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Short Communication

Rainfall variability analysis and trend assessment in Theni district of Tamil Nadu, India: An implication for crop planning

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Rice is the staple food of India and is grown on 2.2 M ha in Tamilnadu. The biggest limiting factor that impacts crop productivity is rainfall (Agrawal and Singh, 2012). The onset, distribution, and cessation of rainfall vary throughout the year which is affecting the agricultural operations (Pradhan *et al.,* 2020). To achieve maximum agricultural productivity and minimizing the risk, it is critical to quantify rainfall variability at local levels. Trend analysis of rainfall is important to study the impact of climate change on water resources planning and management. Rainfall trend analysis studies have been carried out by many researchers worldwide and also in India (Gao *et al.,* 2019). Trend analysis in the Sabarmathi basin showed statistically significant decreasing trends for annual, winter, pre-monsoon and monsoon rainfall (Kale *et al.,* 2022). In this paper, an attempt has been made to analyze the rainfall variability and trend analyses were done by using different methods to identify the trend in rainfall data on a seasonal and annual basis to suggest crop planning in this region.

The daily rainfall data of Theni district comprising of 10 raingauge stations for 40 years (1982-2021) had been collected from PWD, Vaigai dam, Periyar Vaigai Basin Division, Theni. The annual and seasonal data was used to analyse the variability of rainfall which helps to understand the rainfall behaviour of a particular location with respect to agriculture. The coefficient of variation (CV) is expressed as percentage and is used to determine the dependability of rainfall reported by Veeraputhiran *et al.,* (2003). The trend analyses were done by a) using the Mann-Kendall test for trend significance (Kale, 2020) b) using Sen's slope estimator for trend magnitude estimation (Sen, 1968) c) using innovative trend analysis for aiding the results of trend analyses (Kale, 2020) d) using the Sequential Mann-Kendall test for start and end of trend detection (Kale, 2018) and e) also using linear regression method to identify the trend in rainfall data (Kaur and Kaur, 2019). Rainy day is receiving more than 2.5mm of rainfall in a day is used for calculation.

The mean annual rainfall of Theni district was 1100.2 mm with the highest and lowest values of 1990.3 mm and 215.1 mm which was spread over 90 rainy days with a standard deviation of 436 mm and coefficient of variation as 39.6 per cent. The annual rainfall analysis indicated that the rainfall was considered to be not dependable because of the higher CV than the threshold level (level 25%). The trend analysis reflects that the annual rainfall over the past 40 years had been in a decreasing trend ($y = -1.6808x + 34.459$) as the annual rainfall was decreasing as 1.7 mm per year. The annual rainfall deviation from the long period average showed that 19 years received an excess amount of rainfall, 2 years received an above normal amount of rainfall, 3 years received a normal amount of rainfall, 16 years received an deficit amount of rainfall and there was no below normal rainfall (Fig. 1). The seasonal rainfall analysis of this region in terms of winter (January- February), summer (March- May), southwest monsoon (June – September) and northeast monsoon (October – December) showed that mean rainfall of winter, summer, SWM and NEM were 28 mm, 212.3 mm, 466 mm and 393.9 mm respectively, with winter (88.3%) and SWM (59.5%) had higher CV than the threshold level of 50 per cent and the rainfall was much dependable in summer as 36 per cent and northeast monsoon (NEM) as 48.4 per cent (Table 1). Most of the rainfall received during southwest monsoon period was highly used to grow samba rice crop and sugarcane in this region. The farmers in this region are mostly taking sowing of paddy crop during June month which coincides with onset of SWM.

The trend analysis for annual rainfall over Theni district

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Table 1: Variation in Annual and Seasonal rainfall with rainy days in Theni district

Season	Mean rainfall (mm)	Standard deviation	Coefficient of variation (%)	Maximum (mm)	Minimum (mm)	Rainy days
Winter	28.0	24.7	88.3	106.7	0.3	3
Summer	212.3	76.4	36.0	407.9	101.4	22
SWM	466.0	277.4	59.5	1081.7	0.0	38
NEM	393.9	190.7	48.4	767.6	0.0	27
Annual	1100.2	436.0	39.6	1990.3	215.1	90

Table 2: SS, MK and ITA test results for annual and seasonal rainfall trend analysis in Theni district

Variables	SS test	MK test (z value)	ITA
Annual	-14.6	-2.854*	M (-)ve
Winter	-0.33	-1.433	M (-)ve
Summer	-0.50	-0.757	NM (+)ve
SWM	-11.6	-2.738*	M (-)ve
NEM	-3.5	-1.305	NM (+)ve

