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## **Probability Analysis of Rainfall at Udham Singh Nagar, Uttarakhand**

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### **ABSTRACT**

The probability and frequency of rainfall pattern is one of the important parameter for long term planning of agricultural operation and irrigation schemes as well as for watershed management. Keeping above points in view the statistical analysis has been carried out for 20 year period (1996-2015) of rainfall of Udham Singh Nagar. The average annual rainfall was found to be 1706.0 mm. All months, season and years has been distributed as drought, normal and surplus months. The expected rainfall at different rainfall chances (80%, 50% and 20%) has been carried out. The study reveals that the *Kharif* was the wettest season with average rainfall of 1530.705 mm and C.V. = 4.1 and *Rabi* was the driest season with average rainfall of 176.8 mm and C.V. = 0.7. Out of all 20 years months 44.17% months are drought months and 43.75% and 12.08% months are normal and surplus months, respectively. Maximum number of normal months was found in July and August months and maximum number of droughts months in November month followed by October. The expected probability analysis results can be used for crop planning, intercultural operations and planning of irrigation scheme in the command area. The surplus water available in the monsoon season can be stored by constructing water harvesting structures in the command area and that can be used during *Rabi* season when scarcity of water faced due to lack of rainfall.

**Keywords:** Normal, Drought, Surplus season, Normal, Drought, Surplus months.

## **Introduction**

The Indian agriculture and economy is mostly influenced by rainfall but the rainfall distribution in India varies considerably from time to time and space to space. So for planning the agricultural programme and irrigation scheme the knowledge of average rainfall pattern is required. Many times, a particular average annual rainfall shows that the year is normal year but practically it is not true because it may be possible that the rainfall not evenly distributed over whole year and month. So the temporal distribution is uneven and it may damage whole crops of the region. Similarly this problem can be apply on dry spell that damage the crops but average annual rainfall shows that year as a normal month. Therefore the monthly and weekly analysis of rainfall is most important for proper time of sowing and other agricultural operations. Keeping above points in view the probability and frequency analysis of normal, drought and surplus rainfall values (months, seasons and years) on the basis of rainfall data for 20 years (1996- 2015) has been carried out for Udham Singh Nagar, which is situated in state of Uttarakhanad. For seasonal analysis the whole year was divided in two seasons as *kharif* (April to September) and *rabi* (October to March). Therefore the seasons were classified as driest and wettest season on the basis of results.

## **Location**

The Udham Singh Nagar district is a leading agricultural district of Uttarakhanad. It is surrounded by Nainital district in the north, by Champawat district in the northeast and east by Nepal and in the southeast by Pillibhit and in the south by Rampur, Bareilly and in the west by Moradabad and Bijnor district of Uttar Pradesh. The longitude and latitude of district is 79 50' 01 E and 28 56' 22 N and respectively. It is located at an altitude of 550 meters above sea level. The index map of district Udham Singh Nagar is shown in Fig 1.



Figure 1: Index map of Udham Singh Nagar

## Material and Methods

The daily rainfall data of 20 years (1996 - 2015) were collected from Collectrate Office of the Udham Singh Nagar district. The daily data were converted into weekly, monthly, seasonal and annual rainfall. The statistical parameters such as average ( $\bar{x}$ ), standard deviation ( $s$ ) and coefficient of variation ( $Cv$ ) were calculated for month, season and annual rainfall. Following the standard definitions has been used for the analysis of the years and months:

Drought month: Any month receiving precipitation less than 50% of the average monthly rainfall.

Normal month: Any month receiving the precipitation in between 50 and 200% of the average monthly rainfall.

Surplus month: Any month receiving precipitation more than 200% of the average monthly rainfall.

