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551.577.13 (282.4)

A frequency study of rainfall for the Periyar basin of Kerala

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सार — 5398 कि.मी.^{2} के क्षेत्र में बंटित 14 वर्षामापी केन्द्रों के 60 वर्षों के औसत आंकड़ों का प्रयोग करते हुए, केरल के पेरियार नदी थाला की वर्षा गहराई-अवधि-बारम्बारता का अध्ययन किया गया था। 1, 2, 3, 7 और 10 दिनों की अवधि की वार्षिक अधिकतम वर्षा गहराइयों का विश्लेषण किया गया था। आवश्यक सम्बंधों को व्युत्पन्न करने के लिए अधिकतम संभावित आकलन से युक्त चरममान टाइप-1 बंटन को उपयोग में लाया गया है। अलग-अलग केन्द्रों के लिए विश्लेषण किए गए और तत्पश्चात् केन्द्र-वर्ष संकल्पना पर आधारित क्षेत्रीय सम्बंध प्राप्त किए गए। वर्षा और स्थलाकृतिक विशिष्टताओं को ध्यान में रखते हुए प्रदेश की सीमा निर्धारित की गई। इससे सन्तोषजनक परिणाम प्राप्त हुए। आशा है क्षेत्रीय अध्ययन से प्राप्त परिणाम डिजाइन इंजीनीयरों और कृषि वैज्ञानिकों के लिए उपयोगी होंगे।

ABSTRACT. A rainfall depth-duration-frequency study was carried out for the Periyar river basin of Kerala using average sixty years of data from fourteen raingauge stations distributed in an area of 5398 km^2. The annual maximum rainfall depths of 1, 2, 3, 7 and 10 days durations were analysed. The extreme value Type-1 distribution fitted with maximum likelihood estimates was utilized to derive the required relationships. Analyses were carried out for the individual stations and later regional relationships were obtained based on the station-year concept; the regions were demarcated considering rainfall and topographical characteristics. Satisfactory results were obtained. The results obtained from the regional study are expected to be useful for design engineers and agricultural scientists.

1. Area of study and data used

The study area covers the Periyar river basin of the southwest part of India. The *Periyar*, the longest of all the rivers in Kerala, and also the largest in potential, is formed by several streams, having their origin in the Sivagiri group of hills at an elevation of about 1830 m above mean sea level. The length of the river from its origin to its confluence with the Arabian Sea is 244 km. The river has a total drainage area of 5398 km^2, out of which 5284 km^2 lie within Kerala and the rest 114 km^2 in Tamil Nadu (PWD 1974). Fig. 1 shows the Periyar river basin with the location of raingauges from which data were used for the study. Regional rainfall depth-duration-frequency (DDF) studies were carried out with data from 14 stations spread over the basin. Annual maximum rainfall depths for durations of 1, 2, 3, 7 and 10 days were utilized for analyses.

2. Analyses

For each of the 14 stations for durations of 1, 2, 3, 7 and 10 days, relationships were arrived at by fitting extreme value Type 1 (EV1) distribution to the corresponding annual maximum series. The distribution function is defined by :

$$P(x) = \exp\{-\exp-(x-u)/\lambda\}, \quad -\infty < x < \infty \qquad (1)$$

where, $P(x)$ is probability of an event not exceeding x and u and λ are the parameters of the distribution. Eqn. (1) may be written in terms of a reduced variate y :

$$P(x) = \exp\{-\exp(-y)\} \qquad (2)$$

where, $$x = u + \lambda y \qquad (3)$$

Eqn. (2) may also be written in terms of return period T, which is the reciprocal of the probability of exceedence :

$$y = -\ln[\ln\{T/(T-1)\}] \qquad (4)$$

A method based on that developed by Jenkinson (1969) and described by Clarke (1973) and applied in a DDF study by Venniasingam and Shaw (1978) has been adopted for parameter determination by maximum likelihood method. This iterative method requires first estimates of the parameters for initial computations. The method of moments is used to provide the initial estimates :

