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# An Innovative Trend Analysis of Climatological Factors in Tiruvarur District of Tamil Nadu, India

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## ABSTRACT

The climatological factors like rainfall, temperature, humidity, wind patterns, atmospheric pressure, etc, have a profound impact on the environment. The changes in the climatological factors have interconnected effects on ecosystems, water resources, coastal areas, agriculture, forestry, human health and bio-diversity. The objective of the present work is to study the trend patterns in climatological and meteorological factors along with the effect of those variables on the crop yield. The coastal district, Thiruvarur of Tamil Nadu was selected for the study to analyse the climatological factors and their effect on the crop yield. In addition, Mettur dam outflow was analysed with the mann-kendall and innovative trend analysis. The findings of the study revealed the trend patterns in the study area. The monthly mann-kendall trend statistics shown that there is a negative trend in February month and positive trend in the rest of the months. While, the innovative trend analysis inferred that negative trend is realised in the months of February, April, June and positive trend in the remaining months. The trend analysis of the climatological factors is crucial for addressing the impacts, adaption to climate change and protecting the environment for the future.

**Key words:** *Environmental impact, Crop productivity, Mann-kendall trend, Sen's slope, Sen's innovative trend*

## Introduction

Environmental vulnerabilities and hazards to social economy is widely pronounced due to the climate change. The hydro-meteorological variabilities are correlated to the flood and drought incidence in the region (Yildirim *et al.*, 2022, Mallick *et al.*, 2021). The Intergovernmental Panel on climate change (IPCC, 2022) in its latest assessment report has warned about the consequences of climate change that has initiated to witness the effects in India. According to the sixth assessment report regarding the climate vulnerability index (in terms of geographic and socio-economic vulnerabilities), India is the major global hotspot for climate change.

The coastal districts of Tamil Nadu experiences high precipitation and temperature in the past years and the projected precipitation events for the near future reveals that a rising trajectory is observed in the climatological variables (Rajavel *et al.*, 2022). The effect of crop productivity can be improved by understanding the interconnection among the agriculture and climate change (Gadedjisso *et al.*, 2021). With this background, the objectives of the present study were formulated to study the trend patterns in climatological and meteorological factors along with the effect of those variables on the crop yield.

## Methodology

Tiruvarur district of Tamil Nadu is located at the

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East Latitude between 79° 15' and 79° 45' and the Northern Latitude between 10° 20' and 11° 70' and lies in the Cauvery delta climatic zone of Tamil Nadu. The average rainfall and temperature of the district is 1233.98 mm and 28.39 °C respectively in the year 2021, which is above the average of the state. The data of hydro-meteorological variables for the period of 1991-2021 are utilised for below discussed analyses of the study.

**Mann-kendall trend:** The trend analysis and estimation of Sen's slope are calculated by using Mann (1945), Kendall (1975) and Sen (1968) method. The variance correction approach by Yue and Wang (2004) is used to calculate the effective sample size for the coefficients by removing the serial correlation in the series. The z-statistics is used to compute the significance of the trend. The decreasing trend is realised if the z-statistics value is negative and vice versa. The trend is significant if the value is greater than the corresponding value of the 5% level of significance. When the z-value corresponding to the 5% level of significance is less than the z-value, there exists no trend.

**Sen's Innovative trend:** It is a non-parametric trend analysis that has no restrictions to assumptions of magnitude and monotonic trends is applicable to time series that may or may not have serial correlation (Sen, 2011). The time series is divided into two halves below and above the 1:1 line (i.e) 45° slope of the graph. The part, above the 1:1 line indicates the positive trend, below the line indicates the negative trend, and on the line, represents no trend respectively. The first half of the series denotes the earlier

observations in the particular time series and the second half of the series is the recent observations of the time series.

