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A BRIEF APPRAISAL OF RAINFALL DISTRIBUTION IN THE TWO REGIONS OF JAMMU AND KASHMIR STATE

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ABSTRACT: In this study rainfall distribution over the two regions of Jammu and Kashmir state has been studied using the available data of 70-year period from 1901-1970. Meteorological situations which cause rainfall over the state have been briefly described. Based on 70-year data, mean monthly, annual and seasonal rainfal for the two regions have been presented. Highest ever recorded one-day rainfall amounts received by individual stations in each of the regions have also been highlighted in the paper.

Introduction:

The rainfall distribution in the contiguous Indian area is noted for its diversity both in space and time. The bulk (i.e. 50 to 95%) of rainfall is, however, received, year after year, during the four monsoon months of June to September. Mean annual rainfall of the Indian area has been estimated to be about 117 cm (Dhar et al, 1981). As regards its spatial distribution over different states of the country, there is wide variation from one state to another.

The state of Jammu and Kashmir can broadly be divided into three climatic regions, viz., (i) Jammu region, (ii) Kashmir region and (iii) Ladakh region. Each of these regions has a distinct climate of its own. Ladakh region has a climate more or less resembling the climate of the trans-Himalayan region, as this region is located to the north of the Great Himalayan range. Precipitation distribution of this region has not been attempted in this study as Dhar and Mulye (1987) have discussed this in their paper, "Precipitation climatology over the Ladakh region." In the present study, rainfall distribution over the two remaining regions of Jammu and Kashmir state have been attempted, using the available rainfall data of the 70-year period 1901-1970.

Physiographical features of the state:

The state of Jammu and Kashmir is located in the extreme north of Indian Union. The state is bounded by Pakistan in the west, Afghanistan and U.S.S.R. in the northwest, China in the north, Tibet in the east and Himachal Pradesh and Punjab in the south. The boundaries of this state lie within Lat. 32°17′ N to 36°58′ N and Long. 73°26′ E to 80°30′ E. The geographical area of this state is about 2,22,266 sq. km. The three main Himalayan ranges run through this state, viz., (a) the foothills or the Shiwalik hills, (b) the middle or Lesser Himalayas, and (c) the Great Himalayan range. The foodhills or the Shiwalik hills lie between the Lesser Himalayas and the plains of Punjab in the south. The Shiwalik ranges form the southernmost boundary of the Himalalyan mountains (Mithal, 1968 and

Lall, 1981). The middle or lesser Himalayas are a series of broken mountain ranges. These ranges have different names in different sections of the Himalalyas. In the northwest India, this range is called the Pir Panjal range. The Great Himalayan range is the innermost highest range which is covered with snow and ice and terminates in the western Kasmir at Nanga Parbat (8126 m) which is the 10th highest mountani of the world. This highest mountain range forms the northern limit of the Kashmir valley and separates it from the trans-Hima'ayan plateau areas of Baltistan and Ladakh. The Pir Panjal range divides the state, south of the Great Himalayan range into two broad regions, viz., (a) Jammu region, to the south of it and (b) the Kashmir region, to the north of it (Dhar, et al, 1982). The Great Himalayan range, on which the famous 12,000 feet high Zojila and Burzil passes are located, separates the Valley of Kashmir from the trans-Himalayans regions of Ladakh and Baltistan. Important major rivers of the state are the Jhelum in Kashmir region, the Indus and its tributaries in Ladakh-Gilgit region and the Tawi, the Chenab and the Ravi in Jammu region. A good number of lakes are located in this state, famous among them are, the Dal Lake and the Wullar Lake. The Wullar Lake is the largest fresh water lake in India.

Network of rainfall stations and data used:

The J and K state is having some of the oldest meteorological observatories of this country. These are :– a) Srinagar since October, 1891, b) Gulmarg since July, 1897, c) Sonemarg since November, 1901 and d) Jammu since May, 1910, besides Leh (since September, 1873), Dras (since September, 1896) and Kargil (since January, 1908) which are located in the trans-Himalayan region of this state. Total number of rainfall stations whose normals have been pubblished by IMD (1962) are about 37 within these two regions of Jammu and Kashmir. The number of meteorological stations have been increased to more than 50 in recent years. Daily rainfall data of these stations are published in the monthly rainfall tables issued by the State Govt. and IMD includes these rainfall tables in the yearly rainfall volumes of India. The rainfall data of all these stations (numbering more than 50) have been used in this study.