Drought year: Any year receiving rainfall less than or equal to  $X - S.D.$

Normal year: Any year receiving rainfall between  $X - S.D.$  and  $X + S.D.$

Surplus year: Any year receiving rainfall more than  $X + S.D.$

## **Results and Discussion**

The results of present study can be summarized under following points:

### **Probability analysis**

The weekly expected rainfalls at 80%, 50% and 20% chances are given in Table 1. The monthly and seasonal expected rainfalls at 80%, 50% and 20% chances are given in Table 2. From the Table 1 it is observed that at 80% chance, the weekly rainfall is expected only from 25<sup>th</sup> week to 38<sup>th</sup> week of the year. The maximum rainfall of 46.6 mm is observed in 29<sup>th</sup> week and minimum rainfall of 0.8 mm in 38<sup>th</sup> week at 80% chance. Similarly probability level of 50% chances expected from 18<sup>th</sup> to 39<sup>th</sup> week and in 6<sup>th</sup>, 7<sup>th</sup> and 16<sup>th</sup> weeks of the year. The maximum rainfall as 173.35 mm occurs in 33<sup>th</sup> week and minimum in 7<sup>th</sup> and 16<sup>th</sup> weeks with 0.5 mm rainfall. The 20% chances observed from 1<sup>th</sup> to 40<sup>th</sup> weeks with maximum rainfall of 299.6 mm in 33<sup>th</sup> week and minimum in 12<sup>th</sup> week with 1 mm rainfall.

From Table 2 it is observed that maximum 80% chances occur in August month followed by September month with 335.7 mm rainfall and 312 mm rainfall respectively and the minimum 80% chances observed in April month with 1 mm rainfall followed March month. The 50% maximum chances occur in August month with 426.7 mm rainfall followed by July month with 387.4 mm rainfall. Similarly maximum 20% chances occur in July month with 619.7 mm rainfall which followed by August month with 548 mm rainfall. The 80%, 50% and 20% chances in *Rabi* season are 42 mm, 180 mm and 288.6 mm respectively and in *kharif* season the 80%, 50% and 20% chances are 907.2 mm, 1408.65mm and 1994 mm respectively.

**Table 1: Weekly expected rainfall at different percent chances**

Standard weeks	80% chances	50% chances	20% chances	Standard weeks	80% chances	50% chances	20% chances
1	0	0	21.8	27	9.8	72.3	132.8
2	0	0	1.8	28	35	65.3	134.4
3	0	0	20.6	29	46.6	94.6	158.4
4	0	0	2.6	30	20.8	58.2	143.2
5	0	0	7.2	31	11.4	72.9	178.4
6	0	1.5	32.2	32	34.4	67.8	135.2
7	0	0.5	19.4	33	22	173.35	299.6
8	0	0	3.4	34	3.8	85.9	220.2
9	0	0	9.8	35	1.2	40.3	99.6
10	0	0	5.2	36	11.4	50	157.8
11	0	0	3.2	37	4.8	47	71.4
12	0	0	1	38	0.8	22.9	168.8
13	0	0	2.8	39	0	2.4	112
14	0	0	5.6	40	0	0	19.6
15	0	0	3.8	41	0	0	0
16	0	0.5	3	42	0	0	0
17	0	0	2	43	0	0	0
18	0	1.7	10	44	0	0	0
19	0	3.4	30.2	45	0	0	0
20	0	5.2	17.6	46	0	0	0
21	0	1.5	18	47	0	0	0
22	0	2.9	27.8	48	0	0	0
23	0	12.4	50.4	49	0	0	0
24	0	25.5	103	50	0	0	0
25	5.4	36.7	66.4	51	0	0	0
26	28.2	72.1	101.2	52	0	0	4.2

**Table 2: Monthly and seasonally expected rainfall (mm) at different percent chances**

Months	80%	50%	20%
January	1.8	24.4	60.6
February	3.4	26.4	79.2
March	1.4	8.2	26.8
April	1	7.9	20.1
May	25.2	41.8	71.2
June	97.2	195.1	332.6
July	301.4	387.4	619.7
August	335.7	426.7	548
September	312	220.5	453.2
October	0	14.1	85
November	0	0	2
December	0	0.2	14.8
Season			
<i>Rabi</i>	42	180	288.6
<i>Kharif</i>	907.2	1408.65	1994