**Multiple Regression model:** To determine the climatological, meteorological, hydrological variables that influence the paddy crop yield, the following regression model was fitted.

$$Y = \alpha + aX_1 + bX_1^2 + cX_2 + dX_2^2 + e(X_1 + X_2) + fX_3 + \mu_i$$

where,

- Y - Yield of paddy crop (t/ha)
- X<sub>1</sub> - Rainfall (mm)
- X<sub>2</sub> - Annual mean temperature (°C)
- X<sub>3</sub> - Mettur reservoir outflow (TMC)
- a, ..., f - Parameters to be estimated
- μ - Error term

## Results and Discussion

The linear trend of the original annual rainfall shows an increasing trend which would impact the crop yields, shift the agricultural zones and alter the growing seasons and food production. Hence, the mann-kendall trend statistics obtained from mann-kendall test and modified mann-kendall trend test, along with sen's slope and slope of innovative trend analysis is presented for arriving meaningful results (Table 1).

The trend and slope with various trend analysis are analysed. The trend and slope with various trend analysis are analysed because agriculture is predominant in the study area and they depend on rainfall for their cultivation. Agriculture is predominant in the study area and they depend on rainfall

**Table 1.** Trend and slope of rainfall in Tiruvarur district, 1991-2021

S. No	Particulars	Z-statistics	Corrected Z value	Sen's slope	Innovative trend slope
1	January	1.560	1.807	0.000	0.431
2	February	-0.140	-2.350	0.000	-0.498
3	March	1.044	1.681*	0.000	1.043
4	April	0.483	1.115	0.000	-0.362
5	May	1.967***	5.625***	1.054	0.385
6	June	0.565	0.976	0.195	-0.294
7	July	2.994***	6.039***	1.550	1.247
8	August	2.742***	5.228***	2.220	2.041
9	September	1.447	3,196***	1.623	0.612
10	October	1.055	2.364**	1.550	0.861
11	November	0.561	1.454	1.465	1.383
12	December	0.817	2.365**	1.266	1.587
13	Annual	2.108**	6.085***	11.132	8.437

Note - \*\*\*, \*\* and \* refers to significance at 1 %, 5 % and 10 % levels respectively.

for their cultivation. From the results, a negative trend is observed in the February month for the long-term annual rainfall. An increasing trend is

realised in the remaining months. These are the results of the original Mann-Kendall trend test. In continuation, the modified Mann-Kendall trend test exhibits a increasing trend but the observed significant trend is in most of the months, since it has removed the serial correlation among the monthly observations. The magnitude of the trend implies that 11.13 mm of rainfall has increased per year. The innovative trend analysis has also exhibited positive trend in majority of the months, while a negative trend is witnessed in February, April, and June months.

The multiple regression analysis on effect of hydro-climatological variables on crop productivity has different responses with different variables. A positive effect is exhibited on crop productivity of paddy due to rainfall. The temperature in the study area has a negative effect on crop yield. The combined effect of rainfall and temperature is significant at one per cent level. The effect of mettur reservoir outflow is significant on account of crop yield, yet it is positive.