Meteorological situations causing rain fall over the state :

Onset of the southwest monsoon over the state takes place towards the beginning of July and it withdraws from this region by about the beginning of september. Thus, the state comes under the sway of monsoon currents hardly for a period of two months or so only.

It is well known that depressions and cyclonic storms of the southwest monsoon season play an important role in the distribution of rainfall over central parts of the country as well as over northwestern region of India. The great majority of them originate from the head Bay of Bengal and move along the Indo-Gangetic plains in a westnorthwesterly direction and finally merge with the seasonal low over northwest India and Pakistan. Occasionally some active low pressure areas/monsoon depressions, after having reached west Madhya Pradesh, east Rajasthan and neighbourhood along their northwesterly tracks, under the influence of active westerly waves/troughs or active western disturbances, makes these low latitude weather disturbances recurve in a norther-

ly or northnortheasterly direction and move towards Punjab-Kashmir Himalayas causing heavy to very heavy rainfall over the state which ultimately result in devastating floods in the rivers of this region (Ananthakrishnan and Bhatia, 1958; Changrani, 1966 and Ramaswamy, 1987).

Generally speaking the valley of Kashmir is sheltered from the southwest monsoon by the high mountain ranges of the Pir Panjal range. Rainfall of Kashmir region is, however, well distributed all the year round, being more in magnitude in winter and spring months. The rainfall/snowfall received in the valley and its neighbourhood during winter and spring months is caused by the eastward movement of Western Disturbances (WDs) which enter India from the northwest through Iran, Afghanistan and Pakistan. These weather disturbances are extra-tropical disturbances whose origin is still not well understood. They cause incursion of moisture into the region from the Arabian Sea and cause moderate to heavy rainfall/snowfall over the Western Himalayas in association with their eastward movement. Most of the Himalayan snow of winter and spring months is largely due to these disturbances. Their frequency during winter (Dec. – Feb.) and spring (Mar. – Apr.) months is of the order of 3 to 6 disturbances per month. As the season advances, i.e. during summer and monsoon months, these disturbances travel along northern latitudes but occasionally these disturbances come down to lower latitudes. The winter rain of Punjab, which is so important for wheat crop in the state, is mainly due to eastward movement of some of these active disturbances through the latitudes of Kashmir and Punjab. It is thus seen that moderate to heavy rainfall over Jammu and Kashmir regions normally occurs in association with the following meteorological situations :–

(a) During winter and spring months eastward movement of active western disturbances through or near the region from the west,

(b) Generally towards the end of the monsoon season, due to recurving monsoon depressions/active low pressure areas from the head Bay of Bengal or the Arabian Sea after these disturbances have reached east Rajasthan or west Madhya Pradesh and then getting dissipated over the hills of the Western Himalayas. Normally this happens when movement of these disturbances synchronize with the eastward passage of westerly waves/western disturbances in the northern latitudes.

(c) Movement of upper air cyclonic circulations over and near this region, and

(d) Active monsoon conditions prevailing over the northwestern region during the monsoon months.

Mean monthly and annual rainfall:

Long term mean monthly and annual rainfall over a region is needed for various planning purposes by the planners, design engineers, agricultural experts and administrative authorities of a region concerned. Keeping this in view, the rainfall data of stations in Jammu and Kashmir regions have been considered regionwise and mean monthly and annual rainfall estimates have been worked out using mean monthly and annual normals of rainfall of 70 years (1901-1970). Till up to date data of all the stations in each of these two regions becomes avail

Table – 1 : Mean monthly and annual rainfall (1901-1970) for the regions of Jammu and Kashmir

