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Temporal analysis of seasonal temperature and rainfall patterns in the coastal region of Odisha state: A research study

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Abstract
This research aims to evaluate climate-induced alterations and propose viable adaptation measures. The current study focuses on assessing both long-term trends and short-term variations in monthly, annual, and seasonal precipitation and temperature patterns across the Kendrapada district within the state of Odisha. To conduct this comprehensive study, we investigated both annual and seasonal temperature and rainfall trends over 42 years (1981-2022) in the Kendrapada district, using data sourced from the IMD Meteorological Agency. Rigorous quality control procedures were applied to ensure data reliability. For minimum temperature (Tmin), a statistically significant annual cooling trend was observed, indicated by a Sen's slope of -0.033 °C per year.

In contrast, no significant trend was identified for annual maximum temperature (Tmax), and annual mean temperature did not exhibit any significant trend over the study period. However, annual Rainfall showed a statistically significant increase, with a Sen's slope of 13.843 mm/year. These findings highlight a consistent cooling of temperature extremes alongside a long-term increase in precipitation within the study area. During the winter season, Tmin decreased at a rate of -0.032 °C per year, while Tmax experienced a minor decline of -0.023 °C per year. Seasonal mean temperature (Tmean) also followed decreasing trends with a rate of -0.026 °C per year.

On the other hand, seasonal Rainfall exhibited increasing trends with a Sen's slope of 1.582 mm per year. In the rainy season, Tmin showed positive trends with a slope of 0.014 °C per year, and Tmax increased at a rate of 0.014 °C per year. The significant increase in annual Rainfall and seasonal fluctuations underscores the complex climate dynamics within the Kendrapada district. These findings have potential implications for local climate patterns and water resource management, providing valuable insights for stakeholders and policymakers in the region.

Keywords: Minimum temperature, maximum temperature, rainfall, Sen's slope, mean temperature

1. Introduction

The International Organization on Migration estimates that up to 200 million people could be displaced by climate change by 2050 (Migration and Migrants: Regional Dimensions and Developments, 2021) [9]. Extreme weather and climate change impacts are increasing in Asia, which darted between droughts and floods in 2022, ruining lives and destroying livelihoods. Melting ice and glaciers and rising sea levels threaten more socio-economic disruption in future, according to a new report from the World Meteorological Organization. The expected increase in the frequency and severity of extreme events over much of Asia will impact agriculture, which is central to all climate adaptation planning (WMO, 2023) [12]. Climate plays an important role in the hydrological events of the surrounding environment. Thus, its variability over time is a very emerging scientific aspect worldwide. The magnitude of fluctuation of climate varies according to various locations. Since the middle of the twentieth century, India has witnessed a rise in average temperature, a decrease in monsoon precipitation, a rise in extreme temperature and rainfall events, droughts, and sea levels, and an increase in the intensity of severe cyclones, alongside other changes in the monsoon system. There is compelling scientific evidence that human activities have influenced these changes in regional climate A Report of the Ministry of Earth Sciences (MoES), Government of India(Krishnan *et al*., n.d.). The frequent occurrence of unprecedented extreme weather events due to unpredictable climate leads to human casualties, propriety, and economic losses (Felix *et al*., 2021) [1]. As all the metrological events mainly emerged from the coastline area, it is very important to analyze the coastline climate variation. Therefore, it is crucial to investigate

the spatiotemporal dynamics of meteorological parameters within the context of climate cf;lh gfhange, especially in regions where rainfed agriculture is the primary mode of cultivation. Examining long-term shifts in climatic variables is a crucial undertaking when it comes to detecting climate change. The exploration of historical and contemporary climate fluctuations has garnered significant interest due to enhancements in datasets and advancements in more intricate data analysis methods worldwide (Kumar *et al.*, 2010) [7]. Analyzing trends in Rainfall and various climatic variables across diverse spatial scales is essential for building future climate scenarios (Worku *et al*., 2019) [13] (Pal *et al*., 2017) [10] (Gajbhiye *et al*., 2016) [2]. The present studies were carried out to get scientific information about monthly, annual and seasonal variations of Rainfall and temperature, also finding the long-term trend of these data over the region. Therefore, the objective of this study is as follows:
To identify trends in Rainfall and temperature using Man-Kendall trend analysis and Sen's Slope methods.

2. Materials and Methods
2.1 Study Area
The study area, Kendrapara District, is situated in the Central Coastal Plain zone of Odisha. The District is bounded by Bhadrak District at its North, Jagatsinghpur District at its South, Cuttack District at its West and Bay of Bengal at its East. Kendrapara District lies at 20 degrees 21' N to 20 degrees' N Latitude and 86 degrees 14' E to 87 degrees 03' E Longitude(Fig.1). The Coastline of Kendrapara District covers 48 Km stretching from Dhamra Muhan to Batighar. The District covers an area of 2,644 sq km. Kendrapara District lies in the river delta formed by the Brahmani and Baitarani branch rivers of Mahanadi. The monthly maximum temperature was found to be 33.03 °C in May, and the annual mean maximum was 30.91 °C. Annual mean temperature was 27.38 °C. The mean annual rainfall of the study area was 1451.31mm.

2.2 Data Collection: The data was obtained from the National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) Prediction of Worldwide Energy Resource (POWER) Project funded through the NASA Earth Science/Applied Science Program. For our study area, data is downloaded from the NASA data download interface with coordinate Latitude 20.5848 Longitude 86.661. The abbreviation used by these data is T2M_MAX, T2M, T2M_MIN and PRECTOTCORR.

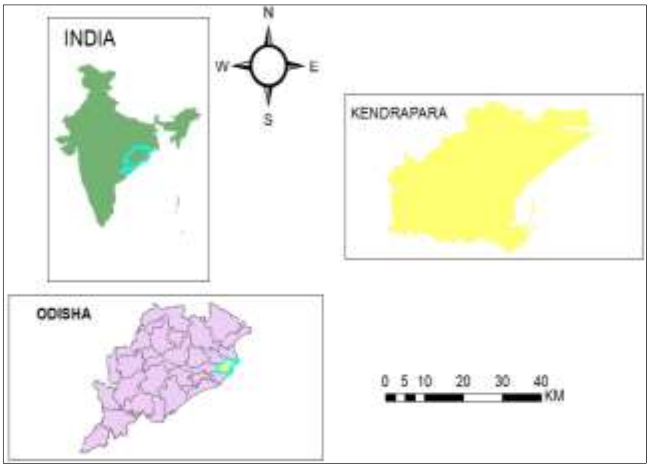


Fig 1: Location Map of the Study Area

2.3 Nonparametric test
The most frequently used nonparametric test for identifying trends in hydrologic variables is the Mann-Kendall (MK) test. The statistical significance trend detected using a nonparametric model such as the Mann-Kendall (MK) test can be complemented with Sen's slope estimation to determine the magnitude of the trend (RESHU YADAV *et al*., 2014) [11]. The purpose of the Mann-Kendall (MK) test (Mann, 1945) [8], (Kendall, 1975) [5], (Gilbert, 1987) [3] is to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time. A monotonic upward (downward) trend means that the variable consistently increases (decreases) through time, but the trend may or may not be linear. The MK test can be used in place of a parametric linear regression analysis, which can be used to test if the slope of the estimated linear regression line is different from zero. The regression analysis requires that the residuals from the fitted regression line be normally distributed, an assumption not required by the MK test; that is, the MK test is a nonparametric (distribution-free) test. (Hirsch *et al*., 1982) [4] Indicate that the MK test is best viewed as an exploratory analysis and is most appropriately used to identify stations where changes are significant or of large magnitude and to quantify these findings.

2.4 Trend analysis Test
Trends were detected in the time series of all the indices analyzed by means of the Mann–Kendall test. Above di this is a rank correlation statistic test based on the comparison of the observed number of discordances and the value of the same quantity expected from a random series. The World Meteorological Organization has suggested the Kendall method to assess the trend in environmental data time series. This test consists of comparing each value of the time series with the others remaining, always in sequential order. The number of times that the remaining terms are greater than that under analysis is counted. The following equation gives Kendall statistic:

$$S = \sum_{i=2}^{n} \sum_{j=1}^{i-1} \mathrm{sign}(x_i - x_j) \qquad (1.0)$$

Where,
n is the length of the data set, x_i and x_j are two generic sequential data values, and the function $\mathrm{sign}(x_i - x_j)$ assumes the following value:

$$\mathrm{sign}(x_i - x_j) = \begin{cases} 1, \mathrm{if}(x_i - x_j) > 0 \\ 0, \mathrm{if}(x_i - x_j) = 0 \\ -1, \mathrm{if}(x_i - x_j) < 0 \end{cases} \qquad (2.0)$$

The S statistic, therefore, represents the number of positive differences minus the number of negative differences found in the analyzed time series. Under the null of that, there is no trend in the data and no correlation between the considered variable and time; each ordering of the data set is equally likely. Under this hypothesis, the statistic S is approximately normally distributed with the mean E(S) and the variance Var (S) as follows:

$$E(S) = 0 \qquad (3.0)$$

$$Var(S) = \sqrt{\frac{n(n-1)(2n+5)-\sum_{p=1}^{q}(t_p)(i-1)(2t_p+5)}{18}} \quad (4.0)$$

Where,
n is the length of the times-series
tp is the number of ties for the pth value, and q is the number of the values, i.e., equals values.
The second term represents an adjustment for tied or censored data. The standardized test statistic Z is given by:

$$Z = \begin{cases} \frac{S+1}{\sqrt{Var(s)}} \text{ if } S > 0 \\ 0 \text{ if } S = 0 \\ \frac{S-1}{\sqrt{Var(s)}} \text{ if } S < 0 \end{cases} \quad (5.0)$$

The presence of a statistically significant trend is evaluated using the Z value. This statistic is used to test the null hypothesis such that no trend exists. A positive Z indicates an increasing trend in the time series, while a negative Z indicates a decreasing trend. To test for either increasing or decreasing monotonic trend at the p significance level, the null hypothesis is rejected if the absolute value of Z is greater than Z (1-p/2), where Z (1-p/2) is obtained from the standard normal cumulative distribution tables. In this work, the significance level of 0.05 is applied, and the significant level p-value was obtained for each analyzed time series.

