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Drought Investigation for Crop Planning in Gagar Watershed in Kumaon Region of Uttarakhand

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ABSTRACT: *Water scarcity is a burning problem for the hill agrarians, as the same is limited particularly during dry period and no irrigation facilities are available except in the valleys where it is possible with perennial water sources. Usually, downstream reaches of the hilly region faces the flood during the monsoon season and drought during the non-monsoon season due to the available topographical variation. Therefore, in this region rainfall amount, variability and distribution pattern plays a vital role in pragmatic planning and management of natural resources. Considering all points and the indispensable role of water in domestic purpose, agriculture, horticulture, animal husbandry, fisheries and forestry, etc., drought analysis of Gagar watershed located in Nainital district of Uttarakhand, have been statistically accomplished. Weekly rainfall data was observed to be more useful for planning of irrigation schemes, cropping patterns, design of natural resources conservation and management measures so as to mitigate situations like flood, and managing harvested rainfall in drought conditions.*

Key words: *Rainfall behaviour, Drought Investigation, Kumaon region, Crop planning, Watershed management*

I. INTRODUCTION

Rainfall plays significant role in deciding the severity of drought prone area in a particular region. In a rainfed farming region, the crop irrigation scheduling is also preferred by analysing the pattern of rainfall in a season. Various water conservation techniques such as rain water harvesting, rainfall cistern system, etc. are all rainfall dependent. Therefore, for implementation of preferential conservation measures, it is essential to study rainfall behaviour in terms of information on rainfall amount, duration and intensity of drought. Rainfall trend analysis performed from past records of rainfall can be used to generate future scenarios of rainfall occurrence and could be useful particularly in rainfed farming areas.

Sharma et al. (1979) analysed annual, seasonal, monthly and weekly rainfall data of Pantnagar. They reported that weekly data of rainfall was found to be more useful than monthly, seasonal or annual data for planning of cropping programme as well as for water management practices Bertoni et al. (1992) studied on rainfall-based real-time flood forecasting. A conceptual rainfall-runoff model (IPH-II) for real time flood forecasting and a simplified stochastic model. The methods were tested using data from a small watershed (the river Ray at Grendon Underwood, UK), for which 17 years of records were available. The results showed that a simple method used to forecast rain falling during the next few hours, might help to improve real-time discharge estimates. Suresh et al. (1993) conducted a study at Pusa (Bihar) for rainfall data of 26 years (1969-1985) by including characteristics and variation in rainfall with respect to normal, abnormal and drought months in a year by using Weibull's method and reported that at 90 per cent probability level the expected annual rainfall obtained was below the drought level and during Rabi season there was hazardous distribution of rainfall. Subudhi et al. (1996) analysed 28 years' rainfall data at Phulbani and based on probability analysis, suggested the crop varieties with growing period of four months from June to September for Phulbani under rainfed conditions. In this paper an attempt has been made to carry out the probability drought analysis on the basis of weekly rainfall data for Gagar watershed of Uttarakhand.

II. MATERIALS AND METHODS

Drought is the period of abnormal dry weather condition / deficit rainfall resulting in moisture stress condition and hydrological disparity of the system It is one of the important parameter for planning and management of various sectors such as agriculture, industrial, domestic, etc. particularly, in rainfed and water scarce region. In this research an attempt has been made to investigate the drought over the Gagar watershed located in Kumaon region of Uttarakhand.

A. Study Area

The study area i.e. Gagar watershed consists the Research Station of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar and nearby area, forming the watershed, which is located near Bhowali in Nainital district of Uttarankhand state in India as shown in Fig 1. The watershed, covering an area of 603.02 ha is located between 79^0 31' 43" E to 79^0 33' 24" E longitude and 29^0 24' 38" N to 29^0 26' 43" N latitude. The elevation varied from 1413 to 2380 m above mean sea level (MSL).

