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551.583 (540.49)

Trend assessment in climate variable by Mann Kendall test of Bastar district of Chhattisgarh

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सार – जलवायु परिवर्तन एक प्राकृतिक घटना है लेकिन वर्तमान दशकों में इसकी परिवर्तनशीलता मुख्य रूप से मानवजनित गतिविधियों के कारण खतरनाकहो गई है। छत्तीसगढ़ राज्य की कृषि मुख्य रूप से मॉनसूनी वर्षा और उसके वितरण पर निर्भर है। इस तथ्य को ध्यान में रखते हुए, वर्तमान अध्ययन में इस क्षेत्र में उनकी प्रवृत्ति का विश्लेषण करने के लिए सबसे महत्वपूर्ण जलवायविक परिवर्ती, जैसे : वर्षा और तापमान का विश्लेषण करने का प्रयास किया गया है। वर्ष 1980 **से** 2014 **के बीच पिछले तीन दशकों में बस्तर जिले के जगदलपुर स्टेशन के मौसम संबंधी आंकड़ों के लिए अधिकतम वायुमंडलीय तापमान, वर्षा और वर्षा के दिनों की प्रवृत्तियों का सांख्यिकीय विश्लेषण किया गया है। तापमान, वर्षा और वर्षा के दिनों में दीर्घकालिक परिवर्तन का विश्लेषण सहसंबंध और रैखिक प्रवृत्ति विश्लेषण के द्वारा किया गया है। जगदलपुर स्टेशन पर इस अवधि के दौरान वार्षिक औसत अधिकतम तापमान** -0.465 **डिग्री सेल्सियस प्रति वर्ष की दर से घट गया है और मॉनसून ऋतु (जून से सितंबर) के दौरान वर्षा के दिनों में कमी होने की प्रवृत्ति भी पाई गई है और इसकी पुष्टि मान-केंडल प्रवृत्ति परीक्षण द्वारा की गई है। ऋतु के दौरान जून से सितंबर महीने की कुल मासिक वर्षा (टीएमआरएफ) में बहुत अल्प वृद्धि की प्रवृत्ति देखी गई है। छत्तीसगढ़ के बस्तर जिले में औसत मासिक वर्षा और दक्षिण पश्चिम (जून-सितंबर) वर्षा में कमी की प्रवृत्तिस देखी गई है। कृषि योजना और पानी का उपयोग मॉनसूनी वर्षा पर निर्भर है और मॉनसून ऋतु में होने वाली** 75% **से अधिक वर्षा समय और स्थान दोनों में असमान होती है। इसलिए फसल नियोजन के लिए इसका विश्लेषण महत्वपूर्ण है।**

ABSTRACT. Climate change is a natural phenomenon but in present decades its variability of change mainly due to anthropogenic activities is alarming. Agriculture of Chhattisgarh state is mainly dependant on monsoon rain and its distribution. Considering this fact, the present study has been tried to analyze the most important climatic variables, *viz*., precipitation and temeperature for analyzing their trend in the area. The trends of maximum atmospheric temperature, rainfall and rainy days are analysed statistically for meteorological data of Jagdalpur station of Bastar district, over last three decades stretching between years 1980 to 2014. The long term change in temperature, rainfall and rainy days has been analysed by correlation and linear trend analysis. The annual MMAX temperature has decreased at a rate of -0.465 °C per year during this period at Jagdalpur station and decreasing trend for rainy days during monsoonal season (June to September) is also found and is confirmed by Mann-Kendall trend test. Very weak increasing trend is observed in total month rainfall (TMRF) during season June to September. There are decreasing trends of mean monthly rainfall and south west (June - September) rainfall observed in Bastar district of Chhattisgarh. The agricultural planning and utilization of water is dependent on monsoon rainfall and more than 75% of rainfall occurring during the monsoon season is uneven both in time and space. Therefore its analysis is important for crop planning.

Key words – Rainfall variability, Mann-Kendall trend test.