2.5 Sen's Slope Test

To estimate the trend of the time series data, Sen's nonparametric method for the estimation of slope is used (Sen, 1968) [14]. To find the slope estimate (Q), slopes of individual data value pairs are calculated using the following function

$$Q_i = \frac{X_i - X_j}{j-k} \quad (6.0)$$

Where X_i and X_j are data values at the ith interval and jth interval, respectively, and j>k. The median value of Qi is Sen's estimator of slope. If the number of data pairs is N, then

$$Q = \begin{cases} Q_{\frac{N*1}{2}} \text{ if N is odd} \\ \frac{Q_{\frac{N}{2}}+Q_{\frac{N+2}{2}}}{2} \text{ if N is even} \end{cases} \quad (7.0)$$

If the value of Q is positive, there is an upward trend, while if negative, there is a downward trend.

3. Results and Discussion

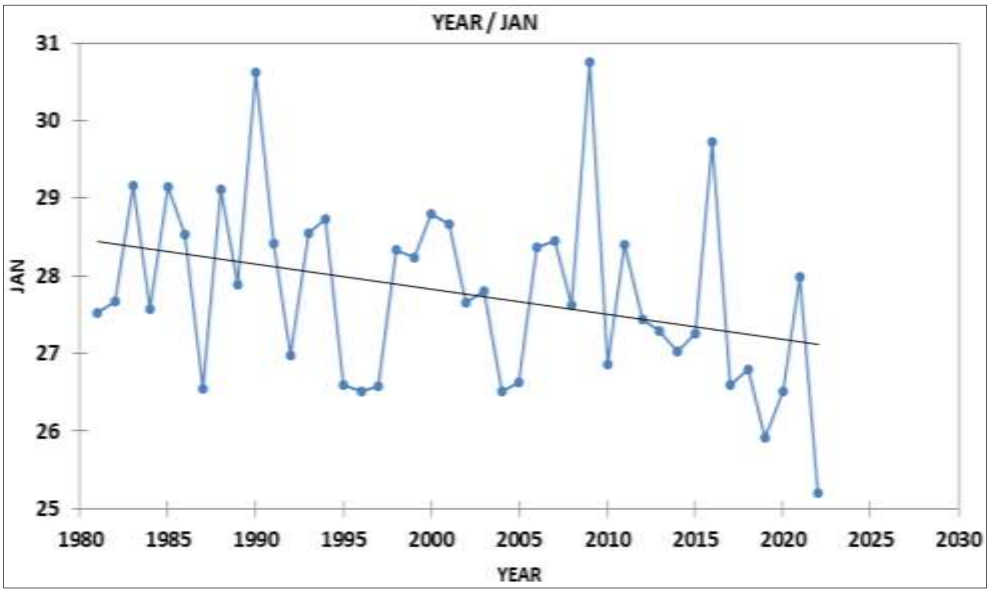
In the analysis of temperature and rainfall data, various statistical measures are computed from 1981 to 2022, including the Mann-Kendall coefficient, two-tailed P-value, alpha value, Sen's slope, and the assessment of the null hypothesis. These calculations are performed to determine the presence and nature of trends in the data. For monthly, annual, and seasonal datasets, the analysis aims to identify whether there is a positive, negative, or no trend. Additionally, the percentage risk of either accepting or rejecting the null hypothesis is determined at specified confidence intervals to provide insights into the data's trend characteristics. Also, the entire test is performed at a 95% level of significance.

3.1 Analysis of Maximum Temperature (Tmax)

Figure 2 and Table 1 show that the analysis of monthly temperature data, we observe a positive trend in August, with a Kendall Tau (τ) value of 0.294 and a p-value of 0.006. The Sen's slope for August is 0.019, falling within the confidence interval (0.015, 0.022). For January, we identify a negative trend, with a Kendall Tau (τ) value of -0.262 and a p-value of 0.015. The Sen's slope for January is -0.036, within the confidence interval (0.015, 0.022). Similarly, for November, we find a negative trend, with a Kendall Tau (τ) value of -0.228 and a p-value of 0.035. The Sen's slope for November is -0.018, falling within the confidence interval (0.015, 0.022). Regarding annual temperature data, no significant trend is currently identified. In the analysis of seasonal data, only the winter season currently exhibits a negative trend, with a Kendall Tau (τ) value of -0.254 and a p-value of 0.018. The Sen's slope for winter is -0.023, falling within the confidence interval (-0.027, -0.018).

Table 1: Mann-Kendall test analysis of maximum temperature (Tmax)

