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Rainfall Climatology of Jammu and Kashmir State, India

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We have written a number of articles on various aspects of weather characterization and forecast verification under temperate environments of Jammu and Kashmir (India). We have also touched on some of the approaches that might help in solving climatically triggered problems (Hasan and Kanth 1997). Fortunately, we were lucky enough to make significant progress in some (if not all) of the approaches. The present article focuses on an analysis of rainfall/precipitation in this state of the Indian Union under different agroclimatic zones, with an update on forecast verification analysis of temperate Kashmir (India) during 1997–98.

India is classified into agroclimatic zones or major agro-ecological regions (Figures 1 and 2). By definition, an agroclimatic zone is a land unit, in terms of major climate and growing period, that is climatically suitable for a certain range of crops and cultivars (FAO, 1983). An ecological region is characterized by distinct ecological responses to macroclimate as expressed in vegetation and reflected in soils, fauna, and aquatic systems. Several attempts have been made to classify our land area into climatic regions or zones, and these are well documented (Sehgal et al., 1992). The important point is the degree of recognition that has been given to these various approaches and their use in promoting the objectives of effective agriculture, macro-level land use planning, and effective transfer of agrotechnology. Two approaches seem to meet these objectives—the National Agricultural Research Project (NARP) approach (Figure 1) and the recent Agro-Ecological Region approach (Figure 2). In the NARP approach, state universities were advised to divide each zone/state into subzones; accordingly, 129 subzones were delineated for India, based pri-

Zone/ Station	Position (lat./long.)	No. of years of data	Annual precipitation
Subtropical			
Jammu	32.40°N/74.50°E	58	1,088
Udhampur	32.55°N/75.05°E	65	1,510
Intermediate			
Ramban	33.15°N/75.15°E	62	1,118
Kisthwar	33.15°N/75.45°E	53	865
Akhnoor	32.53°N/74.44°E	54	1,144
Punch	33.47°N/74.07°E	53	1,486
Reasi	33.05°N/74.50°E	65	1,668
Temperate			
Srinagar	34.05°N/74.50°E	70	635
Sonemarg	34.19°N/75.19°E	62	1,710
Avantipora	33.53°N/74.54°E	64	577
Anantnag	33.45°N/75.05°E	61	608
Kulgam	33.38°N/75.01°E	68	845
Baramulla	34.12°N/74.22°E	66	904
Badgam	33.50°N/74.35°E	59	570
Shalimar	34.08°N/74.83°E	18	835
Cold arid			
Dras	34.26°N/75.46°E	58	556

Table 1. Mean annual precipitation (mm) of important stations. Source: IMD, Pune India.

marily on rainfall, existing cropping patterns, and administrative units. The Jammu and Kashmir state was thus divided into 4 zones (Figure 1). In the agro-ecological region-based approach, recognition was given to the climatic conditions, length of growing period, land form, and soils (Sehgal et al., 1992) (Figure 2). Thus India has been divided into 20 agro-ecoregions. The Jammu and Kashmir state comprises 3 regions, as depicted in Figure 2. The crop distribution in the state is shown in Figure 3.

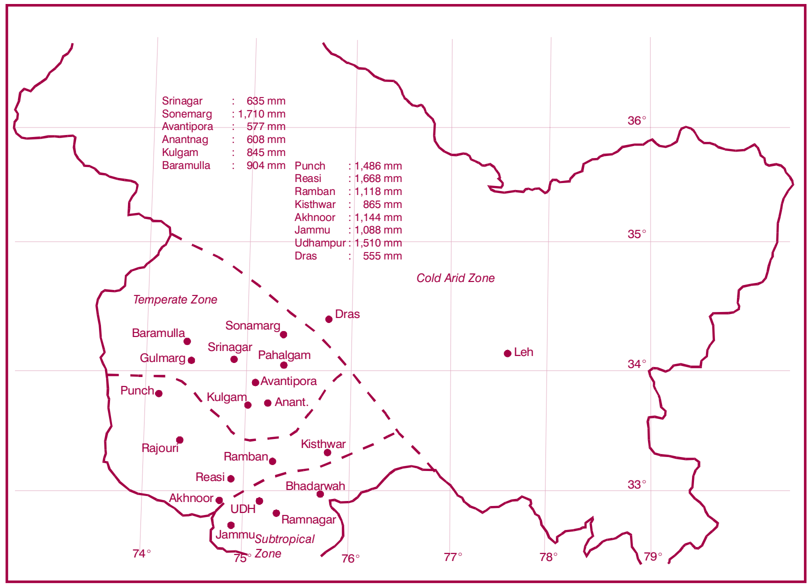

Figure 1. Agroclimatic zones of Jammu and Kashmir (NARP), with average rainfall for selected places. Not to scale.

