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Rainfall Trend Analysis of Anakapalle District of North Coastal Andhra Pradesh

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ABSTRACT: Climate change has become one of the most significant challenges for sustainable development. A thorough understanding of the patterns of rainfall in this dynamic environment will aid in making better decisions and strengthening communities' capacity to withstand extreme weather occurrences. Accurately predicting precipitation trends is crucial in a country's future economic development. Therefore, analysis of trends at the local and regional levels is far more pertinent for specific development and adaptation plans to mitigate the effects of climate change. In this study annual as well as seasonal rainfall trend of Anakapalle district was analysed for the period 1952-2020. Rainfall at RARS, Anakapalle from 1952-2020 exhibited an ascending trend as the value of Mann- Kendall's test and the magnitude of Sen's slope estimator were both positive and were found to be 0.007 and 0.245, respectively. The findings revealed an upward tendency for the months of February, March, April, May, August, and September, and a downward trend for the months of January, June, July, October, and December. The rainfall trend during the monsoon period (South West and North East monsoon period) showed decreasing trend while the pre monsoon period exhibited a positive trend. Overall Rainfall trends indicate that distinct climate change has occurred during the last 69 years.

Keywords: Mann-Kendall test, Monsoon period, Rainfall, Sen's Slope factor, Trend analysis.

INTRODUCTION

Rainfall is a crucial weather element that indicates climate change and shifts in rainfall patterns affect many sectors of a country such as Agriculture, economy and disaster management (Fang *et al.*, 2019; Alam *et al*., 2021). For a developing country, like India, which is an agricultural and agrarian country the uncertainty and non-uniformity associated with rainfall characteristics could result in a severe reduction in agricultural production and could adversely affect water resources planning and management. Being an Agrarian community, the country is mostly dependent upon rain-fed agricultural production. Hence, analysis of precipitation and temperature patterns has paramount importance to cope with the impact on the yield of many crops. The changing rainfall patterns and its impact on water resources is an important climatic problem today. Small and marginal farmers are most vulnerable to climate change due to their limited ability to adapt and reliance on rain-fed agriculture which is very sensitive to climate variability (Speranza, 2010; Easterling, 2011; Asfaw *et al.,* 2018). Rainfall trends and variability are the important factors in explaining various socioeconomic problems such as food insecurity (Cheung *et al*., 2008; Rainfall probability analysis allows us to manage the risks in Agriculture due to climate faced during the season (Kumar *et al*., 2015; Aswad *et al*., 2020). Khan *et al*. (2000); Shrestha *et al*. (2000); Mirza (2002) found that the frequency of intense rainfall has increased in many parts of Asia, but the number of rainy days and total annual rainfall has decreased. After analyzing data for a longer period of time in Wollo and Tigray, Conway (2000) concluded the absence of evidence for a long-term trend or change in the annual rainfall except a slight increase in *Belg* (short rainy season) rainfall (from 1980s up to 1996) and a very slight decrease in *kiremt* rainfall (long rainy season) up to the mid 1980s at Kombolcha.

Phuong *et al.* (2018) demonstrated upward trends in the annual and seasonal rainfall over the time of thirty-seven years. Singh *et al*. (2008) found an increasing trend in annual rainfall in the range of 2–19 % of the mean per 100 years. Cui *et al*. (2017) found that the seasonal precipitation significantly decreased while annual precipitation significantly increased. Parthasarathy (1984) found that the monsoon rainfall for the two subdivisions, *viz.*, Sub-Himalayan West Bengal and Sikkim and the Bihar Plains was in decreasing trend while for the four subdivisions *viz.* Punjab, Konkan and Goa, West Madhya Pradesh and Telengana is in increasing trends. Analysis of rainfall data for the period 1871 to 2002 indicated a decreasing trend in monsoon rainfall and increasing trend in the pre-monsoon and post-monsoon seasons (Dash *et al.*, 2007). Mirza *et al*. (1998) carried out trend and persistence analysis for the Ganges, Brahmaputra and Meghna river basins. The results showed that precipitation in the Ganges basin was stable.