Variable	Kendall (Ʈ)	P-value (two-tailed)	Alpha	Sen's slope	Null hypothesis (Ho)	Confidence interval
JAN	-0.262	0.015	0.05	-0.036	Rejected	(-0.045,-0.030)
FEB	-0.045	0.68	0.05	-0.006	Accepted	(-0.015,0.001)
MAR	-0.166	0.124	0.05	-0.029	Accepted	(-0.035,-0.018)
APR	-0.048	0.665	0.05	-0.007	Accepted	(-0.013,0.00)
MAY	-0.005	0.974	0.05	-0.002	Accepted	(-0.009,0.121)
JUN	-0.181	0.093	0.05	-0.031	Accepted	(-0.043,-0.026)
JUL	0.149	0.169	0.05	0.012	Accepted	(0.009,0.017)
AUG	0.294	0.006	0.05	0.019	Rejected	(0.015,0.022)
SEP	0.059	0.588	0.05	0.003	Accepted	(0.001,0.006)
OCT	0.13	0.229	0.05	0.009	Accepted	(0.006,0.011)
NOV	-0.228	0.035	0.05	-0.018	Rejected	(-0.021,-0.014)
DEC	-0.164	0.129	0.05	-0.002	Accepted	(-0.027,-0.015)
ANN	0.059	0.588	0.05	0.007	Accepted	(0.001,0.013)
FALL	-0.069	0.53	0.05	-0.003	Accepted	(-0.007,-0.001)
WINTER	-0.254	0.018	0.05	-0.023	Rejected	(-0.027,-0.018)
SUMMER	-0.092	0.4	0.05	-0.012	Accepted	(-0.019,-0.007)
RAINY	-0.027	0.813	0.05	-0.002	Accepted	(-0.007,0.002)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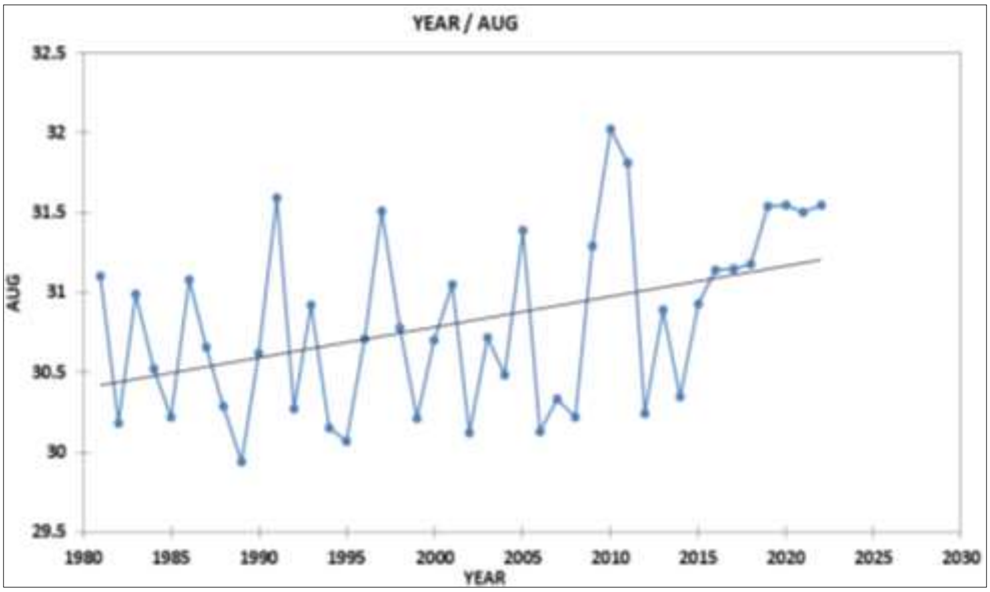
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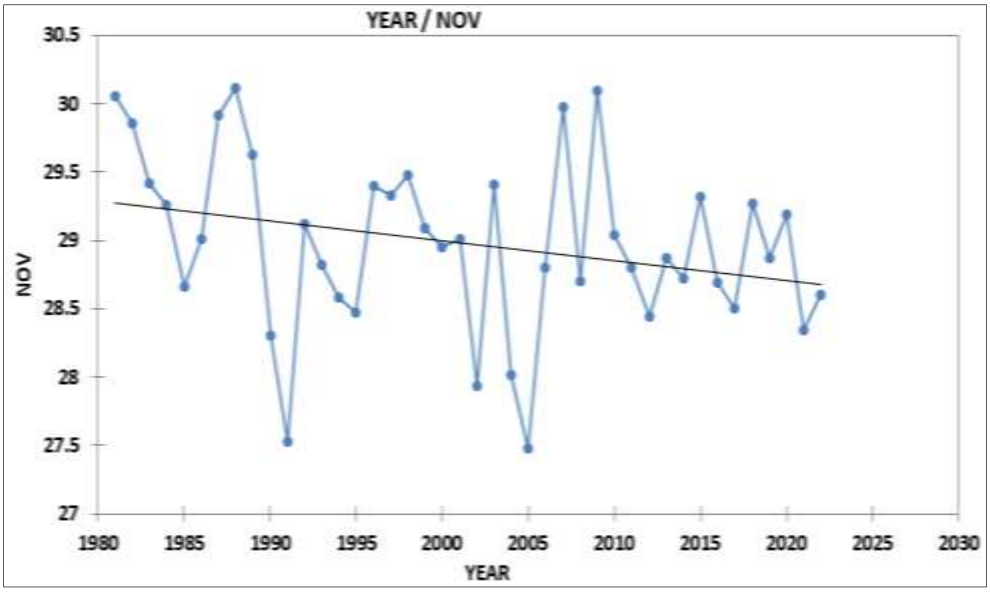
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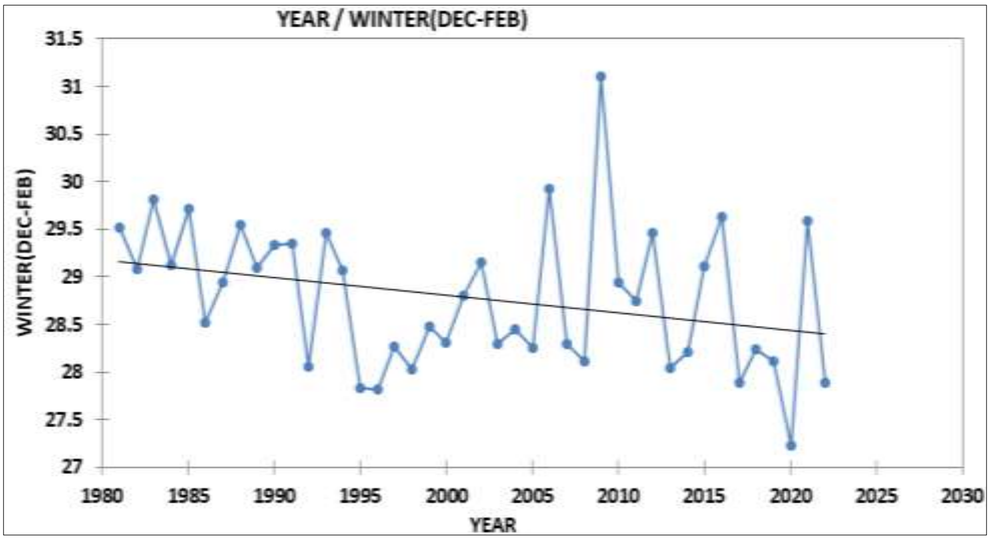

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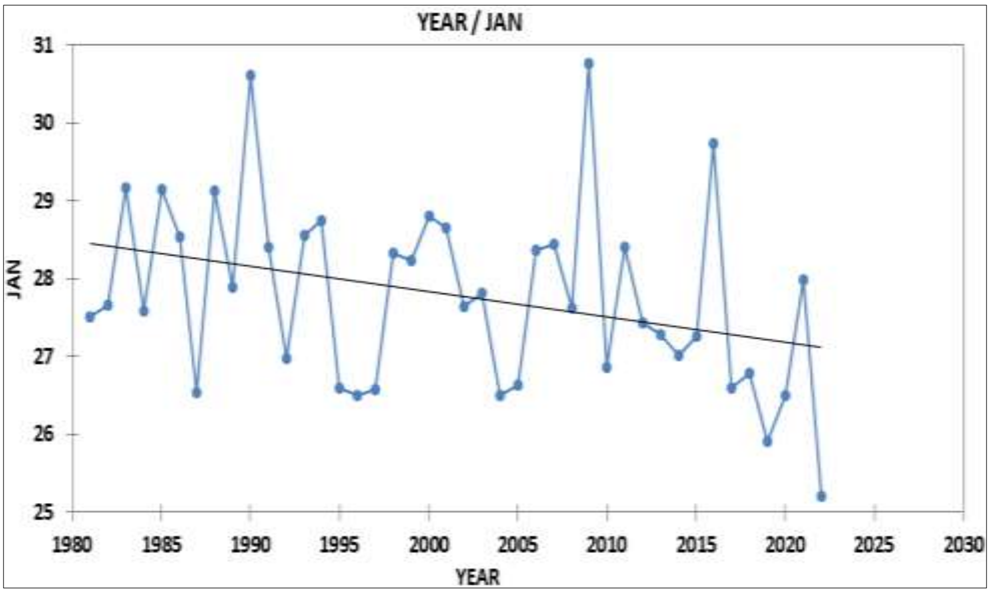
Fig 2: Temporal variation of Maximum (Temperature Tmax) for the period (1981-2022) with trend line. (a) Monthly Maximum Temperature for January, August (b) and November (c). Seasonal Maximum Temperature in the Season Winter (d)

3.2 Analysis of Minimum Temperature (Tmin): Figure 3 and Table 2 show that the monthly temperature data, positive trends are observed in June and August. For June, the Kendall Tau (τ) value is 0.244 with a p-value of 0.024, and the Sen's slope is 0.019, which falls within the confidence interval (0.009, 0.014). In August, the Kendall Tau (τ) value is 0.381 with a p-value of 0, and the Sen's slope is 0.021, falling within the confidence interval (0.018, 0.024). Conversely, negative trends are found in January, February, and December. For January, the Kendall Tau (τ) value is -0.319 with a p-value of 0.003, and the Sen's slope is -0.038, falling within the confidence interval (-0.043, -0.033). For February, the Kendall Tau (τ) value is -0.282 with a p-value of 0.009, and the Sen's slope is -0.04, falling within the confidence interval (-0.047, -0.034). In December, the Kendall Tau (τ) value is -0.231 with a p-value of 0.032, and the Sen's slope is -0.021, falling within the confidence interval (-0.029, -0.016). In the analysis of seasonal data, the winter season exhibits a negative trend with a Kendall Tau (τ) value of -0.352 and a p-value of 0.001. The Sen's slope for winter is -0.032, falling within the confidence interval (-0.035, -0.029). In contrast, the rainy season displays a positive trend with a Kendall Tau (τ) value of -0.285 and a p-value of 0.008. The Sen's slope for the rainy season is 0.014, falling within the confidence interval (0.012, 0.016).

Table 2: Mann-Kendall test analysis of minimum temperature (Tmin)

