

# **A study of trends and extreme weather events took place at the Raipur district blocks**

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## **ABSTRACT**

The climate analysis study was carried out in four blocks viz., Abhanpur, Arang, Raipur, and Tilda of Raipur district. IMD gridded data of rainfall, and maximum (Tx) and minimum (Tn) temperature from 1951 to 2019 were used in this study. Trend analysis for annual and all seasons was carried out by three non-parametric methods: Mann Kendall, Spearman's Rho, Innovative Trend Analysis (ITA), and one parametric test Linear Regression analysis. To evaluate various climate events Weather Cock and RClimdex were used under which sixteen climatic indices were calculated. This data set was divided into two sets viz., 1951-1986 and 1987-2019. Results show that rainfall is in decreasing trend ( $p < 0.01$ ) by a 10 to 15% fall on average. A significant increasing trend of maximum temperature ( $p < 0.01$ ) and minimum temperature has a significant decreasing trend ( $p < 0.01$ ) in ITA and else shows a non-significant decreasing trend. ITA detects trends better than all other methods but data size matters for its performance. All the indices follow different trends before and after 1986 which clearly shows the climate has changed at noticeable levels. Days get warmer, nights are getting colder eventually diurnal temperature range also expands. Heatwave incidence also increased. Increased episodes of moderate drought and all severe drought occurred after 1986. Values of maximum Tx, Tn, and minimum Tx, Tn temperatures reach new peaks.

**Keywords:** *IMD gridded data, Trend analysis, parametric and non-parametric tests, Mann Kendall, Spearman's Rho, Innovative Trend Analysis, Linear Regression analysis, Weather Cock, and RClimdex*

## **1. INTRODUCTION**

The climate is the average of daily atmospheric phenomena shortly known to be the weather for 30 years. Weather is changing frequently and predicting it is a state of the art, on the other hand, the

climate is stable and prediction is easy but this is not the case now. In climate studies, trend analysis plays a vital role. Trends in the climatic parameters will give us an idea of where we are going and whether it is detrimental or normal. There are many tests to identify the trend. We have taken four methods: Mann Kendall, Spearman's Rho, Linear Regression Analysis, and Innovative Trend Analysis (ITA). Among these ITA was the recent one introduced by *Sen in 2011*, gains more popularity in hydrometeorological trend analysis in recent years. Analyzing different methods and comparing results from different methods will help better to identify the trend. To strengthen the results of trend analysis, a detailed analysis of rainfall and temperature in various aspects like meteorological drought, dry spells and wet spells, warmer days and colder days, etc., will give a more elaborate picture of the situation. Eg. Rainfall may show decreasing trend but whether it is due to a decrease in rainfall amount or due to a decrease in the number of rainy days matters. When the spatial scale is small, the practical utility of the research will be high so, this study is carryout at the block level in the Raipur district. This study focuses on the performance of selected trend analysis methods and various climatic indices.

## **2. MATERIALS AND METHODS**

Raipur, the capital of Chhattisgarh, is situated in the middle of the state. It has four blocks: Arang, Abhanpur, Raipur, and Tilda. It is situated 244 to 409 m from AMSL. The study area was located from latitude  $21^{\circ} 23''$  to longitude  $81^{\circ} 65''$ . The total area of Raipur is 2892 sq. km. The mean annual rainfall of the Raipur district is 1370 mm. South West monsoon is the predominant raining period.

Gridded data of Rainfall ( $0.25^{\circ} \times 0.25^{\circ}$ ), Maximum and Minimum temperature ( $0.50^{\circ} \times 0.50^{\circ}$ ) of the study area were collected from the IMD portal. These data were weighted according to the respective blocks' area and location. The time scale of the study was between 1951 to 2019. Climatic indices analysis was done in two phases before 1986 and after 1986. So, the changes or variability in the weather parameters and their indices were clearly visible.

### **2.1. Trend Analysis**

For trend analysis TREND and R studio software were used. Trend detection was carried out in three non-parametric tests Mann-Kendall, Spearman's Rho, and Innovative Trend Analysis, and a

parametric test Linear regression. Trend software was prepared by *Francis Chiew and Lionel Siriwardena* CRC for Catchment Hydrology.

