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Trend analysis of rainfall and frequency of rainy days over Coimbatore

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सार – प्रत्येक देश के आर्थिक विकास, आपदा प्रबंधन और जल संबंधी योजना के लिए वर्षा बहुत महत्वपूर्ण है। जलवायु परिवर्तन के संदर्भ में यह पता लगाना उचित है कि क्या भारतीय वर्षा की विशेषता में भी बदलाव आ रहा है। 1907-2012 की अवधि में दैनिक वर्षा के आँकड़ों के उपयोग से वर्षा में परिवर्तन और वर्षा आवृति की तीव्रता का पता लगाने के लिए विश्लेषण किए गए और परिणाम से यह पता चला कि वार्षिक वर्षा भरोसेमंद नहीं है। कुल वर्षा में उत्तर पूर्वी मॉनसून (N E M) और दक्षिण-पश्चिम मॉनसून (S W M) का योगदान क्रमश: 50.3 प्रतिशत और 26.3 प्रतिशत है। अवधि के हर 30 साल के दौरान उत्तर पूर्वी मॉनसून (N E M) का योगदान लगातार बढ़ा और इस वृद्धि की सांख्यिकीय महत्ता का विश्वसनीयता स्तर 95 प्रतिशत रहा। अध्ययन की अवधि के दौरान वर्षा (बहुत हल्की वर्षा, हल्की वर्षा, मध्यम वर्षा, कुछ भारी वर्षा, भारी वर्षा, बहुत भारी वर्षा के कुल 80.2 दिन रहे जिसमें से बहुत हल्की वर्षा 35.0 दिन) के दिनों की आवृति, हल्की वर्षा (20.7) के दिन और मध्यम वर्षा (20.8 दिन) के दिनों की तुलना में अधिक रही। वर्षा की बढ़ती तथा घटती प्रवृत्ति का पता लगाने के लिए वर्षा की सभी श्रेणियों का प्रवृत्ति विश्लेषण किया गया। वर्षा के दिनों की कुल संख्या उत्तर पूर्वी मॉनसून (N E M) (जहां वर्षा के दिन अधिक रहते हैं) को छोड़कर और सभी मौसमों में कम होती गई, लेकिन यह परिवर्तन सांख्यिकीय रूप से महत्वपूर्ण नहीं है। परिणाम बताते हैं कि लम्बे समय में मासिक, मौसमी, वार्षिक वर्षा और वर्षा के दिनों की आवृत्ति में कोई परिवर्तन नहीं हुआ। इसलिए, यह निष्कर्ष निकाला जा सकता है कि कोयंबटूर में कोई जलवायु परिवर्तन नहीं पाया गया है।

ABSTRACT. Rainfall is very crucial for the economic development, disaster management, hydrological planning for the country. In the context of climate change, it is pertinent to ascertain whether the characteristic of Indian rainfall is also changing. Using daily rainfall data for the period of 1907-2012 analysis were carried out, to find out the change in rainfall and frequency of rainfall intensity. Results indicated that the annual rainfall is not dependable. Contribution of NEM to the total rainfall is 50.3 percent which was followed by SWM (26.3%). Contribution of NEM during every 30 years of periods was constantly increasing and the increasing trend was statistically significant at 95% confidence level. Total number of rainy days (very light, light, moderate, rather heavy, heavy, very heavy rainy days) during the study period was 80.2 days, in which the frequency of very light rainy days (35.0 days) was highest followed by light (20.7 days) and moderate rainy days (20.8 days). Trend analysis was done for all categories of rainfall to find out the presence of increasing or decreasing trend. Total number of rainy days slightly gets decreasing in all the seasons except NEM where the rainy days are increasing but the changes were not statistically significant. The results showed that there is no change in long term of monthly, seasonal, annual rainfall and frequency of rainy days. Hence, it can be concluded that there is no climate change observed over Coimbatore.

Key words – Co-efficient of variation, Rainfall trends, Rainfall intensity, Rainy days, Rainfall analysis.