Slope, drainage, shade cast etc. are the important elements of topography. There was a lot of variation in the topography of the study area. In conformity with the dramatic altitudinal and climatic differences, the region supported variety of forest ecosystems. Mixed forests predominated in the area. The land slope varied from 2 to 75%. The soils of the Gagar watershed varied from extremely acidic to medium acidic with high organic matter content. These soils were fairly

deep and moderately permeable. Very strongly acidic to medium acidic soils were also found at higher elevations, where rainfall was high and strong enough to leach down the bases from the soil minerals under temperate climatic conditions.

The climate of the region was humid temperate but variations existed which largely depend upon the altitude and geological differences. The most common factors which lead to the development of microclimate were altitude, aspect, slope, drainage condition, vegetation etc. The valleys were hot in summer and cold in winter. The minimum temperature of the area was found to be - 4^{o} C in the month of January and maximum temperature was 41^{o} C in the month of May. The average rainfall in the study area was found to be 1040 mm, of which 70 to 80 per cent was received between June to September. With further increase in elevation, rainfall tended to decrease.

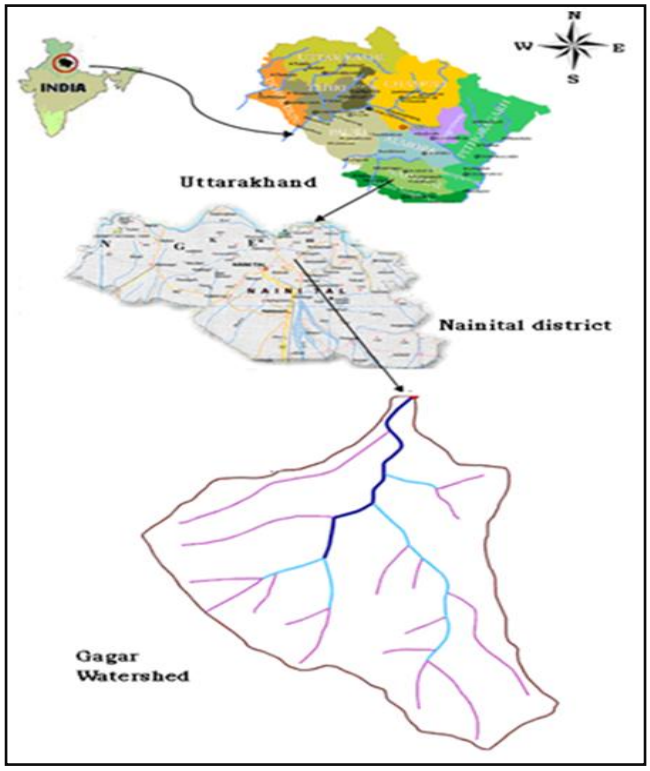

Fig. 1. Drought-rainfall distribution at Gagar watershed

Directional aspect played very important role in the development of vegetation, particularly at higher altitudes. Southern aspect was exposed to more insolation. The insolation on southern aspect was about 1.5 to 2.4 times higher than that of northern aspect. East and west aspects though received an equal amount of insolation; eastern aspect received the highest insolation during morning, before the air temperature becomes fully warm. Western aspects were comparatively hotter and drier than eastern aspects. The difference in the temperature on different aspects of the hills was the result of difference in insolation. The southern aspect was warmest and northern aspect was the coolest. Aspect plays an important role in receiving the rainfall and snowfall. Soil formation is also effected by it.

Drought Analysis

Rainfall data were collected from Agro meteorological Observatory of G. B. Pant University of Agriculture and Technology located at Gagar, Nainital, Uttarakhand which covers the study region of Gagar watershed. The data were organized in to 52 standard meteorological weeks in which each year, 8 days were counted in 52nd meteorological week and in 9th meteorological week in case of leap years and analysed for their yearly, monthly and weekly behaviour.

In this research, the monthly and yearly total rainfall was determined for each year. The monthly and yearly events were then classified as drought, normal and surplus using the following criteria.