### **2.1.1. Mann-Kendall Test**

This method tests whether there is a trend in the time series data. It is a non-parametric test (*Mann, 1945*). The  $n$  time series values ( $X_1, X_2, X_3, \dots, X_n$ ) are replaced by their relative ranks ( $R_1, R_2, R_3, \dots, R_n$ ) (starting at 1 for the lowest up to  $n$ ). (*Kendall, M.G.1975*) (*Yadav et al., 2014*).

### **2.1.2. Spearman's Rho**

This rank-based test determines whether the correlation between two variables is significant (*Spearman, 1904*). In trend analysis, one variable is taken as the time itself (years) and the other as the corresponding time series data. Their ranks replace time series values (*Meshram et al., 2017*).

### **2.1.3. Linear Regression Test**

Parametric test in which data were assumed to be normally distributed. Examining the relationship between time ( $x$ ) and the variable of interest ( $y$ ) and whether there is a linear trend existing was figured out. The linear regression test assumes that the data are normally distributed and that the errors (deviations from the trend) are independent and follow the same normal distribution with zero means.

### **2.1.4. ITA Test**

It's a distribution-free cartesian diagram test introduced by *Sen in 2011*. In order to apply this graphical test, the first half of the entire time series is plotted against the second half. If the plotted to scatter points lie on a 1:1 line ( $45^\circ$  straight line), it means there is no trend in the time series. On the contrary, scatter points above or below the 1:1 line indicate increasing or decreasing monotonic trends, respectively. In this test, the slope ( $s$ ) of the trend is calculated according to the following expression (*Sen, 2011*) (*Singh et al., 2021*).

## **2.2. Indices calculated using Weather Cock**

Weather Cock is a software program developed by *Ramamohan and Rao et.*, under AICRPAM. It has various analysis modules for rainfall and temperatures among which three were used here.

**2.2.1. Agricultural drought (AD) (Kharif drought):** At least four consecutive weeks receiving less than half of the normal rainfall (>5mm)

### 2.2.2. Meteorological drought

It is generally rainfall deficiency based on the level of deficiency from normal rainfall it is classified into three categories.

Mild  $\leq 25\%$ , Medium (MMD) 26-50%, and Severe (SMD)  $>50\%$

### 2.2.3. Heat Wave

**Table 1.a. Heat Wave Criteria**

	<i>When normal Tmax <math>\leq 40^{\circ}\text{C}</math></i>	<i>When normal Tmax <math>\geq 40^{\circ}\text{C}</math></i>
<b>Heat Wave</b>	Departure from normal is $5^{\circ}\text{C}$ to $6^{\circ}\text{C}$	Departure from normal is $4^{\circ}\text{C}$ to $5^{\circ}\text{C}$
<b>Severe Heat Wave</b>	Departure from normal is $7^{\circ}\text{C}$ or more	Departure from normal is $6^{\circ}\text{C}$ or more

Heat Wave is not considered until Tmax reaches  $40^{\circ}\text{C}$  in Plains and  $30^{\circ}\text{C}$  in Hilly regions.

When Tmax remains at  $45^{\circ}\text{C}$ , a heat wave is declared irrespective of the normal Tmax.

### 2.3. RClimdex Indices

It is developed by *Xuebin Zhang and Feng Yang* at the Climate Research Branch of the Meteorological Service of Canada. CCI/CLIVAR Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI). RClimdex 1.0 version was used in this research and among 27 indices available 13 were taken here (*Kaur et al., 2022*) and (*Pavithrapriya et al., 2022*):

**Table 1.b. Indices calculated using RClimdex**

<u>ID</u>	<u>Indicator name</u>	<u>Definitions</u>	<u>UNITS</u>
<b>CDD</b>	Consecutive dry days	Maximum number of consecutive days with $\text{RR} < 1\text{mm}$	Days
<b>CSDI</b>	Cold spell duration indicator	Annual count of days with at least 6 consecutive days when $\text{TN} < 10\text{th percentile}$	Days

