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The quantitative rainfall forecasts through statistical synoptic model and its application in forecasting daily rainfall over Mayurakshi basin area

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सार — 1982 से 1987 की अवधि के दौरान मयूराक्षी घाटी क्षेत्र पर क्षेत्रीय वर्षा राशि के तीन परासों और सिनॉप्टिक स्थितियों की सात श्रेणियों के सांख्यिकी सम्बन्ध पर आधारित एक सरल दृष्टिकोण को लागू किया गया। यह आशा है कि विश्लेषण से प्राप्त की गई सूचना, एक दी गई सिनॉप्टिक स्थिति के अन्तर्गत घाटी में औसत क्षेत्रीय वर्षा के पूर्वानुमान दने में उपयोगी सिद्ध होगी।

ABSTRACT. A simple approach based on statistical association of seven categories of synoptic situations and three ranges of areal rainfall amounts has been appplied over Mayurakshi basin area for the period from 1982 to 1987. The information derived from the analysis is expected to be useful in providing forecasts of average areal rainfall in the basin under a given synoptic situation.

1. Introduction

The most important factor in forecasting quantitative rainfall amount is the synoptic meteorological situation. In India, weather forecasts valid for 24 hours and 48 hours are issued on the basis of weather situations of 03 GMT and 12 GMT observations. Many authors have attempted statistical study of the rainfall, responsible for the floods by considering the associated meteorological situation. Chaudhury (1966) and Dhar and Changraney (1966) have studied floods and the associated meteorological conditions responsible for some spells of heavy rain. Singh *et al.* (1984) have studied the synoptic characteristics of surface pressure anomaly pattern in forecasting daily rainfall distribution over India. Here an attempt has been made for the prediction of rainfall amount by adopting statistical method utilising the synoptic weather situation. Forecasting of rainfall amount is useful in flood forecasting and flood controlling systems.

The statistical theory of association in forecasting the rainfall amount by utilising the prevailing synoptic meteorological condition has been studied here over Mayurakshi basin area during the monsoon period from 1982 to 1987. The meteorological conditions responsible for different rainfall ranges have been classified and the measures of association of such rainfall ranges on the particular synoptic weather situations are calculated by Yule's coefficient of association and Tschuprow's coefficient through contingency table method.

2. Model

2.1. *Contingency table and association of attributes*

The relationship of any kind between two attributes $\bar{A}$ and $\bar{B}$ and their association as suggested by Yule (1912) has been applied here. The statistical frequency distribution O_{ij} for the rainfall ranges responsible for the particular synoptic situations are arranged in two way contingency table. The frequencies of such distribution of three different ranges of rainfall amount as rows (A_i) occurring for seven categories of synoptic weather situations as columns (B_j) can be set into 3×7 contingency table with 12 degrees of freedom.

The expected frequencies e_{ij} in each cell can be found out by :

$$e_{ij} = \frac{(A_i)\times(B_j)}{N} \tag{1}$$

where, (A_i) and (B_j) are the total frequencies of i^{th} row and j^{th} column respectively. N is the total number of frequencies in the contingency table.

The null hypothesis of independence between the two attributes $\bar{A}$ and $\bar{B}$ is tested by χ^2-statistic, given by :

$$\chi^2 = \sum_i \sum_j \frac{(O_{ij} - e_{ij})^2}{e_{ij}} \qquad (2)$$

Now, to measure the association of each of the particular range of rainfall for the particular synoptic situation, the contingency table reduces to a number of 2×2 tables with one degree of freedom. Yate's correction $\pm 1/2$ is to be added with the frequencies for continuity in the 2×2 tables (adding 1/2 to the smaller and subtracting 1/2 from the larger) wherever necessary. This correction factor is applied wherever the frequencies $O_{ij} \leqslant 5$.