Variable	Kendall (T)	P-value (two-tailed)	Alpha	Sen's slope	Null hypothesis (Ho)	Confidence interval
JAN	-0.319	0.003	0.05	-0.038	Rejected	(-0.043,-0.033)
FEB	-0.282	0.009	0.05	-0.04	Rejected	(-0.047,-0.034)
MAR	0	1	0.05	0	Accepted	(-0.006,0.006)
APR	0.126	0.246	0.05	0.01	Accepted	(0.007,0.016)
MAY	0.211	0.051	0.05	0.017	Accepted	(0.013,0.021)
JUN	0.244	0.024	0.05	0.011	Rejected	(0.009,0.014)
JUL	0.19	0.079	0.05	0.01	Accepted	(0.007,0.012)
AUG	0.381	0	0.05	0.021	Rejected	(0.018,0.024)
SEP	0.151	0.162	0.05	0.01	Accepted	(0.008,0.013)
OCT	-0.012	0.922	0.05	-0.002	Accepted	(-0.008,0.005)
NOV	0.091	0.404	0.05	0.011	Accepted	(0.005,0.016)
DEC	-0.231	0.032	0.05	-0.021	Rejected	(-0.029,-0.016)
ANN	-0.333	0.002	0.05	-0.033	Rejected	(-0.0036,-0.027)
FALL	0.079	0.468	0.05	0.01	Accepted	(0.005,0.015)
WINTER	-0.352	0.001	0.05	-0.032	Rejected	(-0.035,-0.029)
SUMMER	0.128	0.237	0.05	0.011	Accepted	(0.006,0.015)
RAINY	0.285	0.008	0.05	0.014	Rejected	(0.012,0.016)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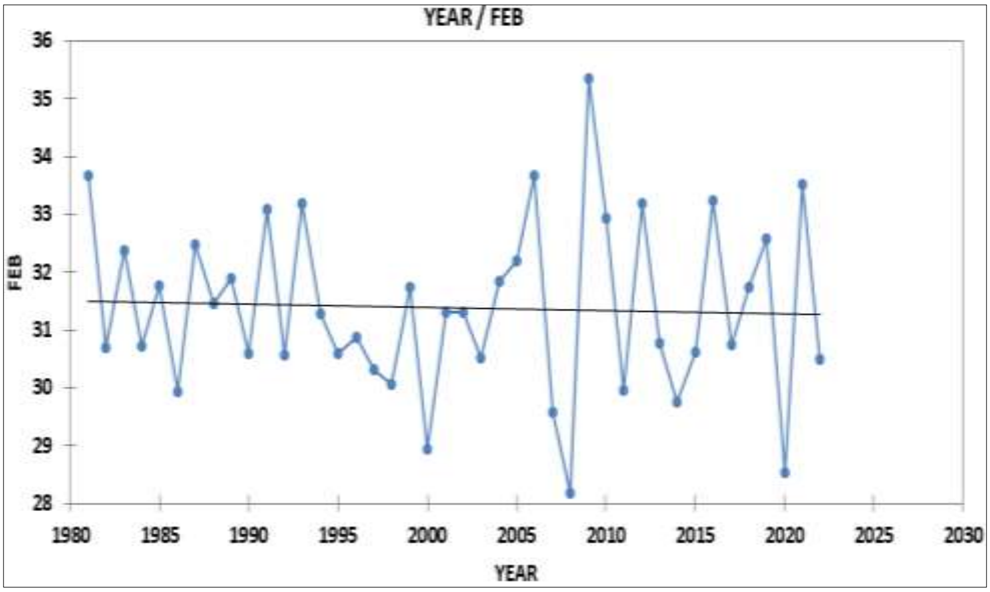
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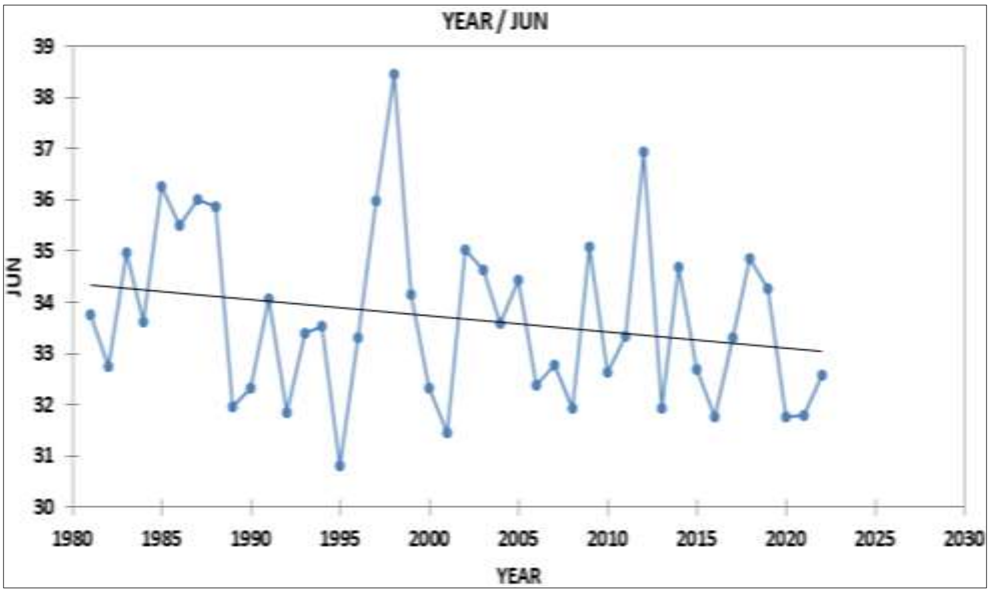
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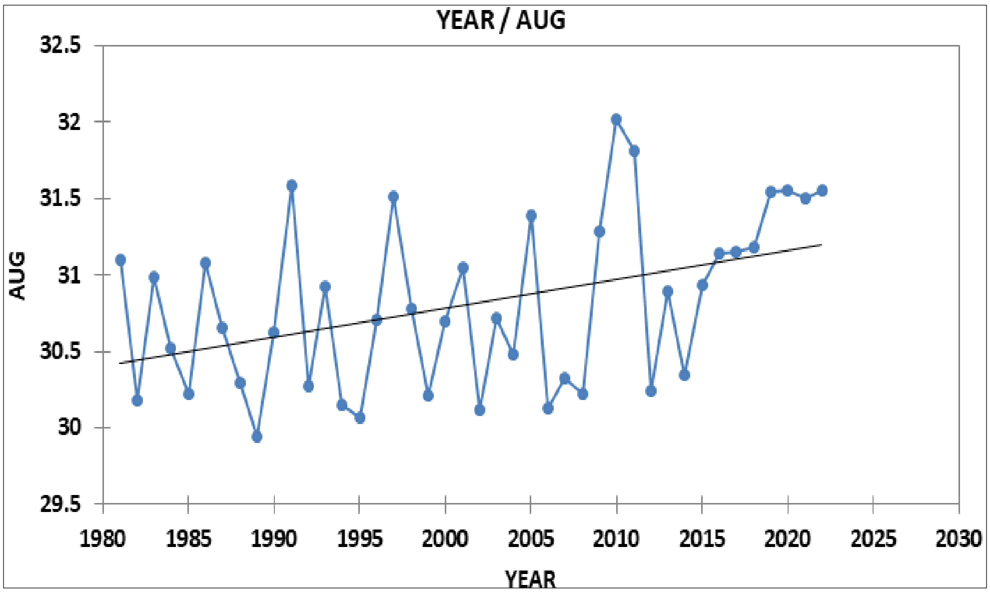
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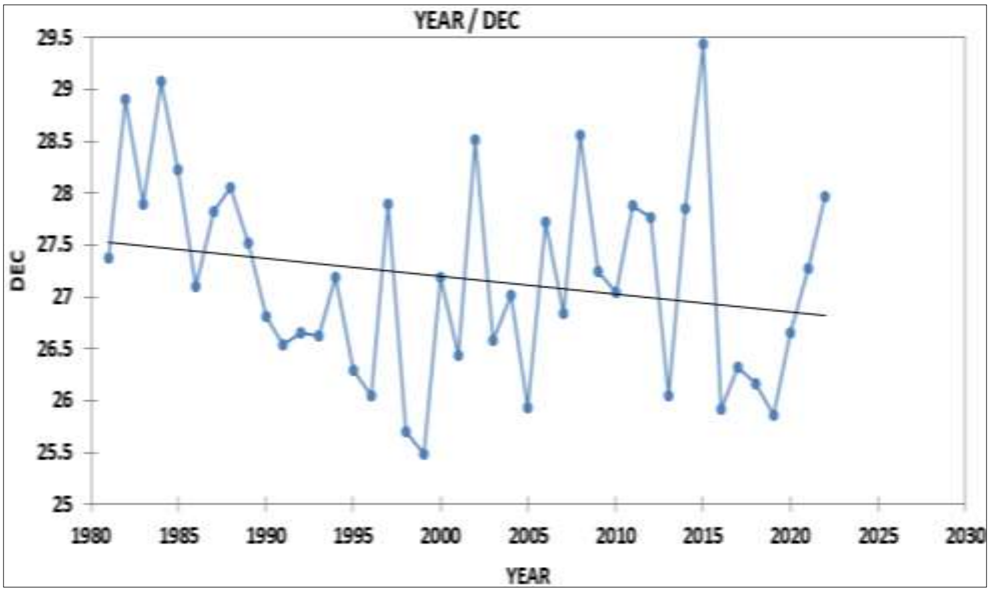
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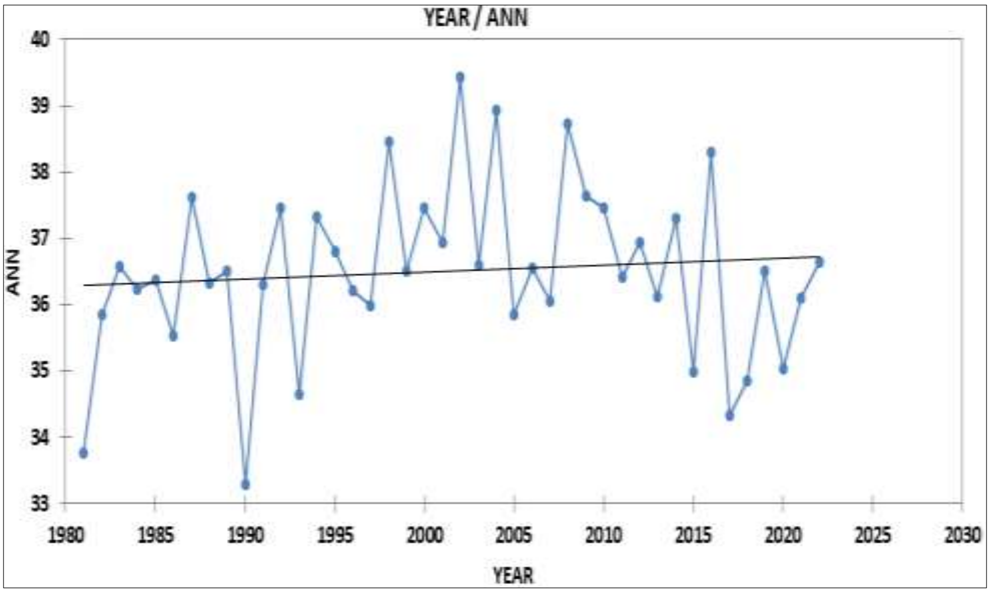
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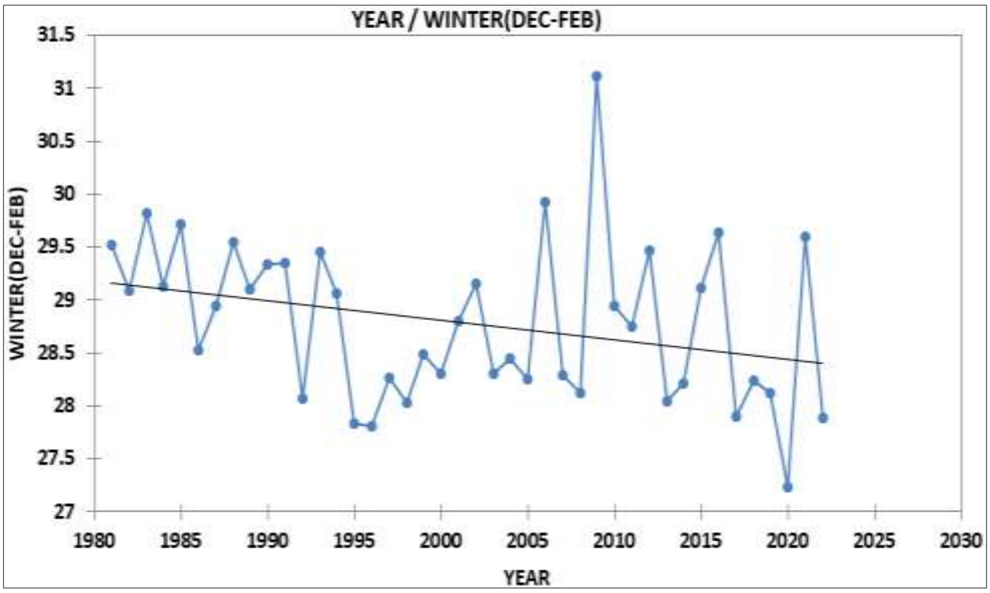