<b>CWD</b>	Consecutive wet days	Maximum number of consecutive days with RR $\geq$ 1mm	Days
<b>DTR</b>	Diurnal temperature range	The monthly mean difference between TX and TN	$^{\circ}$ C
<b>TN10p</b>	Cool nights	Percentage of days when TN<10th percentile	Days
<b>TN90p</b>	Warm nights	Percentage of days when TN>90th percentile	Days
<b>TNn</b>	Min Tmin	The monthly minimum value of the daily minimum temp	$^{\circ}$ C
<b>TNx</b>	Max Tmin	The monthly maximum value of the daily minimum temp	$^{\circ}$ C
<b>TX10p</b>	Cool days	Percentage of days when TX<10th percentile	Days
<b>TX90p</b>	Warm days	Percentage of days when TX>90th percentile	Days
<b>TXn</b>	Min Tmax	The monthly minimum value of the daily maximum temp	$^{\circ}$ C
<b>TXx</b>	Max Tmax	The monthly maximum value of the daily maximum temp	$^{\circ}$ C
<b>WSDI</b>	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX>90th percentile	Days

RR = Rainfall, TX = Maximum Temperature and TN = Minimum Temperature

### 3. RESULTS AND DISCUSSION

#### 3.1. Trend of temperatures

The maximum temperature has a 0.01 % level of the significant increasing trend in Abhanpur during annual and all seasonal scales. While in the Arang annual, NE and SW have a 0.01% significant increasing trend, and summer with non-significant trend whereas winter shows a non-significant decreasing trend (Sanjay et al., 2020). In Raipur annually and all seasons other than winter shows a significant increasing trend at 0.05 and 0.01 level of significance, winter also shows an increasing trend non-significantly. While some results were seen in Tilda like the Raipur block for maximum temperature.

For minimum temperature, in Abhanpur other than SW and Summer, shows a non-significant decreasing trend and these two have a non-significant increasing trend. In Arang other than NE all seasons have decreasing trend non-significantly while SW has a 0.05 level of a significant decreasing trend. The same results were seen in Raipur and Tilda. But in Tilda during SW, a 0.1 and 0.01 level significant decreasing trend was observed in the MK test and ITA. ITA detects minor trends also.

### **3.2. Trend of Rainfall**

In rainfall, there is a 0.01 significant increasing trend was seen during NE, Win (Sanikhani et al., 2018), and Summer for Abhanpur but annually it's in a 0.05 level decreasing trend which is due to a significant decrease of SW (Swain et al., 2015). For Arang annual rainfall was in a significant decreasing trend of 0.1 level while NE and Winter have a non-significant increasing trend whereas, SW and Summer have a non-significant decreasing trend. In Raipur, other than winter all seasons show a non-significant decreasing trend whereas Winter has a non-significant increasing trend. For Tilda 0.05 and 0.01 level of significant decreasing trend is seen during annual and SW (Swain et al., 2015). while NE and Summer are in a non-significant decreasing trend whereas winter is in a non-significant increasing trend.

### **3.3. Drought Analysis**

Agriculture drought has increased in the Arang block and no change in the Raipur block whereas Abhanpur and Tilda have a decreasing trend. Both medium and severe meteorological drought shows a 50% increase in the Raipur district; all severe drought were recorded only after 1986.

### **3.4. Results of Rainfall-based Indices**

CSDI and WSDI both have an increasing trend whereas the cold spell increased by 1 to 2 days but Abhanpur only has a mild decrease of less than a day. While the warm spell increased at an alarming rate of 10 to 15 days it shows hotter days in a consecutive row increased after 1986. This is further proved by the increase in heat waves by 4 days in all blocks. For CDD and CWD, 1 to 2 days fall was in all blocks. Both consolidated rainfall days and amount has shown decreasing trend mainly due to a reduction in the major rainfall season, South West monsoon. Rainfall days were reduced by 2 to 5 days on average and 3 days reductions were noted during SW months. In rainfall amounts, 100 to

175mm of rainfall was reduced, accounting for 10 to 15% of the average rainfall amount major reduction was seen in the SW season.