Kalnay and Cai (2003); Brema (2018) reported that the human intervention by shifting land use from the effects of agriculture and irrigation activities is one of the factors influencing climate change. Kamal *et al*. (2019) concluded that annual, monsoon and winter precipitation in nine states of North Eastern zone of India decreased during 1901-2015. In view of the above the present study was proposed to analyze the monthly, seasonal, and annual rainfall trends in Anakapalle district of North Coastal Andhra Pradesh, to know the rainfall trends which helps in planning of Agricultural operations.

MATERIAL AND METHODS

The main goal of trend analysis is to identify whether an observed estimate of a hydrometeorological time series is trendless, decreased or increased.

The major data utilized for the study is sixty-nine (69) years of monthly rainfall from 1952 to 2020 which was recorded at the Agrometeorological station, Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India.

The non-parametric Mann-Kendall (MK) test (Kendall, 1975 and Mann, 1945) is most commonly used for trends identifying in hydro meteorological data time series. The MK test compares the alternative hypothesis of an increasing or declining trend to the null hypothesis of no trend.

Sen's slope estimator from 1968 is shown to be an effective tool for determining linear relationships. Sen's slope has a benefit over slope of regression, in that it is less affected by large data series errors and outliers. The Sen's estimator has been widely used for determining the magnitude of trend in hydro-meteorological time series.

In the present study, analysis of trend for the monthly and annual rainfall data have been obtained using Sen's slope estimator and Mann – Kendall for Anakapalle district of North Coastal Andhra Pradesh using XLSTAT software.

RESULTS AND DISCUSSION

A. Annual rainfall analysis

The trend analysis of rainfall for a period of 69 years from 1952-2022 revealed that the rainfall varies from 550 mm/year to 1700 mm/year. The average annual rainfall showed that the maximum rainfall existed in 2010 (1763.4 mm), and the minimum rainfall occurred in 1973 (586.2 mm). The annual rainfall is in increasing trend as both the slope estimator of the Sen and the test (Z) values of Kendall were positive and found to be 0.245 and 0.007, respectively. Similar increase in annual rainfall at Kailashahar was reported by Phukan and Saha (2022).

Table 1: Annual trend of rainfall over 69 years (1952-2020).

Years	Mean	Standard Deviation	Sen's slope	Kendall's test statistics (Zc)
1952-2020	1117.654	256.746	0.245	0.007

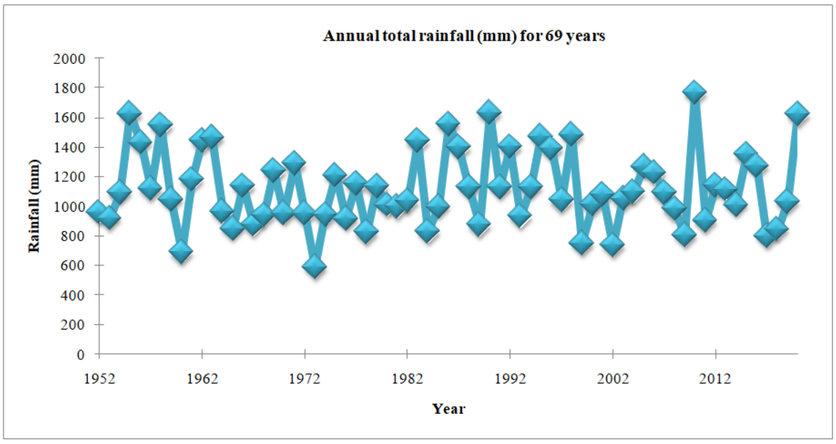

Fig. 1. Annual trend of rainfall over 69 years (1952-2020).

B. Monthly rainfall analysis

In the non-parametric Mann-Kendall test, trend of rainfall for 69 years from January to December has been calculated for each month individually together with the Sen's magnitude of slope (Q) by using XLSTAT software. The magnitude of annual rainfall patterns obtained from the Mann-Kendall test and the slope estimator from Sen are presented in Table 2. Anakapalle district received the highest monthly average rainfall (234.1 mm) in October followed by September (212.7 mm) followed by August (167.9), July (155.1) and June (131.5) months. The lowest annual rainfall of 8.5 mm was recorded in the month of January. There was a positive (increasing) trend for months February (0.033 & 0.0), March (0.017 & 0.0), April (0.115 & 0.149), May (0.043 & 0.156), August (0.037 & 0.221), September (0.011 & 0.099) and November (0.099 & 0.149) as the Kendall's test (Z) values and Sen's slope were both positive, whereas the Kendall's test (Z) and the Sen's slope values indicated a negative trend for January (-0.045 & 0.0), June (-0.023 & -0.125), July (-0.046 & -0.268), October (-0.110 & -1.116) and December (-0.057 & 0.0) months, respectively.