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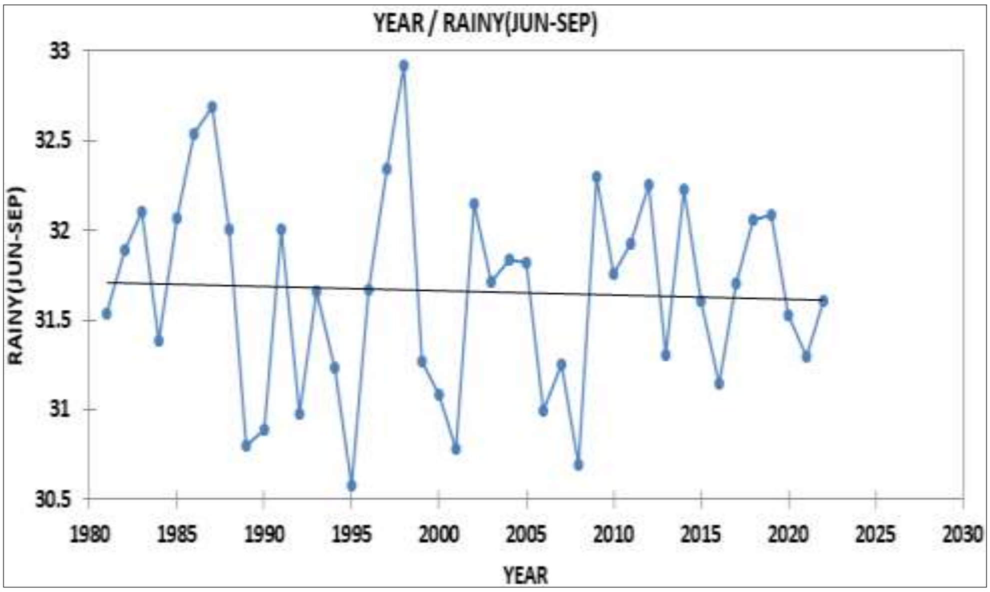


h)

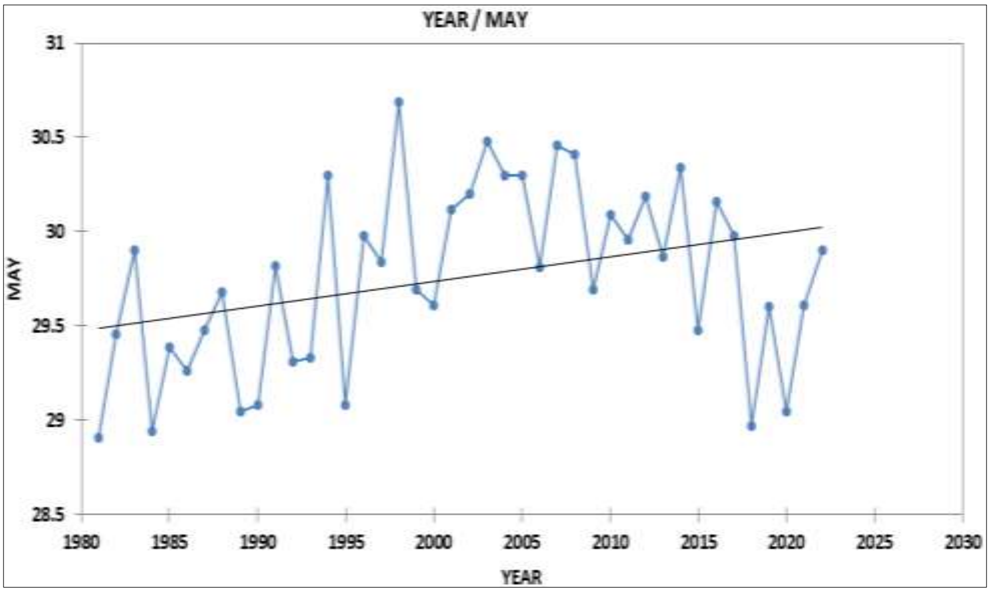
Fig 3: Temporal Variation of Minimum Temperature (Tmin) for the period (1981-2022) with trend line. Monthly Minimum Temperature for January (a), February (b), Jun (c), August (d), December (e). Annual Minimum Temperature (f). Seasonal Minimum Temperature in season of winter (g), and Rainy (h)

3.3 Analysis of Mean Temperature (Tmean)

Figure 4 and Table 3 show that the analysis of monthly mean temperature data, distinct trends emerge for different months. Positive trends are observed in May, July, August, and September, with Sen's slopes indicating an increase in temperature over time. Specifically, the Sen's slope values for May, July, August, and September are (0.016, 0.017, 0.017, 0.015). These positive trends are further supported by Kendall Tau (τ) values of (0.228, 0.354, 0.444, 0.401) with associated p-values of (0.035, 0.001, <0.0010). The Sen's slope values for these months fall comfortably within their respective confidence intervals. In contrast, the months of January, February, and December reveal negative trends, with Sen's slopes indicating a decrease in temperature over time. The Sen's slope values for January, February, and December are (-0.038,-0.024,-0.018), with corresponding Kendall Tau (τ) values of (-0.399,-0.279,-0.28) and associated p-values of (0, 0.01, 0.01). These negative trends are also confirmed by the Sen's slopes falling within their respective confidence intervals.

