). Sudden rainfall bursts at a time near the maturity of the plants is also harmful as it delays maturity. If associated with high winds, such rainfalls and consequent runoff accumulation cause widespread lodging of the rice plants. A prolonged water logging and crop lodging at the maturity stage of rice, during mid-September to mid–October for example, cause delay in harvest resulting in the regermination of paddy grains while still on the plants and also rotting of the plants and the grains (Bhattachrya and Michael, 2003).

Goswami (2005) grown vegetables like pointed gourd, brinjal, cauliflower and cabbage and obtained good yield in rainy season when they were grown on raised bed in sandy loam soils in the lower of Gangetic alluvial plains of West Bengal (India). The provision of open drains consisting of main, lateral and sub lateral in sandy loam soil condition proved worthiness to alternative the water congestion in vegetables grown in rainy season in the study area. The adopted drainage design in the study was trapezoidal sections (top 40-60 cm; bottom 30-50 cm with side slopes 1.2-1.6 and depth 10-25 cm) and drainage channel length varied to the order of 8-16 cm and sub-lateral and main drain were spaced at 0.6-1.0 m, 6-8 m, 8-16 m apart respectively in accordance with the requirement and slope of the land. As a result a provision of open drainage in the vegetable field the drainage rate improved up to 10.8-25 ls^{-1} and 2-6 cm ponded water drained out in 30-40 minutes and excess surface water drains within 4-5 h when peak intensity of rainfall varied from 30-45 mm h^{-1}. He reported damage severity due to drainage problem in vegetables from average rain storm of 30-40 mm at different stages of crop growth with drainage design and with no drainage design. With adopted designed surface drainage system, all vegetables were safe at seedling and fruiting stage for all selected vegetables. With no drainage design the damage severity varied 25%-50% in all selected vegetables during the seedling stage. However, among the selected vegetables brinjal was found more susceptible to waterlogging. He also calculated cost per ha in constructing for surface drains for pointed gourd, brinjal, cauliflower and cabbage □ 2205, 4068,1470,1470 respectively.

Awasthi (1988) during 1982-85 determined the economics of drainage for tea crop based upon the data collected from six different sites in Dooars and Terai region of W.B. (India), covering about 1000 ha under improved drainage system. He reported cost benefit ratio varying 1:3 and 1:9 indicating that total cost incurred in installing drains could be released during the first year itself.

"Humid regions of India receive annual rainfall in excess of 1000 mm, much of which comes as heavy rains in short spells. About 80% of the annual rainfall is received in 3 months and 80% of this occurs in about 8 to 10 rainfall events. In a region receiving 1500 mm annual rainfall, one may expect a rainfall of about 100 mm in one day and a major portion of this may occur in a few hours. The infiltration capacity of soils varies from low of 4 mm h^{-1} in clay loam to a high of 40 mm h^{-1} in sandy soil. Under a monsoon climate, the intensity of rainfall is much higher than the infiltration capacity of the soil. Runoff, therefore, is inevitable. Drainage of humid regions disposes the runoff from agricultural lands (Bhattachrya and Michael, 2003). The study area (Doimukh, Arunachal Pradesh (India)) comes under humid tropical climate of northeast India. Major crops grown are rice (low land), maize and vegetables (Onion, Cabbage, Reddish chilly, Cauliflower, French bean, Pea, Brinjal, Pointed gourd etc.). The average annual rainfall of study area is 3528 mm out of which 72% and 24% is concentrated during monsoon (June to October) and pre-monsoon (March to May) seasons respectively. Drainage problem occurs during rainy season. Since, no scientific information is available on surface drainage coefficient for the study area, present study was planned to determine drainage coefficient for Doimukh (Arunachal Pradesh (India)) for different recurrence intervals using one day to 7 days consecutive days annual maximum rainfall.

