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REGIONAL FLOOD FREQUENCY STUDIES FOR KERALA

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SYNOPSIS

An attempt has been made to study the flood frequency for different regions of Kerala. The peak flow data available for 85 guaging stations in 44 river basins of Kerala have been made use of. For the purpose of this regional approach, Kerala State is divided into 5 regions based on rainfall and topographical characteristics.The individual station data in these regions are subjected to frequency analysis using Gumbel (EV1) distribution. The results are regionalised by carrying out a multiple regression analysis, wherein the frequency floods are treated as dependent variable and the rainfall amounts of different durations for the corresponding recurrence interval as well as catchment characteristics as independent variables.

1.0 INTRODUCTION

1.1 The ever increasing demands for water for varied purposes in every walk of human life, calls for optimal utilization of water resources available over a place in a scientific way. In the scientific exploitation of available water resources over any place, the flood frequency analysis has an important place. Flood frequency studies are often used for arriving at suitable design variables, for the construction of hydraulic structures to bring it to the safer side in extreme conditions. The flood frequency analyses are mainly done by fitting statistical distributions to station data for bringing out their future probabilities of occurrence at the site. Often, data on probabilities of flood are required at sites, where gauged records of floods do not exist.

2.0 METHODOLOGY

2.1 Regionalisation is generally meant for describing the procedures used for estimating flood frequency at ungauged sites.

The procedure in essence is based on the frequency analysis of a combined series of data, produced by joining together, the flood data from the hydrometeorologically related sites. Different approaches are made use of for arriving at this end. In the present study of Kerala the multiple regression method of regionalisation as envisaged by Benson[1] has been made use of. This method utilizes the results of individual flood frequency analysis of gauging stations within the region of choice to fit regression equations. This is the method widely used by USGS in its reports on magnitude and frequency of floods. These relationships commonly take the form:

$$\log Q_t = \log q_o + a \log A + b \log B + \ldots \quad (1)$$

Where Q_t is the estimated magnitude of the flood with a recurrence interval of t - yr; q_o, a, b, ... are regression coefficients; as drainage area and median annual 24 - hr rainfall. Separate regression equations are utilized for different recurrence intervals, and statistical tests and hydrologic information available are used for ensuring consistency among these equations. In the present attempt on evolving regional flood frequency relationships for Kerala, the results of the flood frequency analysis of individual station data and catchment characteristics are used to form multiple regression models.

3.0 DATA USED

3.1 For the reliable quantification of floods of large return periods through frequency analysis, hundreds of years of data under uniform climatic and channel conditions are often required. There are two major limitations with regard to gauged data in Kerala State: (i) stream gauge data are available only for a short period (since 1963), and (ii) gauging stations are limited in number and are not properly distributed. The above limitations can be overcome by a regional study. For the regional analysis, data from all the stations in the same flood region can be used, if the data from a single station is found inadequate.

3.2 The peak flood data (1963 - 1985) from 85 gauging stations spread out in different river basins of Kerala (Fig 1) have been used for the present study. The areas of catchments monitored by stream gauging stations in Kerala vary between 4-29 km^2. Data on rainfall magnitudes for recurrence intervals of 2,5,10,25,50 and 100 years for durations of 1 to 10 days were taken from CWRDM Technical Report [2]. Physiographic characteristics of the catchments such as catchment area, stream slope and stream frequency were obtained from the G T S maps (1:50000 scale). Stream slope was taken as the ratio of the difference in elevations at 10% and 85% of the total length of the stream above gauging site and the stream length between these two points.