2.2. *Measure of association*

The 2×2 tables after Yate's correction (wherever necessary) reduce to a form :

	$\bar{B}$'s	not $\bar{B}$'s	*Total*
$\bar{A}$'s	a	b	$(a+b)$
not $\bar{A}$'s	c	d	$(c+d)$
Total	$(a+c)$	$(b+d)$	N

It is convenient to measure the intensities of the associations of the above 2×2 tables by means of Yule's coefficient (Y) of association and is given by :

$$Y = \frac{ad - bc}{ad + bc} \qquad (3)$$

When Y is zero, the attributes $\bar{A}$ and $\bar{B}$ are independent, when the value of Y is +1, there is a complete association between the attributes. But, when the value of Y is —1, there is a complete dissociation.

Now for the degree of associations or dissociations of the above 2×2 table, Tschuprow's coefficient (T) may be calculated for each of the cases and is given by :

$$T = \left(\frac{\chi_1^2}{N} \right)^{1/2} \qquad (4)$$

where, χ_1^2-statistic represents the sum of χ^2 statistic calculated from the above 2×2 table and N is the total number of frequencies.

3. Significant synoptic feature categorisation

The study of the corresponding synoptic weather situations responsible for the significant amount of rainfall over Mayurakshi basin area based on the inferences from *Indian Daily Weather Reports* (IDWR) and weather charts are categorised into seven classes and are enumerated below :

A — Low pressure area (LOPAR) covering wholly or partly the basin area.

B — LOPAR lying in the neighbourhood, *i.e.*, outside the basin area which may appear over Bihar plains, Bihar plateau, Bangla Desh, north Orissa or east Madhya Pradesh.

C — LOPAR/depression in northwest Bay of Bengal and neighbourhood land areas covering partly or near the basin area.

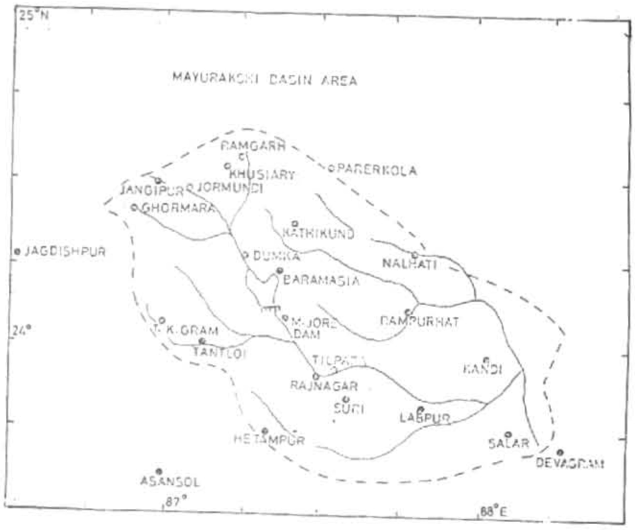

Fig. 1. Stations in Mayurakshi basin area

D — Well-marked LOPAR/Depression covering partly/wholly or near the basin area with associated cyclonic circulation (CYCIR) extending up to mid-tropospheric levels.

E — LOPAR near the basin with axis of the trough line passing near south of the basin area.

F — The axis of the trough line passing through the basin area.

G — The axis of the trough line passing through north of the basin area, *i.e.*, around Lat. 25°N.

4. Data and method of computation

The daily rainfall data based on 03 GMT observations of some selected stations (Fig. 1) over Mayurakshi basin area were plotted on the basin map. The area lies between Longs. 86.5°E & 88.5°E and Lats. 23.5°N & 25°N. The daily average areal rainfall (AAR) over the basin area have been calculated by isohyetal method. Such daily AAR are considered here for study where its AAR values are greater than or equal to 15 mm. These AAR values are categorised into three different classes, namely, 15–25 mm, 26–50 mm and $\geqslant$ 51 mm. The frequencies and probability of occurrences of such rainfall ranges responsible for the particular class of synoptic weather situation are arranged in the 3×7 contingency table (Table 1). The expected frequencies are found out by Eqn. (1) from the observed frequencies of occurrence.

The χ^2-test with the appropriate degrees of freedom for dependency of the system is tested. To estimate the association with different ranges of AAR for different synoptic situations, the original 3×7 contingency table reduces into a number of 2×2 tables. The Yule's coefficient of association and Tschuprow's coefficients are found out by Eqns. (3) and (4) for each of the 2×2 tables, after applying Yate's correction wherever necessary.