Month	Jammu Region		Kashmir Region	
	Mean rainfall (cm)	% of annual (%)	Mean rainfall (cm)	% of annual (%)
January	10.0	8.0	10.5	10.7
February	10.0	8.0	11.6	11.7
March	9.9	7.9	15.0	15.1
April	5.9	4.7	13.3	13.5
May	3.9	3.1	8.5	8.6
June	6.5	5.2	5.1	5.1
July	28.9	23.0	8.1	8.2
August	29.7	23.8	8.0	8.1
September	11.0	8.8	5.5	5.6
October	2.5	2.0	4.7	4.7
November	1.5	1.2	2.6	2.7
December	5.3	4.3	5.9	6.0
Annual	124.8 (say: 125 cm)		98.8 (say: 99 cm)	

able, the mean monthly and annual rainfall values given in Table – 1 of this paper may be taken as tentative.

It is seen from Table – 1 that Jammu region receives annually about 125 cm of rainfall while Kashmir region receives about 99 cm. July and August months are the rainiest months over Jammu region as this region receives an average rainfall of about 29 cm and 30 cm respectively during these principal monsoon months. Over Kashmir region Junuary to April months are found to be the rainiest months as they contribute about 11, 12 15 and 13 cm of rainfall/snowfall respectively in each of these months. Mean rainfall in July and August months over Kashmir region is far less as compared to rainfall in Jammu region. As can be seen from Table-1, July and August months receive about 8 cm of rainfall in each of these months over Kashmir region. November is the lowest rain receiving month as compared to other months for both the regions of Jammu