Various studies (Saadi *et al*., 2019; Mondal *et al*., 2012; Kumar *et al*., 2017) indicated similar results of increasing and decreasing rainfall in certain months, but it was inconsistent across all months. Climate change is a global phenomenon that is to be assessed for its impact on a local scale. The rainfall pattern may vary from one location to another location. The different trends in rainfall are influenced by changes in atmospheric circulation (Trenberth, 2011), which is caused by human activities that increase greenhouse gases in the atmosphere (IPCC, 2013) and also the topographical features of that location (Pitman *et al.*, 2012; SyS and Quesada 2020). The effects of crop cover and land use influence weather and climate processes at local, regional, and global scales (Brown, 2014).

Table 2: Monthly trend of rainfall over 69 years (1952-2020).

Months	Mean	Standard Deviation	Sen's slope	Kendall's test statistics (Zc)
January	8.328	14.093	0.000	-0.045
February	12.446	26.912	0.000	0.033
March	19.904	40.169	0.000	0.017
April	30.580	37.141	0.149	0.115
May	81.210	94.150	0.156	0.043
June	129.596	77.156	-0.125	-0.023
July	152.835	75.513	-0.268	-0.046
August	165.496	80.194	0.221	0.037
September	209.606	86.197	0.099	0.011
October	230.670	145.130	-1.116	-0.110
November	68.354	98.585	0.149	0.099
December	8.630	25.280	0.000	-0.057

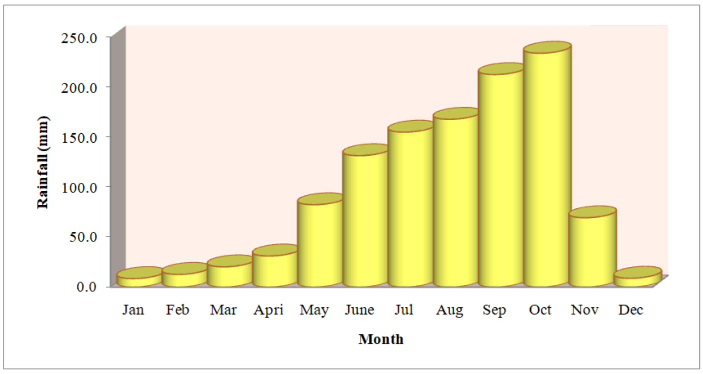

Fig. 2. Monthly mean rainfall over 69 years (1952-2020).

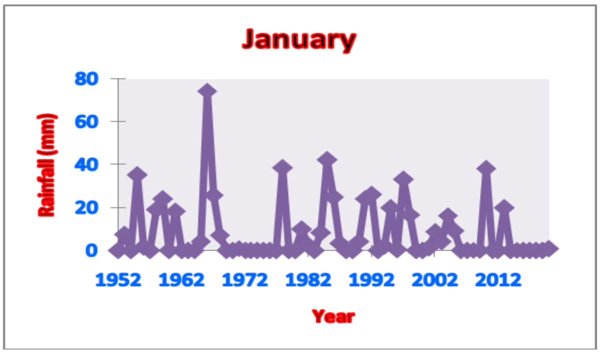

Fig. 3. Rainfall trend for the month of January.

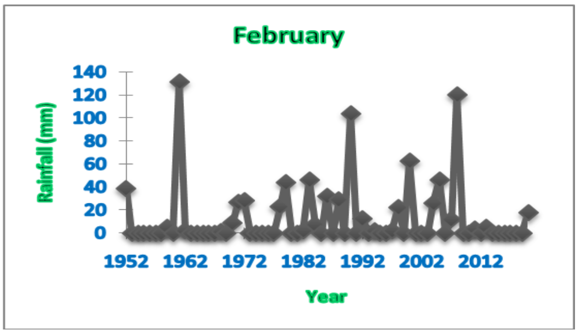

Fig. 4. Rainfall trend for the month of February.