1. Introduction

Coimbatore is situated in the Western zone of Tamil Nadu state at 11° N latitude and 77° E longitude and is at an elevation of 427 m above the mean sea level. The region receives 665.5 mm of annual rainfall with 45 rainy days. It is generally a dry district apart from the Noyyal river basin and occasional over - flowing streams from the Western Ghats, which terminate in the city's large tanks. Agriculture in this region is highly sensitive to variability of rainfall across time and space. The recent drought years of 2002, 2004, 2009, 2012 resulted in low agricultural production and affected rural poor farmers with serious degradation of the environment. Agriculture and related sectors, food security, and energy security of India are crucially dependent on the timely availability of adequate amount of water and a conducive climate. The rainfall received in an area is an important factor in determining the amount of water available to meet various demands, such as agricultural, industrial, domestic water supply and for hydroelectric power generation.

Rakhecha and Soman (1994) reported that 'the extreme rainfall series at stations over the southern

TABLE 1

Contribution of seasonal rainfall during different periods

Period	Winter	% of share	Summer	% of share	SWM	% of share	NEM	% of share	Total
1923-52	21.3	3.5	134.7	21.9	162.9	26.4	297.3	48.2	616.2
1953-82	10.9	1.6	139.5	21.0	185.3	27.9	329.6	49.5	665.3
1983-2012	23.1	3.2	138.8	19.5	179.6	25.2	371.1	52.1	712.5
1907-12	21.7	3.3	133.6	20.3	174.7	26.5	328.8	49.9	665.5
CV (%) (1907-12)	148.7	-	46.3	-	46.7	-	43.0	-	28.8

Peninsula and over the lower Ganga valley showed a decreasing trend at 95% level of confidence. Some past studies related to changes in rainfall over India have concluded that there is no clear trend in average annual rainfall over the country (Thapliyal and Kulshreshtha, 1991; Kumar *et al*., 2010). Parthasarathy and Dhar (1974) found that the annual rainfall for the period 1901–1960 had a positive trend over Central India and the adjoining parts of the peninsula. A stable northeast monsoon rainfall was found over Tamil Nadu by Dhar *et al*. (1982). Analysis of rainfall amount during different seasons indicated decreasing tendency in the summer monsoon rainfall over the Indian land mass and increasing trend in the rainfall during pre monsoon and post-monsoon months (Dash *et al*., 2007).