1. Introduction

The rainfall and temperature are the most fundamental physical parameters among the climate as these determine the environmental factors of the particular region which affect the agricultural productivity. Global warming/Climate change is one of the most important worldwide issue talked among the scientists and researchers. Studies have demonstrated that global surface warming is occurring at a rate of 0.74+0.18 °C over 1906-2005. A number of scientific research studies have shown that surface air temperature increased about 0.2 to 0.6 °C during last century (Abaurrea and Cerian, 2001). This rate of increase may vary in different geographical regions (Colin *et al*., 1999). It is found that all India mean annual temperature is rising at the rate of 0.05 °C/decade over 1901-2003 which is mostly due to the rise of maximum temperature (0.07 °C/decade) rather than because of the rise of minimum temperature (0.02 °C/decade) (Kothawale and Rupa Kumar, 2005). Global warming and significant change in time series of temperature in different parts of the world could be considered as one of the most important factors of climate change in the 21st century (IPCC, 2007). Climate change is considered as one of the leading main environmental problems of the 21st century (Pytrik *et al*., 2010). The annual mean temperature of India as a whole has risen to 0.51 °C over the period 1901-2005 (Fulekar and Kale, 2010). Weather observations indicated that global average surface temperature has increased by 0.60 °C since 19^{th} century (Chahal, 2010).

Kumar and Jain (2010) studied trend detection in seasonal and annual rainfall and rainy days using Mann Kendall test in Kashmir valley and results indicated the upward trend of rainfall and rainy days in one station whereas other stations indicated decreasing trend for both variables. Zende *et al*. (2012) analysed time series of annual rainfall, number of rainy-days per year and monthly rainfall of 10 stations to assess climate variability in semi-arid region of Western Maharashtra and showed mixed trends of increasing and decreasing rainfall which are statistically significant for two stations by Mann Kendall test. Mondal *et al*. (2012) studied rainfall trend by Mann-Kendall test of North-Eastern part of Cuttack station, Orissa for 40 years and concluded that there is evidence of some change in the trend of precipitation of the region in different months.

The main objective of present research is to analyse the 1980 to 2014 rainfall, rainy days and temperature data obtained from Agricultural Meteorological Observatory for Jagdalpur station of Bastar as a basis on sustainability of crop production. The analysis includes mean of maximum temperature, annual rainfall, total month rainfall from June to September, annual number of rainy days and number of rainy days in rainy season from the months of June to September using correlation analysis.

2. Materials and method

Jagdalpur is situated in East Central part of Chhattisgarh at latitude of 19° 08' N, longitude 82° 02' E and altitude 553 m above mean sea level. The climate of Jagdalpur is falling under hot sub-humid with mean annual rainfall of about 1407.5 mm out of which 87 per cent (1126.3 mm) is received during monsoon (June to September). During *winter* (January to February) only 20.7 mm of rainfall is being received on an average. The maximum temperature ranged from 26.7 to 38.7 °C and minimum temperature ranged between 8.9 to 25.7 °C respectively.

The data used are the monthly averages of monthly rainfall, rainy days and mean of maximum temperatures during 1980-2014. Data collected from S. G. College & Research Station, Jagdalpur. The magnitudes of the trends in maximum temperatures, annual rainfall and rainy days were derived by the Mann-Kendall trend test and slope of the regression line by the least squares method using Microsoft Excel.

2.1. *Mann-Kendall (MK) test*

The Mann-Kendall test is a non-parametric test for identifying trends in time series data. The test was suggested by Mann (1945) and has been extensively used with environmental time series (Hipel and McLeod, 2005). The test compares the relative magnitudes of sample data rather than the data values them. One benefit of this test is that the data need not confirm to any particular distribution. Let $X_1, X_2 \ldots\ldots\ldots X_n$ represents n data points where X_j represents the data point at time j. Then the Mann-Kendall statistic (S) is given by :

$$S = \sum\sum \operatorname{sign}\left(X_j - X_k\right),\ j = 2, 3\ldots n;\ k = 1, 2\ldots j\text{-}1$$

where,

$$\operatorname{sign}(X_j - X_k) = 1 \text{ if } X_j - X_k > 0$$
$$= 0 \text{ if } X_j - X_k = 0$$
$$= -1 \text{ if } X_j - X_k < 0$$

