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QUANTITATIVE PRECIPITATION FORECASTS FOR UPPER YAMUNA CATCHMENT BY SYNOPTIC ANALOGUE METHOD

1. The dominant factor in forecasting quantitative precipitation amount is the synoptic meteorological situation. The technique of the synoptic analogue is the most convenient method from the point of view of operational forecasting. Dhar and Changraney (1966) have studied floods and the associated meteorological conditions causing some heavy spells of rain in Assam. Lal *et al.* (1983) used synoptic analogue method for prediction of quantitative rainfall in Gomti river Catchment in Uttar Pradesh using five years of data. Ray and Sahu (1998) have studied a synoptic analogue model for quantitative precipitation forecasts of river Sabarmati basin. Here an attempt has been made for the prediction of quantitative rainfall amounts in Upper Yamuna Catchment by utilising synoptic meteorological situations prevailing over Himachal Pradesh, Hills of west Uttar Pradesh (at present Uttaranchal) and neighbouring areas and using rainfall data for the south-west monsoon period from 1990-97. Results have been verified with monsoon data of 1998.

The river Yamuna is a most important tributary of river Ganga. It rises from Yamunotri Glacier in Tehri-Garhwal district of Uttar Pradesh (at present Uttranchal) at an elevation of 6,330 m. Many small streams, the Rishiganga, the Uma and the Hanuman Ganga and several others join in the mountains. The Tons, the longest tributary, rises at an elevation of 3,900 m and joins Yamuna near Dakpathar. At this site, the Tons carries twice the water that is carried in the Yamuna. The Giri river rises near Shimla and joins Yamuna near Paonta. The river Yamuna emerges from the hills near Tajewala where the water is taken off by the western and eastern Yamuna Cannals. It flows in the southeasterly direction passing through the holy places Mathura and the city of Agra near the world famous Taj Mahal. The river finally joins the river Ganga on its right bank near the holy place Prayag (Allahabad).

2. Eight years rainfall data have been collected from 1990 to 1997 for four monsoon months in respect of 17 rain gauge stations scattered over the catchments areas, as shown in Fig. 1 and Table 1. Synoptic situations based upon 0000 UTC upper air and 0300 UTC surface data in relation to different categories of rainfall ranges have been categorised using Regional Daily Weather Reports and India Daily Weather Reports. The rainstorm less than 11 mm is negligible in changing the river gauge and hence not considered. The higher ranges of rainfall, *viz.* 11-25 mm, 26-50 mm, 51-100 mm and greater than 100 mm have been considered for matching with different categories of synoptic situations.

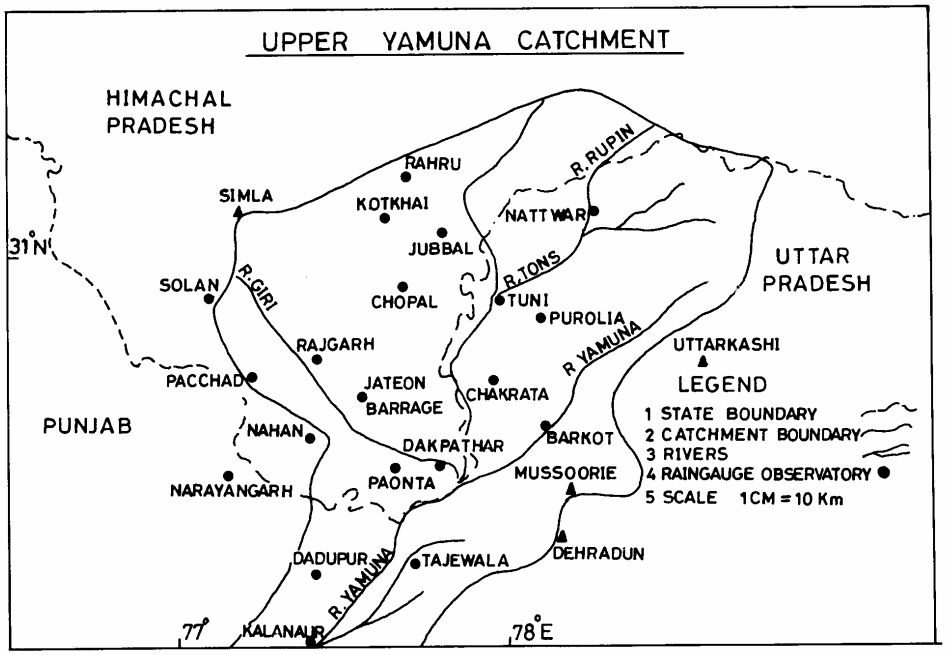

Fig. 1. Locator map of upper Yamuna catchment

TABLE 1

List of raingauge stations in Upper Yamuna Catchment

S. No.	Rain gauge Station
1	Naitwar
2	Rahru
3	Kotkhai
4	Jubbal
5	Chopal
6	Purola
7	Tuni
8	Chakrata
9	Rajgarh
10	Pacchad
11	Jateon
12	Barrage
13	Barkot
14	Dakpathar
15	Paonta
16	Tajewala
17	Dadupur
18	Kalanaur

TABLE 2

Synoptic situations and the rainstorms of monsoon period affecting upper Yamuna catchment during 1990-97 monsoon months

Average areal rainfall range (mm)	Associated synoptic situation (type)	Total number of rainstorms occurring
11-25	S1,1	20
	S1,2	25
	S1,3	25
	S1,4	52
	S1,5	11
	S2,1	36
	S2,2	07
	S3,1	08
	S3,2	02
26-50	S1,1	07
	S1,2	01
	S1,3	04
	S1,4	07
	S1,5	11
	S2,1	04
	S2,2	12
	S3,1	03
	S3,2	01
51-100 or above	S1,5	05
	S2,2	02
	S3,1	02
	S3,2	01
Total		246

The total number of 246 rainstorms associated with different types of synoptic situations are shown in Table 2 and are mentioned below.

