Trans. Inst. Indian Geographers
Vol. 6, No. 2, July 1984

STUDY OF PRECIPITATION TRENDS IN SHIMSHA RIVER BASIN IN KARNATAKA

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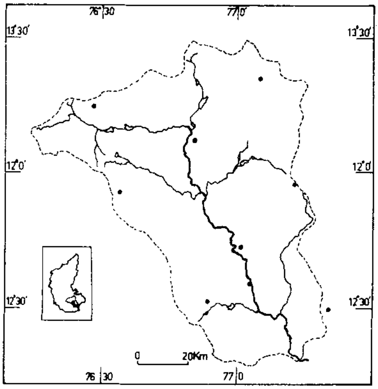
ABSTRACT : Precipitation data from the Shimsha river basin for the years 1901 to 1979 have been analysed to determine the trends and periodicities in the precipitation pattern.

Regression analyses and also the Mann-Kendall rank statistics indicate that no significant trend exists in the precipitation pattern. Lag 1 Serial correlation indicates an absence of persistence effect. Spectral analyses by Fourier method gives a number of peaks in the power spectra having low periodicities. These periodicities when tested rigorously by Fisher's and Walker's methods, turn out to be not significant. The conventional method of moving averages gives a misleading picture of cyclicities in the pattern. The autocorrelation studies indicate absence of significant correlation upto Lag 30, confirming the absence of periodicity. Lag 1 autocorrelation has a significant negative correlation (–0.27) indicating an absence of 'persistence' in precipitation. It is concluded that the precipitation in the basin is of a random nature with no significant long term trend of periodicity.

INTRODUCTION

The Shimsha river is a tributary of Cauvery and drains an area of 8469 sq.kms. in southern parts of Karnataka (Map 1). The study of the precipitation pattern in this basin has gained significance in view of the fact that very close to the point where this river joins Cauvery, the BWSSB draws water to Bangalore City. Further at this point, the river Cauvery crosses the border between Karnataka and Tamil Nadu, where Karnataka has to maintain a steady discharge into Tamil Nadu. The basin receives an average annual rainfall of about 718 millimeters. The variability of precipitation is high. An important aspect of the hydrogeological studies is the determination of long term trends and the periodicities in precipitation pattern, which will be helpful in planning and development of water resources system. In the present paper an attempt has been made to analyse the characteristics of the precipitation pattern of the Shimsha river basin by using different statistical techniques, and to review the degree of reliability of these methods in the matter of determining periodicities.



Map 1 : Shimsha River basin showing rain-guaging stations

PRECIPITATION DATA

Data from nine gauging stations for the years 1901 to 1979 has been used in the computations. Only annual trends have been studied. Locations of gauging stations are indicated on the map (Map 1).

PRECIPITATION CHARACTERISTICS

The entire precipitation of the basin is received in the form of rainfall. The weighted average of rainfall has been calculated by Theissen polygon method. The mean and standard deviation are 718 and 147 mm respectively. The basin receives good amount of rainfall during southwest monsoons (June to September). The reliability of rainfall is very low because of the high variability.

TREND ANALYSIS

The possible presence of trends in the data was tested by Mann-Kendall rank statistic. Mann-Kendall rank statistic (Dhar et al. 1982) reveals the presence or absence of trends in a rainfall series.

$$\text{The statistic. } T = \frac{4 \Sigma n_i}{N (N-1)} - 1$$

where n_i is the number of values larger than i^{th} value in the series subsequent to its position in the series of N values. T has a variance, $\sigma_T^2 \equiv \frac{(4 N + 10)}{9 N (N-1)}$ The statistic----- used to assess the significance of the trend. Values of ------ and-------- calculated for the rainfall data of the basin are 0.0133, .005878 and 0.1734. The value of ------ is not significant and hence it is concluded that there is no trend in the rainfall series of the basin.

PERIODICITIES IN PRECIPITATION PATTERN

For detecting the periodicities two techniques were employed. In the first case, a simple moving average technique was used. Secondly the spectral characteristics and autocorrelation coefficients were determined by Fourier analyses and autocorrelation techniques respectively.