A very high positive value of S is an indicator of an increasing trend and a very low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend. For a sample size >10, a normal approximations to the Mann-Kendall test may be used. For this, variance of S is obtained as,

$$V(S) = \left[n(n-1)(2n+5) - \sum tp\,(tp-1)(2tp+5)\right] /18,$$
$$p = 1, 2\ldots\ldots q$$

where, tp is the number of ties for the p the value and q is the number of tied values.

Then standardized statistical test is computed by:

$$Z = (S\text{-}1)/\sqrt{V(S)}, \quad \text{if } S > 0,$$
$$= 0 \text{ if } S = 0,$$
$$= (S + 1)/\sqrt{V(S)} \text{ if } S < 0$$

The presence of a statistically significant trend is evaluated using Z value.

3. Results and discussion

The average monthly temperature data for the period (1980 -2014) for the Bastar (HQ Jagdalpur) district of Chhattisgarh state and the corresponding SD and CV are shown in Table 1. It can be seen that at Jagdalpur the mean monthly maximum temperature is the highest in the month of May (49.9 °C) followed by March and April (47.6 °C and 43.5 °C). When the CV for the mean

TABLE 1

Statistical summary of monthly mean of maximum temperatures, monthly rainfall and monthly rainy days during 1980-2014 for Jagdalpur Station

Months	Maximum temperature			Rainfall			Rainy days		
	Average	SD	CV(%)	Average	SD	CV (%)	Average	SD	CV(%)
Jan	33.3	1.68	5.04	11.0	16.79	152.40	0.77	1.03	133.7
Feb	37.6	1.37	3.64	9.6	16.16	167.80	1.00	1.73	173.2
Mar	43.5	1.45	3.34	20.5	28.28	138.00	1.80	1.89	105.1
Apr	47.6	2.87	6.03	43.6	30.51	70.00	3.63	2.39	65.9
May	49.9	2.56	5.13	79.4	62.65	78.90	5.20	2.58	49.5
Jun	44.5	2.24	5.04	224.9	103.87	46.20	10.31	2.61	25.3
Jul	39.7	1.18	2.98	345.3	92.36	26.70	17.40	20.73	3.61
Aug	39.1	1.21	3.10	352.4	113.85	32.30	17.51	3.61	20.7
Sep	40.4	1.10	2.73	213.5	98.87	46.30	11.69	3.50	29.9
Oct	39.3	0.70	1.79	84.7	79.03	93.30	4.71	2.79	59.2
Nov	35.4	1.52	4.29	21.2	30.29	142.90	1.29	1.69	131.5
Dec	32.3	1.61	4.98	6.1	17.57	286.10	0.51	1.29	251.2

monthly maximum temperature is examined, it was found that it is the highest in the month of April (6.0%) followed by May and June (5.1% and 5.0). It was noticed that lowest CV was in month of October (1.7%). In case of mean monthly maximum temperature variability, it was observed during the September and October months at Bastar (Jagdalpur HQ) district in Chhattisgarh.

The coefficient of variation for TMRF observed highest in the month of December and it is 286.1% whereas coefficient of variation is minimum for the month of July and it is 26.70% for the Jagdalpur station as shown in Table 1. This shows that rainfall is more stable in the month of August and is more variable in the month of December for the Jagdalpur station. The coefficient of determination $R^2 = 0.048$ indicating only 4.8% of the variation in TMRF can be explained by the regression model.

The coefficient of variation for number of rainy days was observed highest in the month of November and it is 251.2% whereas coefficient of variation is minimum for the month of July and it is 3.61 % for the Jagdalpur station (Table 1). This shows that numbers of rainy days are more stable in the month of July and is more variable in the month of November for the Jagdalpur station.