- Drought Month: The month was classified as drought month in which precipitation received was less than 50 per cent of average monthly rainfall.
- Surplus Month: The month was classified as surplus month in which precipitation received was more than twice of average monthly rainfall.
- Normal Month: The month was classified as normal month in which precipitation received was in between 50 per cent and 200 per cent of average monthly rainfall.
- Drought Year: The year was classified as drought year in which precipitation received was less than or equal to $\bar{x} - \sigma$, where $\bar{x}$ is mean annual precipitation and σ is standard deviation.

- Surplus Year: The year was classified as surplus year in which precipitation received was more than or equal to $\bar{x} + \sigma$.
- Normal Year: The year was classified as normal year in which precipitation received was $\bar{x} \pm \sigma$, i.e. in between $\bar{x} - \sigma$ and $\bar{x} + \sigma$.

To study the drought proneness of area and likely extend of drought following definitions were used. According to Ministry of Agriculture (1976), agricultural drought is an occasion when the rainfall in the week is half of the normal rainfall and normal rainfall should be 5 mm or more. If there are four such consecutive weeks in rainy season, the area may be classified as drought affected. According to Irrigation Commission (1972).

RESULTS AND DISCUSSION

A. Drought, Normal and Surplus Months

On the basis of definitions outlined earlier, the rainfall for a month to be normal, surplus and drought with the average rainfall are given in Table 1. There was very less rainfall in the month of November (average rainfall of 2.19 mm) for the period of study and overall 7 months of November out of 10 months were observed as drought months, therefore, November was categorized as drought month.

Table 1. Monthly rainfall to be drought, surplus and normal month with average rainfall at gagar watershed

Month	Avg. rainfall (mm)	Drought (less than)	Surplus (more than)	Normal (in between)
January	61.05	30.52	122.10	30.52 -122.1
February	90.94	45.47	180.08	45.47 - 180.08
March	75. 99	37.99	151.99	37.99 - 151.99
April	47.08	23.54	94.17	23.54 - 94.17
May	77.56	38.78	155.11	38.77 - 155.11
June	112.86	56.43	225.72	56.43 - 225.72
July	272.19	136.09	544.38	136.09 -544.38
August	251.83	125.91	503.66	125.91 - 503.66
September	144.33	72.17	288.66	72.165 - 288.66
October	41.54	20.77	83.09	20.72 - 83.09
November	10.04	5.02	20.08	5.02 - 20.08
December	32.56	16.27	65.12	16.27 - 65.12

Month wise and year wise distribution of number of months to be drought, surplus and normal are shown in Table 2 and 3, respectively.

Table 2. Month wise distribution of number of months to be drought, surplus and normal at gagar watershed

Month	Drought Month	Normal Month	Surplus Month
January	5	4	1
February	3	5	2
March	4	5	1
April	2	6	2
May	4	5	1
June	1	9	0
July	1	9	0
August	2	8	0
September	4	5	1
October	5	2	3
November	7	0	3
December	4	4	2
Total	42	62	16

From the Table 2 and 3, it can be observed that about 51.67 per cent months were normal months during the period of 10 years (1998 to 2007). It was observed that during this 10 years period, 35.00 per cent months were drought months. Maximum number of normal months in a year was found to be 9, which accounted for only 20 per cent of total years. Most of the drought months had occurred in the post and pre-monsoon periods i.e. October to May having highest frequency for November (7 drought months out of 10 months).

