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Climatic variability and trend at Ranichauri (Uttarakhand)

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ABSTRACT

The present analysis was carried out using the long term (1985-2013) meteorological data recorded at Ranichauri, Tehri Garhwal, Uttarakhand. The results revealed that daily maximum temperature varied between 9.4 to 27.2^{0}C over 29 years, with annual increasing trend of 0.013^{0}C per year, while the minimum temperature was found to decrease at rate of -0.033^{0}C per year and fluctuated between 0.7 to 17.8^{0}C. The long term mean annual rainfall of Ranichauri is 1273.1±315.5 mm with CV of 24.8 % only, indicating that it is highly stable and dependable. The rising trend in the monsoon rain (June-September) at rate of 11.09mm per year was also observed during the study period.

Key words: Temperature, rainfall, trend, variabilty, Ranichauri.

Uttarakhand state is highly vulnerable to frequent climatlogical as well as geographical changes. It is located between 28º43' to 31º27' N latitudes and 77º34' to 81º02' E longitudes. It lies in the northern part of India amidst magnificent Himalayas and dense forests with a total geographical area of 5.33 M ha (55,845 km^2), out of which 92.57% area is mountainous and 7.43% is occupied by plains. According to 2008-09 records, the forest area constitutes almost 65% of the total area of the State. Most of the northern parts of the state are part of Greater Himalayan ranges, covered by high Himalayan peaks and glaciers, while the lower foothills are densely forested. In the southern foothills, the average summer temperature varies between 18 to 30^{0}C and winter is also bearable and normal. In the areas of mid Himalayas, the summer temperatures are usually around 15 to 18^{0}C; however in winter, temperature may even drop below the freezing point. The soils of Ranichauri are Brown Forest, Red to Dark and Black Clay. Crops prominently grown in the *rabi* season are wheat, barley, ragi, pea, masoor, potato, onion, garlic etc. and in *kharif* season are paddy, finger millet, pea, wheat barnyard millet, rice bean, buck, ramdana etc. Cropping pattern in hilly regions of Uttarakhand is primarily rainfed and hence food grain production depends on the main monsoon during July-September. Improved understanding of the influence of climate on agricultural production is essential to cope up with expected changes in temperature and precipitation.

The effects of climatic variations on cropping pattern of hilly region, needs to be documented so that it will be handy to planners for mitigating ill effects. So, looking to the importance of temperature and rainfall in agriculture and various allied sectors, an attempt was made to analyze climatic trend and variability analysis at Ranichauri, Uttarakhand.

MATERIALS AND METHODS

The present analysis was carried out using the long term (1985-2013) daily maximum and minimum data of temperature and daily rainfall data recorded at Agrometeorological observatory situated at College of Forestry, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Ranichauri, Tehri Garhwal, Uttarakhand. Ranicahuri is located between 30° 18' N latitudes and 78° 24' E longitude with an altitude varying from 1600 to 2200 m amsl. The daily meteorological data were collected and verified for any error. Then, data were processed at decadal (ten years) and annual scales and its range, mean, coefficient of variation (CV) were calculated. Trend and variation/shift was determined by the relationship between the two variables *viz*., temperature-time and rainfall-time. The magnitudes of the trends of increasing or decreasing temperatures were derived and tested by the Mann-Kendall (Mann, 1945) trend test and slope of the regression line using the least square method.

RESULTS AND DISCUSSION

Variations and trends in rainfall

Annual and seasonal rainfall variability greatly affects

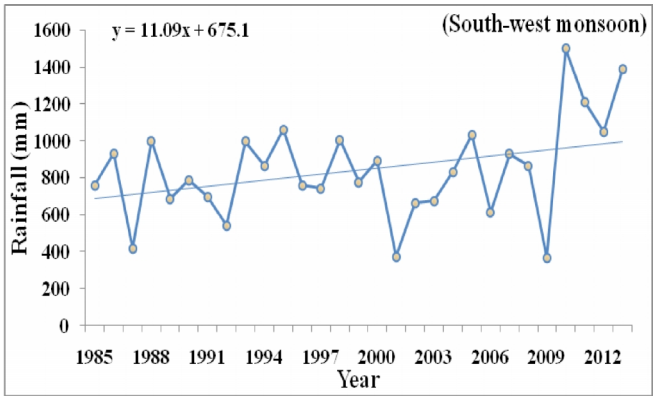

Fig. 1: Trend in SW monsoon rainfall over Ranichauri from 1985-2013

Table 1: Mean monthly seasonal and annual rainfall (1985-2013) over Ranichauri along with CV (%)

Month/Season	Rainfall (mm)	CV (%)
January	57.0	63.8
February	99.0	77.9
March	68.6	79.4
April	45.1	79.3
May	76.5	71.3
June	130.2	81.9
July	287.9	42.6
August	276.4	42.9
September	147.2	78.3
October	36.7	197.6
November	12.5	195.1
December	36.1	133.9
Monsoon (June-Sept)	841.6	31.7
Post Monsoon (Oct-Nov)	49.2	154.4
Winter (Dec-Feb)	192.0	45.8
Summer (Mar-May)	190.3	47.6
Annual (mm)	1273.1	24.8

soil water availability to crops, and thus poses crop production risks. The long term mean annual rainfall of Ranichauri is 1273.1 ± 315.5mm with coefficient of variation of 24.8% only, indicating that it is highly stable and dependable. However, coefficient of variation of monthly rainfall varied from 43% in July and August to more than 195% in October and November. July and August are the rainiest months, while November and December receive the least rainfall (Table 1). The season-wise rainfall distribution over Ranichauri indicated that 66.1% (841.6mm) of annual rainfall is received during the monsoon, followed by winter (192mm) and summer (190.3mm) and least rainfall is seen during post-monsoon (Table 1). The seasonal rainfall during the monsoon is dependable as the CV is 31.7%.