* Trend at 5 % Significance level; NM = Non monotonous, M = Monotonous

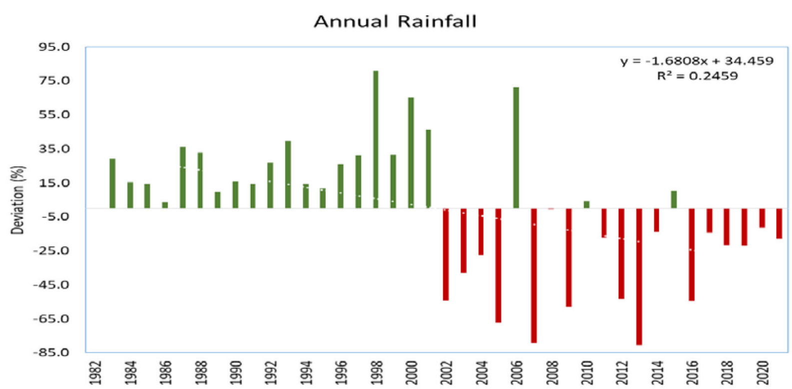

Fig. 1. Deviation in annual rainfall in Theni district (1982-2021)

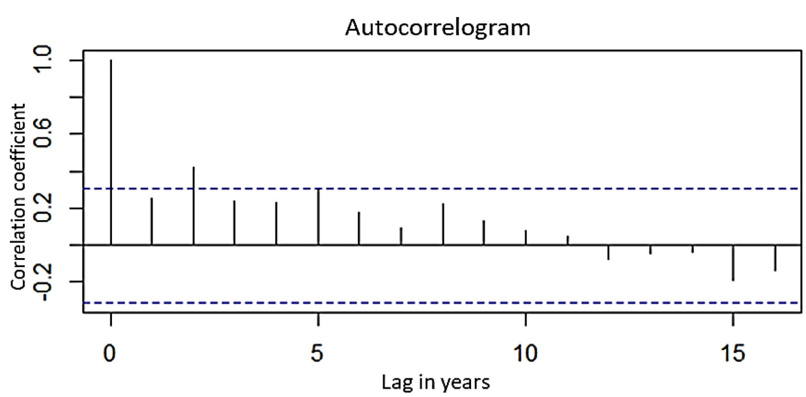

Fig.2: Correlogram of annual rainfall time series

using linear regression analysis in which the rate of change is defined by the slope of the regression line, was about -18.5 mm/year with decreasing trend with statistical significance at 5 per cent. The innovative trend analysis for annual rainfall showed a monotonous decreasing trend (Fig. 3), with negative magnitude of 14.6 mm/ year of rainfall estimated from the Sen's Slope test (Table 2). Correlogram (Fig. 2) shows that, annual rainfall time series data is independent, therefore MK test is applied to the corresponding time series. The results from the Mann-Kendall showed a significant negative trend (p-value = 0.004) in annual rainfall over Theni district for 40 years (1982-2021) and Sequential Mann-Kendall analysis resulted that the trend begins during 2005 and ends during 2007 for annual rainfall (Fig. 4).

Table 3: SQMK and linear regression test results for annual and seasonal rainfall trend analysis in Theni district

Variables	Linear equation	R^2	SQMK Test
			Trend begins and ends
Annual	y = -18.493x + 1479.3	0.246	2005-2007
Winter	y = -0.6239x + 40.79	0.087	2010-11, 2014- still
Summer	y = -0.2777x + 217.99	0.002	1983-84, 2004-05, 2007-09, 2018-19
SWM	y = -13.679x + 746.43	0.332	2001- still
NEM	y = -3.9117x + 474.11	0.056	1985-86, 2004-05, 2016- still