Table 3. Year wise distribution of number of months to be drought, surplus and normal at gagar watershed

Year	Drought Month	Normal Month	Surplus Month
1998	2	9	1
1999	8	3	1
2000	4	7	1
2001	7	5	0
2002	4	7	1
2003	2	10	0
2004	4	6	2
2005	3	7	2
2006	5	6	1
2007	3	5	4
Total	42	65	13

It was also observed that, frequency of occurrence of normality was highest in the month of June and July followed by August, April, February - March – May – September, January and December. It can also be seen that during monsoon, the percentage distribution of drought months was, 40.00, 20.00, 10.00 per cent for, September, August, July-June, respectively, which indicated the assured rainfall during these months. The maximum number of surplus months in a year was 3, occurred during 20.00 per cent of the total years. Normality for the month of June-July was found to be 90.00 per cent followed by August (80%), April (60%), February-March-May-September (50%), January-December (40%) and October (20%). During the monsoon period (June to October), 66 per cent of the total months were normal, 26 per cent under drought and rest 8 per cent were surplus, while for the other period the normality was 41.43 per cent.

During the Rabi season i.e. October to February, out of total 50 months, the number of drought months was worked out to be 24, which was accounted for 48 per cent of the total rabi months. This indicated the likelihood of failure of Rabi crops under rainfed conditions. The percentage distribution of drought months during Rabi season was 70.00, 40.00, 30.00, and 50.00 percent during November, October-December, February and January, respectively.

B. Drought, Normal and Surplus Years

The average or mean annual rainfall was 1040.39 mm and standard deviation for the study region was found to be 302.62 mm. Therefore, any year receiving the rainfall less than or equal to 737.77 mm will be a drought year. Thus, as per the definition for drought year, described in previous chapter, 20.00 per cent of years (1999 and 2001) received rainfall less than 949.54 mm, would be drought years. Distribution of drought years is shown in Fig. 2.

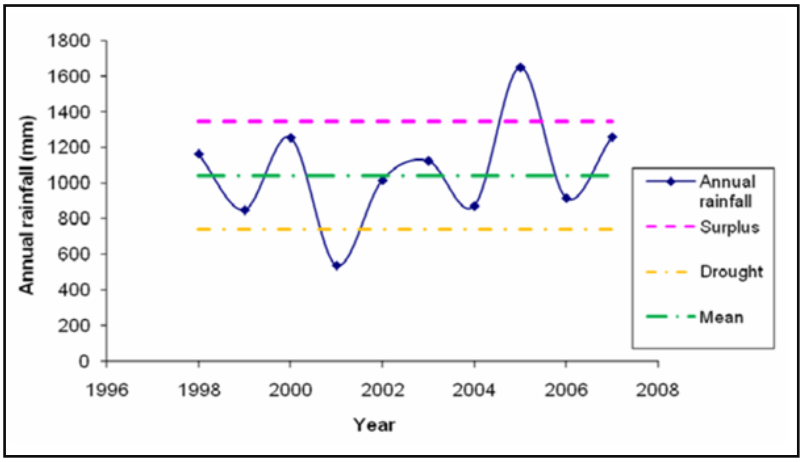

Fig. 2. Drought-rainfall distribution at Gagar watershed

Any year receiving the rainfall equal to or more than 1343.01 mm will be the surplus year, therefore, 10.00 per cent of the year which received rainfall equal to or more than 1343.01 mm (2005) was the surplus year for the period under study. Years receiving rainfall between 737.77 mm and 1343.01 mm would be the normal year. Therefore, remaining 70.00 per cent of years (1998, 2000, 2002, 2003, 2004, 2006 and 2007) were normal years for the period of analysis. Thus, it was inferred from the study that, there were about 70 per cent chance of year to have normal rainfall, 20 per cent chance of year to be the drought year and very less chance of year to be surplus (10%).

III. CONCLUSION

Drought analysis based on rainfall data of Gagar watershed was computed based on weekly rainfall. The analysis indicated the likelihood of failure of Rabi crops under rainfed conditions. It can be seen that during monsoon, the percentage distribution of normal, drought, surplus months was 66, 26, and 8 percent, respectively. It was also inferred from the study that, there was about 70 per cent chance to have normal rainfall year, 20 per cent chance to be the drought year and very less chance to be surplus year (10%). The paradigm developed from analysis of normal, surplus and drought months/years will be useful for planning of various agricultural operations such as sowing, irrigation scheduling schemes, etc. for the area.

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