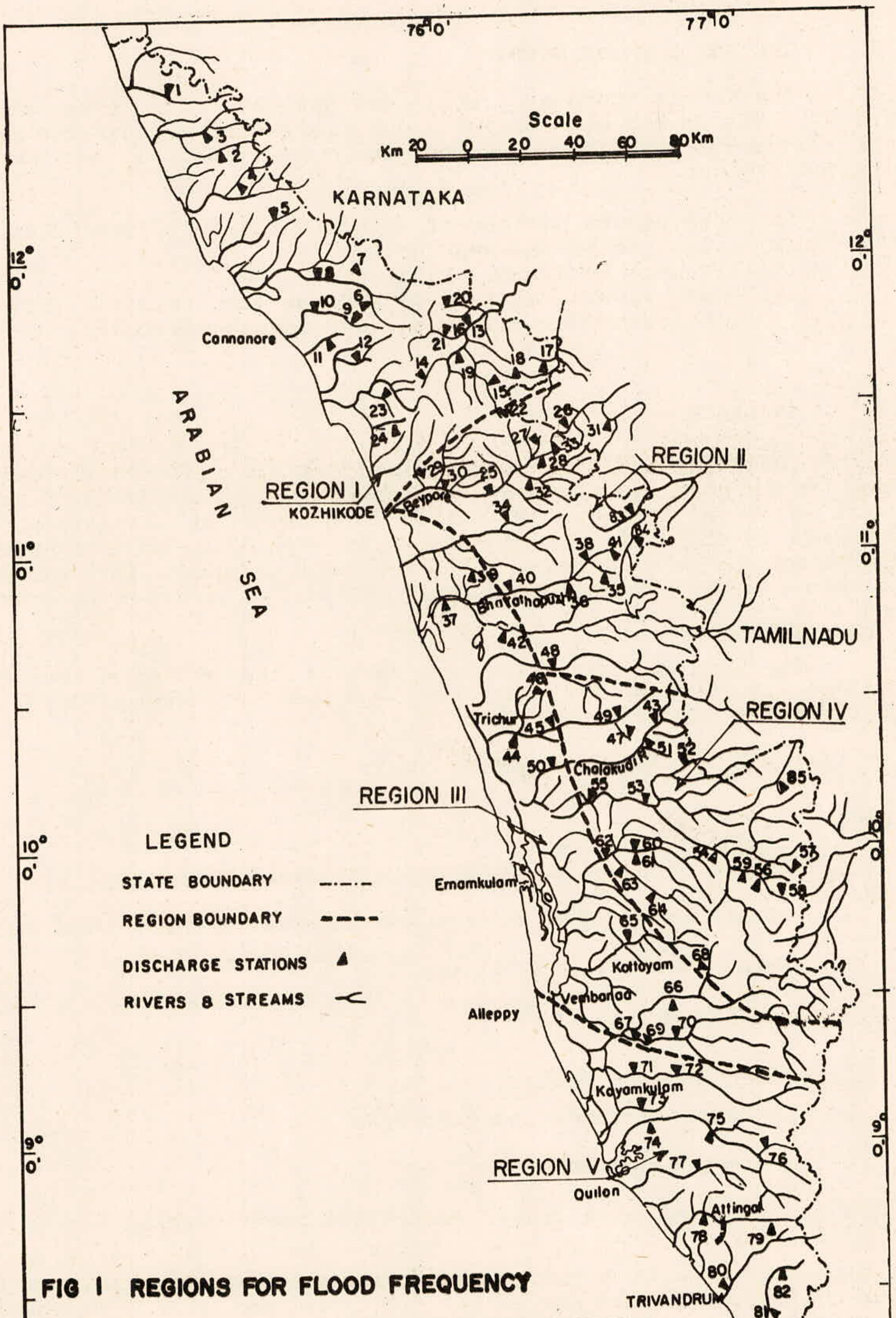

FIG I REGIONS FOR FLOOD FREQUENCY ANALYSIS OF KERALA

4.0 REGIONS FOR THE STUDY

4.1 The Kerala State as a whole was divided into five regions (Fig 1). The following rainfall and topographical characterestics were considered in combining the individual station data sets to form the regions :

(i) the return periods of rainfall for individual stations;
(ii) altitude of the stations;
(iii) leeward locations (rain-shadow); and
(iv) mean annual rainfall as well as mean rainfall variation in south-west and north-east monsoon periods.