### **3.5. Results of Temperature-based Indices**

After 1986 TNn was reduced by 0.3°C and TNx reduced by 0.5°C. TXn was reduced by 0.2°C in all blocks other than Abhanpur where 0.2°C increased and TXx temperature was increased by 0.4°C in all blocks (Sanjay *et al.*, 2020). which shows maximum temperatures were continuously increasing and reaching new peaks and minimum temperatures were decreasing considerably (Dash & Mamgain, 2011). Both of these result in an increased Diurnal Temperature Range of 0.5°C. To understand better our maximum and minimum temperatures were stretching their limits and making the days and nights colder and warmer than in previous decades. This statement is supported by increased warmer days by 5 days annually and cold nights by 2 days annually. Warm nights and cold days were reduced by 1 to 2 days and 2 to 3 days annually. In season wise winter tops the warm days by 7 to 8 days rest of the season with 3 to 5 days. In cold nights South West season tops with 7 days which may be the result of increased moisture availability after the long dry season though it's a regular phenomenon due to increased high-temperature ranges before rainfall brings a sudden drop in temperatures.

### **3.6. Evaluation of ITA**

Among the four trend detection methods we used MK, SR, and R follow a similar pattern in almost all cases though ITA also follows the same pattern some of its results were exactly in the opposite magnitude of else three. For example, in rainfall for Abhanpur non-significant decreasing trend was detected in winter and NE while the other three show a significant increasing trend at a 0.01 confidence level. Similarly in maximum temperature also for Arang in winter else three shows a non-significant increasing trend but ITA alone shows a significant decreasing trend. The same result was noted in the minimum temperature for summer, SW of Abhanpur. NE of the rest of the three blocks has decreasing trend whereas ITA alone shows an increasing trend at 0.01 confidence levels. But compared with indices results, ITA was right and more precise than other methods (Sanikhani *et al.*, 2018). It may be due to ITA splitting the data sets into two halves and rank-based plotting was done so, it reduces the error caused due to continuous stretching.

Table 2.a. Results of Trend Analysis

	Abhanpur					Arang					Raipur					Tilda				
	Rainfall																			
	A	W	S	SW	NE	A	W	S	SW	NE	A	W	S	SW	NE	A	W	S	SW	NE
MK	S (0.0 5)	S (0.01 )	S (0.01 )	NS	S (0.01)	S (0.01 )	NS	NS	NS	NS	NS	NS	NS	NS	NS	S (0.05 )	NS	NS	S (0.05 )	NS
SR	S (0.0 5)	S (0.01 )	S (0.01 )	NS	S (0.01)	S (0.01 )	NS	NS	NS	NS	NS	NS	NS	NS	NS	S (0.05 )	NS	NS	S (0.05 )	NS
R	S (0.0 5)	S (0.01 )	S (0.01 )	NS	S (0.01)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	S (0.01 )	NS	NS	S (0.01 )	NS
ITA	S (0.0 1)	NS	S (0.1)	S (0.1)	NS	S (0.01 )	S (0.0 1)	S (0.0 1)	S (0.1)	S (0.0 5)	S (0.01 )	S (0.01 )	S (0.0 1)	S (0.01 )	NS	S (0.01 )	S (0.1 )	S (0.0 1)	S (0.01 )	NS
	Maximum Temperature																			
	A	W	S	SW	NE	A	W	S	SW	NE	A	W	S	SW	NE	A	W	S	SW	NE
MK	S (0.0 1)	S (0.01 )	S (0.01 )	S (0.01 )	S (0.01)	S (0.01 )	NS	NS	S (0.01 )	S (0.0 1)	S (0.01 )	NS	S (0.0 5)	S (0.01 )	S (0.0 1)	S (0.01 )	NS	S (0.0 5)	S (0.01 )	S (0.0 1)
SR	S (0.0 1)	S (0.01 )	S (0.01 )	S (0.01 )	S (0.01)	S (0.01 )	NS	NS	S (0.01 )	S (0.0 1)	S (0.01 )	NS	S (0.0 1)	S (0.05 )	S (0.0 1)	S (0.01 )	NS	S (0.0 1)	S (0.05 )	S (0.0 1)
R	S (0.0 1)	S (0.01 )	S (0.01 )	S (0.01 )	S (0.01)	S (0.01 )	NS	NS	S (0.01 )	S (0.0 1)	S (0.01 )	NS	S (0.0 5)	S (0.05 )	S (0.0 1)	S (0.01 )	NS	S (0.0 5)	S (0.05 )	S (0.0 1)
	NS	S (0.01)	S (0.1)	S (0.05)	S (0.01)	S (0.01)	S (0.0)	S (0.0)	S (0.01)	S (0.0)	S (0.01)	S (0.01)	S (0.0)	S (0.01)	S (0.0)	S (0.01)	S (0.0)	S (0.0)	S (0.01)	S (0.0)