2 Materials and method

Study area

For determining the surface drainage coefficient, Doimukh (Itanagar), Arunachal Pradesh (India) was selected as a study area (Figure1). Average rainy days and monthly, seasonal and annual rainfall of the study area are given in Table 1. Average annual rainfall and average numbers of rainy days are 3,532 and 132 mm respectively of the said area. Over the year, temperature and relative humidity varies from 10 ℃ to 32 ℃ and 70% to 93% respectively. Rural Works Department, Arunachal Pradesh (India) has a small meteorological laboratory at Doimukh (27°08'39'' N Latitude, 93°45'05'' E Longitude and 118 m above mean sea level) where rainfall is recorded on daily basis using Symon's rain gauge. For the present study, recoded rainfall data for a period of 25 years (1988-2012) were collected. The daily data, in a particular year, is converted to 2-7 days consecutive day rainfall by summing up the rainfall of corresponding previous days. One day to 7 consecutive days annual maximum rainfall for each year was then taken for the analysis.

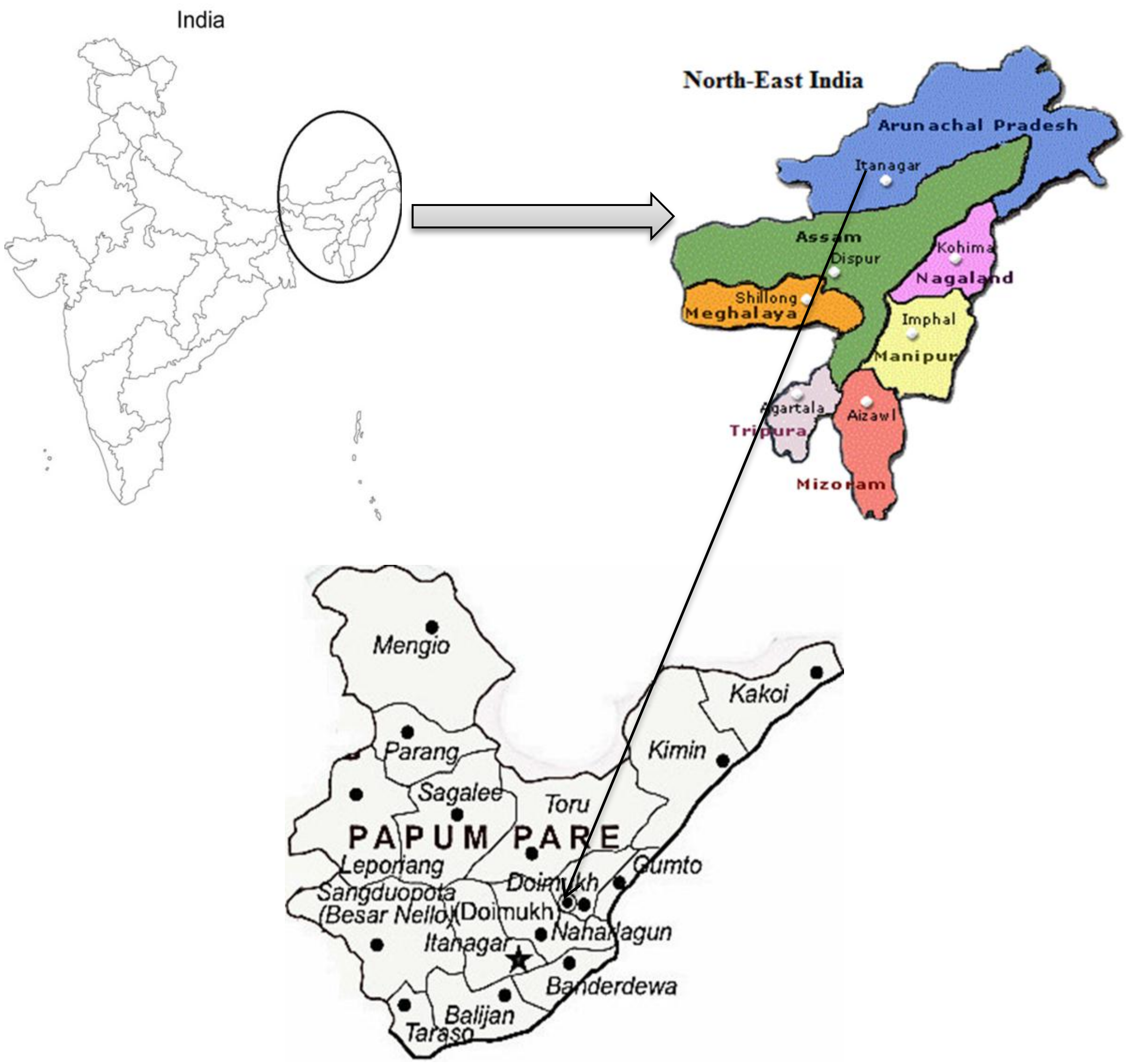

Figure1 Location map of the study area

Table 1 Average rainy days, monthly, seasonal and annual rainfall of the study area

Month/Season/Year	Average rainy days	Rainfall, mm
Jan.	3	39.7(1.1)
Feb.	6	66.8(1.9)
March	7	112.8(3.2)
April	13	227.7(6.4)
May	16	505.9(14.3)
June	22	762.8(21.6)
July	22	638.9(18.1)
August	16	484.5(13.7)
September	16	449.9(12.7)
October	08	206.5(5.8)
November	02	25.2(0.7)
December	01	11.1(0.3)
Pre-monsoon (March to May)	36	846.5(24.0)
Monsoon(June to October)	84	2542.8(72.0)
Post- monsoon (November to February)	12	142.68(4.0)
Annual	32	3531.8

Figures in parenthesis indicate per cent contribution to annual rainfall (Source Dabral et al., 2006)

Randomness checking of data

