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Short communication

Trend analysis of extreme climate indices for Coimbatore using non-parametric method

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Long-term changes in tropical weather patterns are attributed to climate change, which became a global threat to various sectors specifically in agriculture, water resources and coral ecosystem (Abbass *et al.,* 2022). Recently, extreme climatic events have become a major concern across the world particularly for the developing countries like India due to its low resilience (Gedefaw 2023). The incidence of extreme climate events, the biggest factor of climate change has a serious influence for human ecosystem. Climate change is caused due to the extensive long-term temperature, precipitation, pressure and humidity trends in the surrounding environment (Abbass *et al.,* 2022). Consequently, being aware to the trend of major variables rainfall and temperature is important as they are the crucial variables that determine the climate change of region.

Researchers have studied the trend of extreme climate events and climate variables for different regions of the world viz. Ethiopia (Gedafaw 2023), Burkin Faso (Rowamba *et al.,* 2023) and Iraq (Alla *et al.,* 2024) including Indian regions like Tapi basin (Kale 2020), Cherrapunji (Kalita *et al.,* 2023), Maharashtra (Landage *et al.,* 2024) and Ladakh (Ambrish *et al.,* 2025). But studies have not been carried for Coimbatore district of Tamil Nadu. It is located in shadow of western ghats, enjoys a very pleasant climate throughout the year. Nowadays climate change is affecting Coimbatore in several ways. Analysing the trend of extreme climate changes of big city like Coimbatore helps the officials to implement effective adaptation and mitigation strategies.

Daily data of weather variables such as rainfall, minimum temperature (T_{min}) and maximum temperature (T_{max}) from year 1980 to 2023 of Coimbatore (11.0168° N, 76.9558° E) were collected from Agro-Climate Research Center, Tamil Nadu Agricultural University, Coimbatore to analyse the extreme climate indices. Based on the climate characteristics of Coimbatore, 10 extreme climate indices recommended by Expert Team on Sector-Specific Climate Indices (ET-SCI) have been used for the study. These indices include 6 extreme rainfall indices and 4 extreme temperature indices. An explanation of the extreme climate indices is presented in Table 1. The Climpact software is used to calculate the extreme climate indices (Climpact, 2020).

Non-parametric tests for trend analysis

Trend analysis of the annual weather variables and extreme climate indices has been performed using non-parametric test such as Mann-Kendall, Modified Mann-Kendall, Sen's Slope Estimator and Pettit homogeneity test. The Mann-Kendall test (Mann 1945; Kendall 1975) used to find the significant trends of the time series data and detects the monotonic increasing or decreasing trend. The direction of the trend can be determined by the positive or negative symbol of MK test statistic value. The major issue in time series data is serial correlation. Hence, the MMK test which is a modification of MK test is used to detect the trend of data and addresses the serial correlation using a variance correction approach (Hameed and Rao 1998). Sen's Slope estimator is a non-parametric test that determines the slope of the trend or the amount of change in the data (Sen 1968). It gives the magnitude of the trend. Pettit homogeneity test is a non-parametric test used for detecting the point which the shift occurred in the data (Pettitt, 1979).

Trend in annual rainfall and temperature

The results of trend analysis using non-parametric tests are presented in Table 2. The p value of Mann-Kendall test and Modified Mann-Kendall test for rainfall is greater than 0.05. Therefore, by accepting null hypothesis, it can be said that there is no trend in annual rainfall for Coimbatore district. It implies that the rainfall patterns are inconsistent with seasonal variability and irregular fluctuations. The significant value of both MK and MMK tests for minimum and maximum temperature is less than 0.01.

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Table 1: Description of extreme climate indices

Indices	Name	Definition	Units
DTR	Daily temperature range	Monthly mean difference between T_{max} and T_{min}	°C
R20mm	Number of heavy rain days	Annual count of days when rainfall>20mm	days
R95p	Very wet days	Annual rainfall when rainfall>95 percentile	mm
R95ptot	Contribution from very wet days	Fraction of total wet days that comes from very wet days	%
Rx1day	Maximum 1-day rainfall	Maximum 1-day rainfall of a month	mm
Rx5day	Maximum 5-day rainfall	Maximum consecutive 5-day rainfall of a month	mm
SDII	Simple daily intensity index	Average rainfall rate on days with a rainfall of at least 1 mm	mm/day
WSDI	Warm spell duration index	Annual days count with at least 6 consecutive days when T_{min} > 90th percentile	days
TR	Tropical nights	Nights in a year where T_{min} >20°C	days
TNgt5	Number of tropical nights	Nights in a year where T_{min} >5°C	days