$$\lambda_1 = (\sqrt{6}/\pi)\{\Sigma(x-\bar{x})^2/(N-1)\}^{1/2} \qquad (5)$$

$$u_1 = \bar{x} - 0.577216\,\lambda \qquad (6)$$

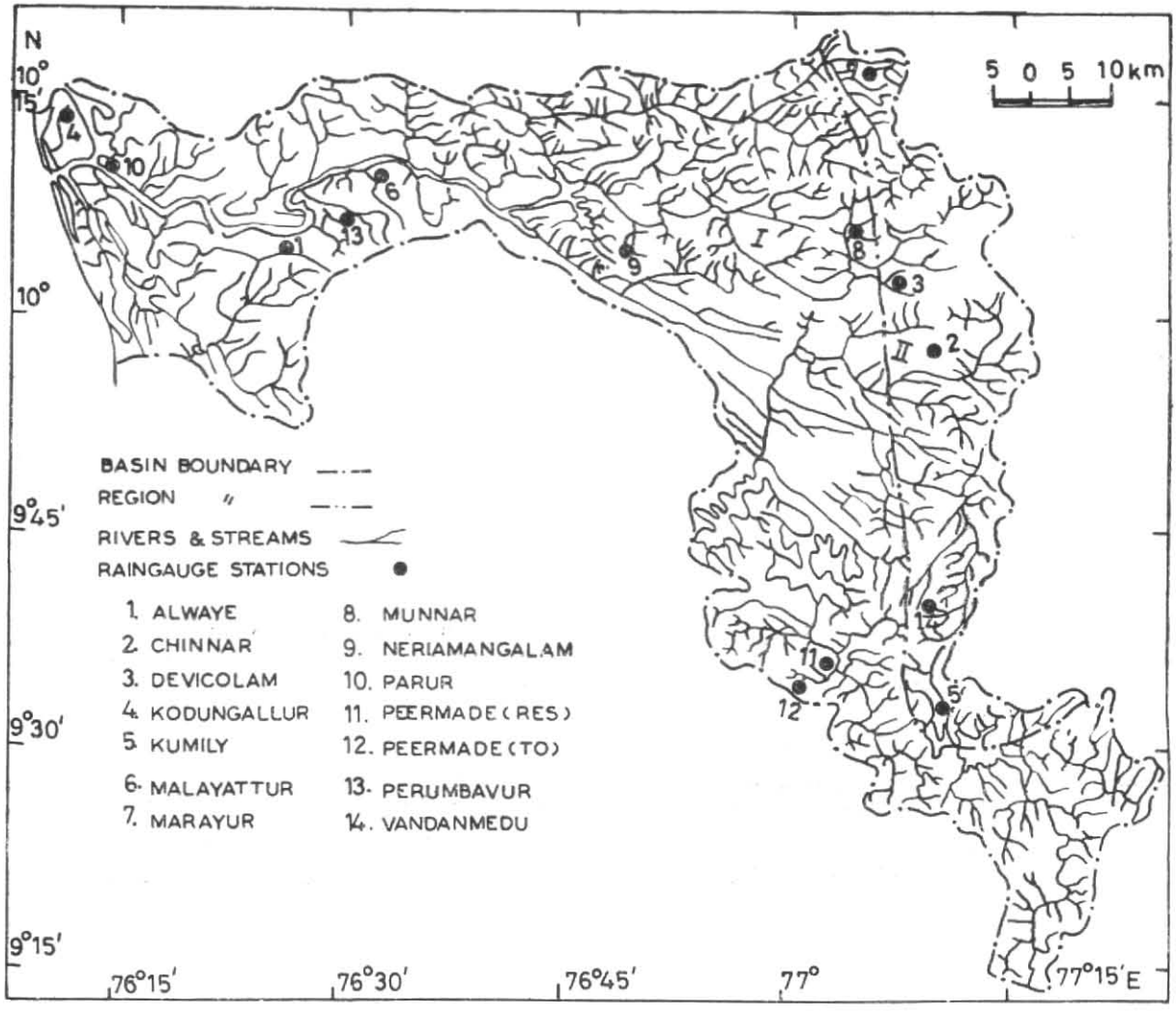

Fig. 1. Periyar basin with location of raingauge stations used for the study

where, x is the mean value of data sample and N the number in sample. The maximum likelihood estimates of λ and u are obtained by solving the equations :

$$\lambda_2 = \bar{x} - \frac{\left\{ \sum_1^N x_i \exp\left(-x_i / \lambda_1\right) \right\}}{\left\{ \sum_1^N \exp -\left(x_i / \lambda_1\right) \right\}} \qquad (7)$$

$$u_2 = -\lambda_1 \ln \left[\sum_1^N \exp \left\{ -(x_i / \lambda_1) \right\} \Big/ N \right] \qquad (8)$$