For checking the randomness of the data of maximum amount of one day and 2 to 7 days consecutive days annual maximum rainfall, turning point test method was applied. The test is applied to derive the number of turning points in a data. A turning point to exit when x_i is either greater than preceding and succeeding values or less than both. Thus, any of the condition for a variate $x_{i-1} < x_i > x_{i+1}$ or $x_{i-1} > x_i < x_{i+1}$ gives a turning point. The procedure of the test is outline as follows. Data were arranged in order of their occurrence. Either of the condition $x_{i-1} < x_i > x_{i+1}$ or $x_{i-1} > x_i < x_{i+1}$ was applied to ascertain how many turning points were there in the series.

1. Let the total number of turning points be p
2. Expected number of turning points in the series is $E(p) = 2(N\text{-}2)/3$, where N is the total no of data.
3. Variance of p is $Var(p) = (16N - 29)/90$.
4. P can be expressed as a standard normal form, $Z = (p\text{-}E(p))/(Var(p))^{1/2}$.
5. If calculated value of Z is within the critical range of ±1.96 for 5% level of significance, the hypothesis of randomness of data was accepted.

Statistical analysis of data

The statistical behavior of any hydrological series can be described on the basis of certain parameters. Generally mean, standard deviation, coefficient of variation, coefficient of skewness are taken as measures of variability of any hydrologic series. In present study all these parameters were determined using Excel software.

One day to 7 days consecutive maximum rainfall at different return periods using different probability distribution functions

One day to seven days maximum rainfall data were fitted to various probability distribution functions as given in Table 2.

Table 2 Descriptions of various probability distribution functions

Distribution	Probability density function	Range	Equation for the parameters in terms of the sample moments
Normal	$f(X) = \frac{1}{\sigma\sqrt{2\pi}} exp\left\{-\frac{(X-\mu)^2}{2\sigma^2}\right\}$	$-\alpha \le x \le \alpha$	$\mu = \overline{X}, \sigma = S_x$
Lognormal	$f(X) = \frac{1}{X\sigma\sqrt{2\pi}} exp\left\{-\frac{(y-\mu_y)^2}{2(\sigma_y)^2}\right\}$	$x > 0$	$\mu_y = y,\ \sigma_y = S_y$
Gamma	$f(X) = \frac{\lambda^\beta X^{\beta-1} e^{-\lambda X}}{(\beta)}$	$x \ge 0$	$\frac{\lambda = \frac{\overline{X}}{s^2 X}}{\beta = \left(\frac{\overline{X}}{s_x}\right)^2}$