5.0 ANALYSIS

5.1 Frequency analysis of the flood data of individual stations were carried out by fitting the Gumbel (EV1) distribution to the annual maximum series. A method developed by Jenkinson [3], described by Clarke [4] and applied by Venniasinagam and Shaw [5] and Sreedharan and James [6,7] has been adopted for parameter determination by maximum likelihood method. A computer program has been used for calculations.

5.2 For regionalisation of the results the multiple regression approach of Benson [1] has been adopted in this study. The relationships take the form :

$$Q_T = a+bR_1+cR_3+dR_5+eR_{10}+fF+gA+hR_A+iN+jS \qquad (2)$$

Where,

Q_T : peak discharge of recurrence interval T (m^3 sec^{-1})

R_i : i day rainfall of recurrence interval T (cm); i=1,3,5,10

F : mean annual flood (m^3 sec^{-1})

A : drainage area (km^2)

R_A : mean annual rainfall (cm)

N : stream frequency (junctions/km^2)

S : stream slope (m/km)

a,b,c... : multiple linear regression coefficients.

Equation (2) is a multiple linear regression equation of the type given below, with one dependent variable and m - 1 independent variables :

$$X_1 = B_1+B_2X_2+B_3X_3+.....+B_mX_m \qquad (3)$$

Equation (3) can be solved using the principle of least squares for m parameters. The flood amounts for recurrence intervals 2,5,10,25,50 and 100 years are treated as dependent variable. The catchment characteristics and rainfall amounts for durations of 1 to 10 days for recurrence intervals corresponding to the dependent variables, are treated as independent parameters and regression models were evolved.

6.0 RESULTS

6.1 Regional flood frequency relationships were made for peak discharges of different recurrence intervals, namely 2,5,10,25,50 and 100 years. Separate relationships were evolved for the 5 flood regions into which the State was divided. The relationships for different regions are presented in Tables 1 to 5.

TABLE 1. Regional flood frequency relationships - Region I

Recurrence interval (years)	Relationships
2	$Q_2=-33.14+1.53R_1+0.73R_3+0.25R_5-0.19R_{10}+0.94F$ $-0.017A-0.047R_A-1.0N-0.18S$
5	$Q_5=186.12-3.17R_1-4.68R_3-0.078R_5+0.91R_{10}+1.35F$ $-0.14A+0.05R_A+2.21N+0.16S$
10	$Q_{10}=416.91-1.69R_1-7.08R_3-2.87R_5+1.50R_{10}+1.60F$ $-0.21A+0.19R_A+1.10N+0.29S$
25	$Q_{25}=686.11-4.15R_1-11.36R_3+2.15R_5-1.05R_{10}+1.90F$ $-0.24A+0.21R_A+9.70N+1.49S$
50	$Q_{50}=792.52-2.66R_1-10.72R_3+0.94R_5-0.85R_{10}+2.14F$ $-0.31A+0.17R_A+16.21N+0.69S$
100	$Q_{100}=845.64-9.21R_1-5.28R_3+2.73R_5-2.94R_{10}+2.39F$ $-0.37A+0.19R_A+15.41N+1.55S$

TABLE 2. Regional flood frequency relationships - Region II

Recurrence interval (years)	Relationships
2	$Q_2=-488.21+19.58R_1+70.97R_3-7.23R_5-13.51R_{10}+0.11F$ $+0.40A-1.26R_A-138.33N+8.09S$
5	$Q_5=-278.56+49.49R_1+68.99R_3-33.29R_5-6.53R_{10}+0.09F$ $+0.57A-1.23R_A-173.65N+9.43S$
10	$Q_{10}=-178.88+212.2R_1-77.47R_3+46.97R_5-26.94R_{10}+0.06F$ $+0.71A-1.25R_A-195.77N+3.07S$
25	$Q_{25}=-96.65+102.68R_1-11.28R_3+20.66R_5-20.2R_{10}+0.14F$ $+0.89A-0.40R_A-259.62N+6.95S$
50	$Q_{50}=820.14-14.48R_1-69.97R_3+127.76R_5-33.93R_{10}+0.35F$ $+0.94A-1.92R_A-262.91N-3.27S$
100	$Q_{100}=421.53+25.64R_1-16.84R_3+48.22R_5-20.89R_{10}+0.40F$ $+1.02A+0.31R_A-395.92N+8.54S$