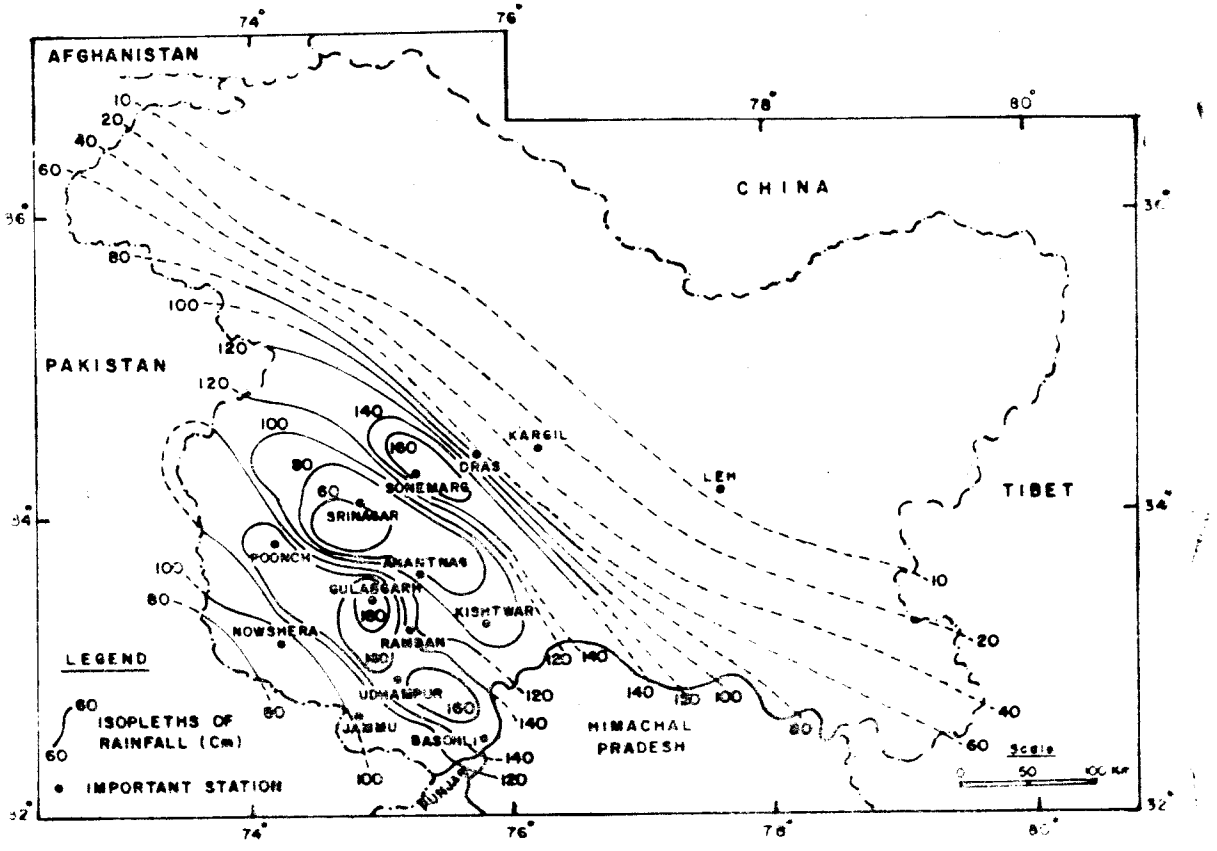

FIG. 1 MEAN ANNUAL RAINFALL OVER JAMMU AND KASHMIR STATE (IN Cm)
(1901 - 1970)

and Kashmir. Fig. 1 shows the mean annual rainfall pattern over the state as a whole. Mean monthly and annual rainfall of 10 representative stations from each of the regions of Jammu and Kashmir have been given in Table-2 for comparison of magnitudes of individual station data in each region. From this table it is seen that during monsoon months individual stations in the south of Pir Panjal range receive far greater rainfall than stations on the northern side of it (Dhar et al, 1982). It is mainly due to the fact that the southern area (i.e. Jammu region) happens to to be located on the windward side of the monsoon currents which on account of orographic lifting are forced to shed most of their moisture on the southern side of the mountain ranges. The Pir Panjal range of the Himalayas acts as a mountain barrier in the northward movement of monsoon currents and as such rainfall considerably decreases in Kashmir region which is evident from a perusal of Table-2 and Fig. 1.

Table — 2 : Mean monthly and annual rainfall (cm) of representative stations in the regions of Jammu and Kashmir (1901-1970)

Sr. No.	Name of the station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						JAMMU REGION								
1.	Banihal	14.8	21.1	22.4	16.0	9.5	5.2	8.4	5.9	7.1	4.5	5.6	12.3	132.8
2.	Gulabgarh	18.0	16.9	14.1	9.8	5.4	9.8	42.8	43.0	16.4	3.3	2.0	8.8	190.3
3.	Jammu	5.9	5.7	5.6	3.2	1.9	6.7	31.7	31.2	12.5	2.3	0.7	3.4	110.8
4.	Kathua	7.0	6.0	5.3	3.0	1.7	5.6	35.5	37.1	15.8	2.9	0.7	3.7	124.3
5.	Kishtwar	10.6	11.1	14.1	10.2	6.2	4.2	7.8	7.1	6.3	3.1	2.0	6.1	88.8
6.	Nowshera	6.5	6.9	6.1	3.9	3.0	5.4	25.3	24.2	9.8	2.2	0.8	3.3	97.4
7.	Ramban	16.4	15.3	14.8	8.9	5.3	4.9	14.5	13.9	8.6	2.8	1.9	9.0	116.3
8.	Rampur Rajouri	10.2	10.2	10.7	7.0	4.8	10.8	32.7	33.7	13.7	2.7	1.4	5.3	143.2
9.	Samba	6.5	5.3	5.3	2.3	2.0	5.4	31.7	34.5	12.5	2.0	0.7	3.4	111.6
10.	Udhampur	10.9	10.6	9.8	4.5	3.1	3.4	38.6	42.2	15.9	2.8	1.2	5.0	148.0

Table — 2 : Contd.