Table 3: Mann-Kendall test analysis of mean temperature (Tmean)

Variable	Kendall (T)	P-value (two-tailed)	Alpha	Sen's slope	Null hypothesis (Ho)	Confidence interval
JAN	-0.399	0	0.05	-0.038	Rejected	(-0.041,-0.034)
FEB	-0.279	0.01	0.05	-0.024	Rejected	(-0.028,-0.020)
MAR	0.009	0.94	0.05	0.005	Accepted	(-0.004,0.005)
APR	0.109	0.313	0.05	0.009	Accepted	(0.005,0.013)
MAY	0.228	0.035	0.05	0.016	Rejected	(0.012,0.018)
JUN	0.092	0.398	0.05	0.066	Accepted	(0.002,0.009)
JUL	0.354	0.001	0.05	0.017	Rejected	(0.015,0.017)
AUG	0.444	<0.001	0.05	0.017	Rejected	(0.016,0.019)
SEP	0.401	0	0.05	0.015	Rejected	(0.013,0.017)
OCT	0.147	0.175	0.05	0.008	Accepted	(0.006,0.010)
NOV	-0.066	0.544	0.05	-0.004	Accepted	(-0.007,-0.001)
DEC	-0.28	0.01	0.05	-0.018	Rejected	(-0.020,-0.016)
ANN	0.015	0.986	0.05	0.003	Accepted	(-0.001,0.001)
FALL	0.061	0.58	0.05	0.002	Accepted	(0.001,0.004)
WINTER	-0.452	<0.0001	0.05	-0.026	Rejected	(-0.028,-0.023)
SUMMER	0.157	0.46	0.05	0.009	Accepted	(0.006,0.012)
RAINY	0.374	0.001	0.05	0.014	Rejected	(0.013,0.015)



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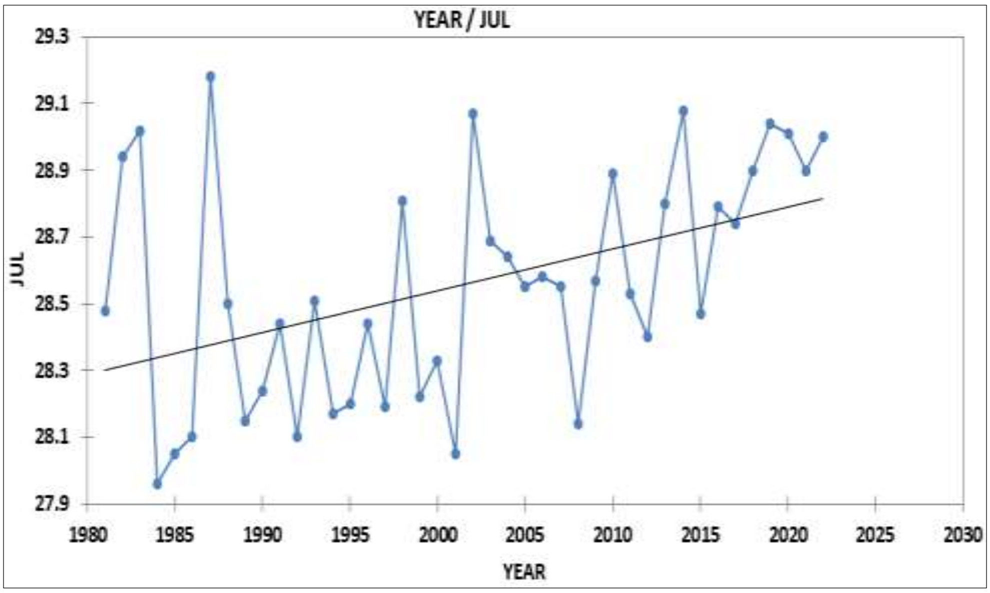

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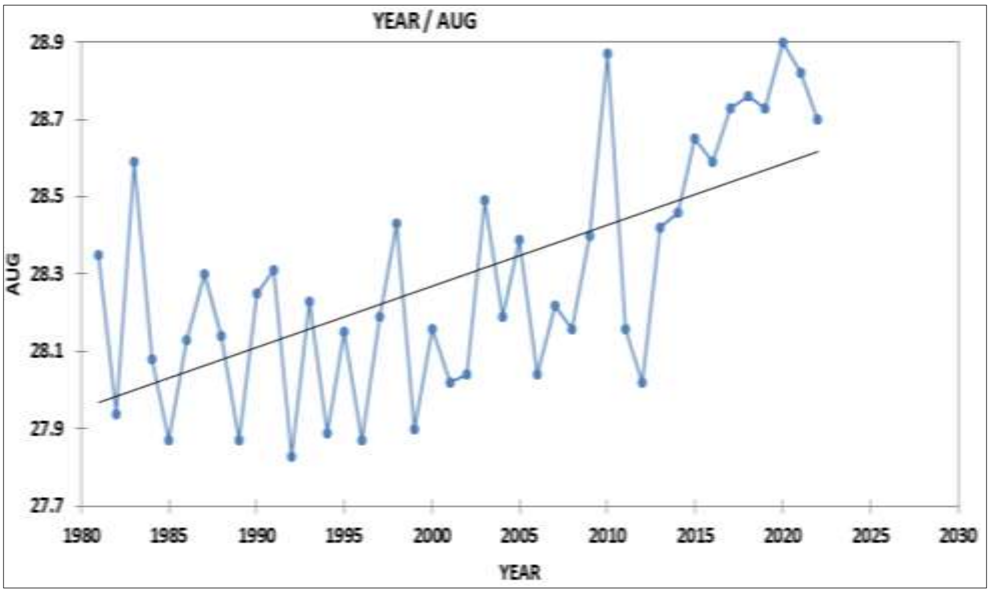
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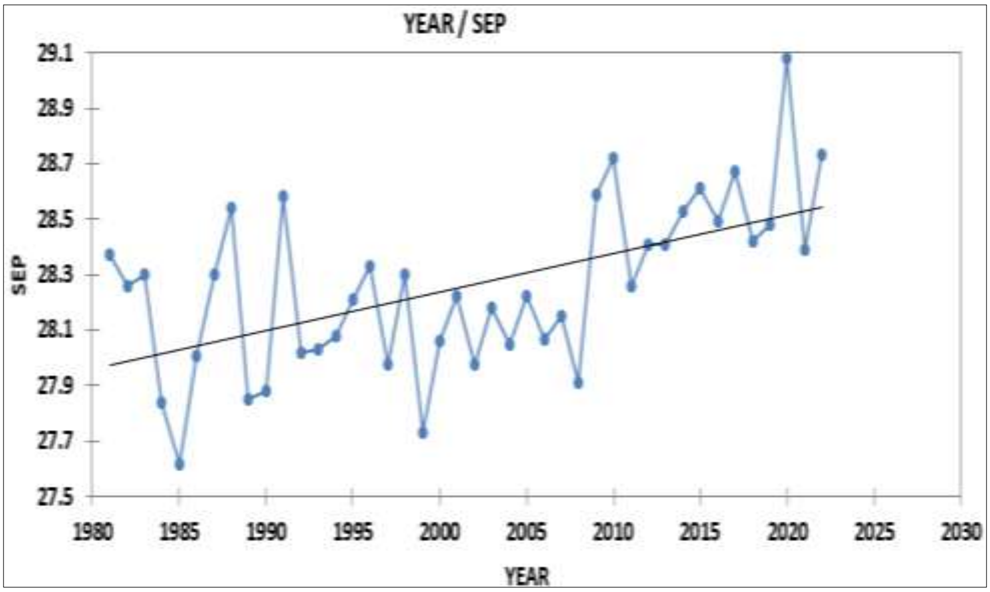
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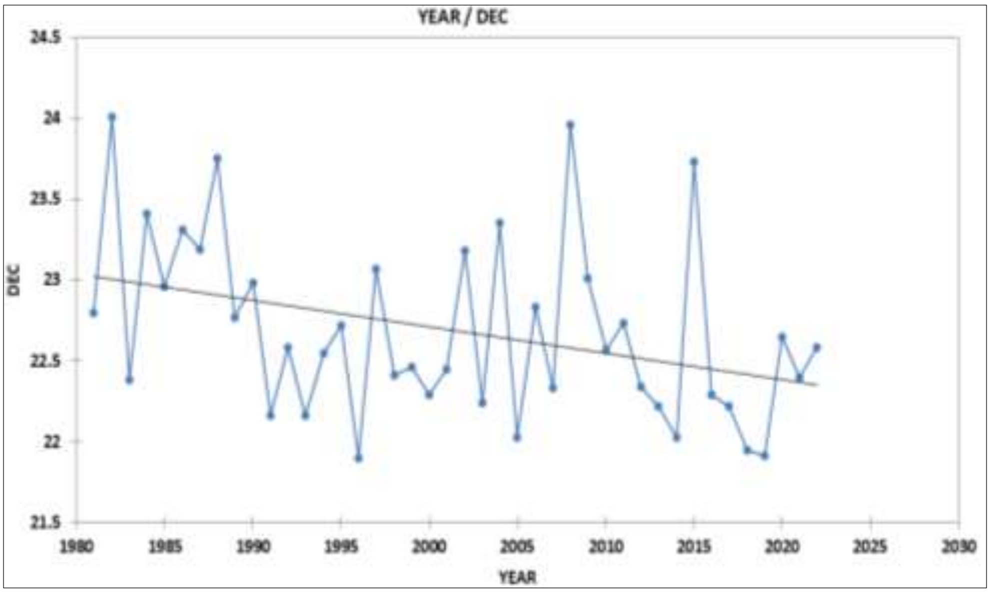
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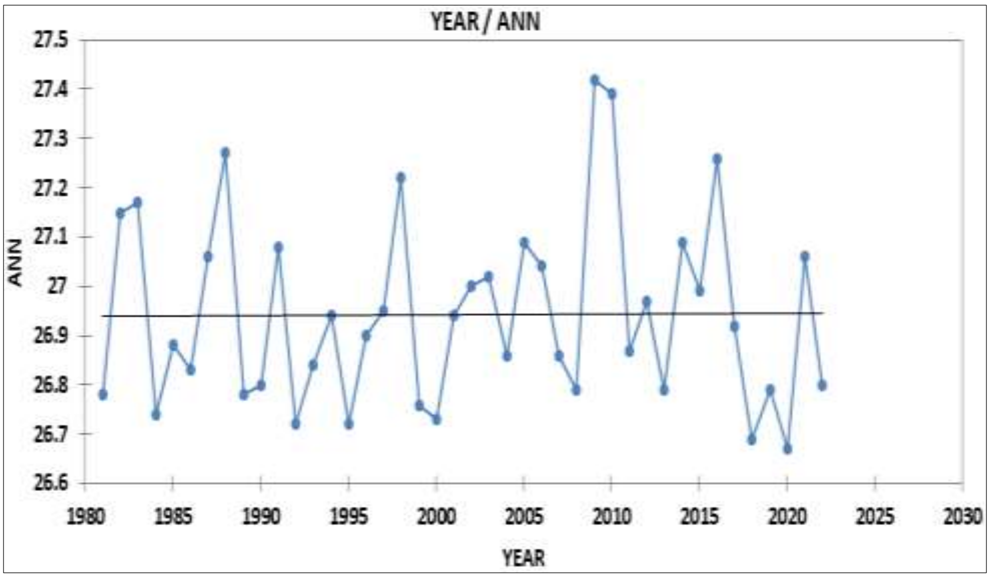
e)