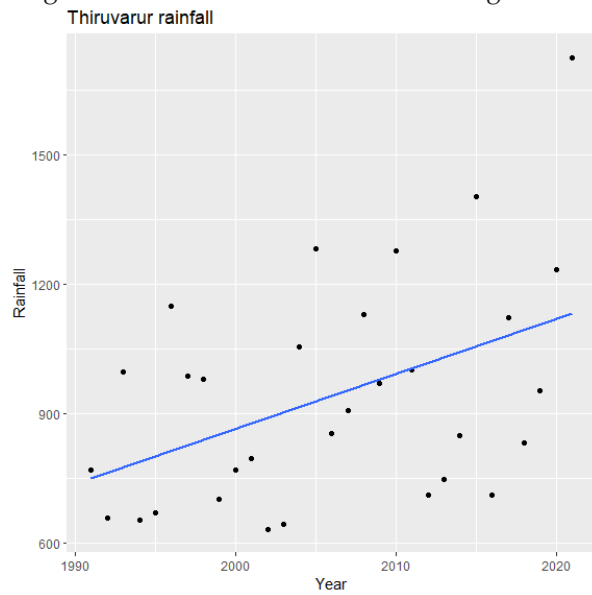


Fig. 1. Trend of the original observation of annual rainfall

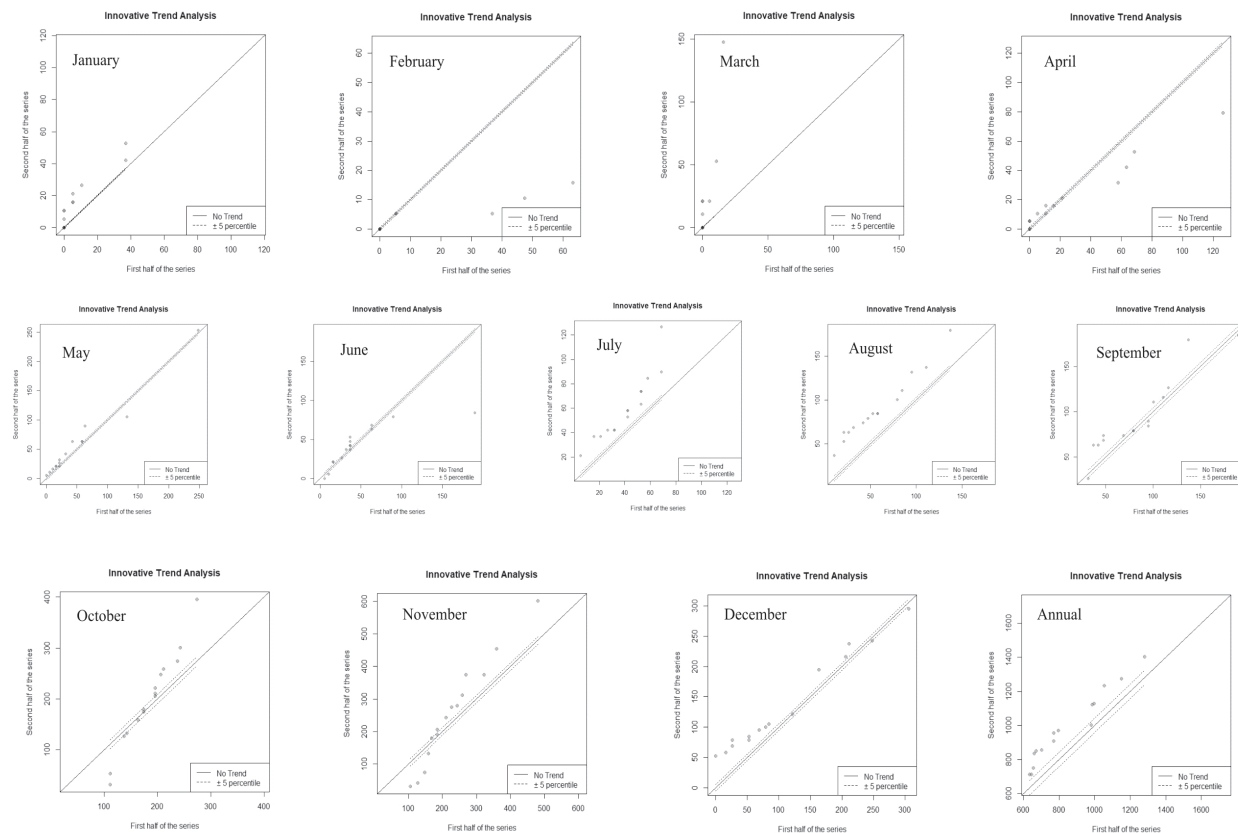


Fig. 2. Monthly Innovative trend analysis of rainfall, 1991-21

**Table 2.** Effect of hydro-climatological variables on crop yield of paddy in Tiruvarur district

S. No	Particulars	Coefficients	Standard error
1	Intercept	-3.833	160.48
2	Rainfall ( $X_1$ )	0.050*	0.026
3	Rainfall squared ( $X_2$ )	0.017**	0.007
4	Temperature ( $X_3$ )	-0.105	5.544
5	Temperature squared ( $X_4$ )	-0.001	0.005
6	Mettur reservoir outflow ( $X_5$ )	0.003***	0.001
7	Rainfall x Temperature ( $X_6$ )	-0.048***	0.014

Note - \*\*\*, \*\* and \* refers to significance at 1 %, 5 % and 10 % levels respectively.