TABLE 3. Regional flood frequency relationships - Region III

Recurrence interval (years)	Relationships
2	$Q_2=-250.24-25.6R_1-2.6R_3+11.09R_5+4.10R_{10}+0.92F$ $+0.02A+0.26R_A-4.51N-0.44S$
5	$Q_5=426.19-50.57R_1+23.3R_3+10.15R_5-2.32R_{10}+1.39F$ $-0.11A-1.98R_A+37.11N-7.09S$
10	$Q_{10}=-5382.15+71.5R_1-1.15R_3+67.5R_5-0.55R_{10}+1.67F$ $-0.19A+1.10R_A+155.90N+11.14S$
25	$Q_{25}=-16942.09+695.7R_1+151.9R_3-196.6R_5+34.91R_{10}+2.3F$ $-0.45A+8.47R_A-401.06N+83.15S$
50	$Q_{50}=3137.07-42.89R_1+38.7R_3-41.7R_5-7.72R_{10}+2.94F$ $-0.66A-2.38R_A+122.25N-16.32S$
100	$Q_{100}=19803.7-395.41R_1+36.6R_3-64.56R_5-28.8R_{10}+2.77F$ $-0.53A-11.25R_A+267.29N-46.18S$

TABLE 4. Regional flood frequency relationships - Region IV

Recurrence interval (years)	Relationships
2	$Q_2=12.51+1.96R_1-4.37R_3+2.07R_5+0.057R_{10}+0.93F$ $-0.007A-0.009R_A+0.38N-0.13S$
5	$Q_5=-80.39+2.66R_1+8.97R_3-6.47R_5+1.23R_{10}+0.02F$ $+0.011A+0.20R_A-1.07N+0.61S$
10	$Q_{10}=-39.88+3.01R_1+6.6R_3-1.3R_5-1.71R_{10}+1.45F$ $+0.049A-0.17R_A+0.67N-0.38S$
25	$Q_{25}=126.59-2.95R_1-2.71R_3+8.48R_5-2.83R_{10}+1.83F$ $-0.005A-0.36R_A-4.4N-1.54S$
50	$Q_{50}=44.97+0.26R_1+2.8R_3+5.47R_5-3.09R_{10}+2.02F$ $+0.02A-0.55R_A+1.46N-1.77S$
100	$Q_{100}=92.52-071R_1-1.86R_3+8.84R_5-2.92R_{10}+2.27F$ $-0.015A-0.43R_A-12.38N-1.58S$

TABLE 5. Regional flood frequency relationships - Region V

Recurrence interval (years)	Relationships
2	$Q_2=-84.54+25.37R_1+20.99R_3-12.28R_5-7.82R_{10}+0.25F$ $+0.27A+0.13R_A-2.99N-0.75S$
5	$Q_5=229.11-20.0R_1-1.38R_3+3.92R_5-0.28R_{10}+1.50F$ $-0.0948+0.83R_A+4.42N-0.26S$
10	$Q_{10}=409.48-32.04R_1-1.43R_3+7.39R_5-0.8R_{10}+1.64F$ $-0.087A+0.088R_A+8.47N+0.46S$
25	$Q_{25}=264.46-9.86R_1+11.14R_3+14.08R_5-11.02R_{10}+1.91F$ $+0.02A-0.65R_A-6.83N-1.95S$
50	$Q_{50}=294.36-11.6R_1+9.9R_3-6.38R_5-2.55R_{10}+2.64F$ $-0.063A+0.067R_A+9.49N+4.61S$
100	$Q_{100}=5257.73+3.84R_1+78.1R_3-165.68R_5+6.6R_{10}+2.26F$ $+0.99A-1.48R_A-10.94N+76.38S$

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