**Drought, normal and surplus months:**

The month wise distribution of months as drought, normal and surplus months is given in Table 3. The probability distribution of drought, normal and surplus months is given in Table 4. Month wise

distribution of normal, drought and surplus rainfall is given in Table 5. Maximum number of normal months in July and August months and maximum number of droughts months in November month. As shown in Table 4 that occurrence of maximum no of drought, normal and surplus months in a year was 9, 5 and 4 respectively with the probability of occurrence 10%, 5 % and 5%, respectively. The minimum possibility of occurrence of drought and surplus month in a year is 5%, 1% with no normal month. From Table 5, it confirms that the highest frequency of occurrence of normality was in both July and August months and percentage distribution of normal months varied from 2.9 to 17.1. Similarly, it is clear that the percentage distribution of drought months varied from 0.9 to 15.1 with highest frequency in November month. Out of all 20 years months 44.17% months are drought months and 43.75% and 12.08% months are normal and surplus months respectively. In *kharif* season (April to September) out of 120 months 38 months are drought months which is 31.67% of the total *kharif* months. In *rabi* season (October to March) out of 120 months, 69 months are drought months which are about 57.5% of the total *Rabi* months. The relationship between average monthly rainfall and coefficient of variation indicates that the rainfall has inverse relationship with coefficient of variation. As shown in Fig 2 July and August were the wettest months with maximum rainfall with minimum C.V.

**Table 3: Month wise distribution of number of months to be drought , normal and surplus**

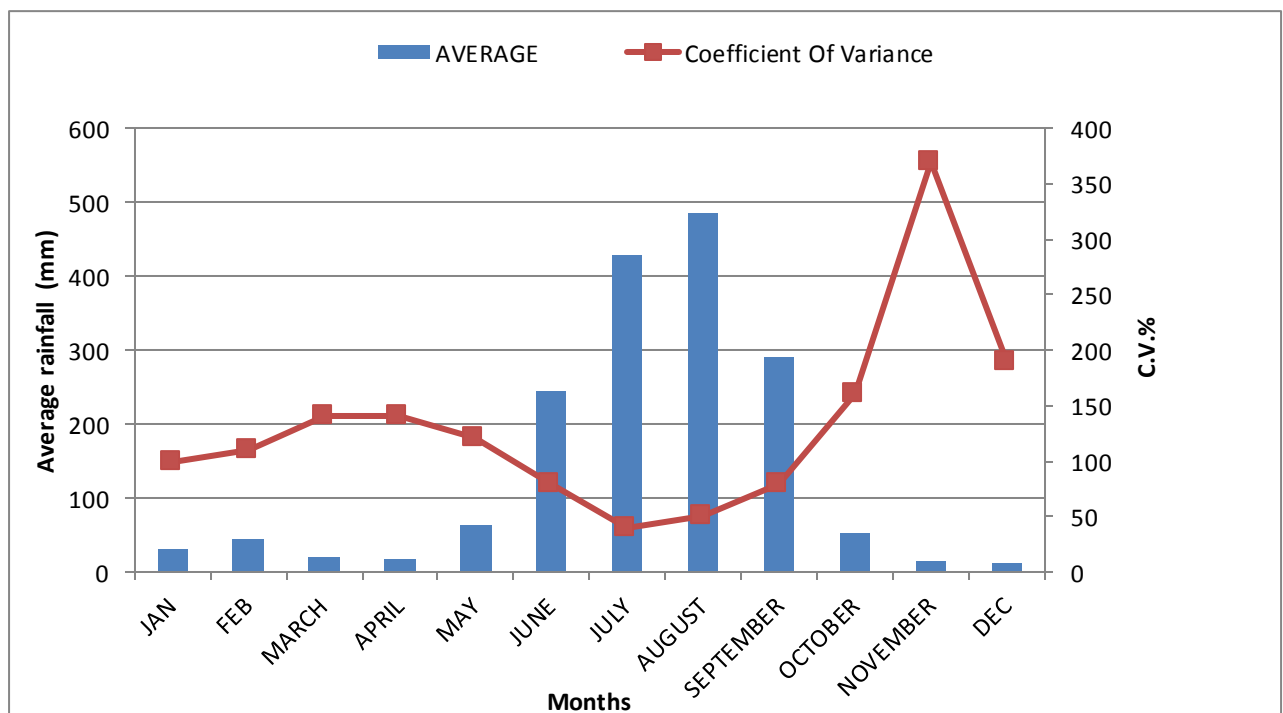
Months	Value of rainfall (mm) to be a			Total number of months		
	Drought (less than)	Surplus (more than )	Normal (between)	Drought	Surplus	Normal
January	15.9	63.7	45.9 - 63.7	8	4	8
February	22.6	90.4	22.6 – 90.4	10	4	6
March	10.1	40.4	10.1 – 40.4	11	4	6
April	8.4	33.7	8.4 – 33.7	11	2	7
May	31.8	127.1	31.8 – 127.1	8	2	10
June	122.7	490.7	122.7 – 490.7	8	3	9
July	214.6	858.5	214.6 – 858.5	2	0	18
August	242.1	968.5	242.1 – 968.5	1	1	18
September	145.7	582.9	145.7 – 582.9	7	3	10
October	26.4	105.4	26.4 – 105.4	13	3	4
November	6.9	27.7	6.9 – 27.7	16	1	3
December	5.7	22.9	5.7 – 22.9	11	3	6