(a) A low pressure area/upper air cyclonic circulation located :

S 1,1 Over Jammu and Kashmir
S 1,2 Over Rajasthan
S 1,3 Over plains of west Uttar Pradesh
S 1,4 Approaching the catchment
S 1,5 Over the catchment

(b) An elongated monsoon axis :

S 2,1 South of the catchment
S 2,2 Passing through the catchment

(c) A north-south westerly trough :

S 3,1 Ahead of the catchment
S 3,2 Over the catchment

3. The following results are found from Table 2.

3.1. It is seen that, out of 186 occasions of Rainstorms in the range of 11-25 mm, the systems like (S1,1; S1,2; S1,3); (S1,4; S1,5); (S2,1; S2,2) and (S3,1; S3,2) have accounted for 38%, 34%, 23% and 5% respectively.

3.2. Out of 50 occasions of rainstorms in the range of 26-50 mm, the systems like (S1,1; S1,2; S1,3); (S1,4; S1,5); (S2,1; S2,2) and (S3,1; S3,2) have accounted for 24%, 36%, 32% and 8% respectively.

3.3. Out of 10 occasions of rainstorms in the range of 51 – 100 mm and above, systems (S1,5); (S2,2) and (S3,1; S3,2) have accounted for 50%, 20% and 30% respectively.

4. Table 3 shows that the rainstorms of different categories during the monsoon months June, July, August and September of 1998 were tested by synoptic analogue method. There were total 33 occasions of rainstorms which are mentioned below.

4.1. Out of 24 occasions the systems under categories (S1,1; S1,2; S1,3); (S1,4; S1,5); (S2,1; S2,2) and (S3,1) have accounted for 46%, 29%, 21% and 04% respectively when the realised rainfall was within the forecast range (11-25 mm). This shows that the percentage of occasions approximately matches well with the analogue in the range 11–25 mm.

TABLE 3

Testing of synoptic analogues of Q. P. F. for upper Yamuna catchment for 1998 monsoon season

S.No.	Date (1998)	Actual average areal rainfall (mm)	Associated synoptic situations categorised (type)	Q. P. F. range as per the analogue (mm)
1	9 June	13	S1,1	11-25
2	10 June	56	S1,5	51-100
3	11June	36	S3,1	26-50
4	16 June	26	S1,5	26-50
5	29 June	15	S1,2	11-25
6	31 June	20	S1,5	11-25
7	1 July	11	S1,2	11-25
8	2 July	12	S1,2	11-25
9	7 July	14	S2,1	11-25
10	8 July	12	S2,1	11-25
11	9 July	18	S2,1	11-25
12	12 July	27	S1,4	26-50
13	15 July	27	S2,2	26-50
14	18 July	18	S2,1	11-25
15	4 August	15	S2,1	11-25
16	9 August	12	S1,1	11-25
17	10 August	17	S1,4	11-25
18	12 August	12	S1,5	11-25
19	13 August	13	S1,5	11-25
20	14 August	31	S2,1	26-50
21	15 August	27	S1,4	26-50
22	16 August	52	S2,2	51-100
23	17 August	18	S1,5	11-25
24	19 August	12	S1,2	11-25
25	20 August	18	S1,3	11-25
26	21 August	14	S1,2	11-25
27	22 August	12	S1,4	11-25
28	27 August	17	S1,4	11-25
29	28 August	11	S1,1	11-25
30	20 September	18	S1,1	11-25
31	21 September	28	S2,1	26-50
32	22 September	22	S1,2	11-25
33	23 September	23	S3,1	11-25

4.2. Out of 7 occasions of rainstorms the systems under categories (S1,4; S1,5) ; (S2,1; S2,2) and (S3,1) accounted for 43%, 43% and 14% respectively which are slightly higher than the analogue values.

4.3. Out of two occasions of rainstorms, the systems under categories (S1,5) and (S2,2) accounted for 50% each which matches well in the favour and slightly higher than the analogue value in the latter category. This shows that the systems which are near or over the catchment play a dominant role in producing rainfall of higher ranges.

4.4. Though the test results are approximately matching with the analogue, it was observed that during the period from 9 to 11 June there was a severe cyclonic storm which crossed Gujarat coast near Porbandar and moved in north-northeasterly direction as a depression/low pressure area and lay centred near / over the catchment area and produced higher ranges of rainfall.

5. The following conclusions are made from the above study.

5.1. The synoptic systems which are far away from the river catchment generally produce rainfall in lower range of 11-25 mm.

5.2. The systems that produce rainfall over the catchment in higher ranges are :

(*i*) Low pressure area/upper air cyclonic circulation located near/over or moving towards the catchment area.

(*ii*) Active monsoon trough over the catchment area with a tendency to move towards the foot hills of the Himalayas.

(*iii*) North-south trough in the upper level westerlies ahead or over the catchment area.

5.3. The synoptic analogue technique can be used to issue fairly accurate quantitative precipitation forecasts by the forecasters in 24 hr advance for Upper Yamuna Catchment.

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