Testing the goodness of fit

Comparing the theoretical and sample values of the relative frequency of the cumulative frequency function can test the goodness of fit of a probability distribution. In case of the relative frequency function, the Chi- square test is used. The sample value of the relative frequency of interval "i" is,

$$f_s(X_i) = \frac{n_i}{n} \quad (1)$$

where, n_i = number of observation in interval I, n = total number of observation

The theoretical value of the relative probability function is

$$P(X_i) = F(X_i) - F(X_{i-1}) \quad (2)$$

The Chi- square test static $\chi_c{}^2$ is given by Equation 3

$$\chi_c^2 = \sum_{i=1}^{m} n \left[\frac{(f_s(X_i) - p(X_i))^2}{p(X_i)}\right] \quad (3)$$

Where, m = number of intervals, $n\, f_s(X_i) = ni$ i.e the observed number of occurrence in interval i and $n\, p(X_i)$ = corresponding expected number of occurrences in interval i .

The χ^2 distribution functions are tabulated in many statistics text. In the χ^2 test, ν = m – p – 1, where, m = number of intervals and p = number of parameters used in fitting the proposed distribution

A confidence level is chosen for the test, it is often expressed as $1-\alpha$, where 'α' is termed as the significant level. A typical value for the confidence level is 95%. The null hypothesis for the test is that the proposed probability fits the data adequately. This hypothesis is rejected if the value of χ_v^2 (which is determined from the χ^2distribution with v degrees of freedom at 5% level of significance), otherwise it was accepted.

Frequency analysis using frequency factors

Chow (1951) has shown that many frequency analyses can be reduced to form

$$X_T = \overline{X}\,(1 + CVK_T) \quad (4)$$

Where, CV = coefficient of variation, K_T = frequency factor, $\overline{X}$ = mean value of X and

X_T = magnitude of the event having a return period T.

For Normal and Lognormal distribution, the frequency factor can be expressed by the following Equation 5

$$K_T = \frac{(X_T - \mu)}{\sigma} \quad (5)$$

Where, X_T = magnitude of the hydrological event, K_T = frequency factor, μ = mean of the sample and σ = standard deviation of the sample. This is the same as the standard normal variable z. The value of z corresponding to an exceeding probability of p ($p = 1/T$) can be calculated by finding the value of an intermediate variable 'w';

Where,

$$w = \left[ln\left(\frac{1}{P^2}\right)\right]^{1/2} \ (0 < \text{p} \leq 0.5) \quad (6)$$

Then calculating z using the Equation 7

$$z = w - \left[\frac{(2.515517+0.802853w+0.010328w^2)}{(1+1.432788w+0.189269w^2+0.001308w^3)}\right] \quad (7)$$

When $p > 0.5$, $1-p$ is substituted for p in Equation (3.9) and the value of z is computed by Equation (3.10) is given a negative sign.

In case of Gamma probability distribution function, values of λ (= mean/(S.D.)^2), β (= (mean)^2/(S.D.)^2) and v (= $2\times\beta$) were calculated for the fitted weeks. For a particular probability level, χ^2 was calculated from the table for a certain v value. Expected value of the rainfall at certain probability was calculated from the following relationship:

$$Xp = \chi^2 / (2\ \lambda) \quad (8)$$

Frequency analysis was carried out for the following return periods as given in Table 3 .

Table 3 Return period and probability level

T (Return Period, Years)	5	10	20	25
P (Probability level in %)	20	10	5	4

Estimation of drainage coefficient

Soil texture (sand, silt and clay percentage) of study site was determined using hydrometer method as used by Pandey et al. (2009). Basic infiltration (Ib) rate values were found by conducting double cylindrical infiltrometer test. The drainage coefficient was estimated for 2, 5, 10 and 20 years R.I. by subtracting basic infiltration rate from estimated consecutive day rainfall (Sharma et al., 1997). The drainage coefficient for different R.I. were estimated by considering the fact that soils are saturated and evapotranspiration, surface retention and raindrop interception are negligible as far as land drainage is concerned.