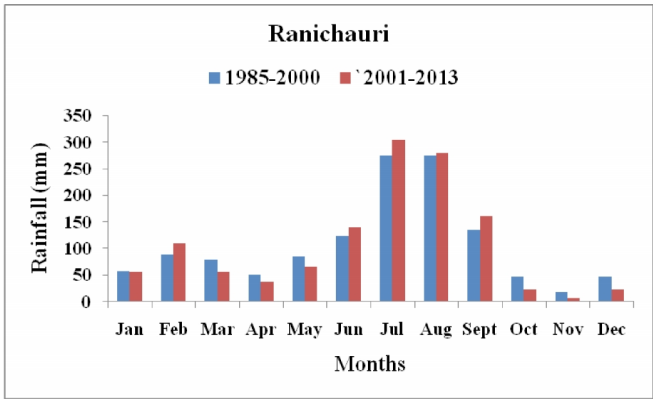

Fig. 2: Shift in monthly rainfall pattern over Ranichauri

Increase of rainfall amount was observed during SW monsoon (June-September), whereas a marginal decrease was noticed in the rainfall of remaining eight months at Ranichauri. The increasing trend (Fig. 1) in the monsoon rain (June-September) @ 11.09 mm per year was observed. The rainfall in post monsoon period (October-November) was found to be decreasing @ 2.18 mm per year. In contrast, a marginal decrease was also noticed in summer and winter rainfall. Similar study conducted by Tripathi *et al.* (2007) for Roorkee of Haridwar district also observed that a rise in the total annual rainfall @ 5.8 mm per year.

The mean rainfall over 1985-2000 and 2001-2013 of Ranichauri indicated a shift in monthly rainfall pattern moving towards later part of the south-west monsoon season (Fig. 2). An increase of 16.9mm in June, 28.9mm in July, 4.6mm in August and 26.5mm in September was noticed, from a period of 1985-2000 over a period of 2001-2013. This has a direct bearing on agricultural crops, as it influences cropping pattern. Rajegowda *et al.* (2001) also reported shifts in rainfall peaks by 2-3 weeks for Karnataka.

Variation and trend in temperature

The results of the analysis carried out on long period average (LPA) of maximum and minimum temperatures on annual basis (1985-2013) presented in Fig. 3, show that annual trend of maximum temperature increases at the rate of 0.013°C per year, whereas minimum temperature decreases at the rate of 0.033°C per year. Similar worked were carried out by Hingane *et al.* (1985) and Arora *et al.* (2005) also reported increasing trend in surface temperature over the period of 1900-82 from 73 well-distributed stations of India. The decadal analysis of maximum and minimum temperatures

Table 2: Statistical analysis of decadal maximum and minimum temperature conditions at Ranichauri during 1985-2013

Decade No.	Decade /Duration	Range	Mean	CV (%)
Maximum temperature (°C)				
1	1985-1994	10.1 - 26.7	19.7	23.5
2	1995-2004	9.4 - 26.8	19.4	24.9
3	2005-2013	9.6 - 27.2	20.0	22.4
Minimum temperature (°C)				
1	1985-94	1.5 - 17.8	10.5	51.5
2	1995-04	0.9 - 17.3	9.9	53.5
3	2005-13	0.7 - 17.4	9.8	54.3

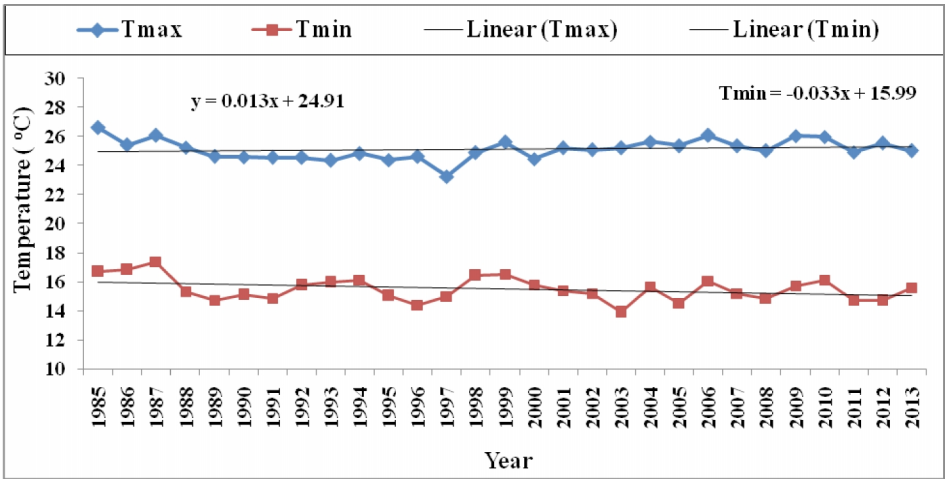

Fig. 3: Annual average maximum and minimum temperature pattern over Ranichauri

is presented in Table 2. The maximum temperature ranged between 9.4 to 27.2 °C over the period. During the first decade (1985-1994), the mean maximum temperature (19.7^{0}C) was higher than the second decade (19.4^{0}C). However, in the third decade (2004-2013) the mean maximum temperature was highest (20.0^{0}C). The CV percent of decadal maximum temperature was between 22 to 25%.

The decadal minimum temperature variation (Table 2) show that it varied between 0.7 to 17.8^{0}C over the 29 years period. During the first decade the mean minimum temperature was 10.5^{0}C which varied between 1.5 to 17.8^{0}C. During 1995 to 2004 decade the mean minimum temperature decreased to 9.9^{0}C which further decreased to 9.8^{0}C during 2005-2013 decade.

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