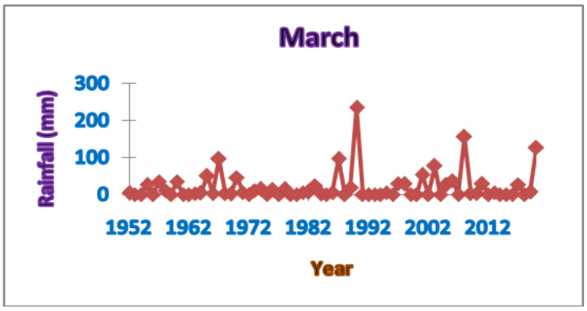

Fig. 5. Rainfall trend for the month of March.

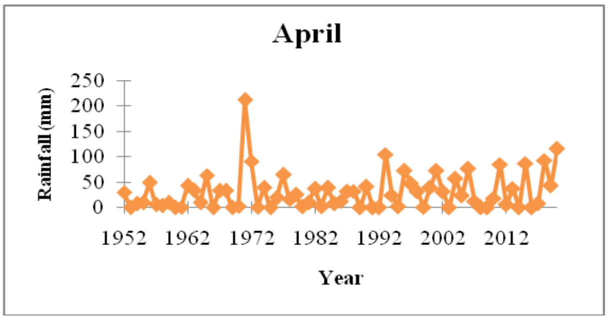

Fig. 6. Rainfall trend for the month of April.

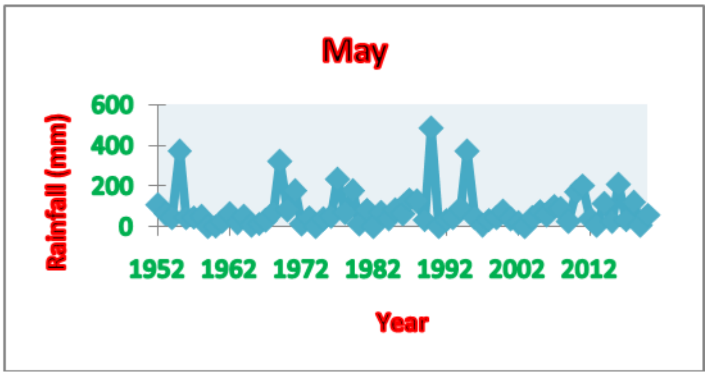

Fig. 7. Rainfall trend for the month of May.

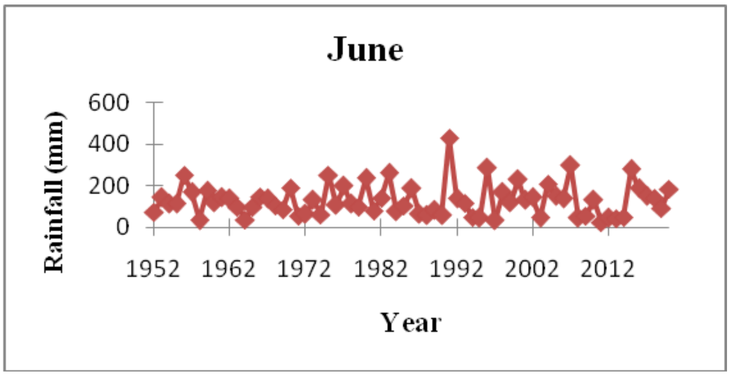

Fig. 8. Rainfall trend for the month of June.

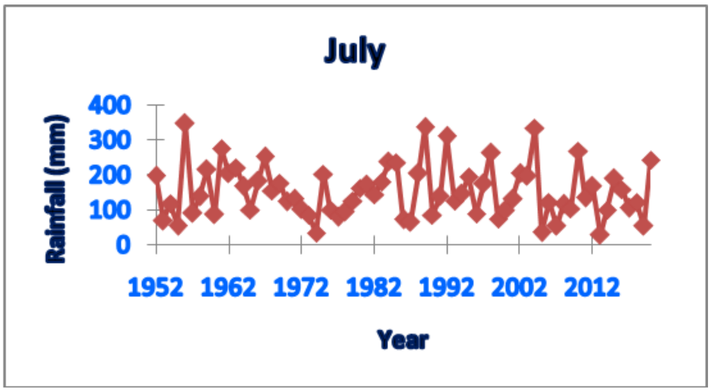

Fig. 9. Rainfall trend for the month of July.