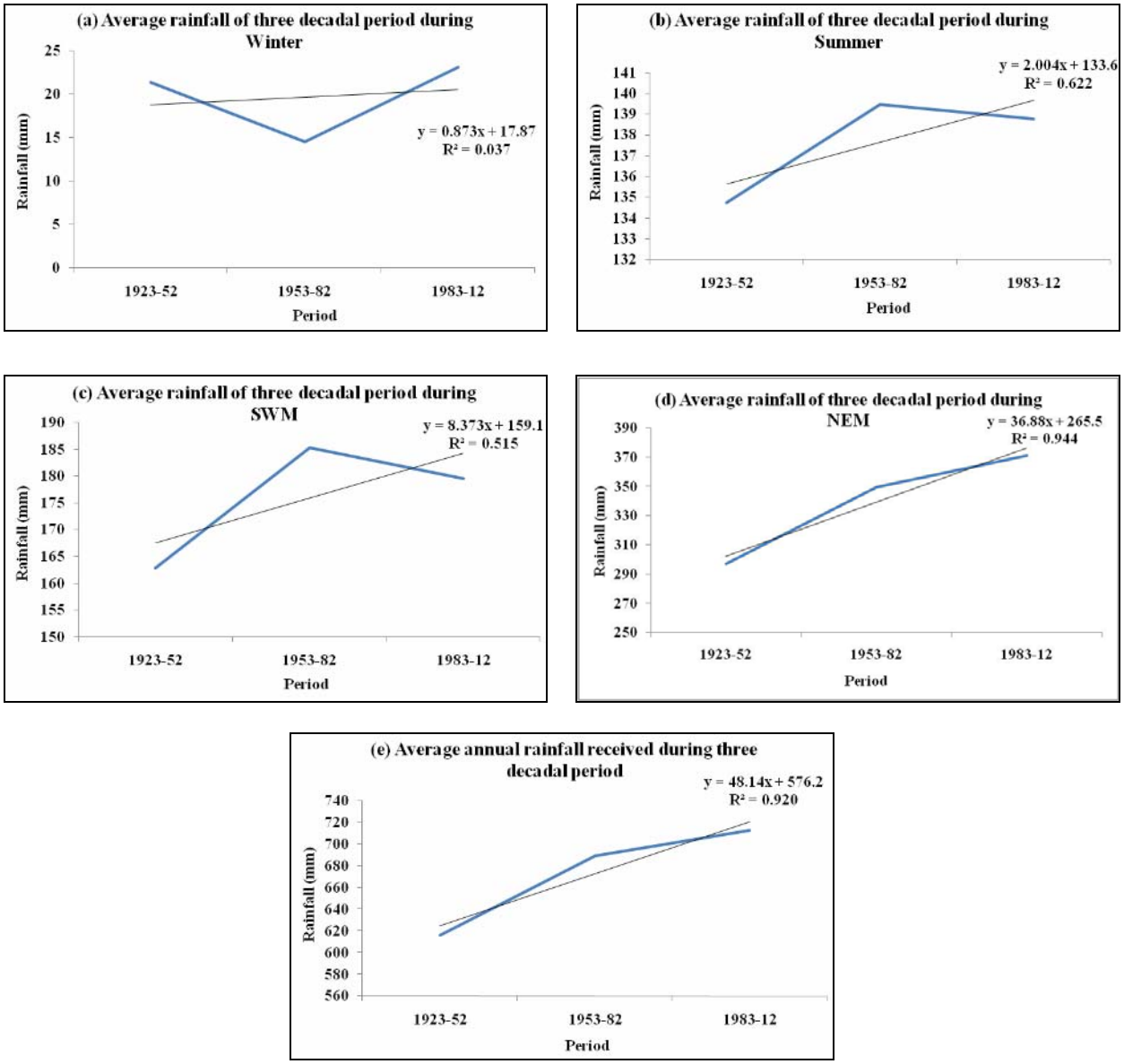
According to Goswami *et al*., (2006) the frequency of more intense rainfall events in many parts of Asia has increased whereas the number of rainy days and total annual precipitation has decreased. Variability and long-term trends of extreme rainfall events over central India were examined by Rajeevan *et al*. (2008) using 104 years (1901–2004) of high-resolution daily gridded rainfall data. They found statistically significant long-term trend of 6% per decade in the frequency of extreme rainfall events. According to them, the increasing trend of extreme rainfall events in the last five decades could be associated with the increasing trend of sea surface temperatures and surface latent heat flux over the tropical Indian Ocean. Analysis of daily gridded observed rainfall data for the period 1951–2003, indicated that there are decreasing trends in both early and late monsoon rainfall and number of rainy days, implying a shorter monsoon over India. Similarly, there is a sharp decrease in the area that receives a certain amount of rainfall and number of rainy days during the season (Ramesh and Goswami, 2007).

Changes in climate over the Indian region, particularly the SW monsoon, would have a significant impact on agricultural production, water resources management and overall economy of the country. In view of the above, an attempt was made to study the trends in rainfall and rainy days. The trend analysis of rainfall on different temporal scales will also help in the construction of future climate scenarios.

2. Data and methodology

The daily rainfall data for the period of 106 years (1907-2012) has been collected from Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore. The data are quality checked and the time series of monthly and seasonal rainfall over different periods are prepared from the daily rainfall. Based on the India Meteorological Department (IMD), intensity of rainfall was categorized into very light rain (0.1-2.4 mm), light rain (2.5-7.5 mm), moderate rain (7.6-35.5 mm), rather heavy (35.6-64.4 mm), heavy (64.5-124.4 mm) and very heavy (124.5-244.4 mm). Number of days was counted on different category for each month and season. Different statistical characteristics like mean and coefficients of variation (CV) of rainfall and rainy days of different intensity were calculated for different months, seasons and year as a whole. To study the rainfall trend the data were analyzed for decadal and 30 years average to understand the climate variability or climate change, if any.