The operation begins with the moments estimates (λ_1 and u_1) using Eqns. (5) and (6); the first cycle of calculation of estimates brings about the corrections to be applied. Thereafter the iterative processes continue till corrections are negligible.

The standard error of estimates, SE, obtained from EV1 distribution is given by NERC (1975) as :

$$\mathrm{SE}\left[x(T)\right] = \{ (\lambda^2/N)\,(1.11 + 0.52y + 0.61y^2) \}^{1/2} \qquad (9)$$

where $x(T)$ is the estimate with T-year return period and y the reduced variate corresponding to T.

A computer program was used to fit EV1 distribution to the annual maximum series for computing rainfall estimates for different durations (1, 2, 3, 7 and 10 days) and for return periods 2, 5, 10, 25, 50, 100 and 500 years and for obtaining the standard errors. The derived EV1 distributions have been found to fit at a level of significance greater than 10% implying a satisfactory fit. A summary of the DDF relationships obtained for individual stations is given in Table 1. The regional values of frequency analyses are provided in Tables 2 and 3.

TABLE 1

Rainfall (in cm) DDF relationships for individual stations

Duration	Relationships for stations		
	Alwaye	*Chinnar*	*Devicolam*
1-day	$x=12.626+3.358\ y$	$x=5.982+2.412\ y$	$x=10.178+3.390\ y$
2-day	$x=19.096+4.784\ y$	$x=7.395+3.729\ y$	$x=16.199+5.573\ y$
3-day	$x=24.584+6.595\ y$	$x=8.916+3.773\ y$	$x=21.059+7.216\ y$
7-day	$x=39.454+10.214\ y$	$x=11.295+5.058\ y$	$x=34.155+12.029\ y$
10-day	$x=48.478+11.172\ y$	$x=12.629+5.739\ y$	$x=41.260+14.825\ y$
	Kondungallur	*Kumily*	*Malayattur*
1-day	$x=13.157+3.281\ y$	$x=7.565+2.867\ y$	$x=12.583+3.134\ y$
2-day	$x=19.150+4.713\ y$	$x=11.125+4.279\ y$	$x=18.034+4.349\ y$
3-day	$x=23.763+6.172\ y$	$x=14.266+5.524\ y$	$x=22.702+5.397\ y$
7-day	$x=37.524+9.910\ y$	$x=20.713+7.539\ y$	$x=36.359+7.728\ y$
10-day	$x=45.515+11.924\ y$	$x=24.411+8.617\ y$	$x=44.935+10.053\ y$
	Marayur	*Munnar*	*Neriamangalam*
1-day	$x=6.662+3.396\ y$	$x=13.935+3.343\ y$	$x=13.056+3.618\ y$
2-day	$x=9.883+5.167\ y$	$x=23.783+6.436\ y$	$x=21.348+5.902\ y$
3-day	$x=12.026+6.402\ y$	$x=31.670+8.820\ y$	$x=28.176+8.078\ y$
7-day	$x=17.730+7.913\ y$	$x=53.783+16.094\ y$	$x=49.223+16.030\ y$
10-day	$x=20.118+9.140\ y$	$x=65.828+20.546\ y$	$x=60.920+18.760\ y$
	Parur	*Peermade (Res)*	*Peermade (TO)*
1-day	$x=10.443+3.810\ y$	$x=16.971+4.602\ y$	$x=14.688+5.681\ y$
2-day	$x=15.755+5.282\ y$	$x=26.788+7.235\ y$	$x=23.339+7.804\ y$
3-day	$x=20.183+6.493\ y$	$x=34.996+9.399\ y$	$x=30.710+10.007\ y$
7-day	$x=32.969+9.703\ y$	$x=57.091+15.539\ y$	$x=50.176+15.496\ y$
10-day	$x=40.134+11.407\ y$	$x=69.331+19.748\ y$	$x=61.201+19.259\ y$
	Perumbavur	*Vandanmedu*	
1-day	$x=12.106+3.308\ y$	$x=7.823+2.077\ y$	
2-day	$x=18.301+4.326\ y$	$x=12.421+3.562\ y$	
3-day	$x=23.525+5.271\ y$	$x=15.653+4.942\ y$	
7-day	$x=37.607+8.395\ y$	$x=25.471+8.161\ y$	
10-day	$x=45.928+10.420\ y$	$x=30.946+9.662\ y$	