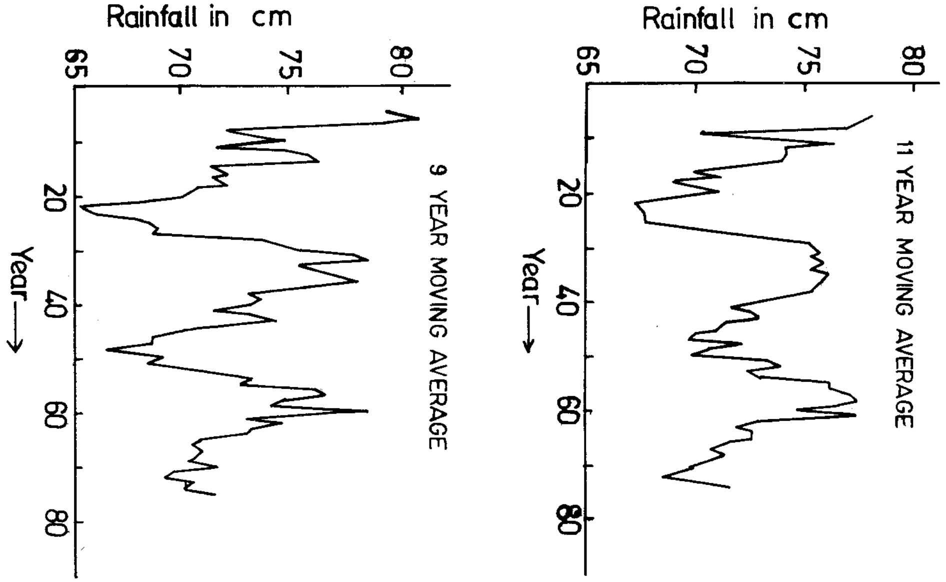
MOVING AVERAGES

In the temporal precipitation pattern in its raw form, the periodicity is not clear except for the noise. In order to remove the noise, moving, averages have been calculated for three different orders namely 5 year, 9 year and 11 year. The moving averages have been plotted in Fig. 1. In all the three graphs a 25 year cycle is prominent.

FOURIER ANALYSIS

Fourier analysis is one of the best methods of determining periodicities. A periodic function can be represented by a fourier series of the type

$$Y_i = \sum_{n=0}^{\infty} a_n \operatorname{Cos} \frac{2n \pi x_i}{\lambda} + b_n \sin \frac{2n\pi x_i}{\lambda}$$



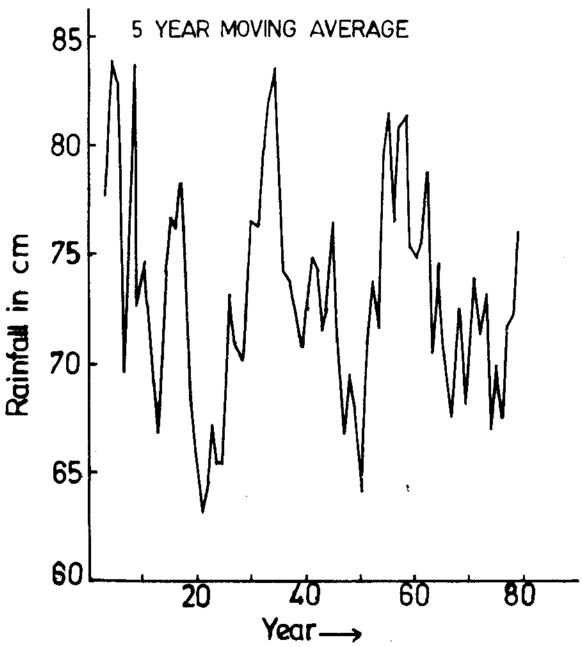


Fig 1 : Moving Average of Precipitation Data

where a_n, b_n are fourier coefficients, --- is the fundamental wave length equal to length of data, n is the harmonic number, x_i is the variable, whose trend is being studied. The components a_n and b_n can be obtained by matrix inversion methods (Davis 1973). The power of harmonic, determined by $a_n^2 + b_n^2$, indicates its importance.

The precipitation data of the basin for the years 1901 to 1979 has been used in the spectral analysis. 0 to 39 characteristics have been determined. Table 1 gives the power of the different harmonics which have been plotted graphically in Fig. 2 to get the power spectrum. The zero harmonic has the power of 825.8 whose square root 28.7 is equal to the mean precipitation. Of the remaining harmonics the maximum power of 8.6 is for the 25th harmonic. The next in importance are 22nd, 30th, 34th and 35th whose powers are 6.8, 4.8, 4.3 and 4.1 respectively. The power values obtained above have been tested for their significance.

TABLE 1 : TABLE SHOWING POWER OF DIFFERENT HARMONICS

Harmonic	Power
0	825.84
1	0.29
2	0.57
3	2.49
4	0.36
5	0.15
6	2.42
7	0.04
8	0.19
9	1.03
10	1.73
11	1.08
12	0.36
13	0.59
14	0.53
15	0.01
16	0.49
17	0.22
18	1.76
19	2.76
20	0.29
21	2.44
22	6.79
23	0.95
24	3.30
25	8.61
26	0.69
27	3.19
28	0.17
29	3.18
30	4.84
31	0.36
32	0.56
33	1.17
34	4.26
35	4.05.
36	0.57
37	1.42
38	1.37
39	0.54

TABLE 2 : AUTOCORRELATION COEFFICIENTS FOR DIFFERENT LAGS

Lag	Autocorrelation Coefficient	Z value (only values above one are shown)
0	1.00	
1	– 0.27	
2	– 0.16	
3	0.22	1.92
4	0.04	
5	– 0.19	
6	0.04	
7	0.14	1.23
8	– 0.12	
9	0.04	
10	– 0.07	
11	0.00	
12	– 0.14	
13	0.13	1.08
14	– 0.02	
15	– 0.01	
16	0.00	
17	– 0.09	
18	0.06	
19	0.01	
20	– 0.24	
21	0.04	
22	0.04	
23	– 0.01	
24	– 0.04	
25	0.12	
26	0.07	
27	– 0.03	
28	0.01	
29	0.14	
30	0.01	