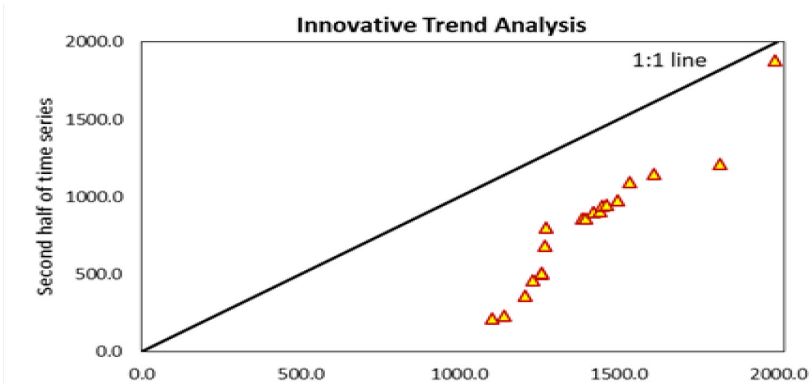

Fig. 3: ITA plot for annual rainfall time series

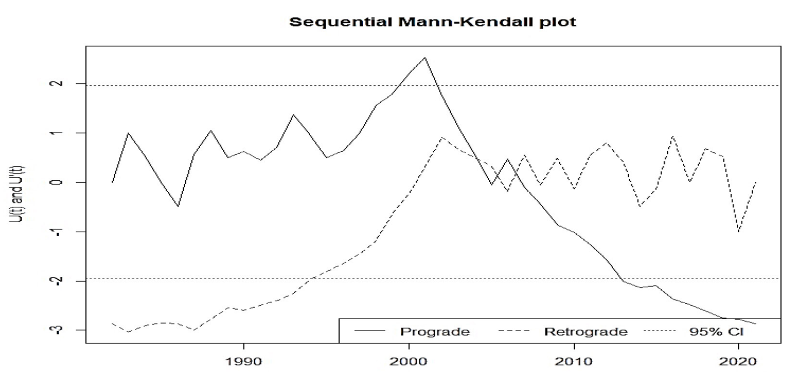

Fig. 4: SQMK test for annual rainfall time series with Prograde U(t) and Retrograde U'(t)

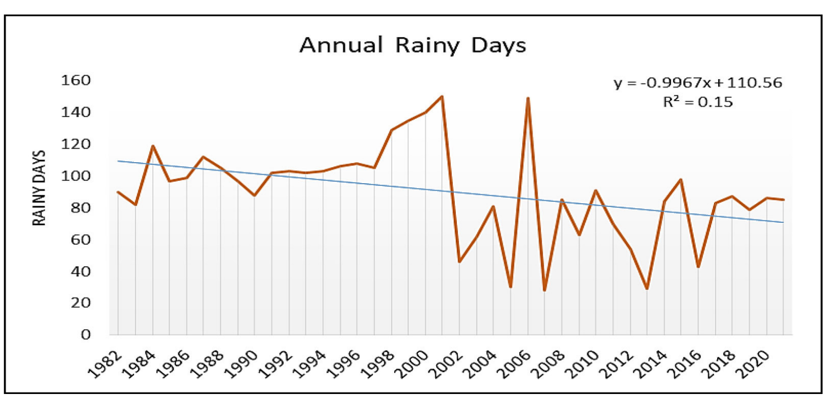

Fig. 5: Mean annual rainy day in Theni district

The seasonal trend analyses resulted that the linear regression analysis showed a decreasing trend in all seasons which was supported by Sen's slope analysis. ITA test resulted that a monotonous decreasing trend was observed in winter and SWM, but in summer and NEM there was an increasing non-monotonous trend. However, there was no significant trend observed through the Mann-Kendall test for winter, summer and NEM seasons but SWM showed a significant decreasing trend (p-value = 0.006) and SQMK test resulted with more significant variability in the beginning and ending of trend in seasonal rainfall (Table 3).

The mean annual rainy day for Theni district from 1982-2021 was 90 days with a maximum of 150 rainy days received during the year 2001 and a minimum of 28 days received during 2007. The trend analysis showed that there was a decreasing trend in annual mean rainy days with a linear equation of $Y= -0.9967X + 110.6$ with the R^2 value of 0.15 (Fig. 5). The seasonal rainy days analysis showed that southwest monsoon is predominant with 38 mean rainy days in this region followed by northeast monsoon with 27 rainy days (Table 1).

Rice is the predominant single crop grown by farmers in this region. On the other hand, some farmers grow sugarcane and banana as a wetland crop, which is highly water demanding should be replaced by low water requiring crops like maize, pearl millet, sorghum, pulses, ragi, other minor millets and vegetable crops like onion, chilli, tomato. Sowing of maize, cowpea, groundnut and black gram during second fortnight of June can utilize the monsoon rain (Bhargava *et al.,* 2010). In order to mitigate the monsoon anomalous, the existing cropping pattern should be modified. Altering the double crop of rice to single crop area and soon after the harvest of rice crop, farmers can grow green gram, blackgram, horsegram, cowpea, maize and minor millets such as finger millet, foxtail millet, proso millet and others are drought resistant and may be grown with little soil moisture suitable for weather prevailed in this region.

Intercropping/mixed cropping of maize with cowpea/ green gram/ black gram should be followed in this region. For enhanced germination and optimum plant stand, pruning and thinning of overage paddy seedlings may be beneficial. In order to boost the productivity of the land and attain sustainability, growing green manures would benefit from the rainfall that was obtained throughout the summer. Hence, there should be a change in cropping pattern/cropping system including the variety.

The major cropping period in this region is observed from June to November for single crop and June to February for double crop of rice which is coincides with the southwest and northeast monsoon period. From the analysis, farmers can grow short duration crops like pulses, sorghum, maize and millets during summer which can produce good amount of yield using less water and can withstand drought conditions. Also farmers can grow vegetable and flower crops which can best suitable for the weather prevailing in Theni district. As a result, in the face of significant climate variability, crops like maize, pulses and millets production and consumption need to be encouraged.

Conflict of Interest Statement: The author (s) declares (s) that there is no conflict of interest.

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