Sr. No.	Name of the station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						KASHMIR REGION								
1.	Anantnag	7.0	7.2	8.8	8.4	5.6	3.5	5.6	5.5	4.8	2.6	1.3	4.1	64.4
2.	Baramulla	10.9	11.9	16.1	13.9	8.9	4.8	4.9	4.8	3.9	4.4	2.5	6.2	93.2
3.	Durroo	15.6	15.7	16.6	12.2	8.9	5.4	8.5	8.0	8.1	3.7	3.7	8.4	114.8
4.	Sopore	11.0	11.9	14.6	11.5	7.2	3.5	4.4	3.9	3.9	4.2	2.5	4.0	82.6
5.	Sonemarg	25.0	23.4	31.5	23.7	14.3	8.3	9.5	8.5	9.4	7.7	4.0	13.2	178.5
6.	Srinagar	6.8	7.0	9.7	9.4	6.3	3.5	5.1	6.3	3.7	3.1	1.7	3.9	66.5
7.	Quazigund	13.4	16.5	19.7	13.6	12.1	6.9	9.0	7.9	7.0	3.1	3.8	6.8	119.8
8.	Uttarmachipura	13.8	13.3	19.1	16.1	9.9	4.8	5.7	6.9	4.5	5.5	2.6	7.0	109.2
9.	Uri	13.8	14.3	18.9	14.5	9.9	8.0	10.1	9.7	7.2	5.5	2.7	8.2	122.8
10.	Vantipore (Pulwama)	5.7	66.5	8.1	7.9	5.6	3.8	6.0	6.1	3.5	2.3	1.4	3.3	60.2

Seasonal rainfall in the regions of Jammu and Kashmir :

For agricultural, industrial and other water resources developmental activities, mean seasonal rainfall of a region are often required. With this aim in view, the seasonal rainfall for the regions of Jammu and Kashmir have been studied. The year has been divided into the following 5 broad seasons taking into consideration the climatology of these two regions :—

Table — 3 : Mean seasonal rainfall (cm) for the regions of Jammu and Kashmir (1901-1970)

Seasons	Jammu Region		Kashmir Region	
	Rainfall (cm)	% of Annual (%)	Rainfall (cm)	% of Annual (%)
Winter (Dec. – Feb.)	25.3	20.3	28.0	28.4
Spring (Mar. – Apr.)	15.8	12.6	28.3	28.6
Summer (May – June)	10.4	8.3	13.3	13.7
Monsoon (July – Sept.)	69.3	55.5	21.6	21.9
Autumn (Oct. – Nov.)	4.0	3.2	7.3	7.4

i) Winter – December to February,

ii) Spring – March and April,

iii) Summer – May and June,

iv) Monsoon – July to September and

v) Autumn – October and November.

Based on the above classification of seasons, mean seasonal rainfall for the two regions has been worked out. Table–3 shows the mean seasonal rainfall for the two regions. From this table it is seen that the monsoon rainfall for Jammu region is about 69 cm which is about 56% of the annual while for Kashmir region it is hardly 22 cm which is just 22% of the annual. The winter season receives 28 cm of rainfall in Kashmir region which is about 28% of the annual. Compared to this the Jammu region receives only 25 cm which is about 20% of the annual. Table–3 also shows that for Jammu region monsoon season is the main rainy season and next to it is the winter season. In the case of Kashmir region, the winter and the spring seasons are the principal rainy seasons while the monsoon season receives only 22% of the annual. It is thus seen that so far Kashmir region is concerned monsoon rainfall is less than what is received in winter and spring seasons. Most of the winter rainfall in Kashmir region occurs in the form of snow/snow-rain. Unlike rainfall, precipitation in the form of snow has the advantage that it remains locked up in the higher altitudes till the arrival of summer months when higher atmospheric temperatures cause the frozen snow to melt. The snow-melt water in the rivers of the region is used for paddy cultivation or other agricultural operations and power generation when there is little contribution from rainfall activity during summer and monsoon seasons.

Highest observed one-day rainfall:

Information about the highest observed one-day point rainfall is required for planning and design of hydraulic structure of medium and minor nature like storm water drainage systems, airport drainage etc. etc. Highest observed one-day point rainfall for each of the stations in the two regions were picked out from a careful scrutiny of the last 80-90 years rainfall/snowfall records.