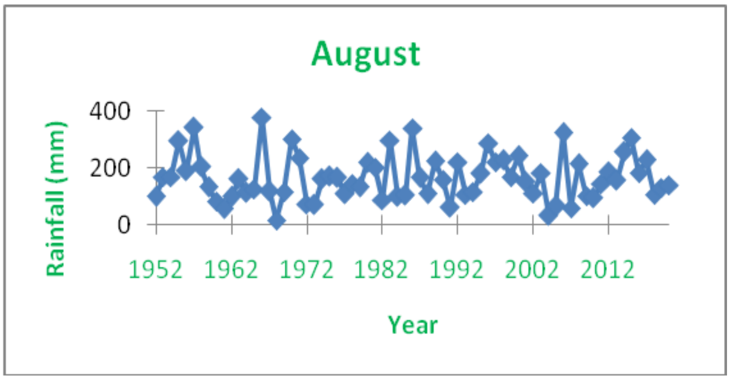

Fig. 10. Rainfall trend for the month of August.

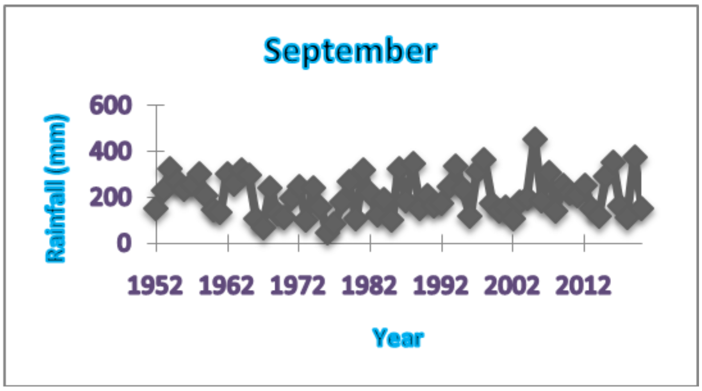

Fig. 11. Rainfall trend for the month of September.

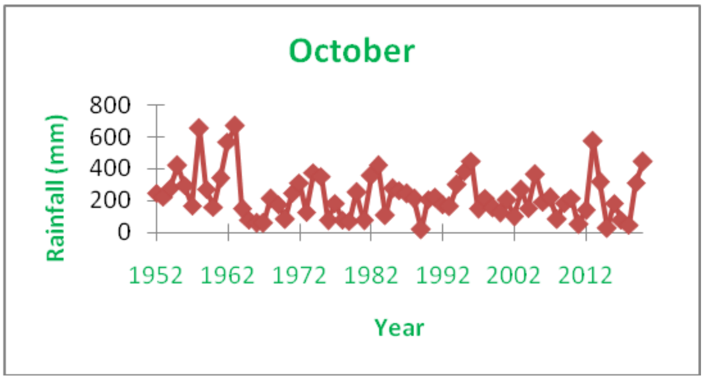

Fig. 12. Rainfall trend for the month of October.

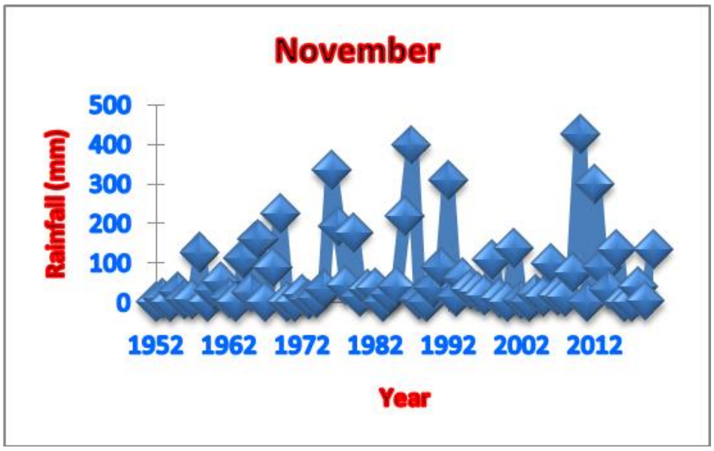

Fig. 13. Rainfall trend for the month of November.