3 Results and discussion one day to 7 consecutive days annual maximum rainfall and results of turning

Point test

Year wise one to seven consecutive days maximum rainfall (1988-2012) are shown in Table 4. For checking the randomness the data of one day to 7 consecutive days annual maximum rainfall, turning test was carried out. The hypothesis of randomness was formulated and checked. Using the test statistics, the results of turning test are presented in Table 5. The values of the test statistics have been found to fall within the limits of 5% level of significance. Therefore, all the one day to seven consecutive days annual maximum rainfall data could be considered random.

Table 4 Year wise one day to seven consecutive days maximum annual rainfall

S. No.	Year	1day, mm	2days, mm	3days, mm	4days, mm	5days, mm	6days, mm	7days, mm
1	1988	119.2	210.2	294.9	335.4	365.6	376.05	385.7
2	1989	143.8	218.8	308.8	377.6	422.6	490.6	531.8
3	1990	185	292	364	420	434.5	446.5	483.4
4	1991	114	200	290.4	335.4	360.6	386.4	411.6
5	1992	102	134.6	177.2	235.3	277.9	311.3	328.5
6	1993	123.3	231.4	351.4	365.7	434.7	445.7	475.7
7	1994	120	219.5	319.9	363	398.3	437.7	543
8	1995	175	246.2	303.2	371.2	412.4	420.5	430.3
9	1996	173	208	218.2	264.2	291.2	331.7	347.8
10	1997	139.1	246.1	319.1	336.1	354.1	372.3	429.5
11	1998	53	93	116.1	141.2	168.2	175.4	199.9
12	1999	130	222.3	334.5	340.7	380	386.2	386.2
13	2000	78	109.4	153.6	177.8	215.2	239.4	252.3
14	2001	99.4	106.4	133.2	154.8	161.6	183	203.2
15	2002	149.2	216.2	254.6	291.6	318	343	362.4
16	2003	111.4	140	154.6	186.6	217.2	239.4	284.6
17	2004	125	203	297	342.2	437.2	495.2	538.8
18	2005	115.4	158.4	177	229	280	307.4	323.6
19	2006	134	181.4	201.8	233	273.4	326.8	372.8
20	2007	127	202	312.4	336.9	338.9	338.9	386.6
21	2008	178	185.8	243.6	300.4	305.8	325.4	383.2
22	2009	62.6	74.6	81	99	110.2	127.4	146.8
23	2010	69.8	102.4	129.6	130.3	144.5	159.8	174.2
24	2011	155.7	188.3	192.1	212.9	247.3	291.5	312.3
25	2012	66	81.4	108.3	135.6	158.7	186.2	207.1

Table 5 Results of turning point test

Maximum annual rainfall series	Turning point test				
	N	*P*	*E, p*	*Var, p*	*Z*
1 day	25	16	15.333	4.122	0.33
2 days	25	16	15.333	4.122	0.33
3 days	25	15	15.333	4.122	-0.164
4 days	25	14	15.333	4.122	-0.657
5 days	25	16	15.333	4.122	0.328
6 days	25	16	15.333	4.122	0.328
7 days	25	14	15.333	4.122	-0.657

Statistical parameters of one day to 7 consecutive days annual maximum rainfall

The statistical parameters of annual 1-day as well as 2 to 7 consecutive days annual maximum rainfall are shown in Table 6. The mean value of one-day maximum rainfall was found to be 121 mm with standard deviation and coefficient of variation of 36.87 and 30.23 respectively. The coefficient of skewness was observed to be -0.16. For 2 to 7 consecutive days annual maximum rainfall, range values for mean, standard deviation, coefficient of variation and coefficient of skewness were observed to be 178.6 to 356.05 mm, 58.54 to 114.38, 32.25 to 37.07, -0.14 to -0.33 respectively (Table 6).