Table 2: Non-parametric test for annual rainfall and temperatures

Climate variables	MK test		MMK test		Sen's Slope estimator
	Z test	p value	Z test	p value	
Rainfall	0.36	0.71	1.03	0.3	-
T_{min}	5.92	<0.01**	10.11	<0.01**	0.02
T_{max}	3.68	<0.01**	8.25	<0.01**	0.01

** Significant at 1% level

Table 3: Trend of extreme climate indices

Extreme climate indices	MK test		MMK test		Sen's Slope estimator
	Z test	p value	Z test	p value	
DTR	-5.3	<0.01**	12.67	<0.01**	0.03
R20mm	0.91	0.35	1.83	0.03*	0.02
R95p	1.3	0.19	3.01	<0.01**	1.93
R95ptot	1.17	0.24	2.85	<0.01**	0.2
Rx1day	1.28	0.19	3.59	<0.01**	0.36
Rx5day	0.68	0.49	1.25	0.02*	0.33
SDII	-0.01	0.99	-0.01	0.98	-
WSDI	0.54	0.58	1.14	0.25	-
TR	5.81	<0.01**	12.31	<0.01**	1.29
TNgt5	-0.91	0.36	-1.9	0.05	-

* Significant at 5% level; ** Significant at 1% level

Table 4: Change point of extreme climate indices

Extreme Indices	p value	Detection of change point	Year
DTR	<0.01**	YES	2004
R20mm	0.03	YES	1993
R95p	0.02	YES	1997
R95ptot	0.03	YES	1997
Rx1day	0.09	NO	-
Rx5day	0.02	YES	1991
SDII	0.05	NO	-
WSDI	0.99	NO	-
TR	<0.01**	YES	2008
TNgt5	0.99	NO	-

** Significant at 1% level

Therefore, by rejecting null hypothesis, it can be said that there is a linear trend in both T_{min} and T_{max} at 1% level of significance. The positive direction of z test implies that temperature has an increasing trend. From the result of Sen's slope estimator, it is clear that there is an increase of 0.02°C and 0.01°C in T_{min} and T_{max} respectively per year for Coimbatore district.

Trend analysis of extreme climate indices

Calculating extreme climate indices is essential for assessing climate variability and extremes. The extreme climate indices calculated are DTR, R20mm, R95p, R95ptot, Rx1day, Rx5day, SDII, WSDI, TR and TNgt5. The results of the trend of extreme climate indices are presented in Table 3. The p value of all extreme indices except DTR and TR is greater than 0.5 for MK test. But, the p value of MMK test for extreme indices such as DTR, R20mm, R95p, R95ptot, Rx1day, Rx5day and TR are less than 0.05. Also, Z test statistic of MMK for these indices is positive, thereby a linear increasing trend in analysed for these indices. Since p values of indices SDII, WSDI and TNgt5 is not significant, these indices do not exhibit any trend.

The increasing trend in DTR indicates that the increase of temperature in upcoming years indicating the increase of heatwaves and global warming. From the result of Sen's slope estimator, there is increase of 0.03°C in daily temperature range per year. The increasing trend of R20mm index indicates the increased heavy rainfall events and risk of flooding. Sen's slope estimator of R95p shows that there is an increase of 1.93mm rainfall on heavy rainfall days. The increasing trend of R95ptot which measures total amount

of rainfall where daily rainfall exceeds 95th percentile. These indicates the risk of flash flooding and more intense rainfall events.

The increasing trend of Rx1day and Rx5day shows that the highest amount of rainfall occurring in a single day and maximum 5 days is becoming more extreme. This means that short and intense rainstorms are becoming more severe. Though the annual rainfall does not show any trend these indices show the risk of flooding and irregular rainfall in future years. This can cause severe damage to soil and ecology. It may cause soil erosion, land degradation, crop damage, etc. The increasing trend of TR indicates the increase of hot nights which may leads to longer heat waves.

Change point detection

The indices SDII, WSDI and TNgt5 does not show any trend because the p value is not significant. The change point (year) of these indices is analysed by Pettit homogeneity test and the result is presented in Table 4. The indices Rx1day, SDII, WSDI and TNgt5 does not have any change point because the p value is not significant. The trend of extreme indices has commonly changed from the years of 1991-1997. The reason for this change is starting of urbanization and commercialisation of Coimbatore district. Many industries have been started from those years which leads in climate change of the district. It has led on the increasing of extreme climatic conditions.

Based on the study, the annual minimum, maximum temperature and many extreme climate indices have an increasing trend. The increasing trend of these variables indicates the risk of sudden flooding, extreme rainfall, rising heat waves, etc. The main causes of these increased extreme climate conditions are urbanization, deforestation, greenhouse gas emissions, global warming, etc. This leads to the climate change of the city. Climate change poses a serious risk to the survival of marine and terrestrial species. The risk can be reduced by taking measures like converting to renewable energy sources, implementing sustainable agriculture, recycling waste, conserving water, etc.

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