Trend analysis of a time series consists of the magnitude of trend and its statistical significance. Obviously, different workers have used different methodologies for trend detection. Kundzewicz (2004) has discussed the change detection methodologies for hydrologic data. The magnitude of trend in a time series is determined by regression analysis (parametric test). This method assumes a linear trend in the time series. Regression analysis is conducted with time as the independent variable and rainfall as the dependent variable. A linear equation, $y = mx + b$, defined by b (the intercept) and trend m (the slope), can be fitted by

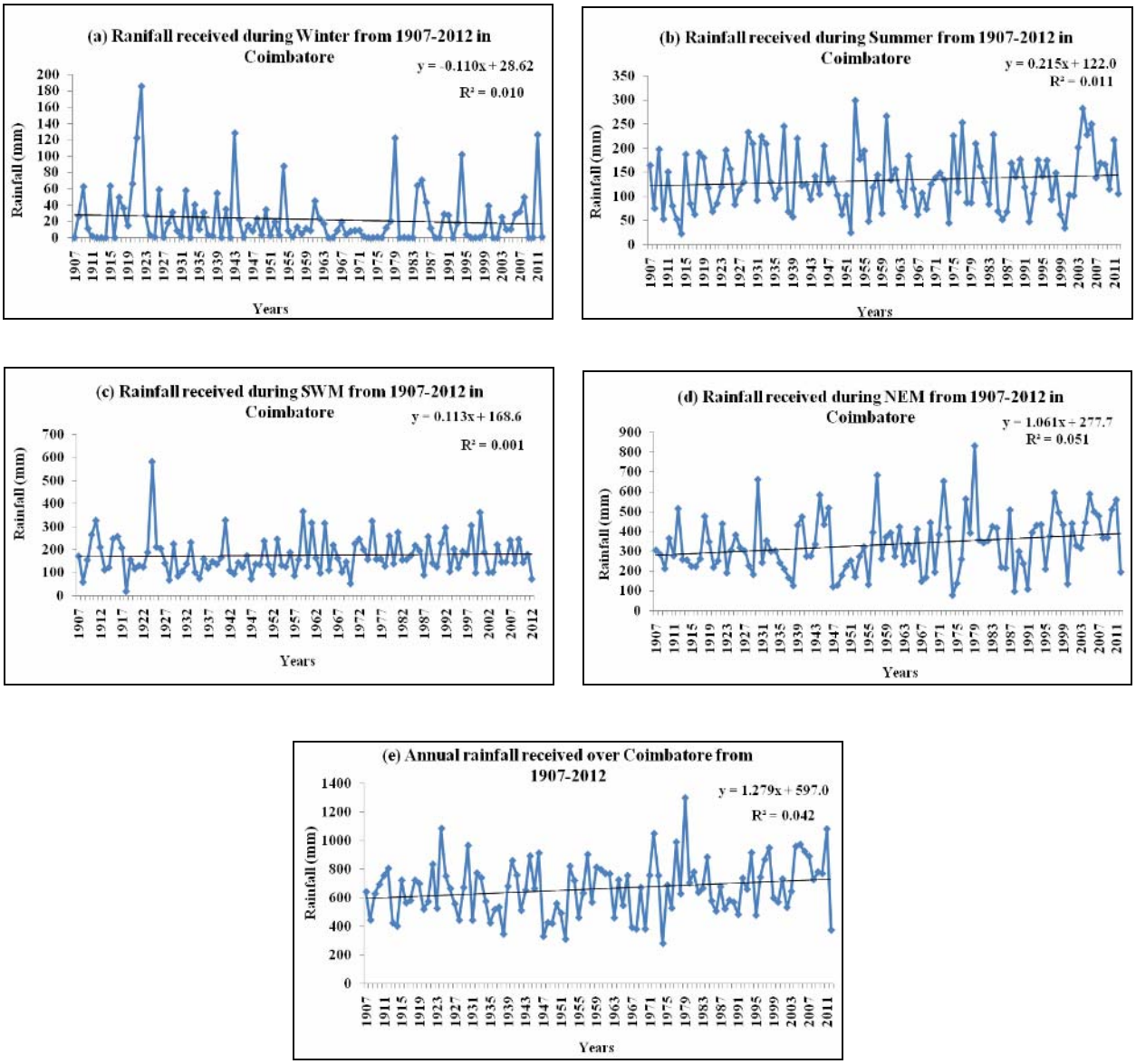


Figs. 1. (a-e). Average rainfall of three decadal periods at Coimbatore (a) Winter season (b) Summer season (c) SW monsoon season (d) NE monsoon season and (e) Annual average rainfall

regression. The linear trend value represented by the slope of the simple least-square regression line provided the rate of rise/fall in the variable.