Table — 4 : Highest observed one-day rainfall (cm) for stations in the regions of Jammu and Kashmir

Jammu Region			Kashmir Region		
Name of the station	Highest 1-day rainfall (cm)	Date of occurrence	Name of the station	Highest 1-day rainfall (cm)	Date of occurrence
Akhnur	24.9	25-9-1917	Anantnag	14.9	1-9-1928
Banihal	16.3	25-9-1988	Baramulla	10.7	17-2-1925
Basohli	22.9	4-10-1955	Durroo	20.3	29-11-1946
Bhadarwah	16.2	26-9-1988	Gulmarg	23.8	5-7-1959
Gulabgarh	37.1	14-9-1906	Karnah	20.3	24-5-1901
Jammu	29.9	31-7-1961	Kulgam	14.3	11-9-1905
Jasmirgarh	16.3	29-8-1926	Langet	14.5	5-7-1949
Kathua	36.5	26-9-1988	Malashahibag	10.1	22-7-1945
Kishtwar	22.9	13-4-1955	Muzaffarabad	17.6	24-7-1939
Nowshera	23.7	1-9-1928	Quazigund	11.3	13-2-1972
Poonch	26.8	31-8-1928	Sonemarg	30.0	27-2-1936
Ramban	18.5	25-8-1957	Sopore	10.8	11-11-1952
Ramnagar	22.3	18-9-1950	Srinagar	15.3	6-2-1893 & 31-1-1930
Rampur Rajouri	25.0	29-8-1929	Sri Pratapsingh Pura	30.5	11-9-1941
Reasi	30.5	28-8-1929	Uri	13.1	3-3-1920
Samba	24.1	9-8-1914	Uttarmachi-pura	21.8	16-4-1915
Sri Ranbirsingh Pura	20.7	5-7-1967	Vantipore	17.8	7-8-1958

Table–4 shows the list of stations whose highest one-day rainfall data were examined alongwith magnitudes of the highest one-day rainfall with their respective dates of occurrence. The magnitudes of such highest rainfall are also useful as background material for estimation of probable maximum precipitation (PMP) or extreme rainfall which nature is capable of producing over a given location. It is seen from Table-4 that the highest ever recorded one-day rainfall by any station in the two regions is of the order of 37 cm which was recorded at Gulabgarh on 14 Sept., 1906. In Kashmir valley the highest one-day rainfall is 30.5 cm and it was recorded at Sri Pratapsinghpura on 11 September, 1941. Jammu recorded 30 cm in one-day on 31 July, 1961 while for Srinagar, magnitude of the highest one-day rainfall was found to be 15 cm and it was recorded on two occasions in the winter months, viz., 6 Feb., 1893 and 31 Jan., 1930.

Summary and conclusions:

From the foregoing the following broad conclusions can be obtained:-

1. On the basis of 70-year data, mean annual rainfall for Jammu region has been estimated as 125 cm while for Kashmir region it is about 99 cm.

2. In the monsoon season, Jammu region receives about 69 cm of rainfall which is about 56% of its mean annual while Kashmir region, on the other hand receives hardly 22 cm of rainfall which is only 22% of the annual. From a perusal of individual station data given in Table–2 it is evident that all stations in Jammu region get higher rain amounts in the monsoon months than stations located in Kashmir region.

3. During winter and spring seasons, Kashmir region gets more rainfall than Jammu region. Rainfall in these seasons over Kashmir region is normally found to occur due to the eastward movement of Western Disturbances which enter India through Iran, Afghanistan and Pakistan.

4. The highest ever recorded one-day rainfall in Jammu region was found to be 37 cm which was recorded at Gulabgarh on 14 Sept., 1906. The highest ever recorded one-day rainfall by any individual station in Kashmir region was found to be 30.5 cm and this was recorded at Sri Pratapsinghpura on 11 Sept., 1941. It is also seen that Jammu city recorded highest one-day rainfa l of 30 cm on 31 Jul., 1961 and Srinagar recorded about 15 cm on 6 Feb., 1893 and 31 Jan., 1930.

In this study an attempt has been made to present working estimates of mean rainfall etc. for the two regions of Jammu and Kashmir on the basis of rainfall data available to the authors at present. It is hoped that this information will be helpful to various users of this data. What is urgently required for the batter understanding of rainfall climatology of this state is that a denser network of rainfall stations may be installed at representative sites and different altitudes in the two regions. Also it is necessary to have automatic recording rainfall/snowfall stations installed at different places, specially at higher altitudes in order to have an idea of maximum intensity of rainfall for shorter durations.

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