## Conclusion

The trend analysis of climatological factors is one among the issues in climate change. The climatological, meteorological, and hydrological factors are well connected and are pronounced in the trend phenomenon. The findings of the study through Mann-Kendall and innovative trend test clearly shows that there exists a trend in the selected variables. The effect of those variables on agricultural productivity has given implications and a priori knowledge to the future researchers.

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## References

- Ahmed, A., Deb, D. and Mondal, S. 2019. Assessment of rainfall variability and its impact on groundnut yield in Bundelkhand region of India. *Current Science*. 117(5): 794-803.
- Gadedjisso-Tossou, A., Adjegan, K.I. and Kablan, A.K.M. 2021. Rainfall and temperature trend analysis by Mann-Kendall test and significance for Rainfed Cereal Yields in Northern Togo. *Sci*. 3(1): 17.
- Technical summary on Sixth assessment report of Intergovernmental Panel on Climate Change, 2022. <https://www.ipcc.ch/report/art/wg2/downloads/report/>
- Kendall, M. 1975. *Rank Correlation Methods*. Griffin, London, 202 pp.
- Kisi, O., Santos, C. A.G., da Silva, R. M. and Zounemat-Kermani, M. 2018. Trend analysis of monthly streamflows using a new innovative trend method. *Geofizika*. 35(1): 53-68.
- Lobell, D.B. and Field, C.B. 2017. Global scale climate-crop yield relationships and the impacts of recent warming. *Environ. Res. Lett.* 2: 1-7
- Mallick, J., Talukdar, S., Alsubih, M., Salam, R., Ahmed, M., Kahla, N.B. and Shamimuzzaman, M. 2021. Analysing the trend of rainfall in Asir region of Saudi Arabia using the family of Mann-Kendall tests, innovative trend analysis, and detrended fluctuation analysis. *Theoretical and Applied Climatology*. 143: 823-841.
- Mann, H.B. 1945. Nonparametric Tests Against Trend. *Econometrica*. 13(3): 245-259.
- Phuong, D.N.D., Huyen, N.T., Liem, N.D., Hong, N.T., Cuong, D.K. and Loi, N.K. 2022. On the use of an innovative trend analysis methodology for temporal trend identification in extreme rainfall indices over the Central Highlands, Vietnam. *Theoretical and Applied Climatology*. 1-18.
- Rajavel, M., Kumar, M.S., Bhuvaneshwari, K., Vakeswaran, V., Kumar, S.M., Sathyamoorthy, N. K. and Priyanka, S. 2022. Projected Changes in Climate Over Cauvery Delta Zone of Tamil Nadu in Southern India. *International Journal of Environment and Climate Change*. 12(10): 1287-1294.
- Sen, P.K. 1968. Estimates of the Regression Coefficient Based on Kendall's Tau. *Journal of the American statistical Association*. 63(324): 1379. <https://doi.org/10.2307/2285891>
- Sen, Z. 2011. Innovative Trend Analysis Methodology. *J Hydrol Eng*. 17:1042-1046. [https://ascelibrary.org/doi/full/10.1061/\(ASCE\)HE.1943-5584.0000556](https://ascelibrary.org/doi/full/10.1061/(ASCE)HE.1943-5584.0000556)
- Yildirim, G. And Rahman, A. 2022. Homogeneity and trend analysis of rainfall and droughts over Southeast Australia. *Natural Hazards*. 112(2): 1657-1683
- Yue, S. and Wang, C.Y. 2004. The Mann-Kendall test modified by effective sample size to detect trend in serially correlated hydrological series. *Water Resources Management*. 18(3): 201-218. <https://doi.org/10.1023/B:WARM.0000043140.61082.60>