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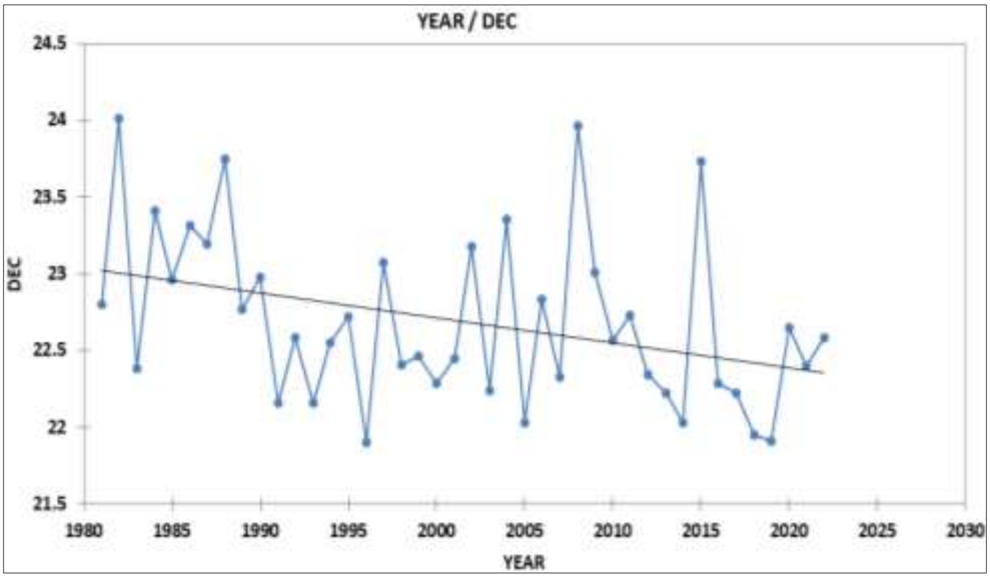


g)

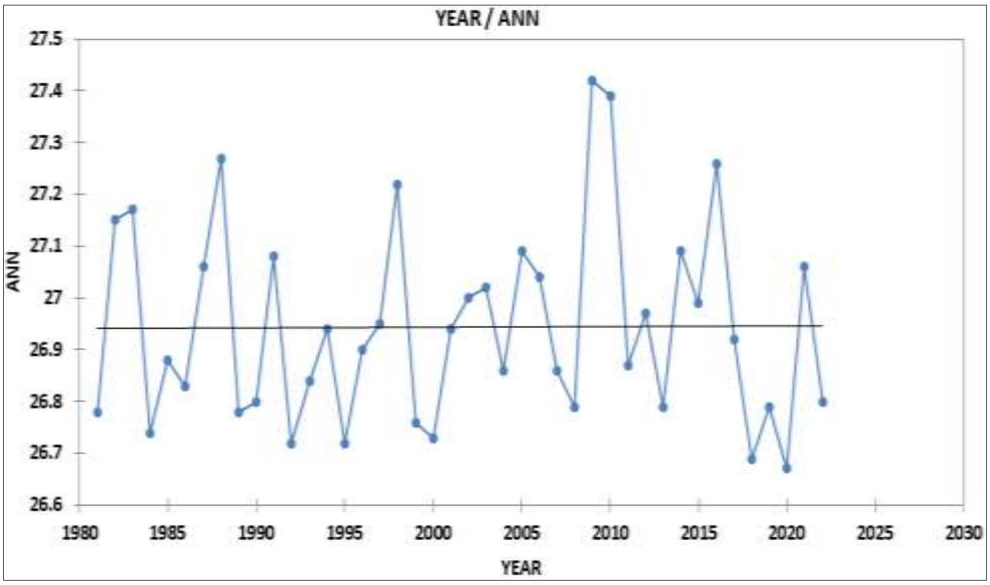


Fig 4: Temporal Variation of Mean Temperature (Tmean) for the period (1981-2022) with trend line. Monthly Mean Temperature for January (a), February (b), May (c), July (d), August (e), September (f), and December (g). Annual Mean Temperature (h). Seasonal Mean Temperature in the season Winter (i) and Rainy (j)

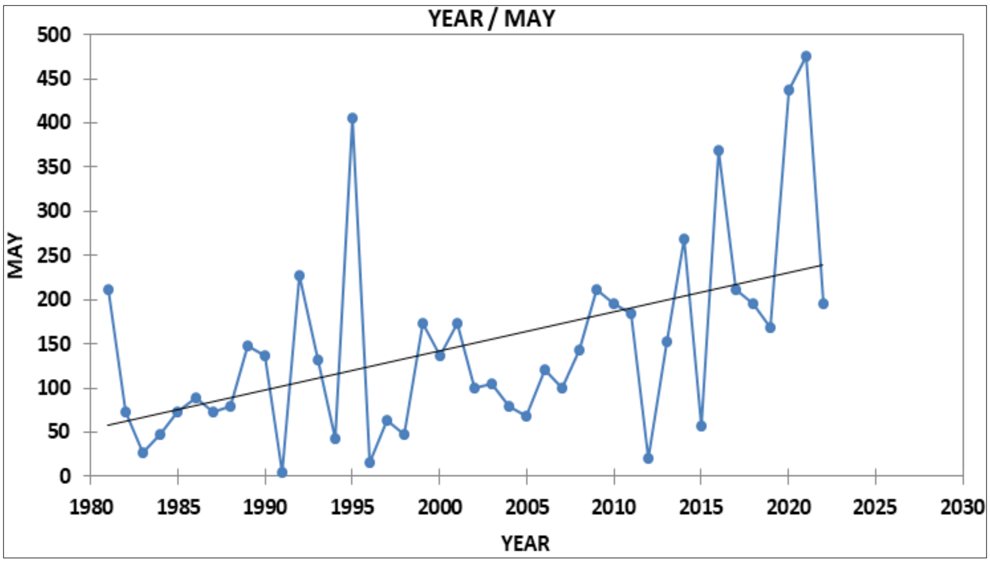
In the analysis of seasonal temperature data, contrasting trends are evident for the winter and rainy seasons. The winter season displays a distinct negative trend, as indicated by Sen's slope, which suggests a decrease in temperature over time. The Sen's slope for the winter season is (-0.026). This negative trend is further supported by a Kendall Tau (τ) value of (-0.452) and an associated p-value of (<0.0001). The Sen's slope for the winter season remains well within the confidence interval, underlining the significance of the observed negative trend during the winter months. In contrast, the rainy season exhibits a positive trend, with the Sen's slope indicating an increase in temperature over time. The Sen's slope for the rainy season is (0.014). This positive trend is also substantiated by a Kendall Tau (τ) value of (0.374) and a corresponding p-value of (0.001). The Sen's slope for the rainy season remains comfortably within the confidence interval, emphasizing the statistical significance of the positive trend during the rainy months. These findings provide valuable insights into the distinct temperature patterns observed during the winter and rainy seasons, with a clear negative trend in winter and a positive trend in the rainy season.