**Table 4: Probability distribution of normal month (NM), drought month (DM), and surplus month (SM) in a year and percentage of total years having the given number of NM, DM and SM**

DM	Probability	% of total years having given no. of DM	NM	Probability	% of total years having given no. of NM	SM	Probability	% of total years having given no. of SM
9	0.1	10%	5	0.05	5%	4	0.05	5%
8	0.3	20%	4	0.15	10%	3	0.7	65%
7	0.7	40%	3	0.45	30%	2	0.95	25%
6	0.95	25%	2	0.75	30%	1	1	5%
5	1	5%	1	0.85	10%			
			0	1	15%			

**Table 5: Month wise distribution of drought, normal and surplus**

Months	% of total drought months falling in the given months	% of total years having the given month as a drought month	% of total normal months falling in the given months	% of total years having the given month as a normal month	% of total surplus months falling in the given months	% of total years having the given month as a surplus Month
January	7.5	40	7.6	40	13.3	20
February	9.4	50	5.7	30	13.3	20
March	10.4	55	5.7	30	13.3	15
April	10.4	55	6.7	35	6.7	10
May	7.5	40	9.5	50	6.7	10
June	7.5	40	8.6	45	10.0	15
July	1.9	10	17.1	90	0.0	0
August	0.9	5	17.1	90	3.3	5
September	6.6	35	9.5	50	10.0	15
October	12.3	65	3.8	20	10.0	15
November	15.1	80	2.9	15	3.3	5
December	10.4	55	5.7	30	10.0	15