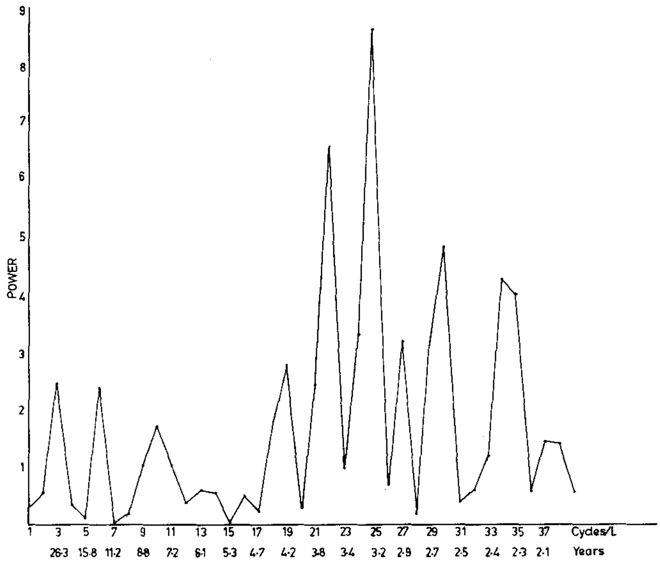


Fig 2 : Power Spectrum of Precipitation Data

Number of tests are available to test the significance of the powers, like, Schuster's Walker's and Fisher's (Davis, 1963). Of these, the Fisher's test is most powerful. In the present analyses, the Fisher's test has been applied. For carrying out the Fisher's test, the ratio g' = R^2----------, where R^2 is the maximum power and----- is the variance, is calculated. The Fisher's probability of g' exceeding a critical value g can be calculated (Davis, 1963). The value of 'g' at significant levels 0.01, 0.05 and 0.1 are 0.197, 0.162 and 0.46 respectively. g' is equal to 0.129 and is less than the critical values, indicating thereby that the powers are not significant. Even the 25 year cycle (approximately the 3rd harmonic) indicated in the moving average pattern is not brought out. The fourier analysis thus indicates that there is no periodicity in the precipitation pattern.

AUTOCORRELATION ANALYSIS

The autocorrelation function is obtained by finding linear correlation between a time series and the same series at a later interval of time for different time lags. The autocorrelation of a time series at lag 'L' is given by $r_L = \frac{Cov\ (X_i, X_{i+L})}{Var.\ X_i}$ Lag is the amount of offset between the two series being compared. The power spectra and autocorrelation are related, the power spectra being the fourier transform of the autocorrelation function. The autocorrelation values are generally considered meaningful only upto a lag position n/4, where n is the length of the sequence (Davis, 1973).

The significance of the autocorrelation of a particular Lag can be determined by finding out the Z value: $ZL = r_L \quad n-L$, where n is specified length and L is lag.

The autocorrelation coefficient values upto lag 30 are indicated in Table 2, along with those Z values above 1. The autocorrelation coefficients are plotted as a correlogram (Fig. 3). From the table it is evident that none of the positive correlation coefficients are significant, the maximum Z values being 1.92 for Lag 3. A particularly interesting feature is the absence of signifi-

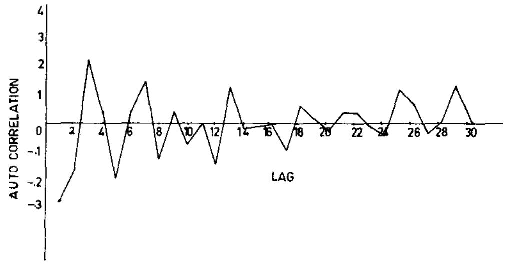


Fig 3 : Correlogram of Precipitation Data

cance in the lag position around 25, where a periodicity is indicated in the moving averages method. Of course the autocorrelation values for this high lag is not very meaningful. The absence of periodicity was also confirmed by the fourier analysis. This shows that the moving averages method could be misleading. Lag 1 autocorrelation shows a negative correlation of 0.27, which is significant, the Z value being 2.38. This means that the persistence effect is absent and the precipitation pattern is characterised by high frequency oscillations.

CONCLUSION

The precipitation pattern in the Shimsha river basin is characterised by high variability. There is no long term trend in the pattern. The moving averages of different orders indicate the presence of a 25 year cycle, which, however, is not confirmed by fourier and autocorrelation analysis. Both fourier analysis and autocorrelation analysis indicate the absence of any periodicity in the precipitation pattern. Persistence effect is absent and the pattern is characterised by high frequency oscillations.

ACKNOWLEDGEMENT

The authors are thankful to the Director, Bureau of Economics and Statistics, Government of Karnataka, Bangalore for providing rainfall data.

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