3.4 Analysis of Rainfall

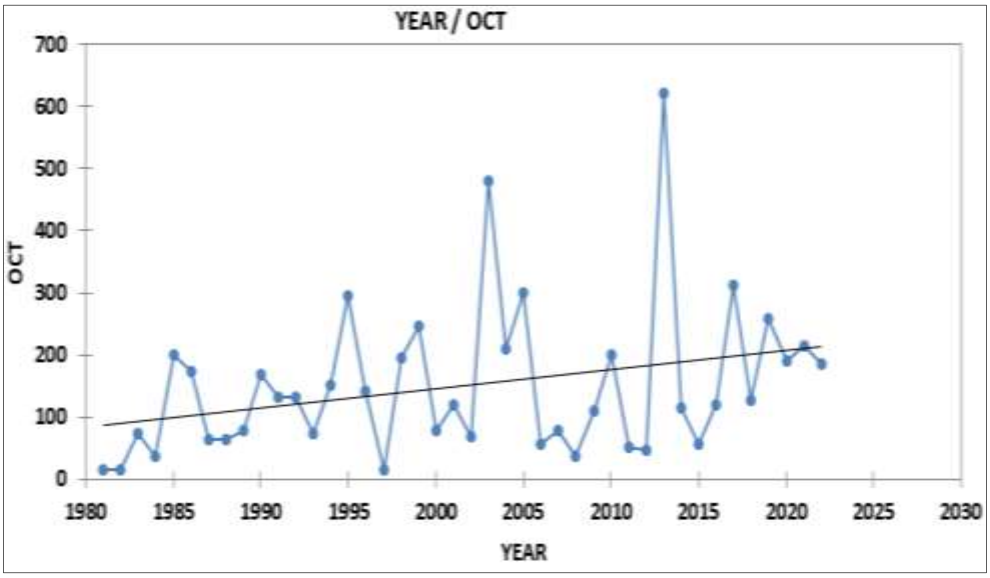
Figure 5 and Table 4 show that the analysis of rainfall data, several positive trends is discerned, showcasing consistent patterns in various timeframes. Both May and October display positive trends in the monthly rainfall data. The Kendall Tau (τ) values for these months are (0.364, 0.227), with p-values of (0.001, 0.036). The Sen's slopes for May and October are (3.955), (2.511), respectively. These positive trends are confirmed by Sen's slopes falling comfortably within the respective confidence intervals, underscoring the significance of the upward trends during these months. The annual rainfall data also exhibits a positive trend, as indicated by the Kendall Tau (τ) value of (0.346) and a p-value of (0.001). The Sen's slope for the annual data is (13.843), which remains within the confidence interval, further reinforcing the presence of a positive trend over the entire year. In the seasonal data, specifically during the summer season, a positive trend is observed. The Kendall Tau (τ) value for the summer months is (0.331) with a p-value of (0.002). The Sen's slope for the summer season is (1.582), and it falls within the confidence interval, emphasizing the statistical significance of the positive trend during the summer months. These findings offer valuable insights into the consistent positive trends in the rainfall data, evident in specific months, annually, and during the summer season.

Table 4: Mann-Kendall test analysis of rainfall

Variable	Kendall (T)	P-value (two-tailed)	Alpha	Sen's slope	Null hypothesis (Ho)	Confidence interval
AN	-0.034	0.782	0.05	0	Accepted	(0.00,0.00)
FEB	-0.137	0.235	0.05	0	Accepted	(-0.141,0.00)
MAR	-0.026	0.825	0.05	0	Accepted	(0.00,0.00)
APR	0.076	0.493	0.05	0.278	Accepted	(0.00,0.584)
MAY	0.364	0.001	0.05	3.955	Rejected	(3.414,4.520)
JUN	0.045	0.688	0.05	0.31	Accepted	(0.00,0.753)
JUL	0.163	0.134	0.05	1.758	Accepted	(1.363,2.445)
AUG	0.012	0.922	0.05	0	Accepted	(-0.359,0.958)
SEP	0.186	0.087	0.05	2.26	Accepted	(1.675,3.013)
OCT	0.227	0.036	0.05	2.511	Rejected	(1.984,2.892)
NOV	0.055	0.629	0.05	0	Accepted	(-0.136,0.00)
DEC	0.217	0.073	0.05	0	Accepted	(0.00,0.00)
ANN	0.346	0.001	0.05	13.843	Rejected	(11.569,-11.592)
FALL	0.199	0.065	0.05	1.273	Accepted	(1.014,1.484)
WINTER	0.066	0.556	0.05	0.0001	Accepted	(0.00,0.126)
SUMMER	0.331	0.002	0.05	1.582	Rejected	(1.341,1.757)
RAINY	0.105	0.087	0.05	1.236	Accepted	(0.836,1.507)



a)



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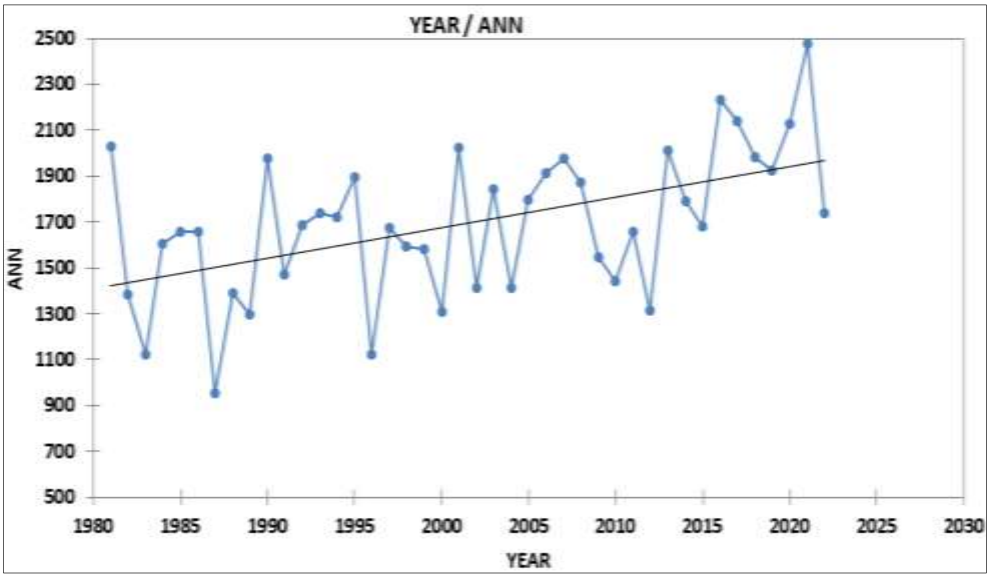
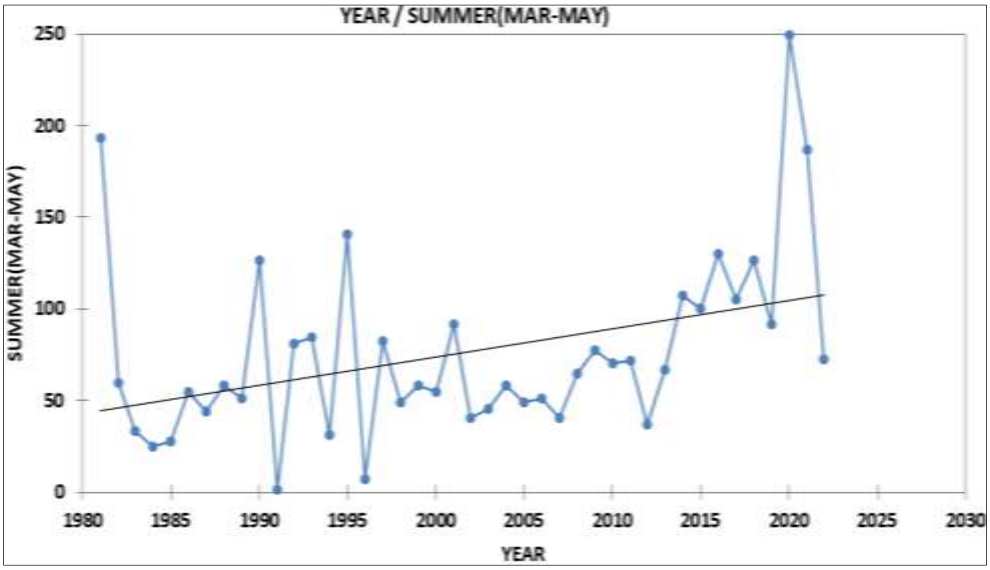


c)



d)

Fig 5: Temporal Variation of Rainfall for the period (1981-2022) with trend line. Monthly Rainfall for January (a), February (b), May (c), July (d), August (e), September (f), and December (g). Annual Rainfall (c). Seasonal Rainfall in summer (d)

4. Summary and Conclusion

- In Mann-Kendal analysis of maximum temperature, the analysis reveals positive trends in August, negative trends in January and November, no significant trend in annual data, and a negative trend during the winter season. These findings provide valuable insights into the current temperature patterns over the months and seasons.
- In Mann-Kendal analysis of minimum temperature, the this analysis reveals positive trends in June and August, negative trends in January, February, and December, a significant negative trend in annual temperature data, a negative trend in the winter season, and a positive trend in the rainy season.
- In Mann-Kendal analysis of mean temperature, the analysis provides valuable insights into the distinct monthly temperature patterns, showing positive trends during the warmer months and negative trends during the colder months. In seasonal data analysis, a negative trend was observed in the winter season, and the rainy season followed the positive trend. The annual mean temperature data does not give any significant trends to be analyzed.
- In Mann-Kendal analysis of rainfall both May and October display positive trends in the monthly rainfall data. These findings offer valuable insights into the consistent positive trends in the rainfall data, evident in specific months, annually, and during the summer season.

5. References

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