Total rainfall analysis

Rainfall has been analyzed in various ways, including studying the mean total rainfall for the entire year from different stations (Figure 1 and Table 1). This analysis has been confined mainly to the southwestern region of the state because of lack of meteorological data. In spite of this, the data available from some of the representative sites in each zone seems to be sufficient for an objective characterization. We see that there is a lot of variation within the state and further within each zone (Figure 1). For example, minimum rainfall occurs in the cold arid zone (556 mm) and maximum rainfall occurs in the temperate zone (1,710 mm). Within the temperate zone itself, there is a lot of variation between sites that are in proximity or located at similar latitudes/longitudes. For example, Baramulla and Sonemarg are located at almost the same latitude but differ in precipitation by 800 mm. The same is true in the intermediate zone, where the difference between Kisthwar and Reasi stations is as high as 1,000 mm.

Assured weekly rainfall analysis

The India Meteorological Department (IMD) in Pune has done a commendable job of analyzing the weekly rainfall data available for the period 1901–85. The analysis was performed by fitting a theoretical distribution to the available data series and then determining the frequency of different amounts from this distribution. Of the theoretical distributions, normal distribution is the easiest to handle and, if applicable, yields quicker results. But in the case of weekly rainfall, the distribution is generally skewed. To overcome this skewness, and because of some other important limitations of the available data on weekly totals (abnormally high total rainfall for any week, occurrence of a number of zero rainfall cases, etc.), an incomplete gamma distribution model was used by the IMD for carrying out weekly rainfall probability analysis. This is expressed as

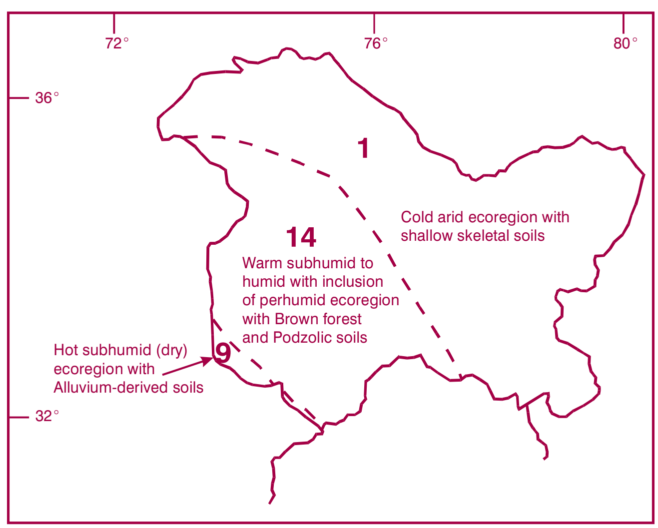

Figure 2. Agro-ecological regions of Jammu and Kashmir. Not to scale.

SMW	JAMMU (subtropical) 70%	50%	30%	PUNCH (intermediate) 70%	50%	30%	ANANTNAG (temperate) 70%	50%	30%	DRAS (cold arid) 70%	50%	30%
17	0	0	5	0	6	21	2	8	19	3	13	28
18	0	0	2	0	3	17	1	5	14	1	5	14
19	0	0	4	0	8	22	1	7	16	0	6	16
20	0	0	4	1	10	23	2	9	21	0	4	10
21	0	0	4	0	7	17	0	3	11	2	6	13
22	0	0	3	0	3	16	0	1	8	0	1	7
23	0	0	6	0	4	22	0	1	7	0	0	4
24	0	2	13	0	16	30	0	2	10	0	0	2
25	0	3	16	5	18	34	0	1	8	0	1	3
26	2	11	27	8	21	39	0	2	8	0	0	1
27	8	24	49	16	34	58	0	2	6	0	0	0
28	22	45	81	30	48	71	0	2	8	0	0	3
29	37	59	90	47	69	97	1	8	18	0	0	1
30	56	89	137	51	81	122	3	9	19	0	0	4
31	52	82	120	47	69	97	1	8	18	0	0	1
32	40	70	115	44	70	103	1	7	13	0	0	1
33	27	50	80	32	51	76	1	5	12	0	1	3
34	22	45	74	21	36	57	1	6	13	0	1	4
35	11	30	58	15	38	72	0	3	16	0	0	3
36	3	18	51	4	18	40	0	0	4	0	0	2
37	0	10	35	5	22	48	0	1	8	0	0	2
38	0	0	10	0	12	24	0	0	4	0	0	2
39	0	1	9	0	0	14	0	0	6	0	0	2
40	0	0	1	0	0	8	0	0	2	0	0	2

Table 2. Assured rainfall amounts (mm) at different percentages of probability levels (from representative stations in each zone). SMW = standard meteorological weeks. Source: IMD Pune India.

Error structure	Summer —55 reports day 1	day 2	day 3	Overall	Winter —29 reports day 1	day 2	day 3	Overall
Correct	6	11	9	26 (47.3)	5	6	6	17 (58.6)
Usable	2	0	2	4 (7.2)	0	0	0	4 (13.8)
Total usable	8 (27)	11 (36.5)	11 (36.5)	30 (54.5)	5 (23.8)	6 (28.6)	10 (47.6)	21 (72.4)
Unusable	11	7	7	25 (45.5)	4	4	0	8 (27.6)
RMSE	16.9	14.4	9.3	14.0	9.9	8.5	3.3	7.7
Ratio score	68.4	83.3	72.2	74.5	66.7	70.0	80.0	72.4
H.K. score	0.42	0.65	0.42	0.51	0.1	0.25	0.75	0.54

(figures in parentheses indicate percent)

Table 3. Forecast verification analysis of precipitation at Shalimar (temperate zone) during 1997–98 summer and winter seasons. Source: Experimental Agromet Advisories Services (NCMRWF) Annual Report 1997–98, Division of Agronomy, SKUAST, Shalimar, Kashmir, India.