3. Results and discussion

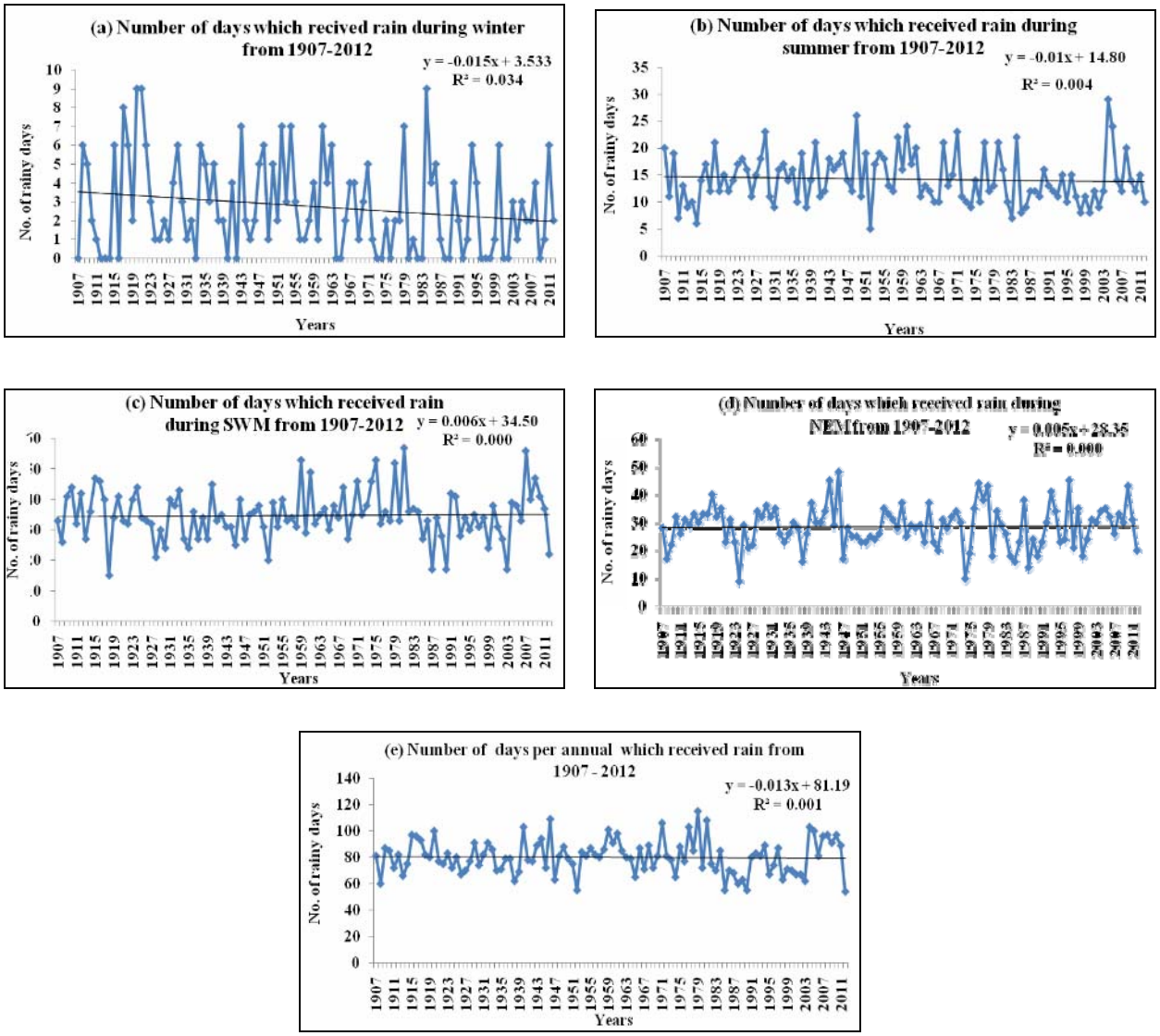
The mean annual rainfall was 665.5 mm with CV of 28.8 per cent. It showed that the annual rainfall is not dependable (dependable < 25 per cent). In seasons, the NEM has topped with the rainfall of 334.5 mm contributing 50.3 per cent in the annual total. It was followed by SWM with 174.7 mm contributing 26.3 per cent, respectively (Table 1). The contribution of summer and winter is 20.1 and 3.4 per cent, respectively. The CV for NEM, SWM, summer and winter is 43, 46.7, 46.3 and 148.7, respectively, indicating that, except winter all other seasonal rainfall are dependable. The lowest rainfall (373.7mm) was recorded in 2012 during the study period, where as the highest amount (1299.8 mm) was recorded during 1979. The lowest rainfall recorded during 2012 can be attributed to the collective failure of SWM and NEM.