5. Discussion

The measure of intensities of association by Yule's coefficients (Y) and by Tschuprow's coefficients (T) for each of the rainfall ranges for particular synoptic weather situation, considering 2×2 tables (occurrence and

TABLE 1(a)

Frequency of average areal rainfall in different categories of synoptic weather situations over Mayurakshi basin area

Range (mm)	A	B	C	D	E	F	G	Total
15-25	6	10	8	6	3	14	16	63
26-50	4	2	5	9	4	6	4	34
51 or more	1	0	1	7	0	1	0	10
Total	11	12	14	22	7	21	20	107

TABLE 1(b)

Value of Yule's coefficient of association of average areal rainfall in different categories of synoptic weather situations over Mayurakshi basin area. The figures in the brackets are the corresponding values of Tschuprow's coefficients

Range (mm)	A	B	C	D	E	F	G
15–25	–0.198 (0.063)	0.493 (0.145)	–0.041 (0.015)	–0.689 (0.327)	–0.684 (0.262)	0.203 (0.077)	0.482 (0.137)
26-50	0.219 (0.065)	–0.307 (0.083)	0.188 (0.064)	0.249 (0.099)	0.390 (0.106)	–0.094 (0.035)	0.277 (0.095)
51 or more	0.238 (0.053)	—	0.088 (0.019)	0.814 (0.347)	—	0.175 (0.040)	—

non-occurrence of two attributes) are calculated by Eqns. (3) and (4) respectively and are given in Table 1 (b). The degree of association or dissociation of the system is related to the measure of Tschuprow's coefficient.

The study of this association and dissociation over Mayurakshi basin area reveals the following facts for occurrences of each of the different AAR ranges associated with corresponding synoptic weather situation :

(*i*) The AAR ranges greater than 50 mm has the highest association of about 81% for the category situation D and the corresponding Tschuprow's coefficient is 0.347.

(*ii*) The AAR ranges 26–50 mm has the highest association of 39% for the category situation E and the corresponding Tschuprow's coefficient is 0.106.

(*iii*) The AAR ranges 15–25 mm has got two maximum associations of 49% and 48% for the category situations B and G respectively and the corresponding Tschuprow's coefficients are 0.145 and 0.137 respectively.

With the values of association and Tschuprow's coefficients in Table 1(b), a general idea of the possibility of occurrences of AAR ranges over Mayurakshi basin area can be obtained which are associated with the corresponding synoptic weather situation.

6. Application in forecasting

The association analysis with reference to the synoptic weather situation which results in a significant AAR over the basin area provides useful information from the forecasting point of view. The chances of occurrences or non-occurrences of the particular rainfall ranges due to the corresponding category of synoptic weather situation can be predicted well in advance by knowing the intensity of association or dissociation of the system. This statistical synoptic model derived from association method could be a useful guide in forecasting the AAR over any other basin area considering the geographical location of the basin.

7. Conclusions

The present study based on the statistical association method applied for areal average rainfall and seven categories of synoptic situations over Mayurakshi basin area reveals the following :

(*i*) The association of rainfall range 50 mm or more is maximum with the synoptic situation of category D, *viz.*, "well marked low pressure area/depression covering partly/wholly near the basin area with associated cyclonic circulation extending up to mid-tropospheric levels". The least association of this range is with the synoptic situation of category C, *viz.*, "low pressure area/depression in northwest Bay of Bengal and neighbourhood land areas covering partly or near the basin area".

(*ii*) The association of rainfall range 26–50 mm is maximum with the synoptic situation of category E, *viz.*, "low pressure area near the basin with axis of the trough line passing near south of the basin area".

(*iii*) The association of rainfall range 15–25 mm is maximum with the synoptic situation of category B, *viz.*, "low pressure area lying in the neighbourhood, *i.e.*, outside the basin area which may appear over Bihar plains, Bihar plateau, Bangladesh, north Orissa or east Madhya Pradesh".

The above information is expected to be useful in providing forecasts of average areal rainfall under one of the synoptic situations categorised here. Further detailed studies are required to take into consideration the position, movement and intensity of the weather systems.

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