**Figure 2: Variation of monthly rainfall**

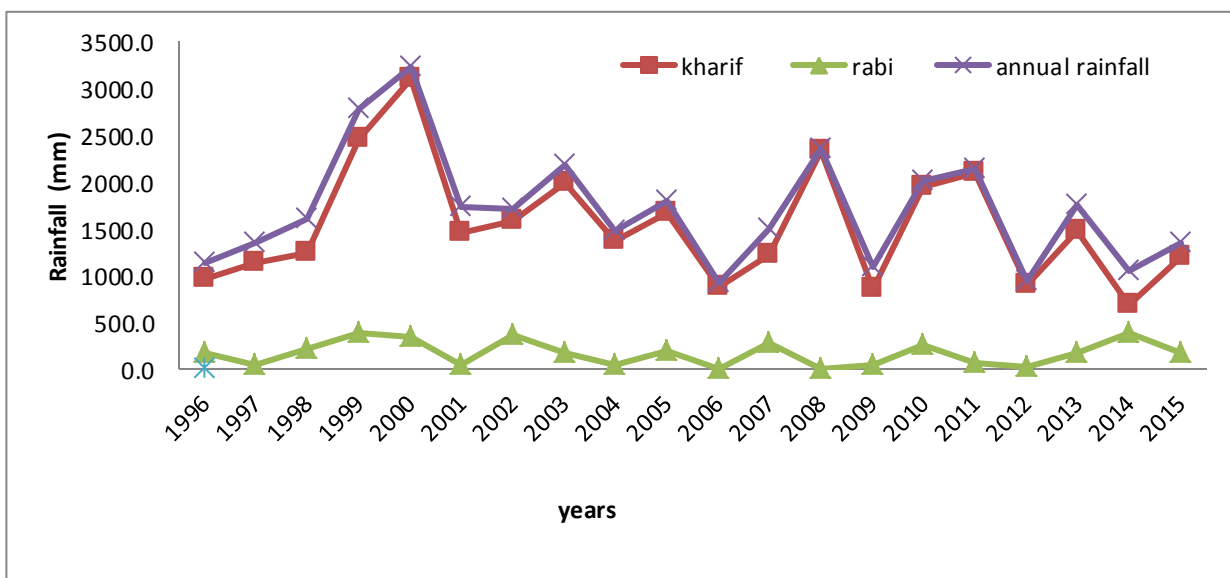


**Drought, normal and surplus years:**

The variation in *Rabi*, *Kharif* season and annual rainfall is shown in Fig. 3. The average annual rainfall was found to be 1706.0 mm for 20 years (1996 to 2015). The standard deviation of these data is 610.2 mm. Any year receiving the rainfall less than or equal to 1095.8 mm ( $\bar{x} - \sigma$ ) will be drought year. As per the definition 15% of the total years (2006, 2012 and 2014) were drought years. Any year receiving the rainfall equal to more than 2316.2 mm ( $\bar{x} + \sigma$ ) will be the surplus year; therefore, 15% of the years (1999, 2000 and 2008) would be the surplus years for the study period. The year receiving rainfall between 1095.8 mm to 2316.2 mm will be the normal years (70%). So 1996, 1997, 1998, 2001, 2002, 2003, 2004, 2005, 2007, 2009, 2010, 2011, 2013 and 2015 may be termed as normal years.

**Monthly and seasonal rainfall:**

The statistical analysis such as Average, standard deviation ( $\sigma$ ) and coefficient of variation (Cv) has been carried out for monthly and seasonally rainfall in presented study and calculated values is given in Table 6. It is clearly seen in Table 6 that August was the wettest month with average rainfall of about 484.3 mm and C.V. equal to 0.5; it was followed by July month with average rainfall of 429.2mm and C.V. of 0.4. December was the driest month which received minimum average rainfall of 11.4 mm with C.V. of 1.9 and it was followed by November with average rainfall of 13.9 mm with C.V. of 3.7 mm. The value which has higher value of coefficient of variation that value has lesser irregularity and randomness and condition applied vice - versa. Out of total 200 months (20 years) drought, normal and surplus and months were found to be 44.17%, 43.75% and 12.1% of the total months, respectively. Similarly for season, it is clearly concluded from Table 6 that *kharif* was the wettest season with average rainfall of 1530.705 mm and C.V. = 4.1 and *rabi* was the driest season with average rainfall of 176.8 mm and C.V. = 0.7.



**Figure 3: Variation of seasonal rainfall**

**Table 6: Monthly rainfall (1996-2015) statistics at Udham Singh Nagar**

Months	Average	Variance	Standard Deviation	Coefficient Of Variance
January	31.9	1107.3	33.3	1.0
February	45.2	2425.0	49.2	1.1
March	20.2	806.2	28.4	1.4
April	16.8	524.5	22.9	1.4
May	63.6	5565.8	74.6	1.2
June	245.4	35929.3	189.6	0.8
July	429.2	30447.5	174.5	0.4
August	484.3	52389.7	228.9	0.5
September	291.5	48758.8	220.8	0.8
October	52.7	6999.1	83.7	1.6
November	13.9	2654.3	51.5	3.7
December	11.4	460.9	21.5	1.9
<b>Season</b>				
<i>Kharif</i>	1530.7	390493.4	6375.6	4.1
<i>Rabi</i>	176.8	17706.17	133.1	0.7

## Conclusion

In the present study the probability and frequency analysis of rainfall data of district Udham Singh Nagar has been done by converting the daily rainfall data into weekly, monthly and seasonal values. The expected weekly, monthly and seasonal rainfall at different chances (80%, 50% and 20%) has been represented. From the study it was found that August was the wettest month and December was the driest month in the study area. The expected rainfall at different probability levels can be used for the planning of agricultural programme and irrigation schemes in the area. The monthly analysis has been done for drought, normal and surplus months and similarly this analysis worked for years. The expected probability analysis results can be used for crop planning, intercultural operations and planning of irrigation scheme in the command area. The surplus water available in the monsoon season can be stored by constructing water harvesting structures in the command area and that can be used during *rabi* season when scarcity of water faced due to lack of rainfall.

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