ITA	)	)	)	)	)	)	)	)	)	)	)	)	)	)	)	)	)	)	)	)
Minimum Temperature																				
	A	W	S	SW	NE	A	W	S	SW	NE	A	W	S	SW	NE	A	W	S	SW	NE
<b>MK</b>	NS	NS	NS	NS	NS	NS	NS	NS	S (0.05)	NS	NS	NS	NS	S (0.05)	NS	NS	NS	NS	S (0.1)	NS
<b>SR</b>	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
<b>R</b>	NS	NS	NS	NS	NS	NS	NS	NS	S (0.05)	NS	NS	NS	NS	S (0.05)	NS	NS	NS	NS	NS	NS
<b>ITA</b>	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)	S (0.01)

S / S = Significant increasing/decreasing trend at 0.05 or 0.01 level of the confidence interval

NS / NS = non-significant increasing/decreasing trend at 0.05 or 0.01 level of the confidence interval

Table 2.b. Results of RClindex and Weather Cock Indices

Indices	Abhanpur			Arang			Raipur			Tilda		
	<86	>86	Difference	<86	>86	Difference	<86	>86	Difference	<86	>86	Difference
AD	4	2	2	3	5	2	3	3	0	3	2	1
CDD	110.6	109.0	1.6	108.1	107.3	0.7	100.0	91.1	8.9	48.3	47.1	1.1
CWD	14.4	12.3	2.1	17.1	15.3	1.8	17.1	15.3	1.7	14.3	13.2	1.1
CSDI	6.8	6.1	0.7	7.5	10.2	2.7	7.5	10.2	2.7	8	10.2	2.2
HW	38.2	42.3	4.1	37.1	41.2	4.1	37.1	41.6	4.5	37.1	41.6	4.5
MMD	4	6	2	3	4	1	4	7	3	3	7	4
SMD	0	1	1	0	1	1	0	0	0	0	1	1
TNn	6.9	6.5	0.4	6.8	6.5	0.3	6.8	6.5	0.3	6.9	6.5	0.3
TNx	29.8	29.3	0.5	29.9	29.3	0.5	28.8	28.3	0.5	29.9	29.3	0.5
TXn	22.1	21.8	0.2	22.2	22.0	0.2	22.2	22.0	0.2	21.9	21.7	0.2
TXx	43.6	44.0	0.4	43.7	44.1	0.4	43.7	44.1	0.4	43.6	44.1	0.4
WSDI	6.4	16.4	9.9	10.8	24.7	13.9	10.8	24.7	13.9	9.8	24.7	14.9
<b>Consolidated Rainfall (Days)</b>												
Annual	71.0	66.3	4.7	73.2	69.0	4.2	68.6	66.0	2.6	68.2	65.4	2.8
Winter	1.8	1.5	0.3	1.7	1.5	0.1	1.5	1.8	0.2	1.6	1.5	0.1
Summer	4.5	3.0	1.4	3.8	3.2	0.5	3.8	3.8	0	3.1	3.0	0.1
SW	60.1	57.5	2.5	63.3	60.0	3.2	58.7	55.9	2.7	59.4	56.7	2.7
NE	4.5	4.5	0	4.2	4.3	0.1	4.4	4.5	0.1	4.0	4.2	0.2
<b>Consolidated Rainfall (Amount)</b>												
Annual	1270.5	1093.8	176.7	1201.6	1107.8	93.83	1210.6	1105.9	104.7	1175.7	1022.5	153.1
Winter	15.3	14.8	0.5	14.2	17.3	3.0	16.0	19.5	3.4	14.8	16.0	1.2
Summer	49.1	27.3	21.7	36.7	28.9	7.8	39.4	35.5	3.9	33.3	28.5	4.8
SW	1147.4	996.1	151.3	1097.0	1008.0	88.97	1097.9	993.8	104.1	1077.7	924.8	152.9
NE	62.7	56.4	6.3	55.6	53.9	1.7	57.0	60.1	3.1	52.9	54.3	1.4
<b>Diurnal Temperature Range</b>												
Annual	12.3	12.9	0.5	12.5	13.0	0.5	12.5	13.0	0.5	12.3	12.9	0.6
Winter	14.9	15.3	0.4	15.1	15.7	0.6	15.1	15.7	0.6	15.0	15.6	0.6
Summer	15.1	15.4	0.3	15.3	15.8	0.5	15.3	15.8	0.5	15.2	15.8	0.6
SW	8.0	8.6	0.6	8.2	8.6	0.4	8.2	8.6	0.4	8.0	8.5	0.5
NE	13.6	14.4	0.8	13.7	14.2	0.5	13.7	14.2	0.5	13.5	14.0	0.5
<b>TXp 90 warm days</b>												