Table 6 Statistical parameters of 1-day to 7 consecutive days maximum rainfall

S.No.	Parameters	1-day	2-days	3-days	4-days	5-days	6-days	7-days
1.	Minimum, mm	53	74.60	81.00	99.00	110.20	127.40	146.80
2.	Maximum, mm	185	292.00	364.00	420.00	437.20	495.20	543.00
3.	Mean, mm	121	178.86	233.46	268.64	300.32	325.75	356.05
4.	Standard deviation	36.87	58.54	86.54	93.71	101.40	105.05	114.38
5.	Coefficient of variation,%	30.23	32.73	37.07	34.88	33.76	32.25	32.12
6.	Co-efficient of Skewness	-0.16	-0.33	-0.18	-0.30	-0.31	-0.27	-0.14

Fitting of various probability distribution functions

One-day annual maximum, 2-7 consecutive annual maximum rainfall data in its original form was fitted to different probability distribution function i.e. Normal, Lognormal and Gamma. Calculated chi-square values were compared with tabular value at 5% level of significance. It was observed that all distribution functions fitted significantly. As per chi-square value, Lognormal probability distribution function was found to be the best fitted to 1 one day annual maximum rainfall data. Normal probability distribution was found to be best fitted for 24 days to 7 days annual maximum rainfall data (Table 7).

Table 7 Chi-square values for different distribution

Rainfall, maximum	Calculated Chi-square value			Tabulated Chi-square value, 95% confidence level
	Gamma dist.	Normal dist.	Log normal dist.	
1-day	19.382	16.517	16.415*	19.68
2-days	59.774	54.025*	63.243	58.108
3-days	66.661	62.194*	70.848	72.132
4-days	96.938	84.349*	107.605	85.95
5-days	76.885	69.965*	79.546	82.515
6-days	92.928	85.554*	96.228	92.8
7-days	91.097	85.155*	94.505	98.475

*= The best fitted probability distribution function

Estimation of one-day to 7 consecutive days annual maximum rainfall for different return periods

Table 8 gives the 1-day to7 consecutive days annual maximum rainfall for different return periods as determined by selected distribution. A maximum of 115.90 mm in 1-day,1 78.86 mm in 2 days, 233.46 mm in 3 days, 268.64 mm in 4 days, 300.32 mm in 5 days, 325.75 mm in 6 days, 356.05 mm in 7 days is expected to occur at every 2 years. For a recurrence interval of 100 years, the maximum rainfall expected in 1-day, 2-days, 3-days, 4-days, 5-days, 6-days and 7-days is 255.95 mm, 314.21 mm, 434 mm, 83 mm, 536.25 mm, 570.19 mm and 622.19 mm respectively. It is generally recommended that 2 to 100 years is the sufficient return period for soil and water conservation measures, construction of dams, irrigation and drainage works.

Table 8 One day to 7 consecutive day rainfall values for different recurrence intervals

Sl. No.	Recurrence Interval, years	Rainfall for consecutive days, mm						
		1	2	3	4	5	6	7
2	5	154.36	228.11	306.28	347.49	385.64	414.15	452.30
3	10	179.32	253.89	344.39	388.75	430.29	460.40	502.66
4	20	202.94	275.17	375.84	422.81	467.14	498.59	544.23
5	25	210.39	281.37	385.01	432.73	477.88	509.71	556.34

Determination of infiltration rate of study area

Soil texture was determined by using hydrometer. Results indicated that soil of study area was sandy (Table 9). Infiltration rate was determined by using double infiltrometer. Results indicated that basic infiltration rate of soil was observed to be 1 cm h^{-1} (Table 10).