TABLE 2

Rainfall DDF relationships for the regions of Periyar basin

Duration	Fitted distribution	
	Region I	Region II
1-day	$x=13.081+4.205\ y$	$x=7.614+3.282\ y$
2-day	$x=20.064+6.380\ y$	$x=11.247+5.267\ y$
3-day	$x=25.828+8.357\ y$	$x=14.027+6.905\ y$
7-day	$x=41.963+13.562\ y$	$x=20.748+10.990\ y$
10-day	$x=51.302+16.541\ y$	$x=24.253+13.356\ y$

3. Regionalization

The individual station data sets were combined together to produce larger regional data samples. The assumption is that the annual maximum events are independent and that the combined data sets have a selection varied to represent a long period. The Periyar river basin was divided into two regions (Fig. 1) considering the rainfall and topographic characteristics. The combined records of these regions could be analysed similar to the procedure adopted for individual stations.

4. Conclusions

The depth-duration-frequency relationships for the basin are expected to be useful for many engineering

TABLE 3

Rainfall depth-duration estimates for the regions of Periyar basin

Return period (years)		Region I Duration (days)					Region II Duration (days)				
		1	2	3	7	10	1	2	3	7	10
2	RF*	14.62	22.40	28.89	46.93	57.36	8.82	13.17	16.56	24.78	29.15
	CL**	0.43	0.65	0.85	1.37	1.66	0.46	0.74	0.97	1.55	1.88
5	RF	19.39	29.63	38.36	62.30	76.11	12.54	19.13	24.38	37.23	44.29
	CL	0.65	0.99	1.30	2.11	2.58	0.71	1.14	1.49	2.38	2.89
10	RF	22.54	32.42	44.63	72.48	88.53	15.00	23.03	29.57	45.48	54.31
	CL	0.84	1.27	1.67	2.71	3.30	0.91	1.46	1.91	3.05	3.70
25	RF	26.53	40.47	52.56	85.34	104.21	18.11	28.06	32.11	55.90	66.97
	CL	1.09	1.65	2.16	3.51	4.28	1.18	1.89	2.48	3.95	4.80
50	RF	29.49	44.96	58.44	94.88	115.84	20.42	31.76	40.97	63.69	76.37
	CL	1.28	1.94	2.54	4.12	5.02	1.38	2.21	2.91	4.64	5.64
100	RF	32.42	49.41	64.27	104.35	127.32	22.71	35.43	45.79	71.30	85.60
	CL	1.47	2.23	2.92	4.74	5.78	1.59	2.55	3.34	5.32	6.48
500	RF	39.21	59.71	77.76	126.23	154.08	28.01	43.91	56.93	89.04	107.24
	CL	1.91	2.90	3.80	6.18	7.50	2.07	3.32	4.37	6.95	8.45

*RF=Rainfall estimates, **CL=95% confidence limits (2 SE)=RF±CL

and agricultural design need. A number of development schemes are being executed in this basin, being the most resourceful one of the State and rainfall DDF relationships are often necessary for the design engineers. The applicability of the EV1 distribution with the maximum likelihood method of estimation has been justified from the goodness-of-fit test. The regionalization of results will help in determining the DDF for those areas where satisfactory distribution of raingauges are not there. The regions reflect the influence of monsoon and topography.

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