3.1. *Trend analysis*

The Fig. 1 indicate the trend line for annual mean of maximum temperature against time is decreasing Annual MMAX temperature has decreased by 0.1495 °C during the last 35 years in Jagdalpur station. Total annual rainfall increased @2.603 mm/ year during the last 35 years in Jagdalpur station. The Fig. 2 indicates the trend lines for total rainfall in the rainy season during June to September were increasing. Average total month rainfall during June to September increased by 1.961 mm per year during the last 35 years in Jagdalpur station (Table 2). The number of rainy days during June to September decreased @ 0.087 days per year during the last 35 years in Jagdalpur station.

TABLE 2

Result of Mann Kendall test for climatic variables of Jagdalpur station

Variables	*S* value	*Z*- values	*P*-values	Results
J-S (RD)	-33	-0.454	0.139	NS
J-S (RF)	13	0.17	3.831	NS
Annual RD	-57	-0.795	0.191	NS
Annual RF	27	0.369	4.752	NS
Mean maximum temp.	-155	-2.187	0.012	Significant

As *p*-value is less than 0.05, the null hypotheses is rejected at 5% level of significance and it can be concluded that the correlation coefficient between total month rainfall and rainy days are statistically extremely significant for the months of June, July, August and September. Where as it is extremely statistically significant (Table 2).

For MMAX temperature, the value of *S* obtained as -155, a very high negative value indicating decreasing trend and is statistically significant that there is enough evidence to determine downward trend as shown in Fig. 1 which is confirmed by the M-K trend test at 5% level of significance. For TMRF, TMRF (J-S), the respective value of S obtained as 27, 13, indicating statistically not significant increasing trend where as RD, RD (J-S) obtained as -33 and -57 a negative value of S indicating decreasing trend but statistically not significant are shown in Table 2.

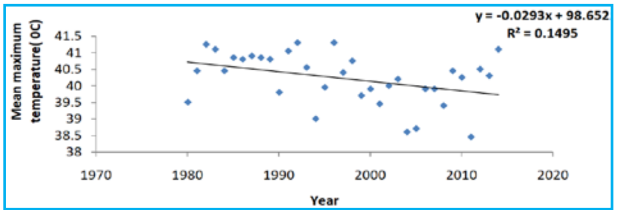

Fig. 1. Trend analysis of Mean maximum temperature (°C) of Jagdalpur station during period 1980-2014

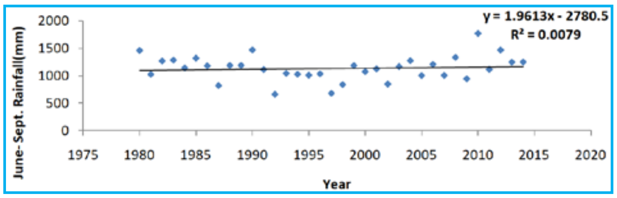

Fig. 2. Trend analysis of Mean monthly rainfall (mm) of June to September of Jagdalpur station during period 1980-2014

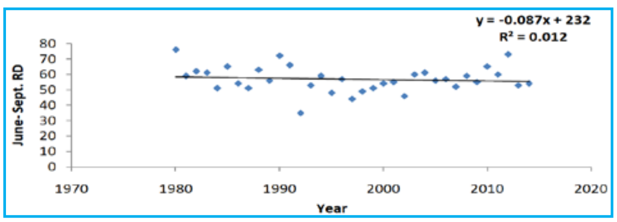

Fig. 3. Trend analysis of Rainy days of June to September of Jagdalpur station during period 1980-2014

4. Conclusions

The annual MMAX temperature has decreased at a rate of -0.465 °C per year in Jagdalpur station. Monthly rainfall TMRF (June-September) during rainy season from June to September showed statistically insignificant increasing trend during 1980 to 2014 and is confirmed by Mann Kendall trend at 5% level of significance.

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