<b>Annual</b>	6.4	11.5	5.1	9.3	14.2	4.9	9.3	14.2	4.9	9.1	14.6	5.5
<b>Winter</b>	5.8	12.8	7.0	10.1	18.1	8.0	10.1	18.1	8.0	9.9	17.0	7.1
<b>Summer</b>	6.1	11.2	5.1	9.1	13.3	4.2	9.1	13.3	4.2	9.0	14.0	4.9
<b>SW</b>	6.4	11.7	5.2	8.8	14.2	5.4	8.8	14.2	5.4	8.7	14.8	6.0
<b>NE</b>	7.0	10.7	3.6	9.7	12.6	2.8	9.7	12.6	2.8	9.3	13.6	4.2
<b>TNp 90 warm nights</b>												
<b>Annual</b>	11.0	8.8	2.2	9.9	8.7	1.2	9.9	8.7	1.2	9.6	8.7	0.8
<b>Winter</b>	9.5	9.5	0	10.4	8.9	1.4	10.4	8.9	1.4	10.8	8.9	1.8
<b>Summer</b>	10.6	8.6	1.9	11.1	7.4	3.6	11.1	7.4	3.6	11.2	7.5	3.7
<b>SW</b>	11.8	8.3	3.5	11.1	9.5	1.5	11.1	9.5	1.5	10.9	9.5	1.3
<b>NE</b>	11.0	8.4	2.6	9.9	8.8	1.0	9.9	8.8	1.0	9.6	8.8	0.7
<b>TXp 10 cold days</b>												
<b>Annual</b>	12.3	9.12	3.2	11.2	8.7	2.5	11.2	8.7	2.5	11.4	8.6	2.7
<b>Winter</b>	9.9	9.4	0.4	10.3	9.4	0.9	10.3	9.4	0.9	10.2	9.1	1.0
<b>Summer</b>	11.5	8.9	2.6	10.5	8.5	1.9	10.5	8.5	1.9	11.0	8.3	2.6
<b>SW</b>	11.8	9.4	2.4	11.2	9.7	1.4	11.2	9.7	1.4	11.5	9.5	1.9
<b>NE</b>	15.3	8.5	6.7	12.5	6.8	5.7	12.5	6.8	5.7	12.3	7.1	5.1
<b>TNp 10 cold nights</b>												
<b>Annual</b>	8.5	10.7	2.1	10.2	12.4	2.2	10.2	12.4	2.2	10.3	12.4	2.1
<b>Winter</b>	11.8	10.6	1.1	12.2	13.7	1.5	12.2	13.7	1.5	12.0	13.8	1.8
<b>Summer</b>	10.8	9.1	1.6	10.1	10.8	0.7	10.1	10.8	0.7	9.9	10.8	0.8
<b>SW</b>	5.0	11.7	6.7	7.9	15.11	7.1	7.9	15.1	7.1	8.1	15.1	6.9
<b>NE</b>	9.0	10.7	1.7	12.0	9.5	2.5	12.0	9.5	2.5	12.4	9.4	3.0



Increasing trend



Decreasing trend

#### 4. CONCLUSION

A significant ( $p < 0.01$ ) increasing trend of maximum and decreasing trend of rainfall and a non-significant decreasing trend of minimum temperature was seen in the study area.

Rainfall is getting decreased at an alarming rate of 10 to 15%, days are getting warmer and nights are getting cooler taking the Raipur district into temperature fluctuated water scarcity future.

ITA detects trends much more accurately than the rest of the methods but its precision has to check with data size.

Dividing data sets into two halves and carrying out the climate research is much recommended because big data size dilutes the results and couldn't assess little changes.

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