Figs. 2(a-e). Rainfall received in Coimbatore from 1907-2012 (a) Winter season (b) Summer season (c) SW monsoon season (d) NE monsoon season and (e) Annual

The results indicated that, the contribution NEM during different 30 years periods was constantly increasing (Fig. 1). During 1923-52, the rainfall was 297.3 mm with 48.2 per cent contribution to the total. But the same has increased to 371.1 mm during 1983-2012 period with the contribution of 52.1 per cent. This increasing trend was statistically significant at 95% confidence level. The increasing trend was noticed during SWM and summer also. But, no significant increasing or decreasing trend was noticed in rainfall for the whole study period, *i.e.*, 1907-2012 (Fig. 2). Long term monthly rainfall analysis for the study period showed that there are both increasing (February, March, April, August, September, October and November) and decreasing (January, May, June, July and December) trends but none of them are statistically significant.

Total number of rainy days (very light, light, moderate, rather heavy, heavy, very heavy rainy days) during the study period was 80.2 days, in which the frequency of very light rainy days (0.1-2.4 mm) was highest followed by light (20.7 days) and moderate rainy days (20.8 days). Season wise analysis indicated that the very light rainy day during SWM was more (18.8 days)



Figs. 3(a-e). Number of days which received rain at Coimbatore from 1907-2012 during (a) Winter season (b) Summer season (c) SW monsoon season (d) NE monsoon season and (e) Annual

compared to other seasons. Light rainy days contribution was more (9.4 days) during SWM which was followed by NEM (6.8 days) and summer (4.0 days). Frequency of moderate rainy days received during NEM was higher (9.6 days) which was followed by SWM (6.0 days) and summer (4.5 days). Total number of days which received rather heavy rainfall (35.6-64.4 mm) was very less during all the seasons. Heavy and very heavy rainfall days were almost absent during all the seasons during the study period except one or two instances during NEM (Table 2). Trend analysis was done for all categories of rainfall to find out the presence of increasing or decreasing trend. Total number of days which received rainfall is slightly decreasing in all the seasons except NEM where the rainy days are increasing but the changes were not statistically significant (Fig. 3).

In trend analysis studies, the results significantly depend upon the period of data and the stations whose data are used. The results showed that there is no change in long term monthly, seasonal and annual rainfall and frequency of rainy days. In the context of climate change, it is pertinent to ascertain whether the characteristic of rainfall is also changing. The linear regression test results show that there is no significant trend in the annual and seasonal rainfall totals.

TABLE 2

Frequency of different amount of rainy days during different seasons from 1907 -2012

Period	Very light rain (0.1 - 2.4mm)	Light rain (2.5 -7.5mm)	Moderate rain (7.6 - 35.5mm)	Rather heavy rain (35.6 - 64.4mm)	Heavy rain (64.5 - 124.4mm)	Very heavy rain (124.5 - 244.4mm)	Total
SWM	18.8	9.4	6.0	0.5	0.0	0.0	34.7
NEM	9.8	6.8	9.6	1.9	0.5	0.0	28.6
Summer	5.1	4.0	4.5	0.6	0.1	0.0	14.3
Winter	1.3	0.5	0.7	0.1	0.0	0.0	2.6
Total	35.0	20.7	20.8	3.1	0.6	0.0	80.2

Finally, while interpreting the results of trend analysis, the observations of Timothy *et al*. (2005) are worth repeating: 'that reported trends are real yet insignificant indicates a worrisome possibility: natural climatic excursions may be much larger than we imagine. So large, perhaps, that they render insignificant changes, human-induced or otherwise, observed during the past century'.

4. Conclusion

The rainfall data analysis of Coimbatore for a period of 106 years (1907-2012) concludes that no climate change was observed. In contrast, climate variability is noticed in NEM, SWM and summer rainfall, if three decadal periods are considered for the study. An increasing trend was noticed in all the seasonal (except winter) and annual rainfall at 95 per cent significant level. There was no significant trend noticed in weekly and monthly rainfall.

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