Table 9 Mechanical analysis of soil

Location	Land Use	Percentage, %			Soil type
		Sand	Silt	Clay	
Doimukh	Agricultural Land	95.19	0.01	4.80	Sandy

Table 10 Elapsed time and infiltration rate of study area

Elapsed time, min	0	1	2	4	6	8	13	18	28	38	53	73	103	130	190	250	300
Infiltration rate, cm h^{-1}	0	12	12	9	6	6	4.8	4.8	3.6	3	2.8	2.7	2.6	2.4	2.1	1	1

Determination of drainage coefficient

The drainage coefficient was calculated by subtracting basic infiltration rate from consecutive days rainfall for R. I. of 5, 10, 20 and 25 years. For two consecutive days maximum rainfall, the estimated values of drainage coefficient at 10 , 20 and 25 years RI are 13.89 mm $day^{-1,}$ 35.17 mm day^{-1} and 41.47 mm day^{-1}. In case of 03 consecutive days maximum rainfall the estimated values of drainage coefficient at 5 , 10 , 20 and 25 years RI are 66.28 mm day^{-1}, 104.39 mm day^{-1}, 135.84 mm $day^{-1}$and 145.0128 mm day^{-1}. For 04 consecutive days maximum rainfall the estimated values of drainage coefficient at 5, 10, 20 and 25 years, RI are 107.49 mm day^{-1}, 148.75 mm day^{-1}, 182.81 mm day^{-1} and 192.73 mm day^{-1}. In case of 05 consecutive days maximum rainfall the estimated values of drainage coefficient at 5 , 10, 20 and 25 years RI are 145.64 mm day^{-1}, 190.29 mm day^{-1}, 227.14 mm $day^{-1}$and 237.88 mm day^{-1}. For 06 consecutive days maximum rainfall the estimated values of drainage coefficient at 5 , 10, 20 and 25 years RI are 174.15 mm day^{-1}, 220.40 mm day^{-1}, 258.59 mm day^{-1} and 269.71 mm day^{-1}. In case of 07 consecutive days maximum rainfall the estimated values of drainage coefficient at 5, 10 , 20 and 25 years RI are 212.30 mm day^{-1}, 262.66 mm day^{-1}, 304.23 mm day^{-}1 and 316.34 mm day^{-1} (Table 11).

Table 11 Estimated drainage coefficient, mm day^{-1}

Sl. No.	Ib, (mm h^{-1})	DC (mm day^{-1}) for 2-days rainfall (mm) for R.I. (years)			
		5	10	20	25
1	10	0	13.89	35.17	41.37

Sl. No.	Ib (mm h^{-1})	DC (mm day^{-1}) for 3-days rainfall (mm) for R.I. (years)			
		5	10	20	25
1	10	66.28	104.39	135.84	145.01

Sl. No.	Ib (mm h^{-1})	DC (mm day^{-1}) for 4-days rainfall (mm) for R.I. (years)			
		5	10	20	25
1	10	107.49	148.75	182.81	192.73

Sl. No.	Ib (mm h^{-1})	DC (mm day^{-1}) for 5-days rainfall (mm) for R.I. (years)			
		5	10	20	25
1	10	145.64	190.29	227.14	237.88

Sl. No.	Ib (mm h^{-1})	DC (mm day^{-1}) for 6-days rainfall (mm) for R.I. (years)			
		5	10	20	25
1	10	174.15	220.40	258.59	269.71

Sl. No.	Ib (mm hr^{-1})	DC (mm day^{-1}) for 7-days rainfall (mm) for R.I. (years)			
		5	10	20	25
1	10	212.30	262.66	304.23	316.34

Results reported above are for sandy soil of Doimukh (Arunachal Pradesh) having basic infiltration rate 10 mm h^{-1} which are different from Dabral and Baithuri (2008) who had carried out the similar study for the humid tropical climate of the northeast India at North Lakhimpur, (Assam) having predominantly loamy to clay loam soil and having basic infiltration rate between one to 5 mm h^{-1}.

4 Conclusions

For the study area, the maximum value of drainage coefficient at 25 years recurrence interval varied from 41.37 mm day^{-1} to 304.23 mm day^{-1} for 2 to 7 days consecutive rainfall. The minimum value of drainage coefficient at 5 years interval varied from 0 to 212.30 mm day^{-1} for 2 to7days consecutive rainfall. From the study, it may be concluded that soil of Doimukh (Arunachal Pradesh) has basic infiltration rate of 10 mm h^{-1} and it has to be provided with agricultural drainage for its major crops grown in the area.

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