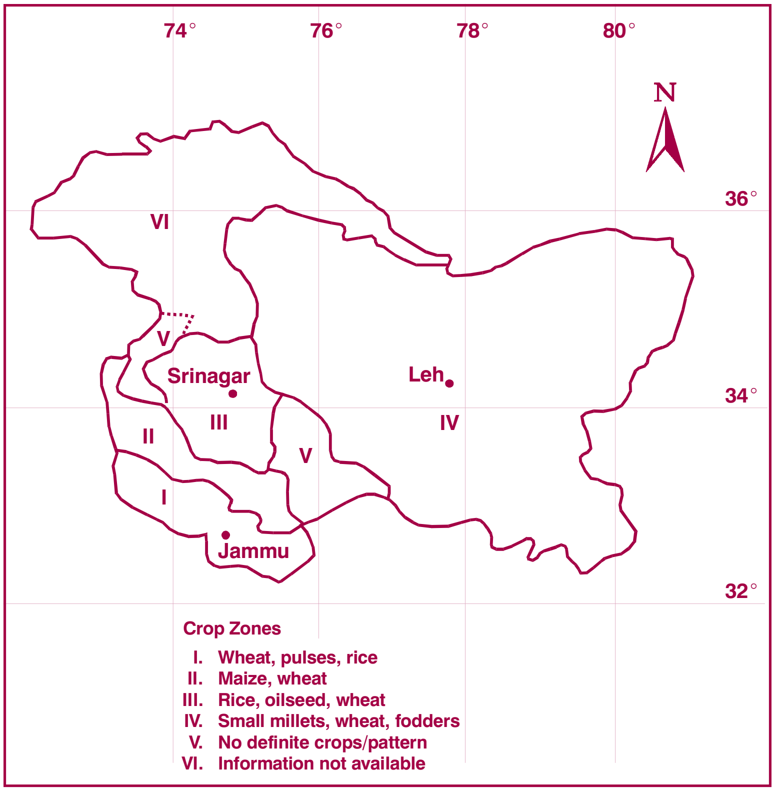

Figure 3. Crop zones of Jammu and Kashmir. Not to scale.

$$H(X) = q + pF(X)$$

where F(X) is the gamma distribution function, q is the probability of zero precipitation cases, and p = 1-q.

Eighteen stations have been analyzed in the state, and the results from representative stations of each zone are shown in Table 2. It is obvious from this table that different amounts of weekly rainfall are expected at different probability levels between the last week of April and the first week of October (i.e., meteorological weeks 17–40). Assured rainfall amounts decrease with the increase in probability levels from 30% to 70%. A zonal analysis of representative stations showed different trends. For example, in Jammu (representing subtropical zones) and Punch (representing intermediate zones), higher rainfall is expected between 26 and 36 meteorological weeks for the temperate zone, although the weekly totals were comparatively lower. For the cold arid zone, however, there is a very narrow time period of assured rainfall (17–20 meteorological weeks).

Table 3 depicts the forecast verification analysis recently carried out for precipitation at Shalimar (temperate zone). This was performed using the procedure mentioned earlier (Hasan and Kanth, 1997). The number of usable forecasts was higher during winter than summer (72.4% vs. 54.5%). In the present case, the precipitation events could be more reliably forecasted for day 2 and day 3 in both summer and winter, and this result is different from the trends observed earlier, wherein forecasts were more reliable for day 1 (Hasan and Kanth, 1997).

For agricultural planning and complex hydrological problems, knowledge of the characteristics of rainfall is a must. Long-term averages of annual, monthly, and weekly rainfall are quite useful and have widespread applications in regions/years of normal rainfall. But in regions of uncertain precipitation, like the one we have just reviewed, or in an arid/semiarid climate, one cannot fully depend on averages. Many agricultural operations revolve around the probability of receiving a definite amount of rainfall, and such an analysis can be useful for land use planning, identification of crop growing periods, choice of cropping pattern, and resource allocation.

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References

Anonymous. 1995. *Weekly Rainfall Probability for Selected Stations of India*, Vol. I and II. ADGM (Agric. Met.) IMD, Pune 411005, India.

FAO. 1983. "Guidelines: Land evaluation for rainfed agriculture." *Soils Bulletin* 52, FAO, Rome.

Hasan, B.; and R. H. Kanth. 1997. "Climatic uncertainties and recent experience in medium-range weather forecasting over Kashmir." *Drought Network News* 9(1): 12–14.

Sehgal, J.; D. K. Mandal; C. Mandal; and S. Vadivelu. 1992. *Agro-Ecological Regions of India*, II Edition. Tech. Bull., NBSS&LUP, Pub. 24, p. 130, NBSS&LUP, Nagpur 440 010, India.