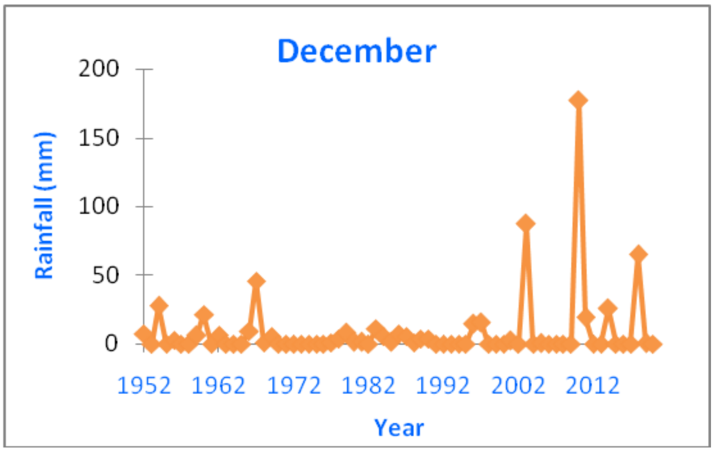

Fig. 14. Rainfall trend for the month of December.

C. Seasonal rainfall analysis

For agriculture, it is very much essential to know the seasonal variations of precipitation in order to get a precise assessment of supplemental water requirements (Gajbhiye *et al*., 2015; Ali and Abubaker 2019). The variability in rainfall patterns for 1952–2020 for the Anakapalle district of North Coastal Andhra Pradesh was studied and the analysis indicated that the monsoon period rainfall (South west and North east monsoon period) showed a decreasing trend while the pre monsoon period exhibited a positive trend (Table 3). Guhathakurta *et al.* (2020) found decreasing trends of rainfall in West Tripura and Unakoti districts during southwest monsoon season for the period of 1989-2018.

Table 3: Season wise rainfall trend for over 69 years (1952-2020).

Season	Mean Rainfall (mm)	Standard Deviation	Sen's slope	Kendall's test Statistics (Zc)
Pre monsoon (March- May)	131.69	121.538	0.680	0.126
SW monsoon period (June-Sep)	657.53	149.668	-0.113	-0.012
NE monsoon period. (Oct-Dec)	307.65	172.168	-0.508	-0.047
Winter (January and February)	20.77	30.064	0.000	-0.038

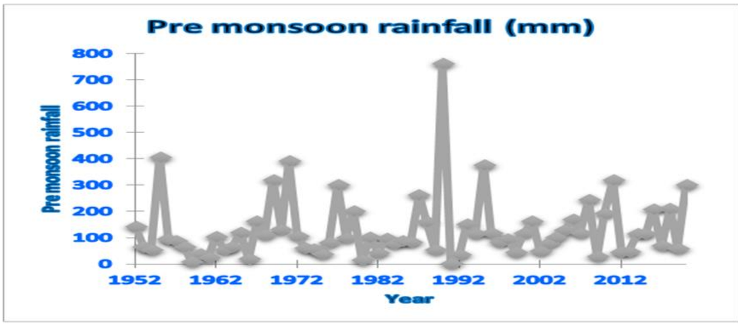

Fig. 15. Trend of pre monsoon rainfall trend over 69 years (1952-2020).

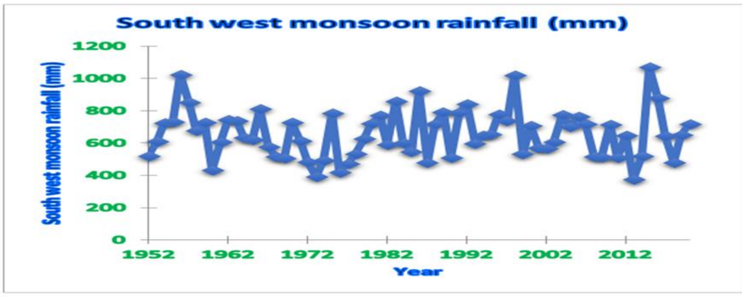

Fig. 16. Trend of SW monsoon period over 69 years (1952-2020).

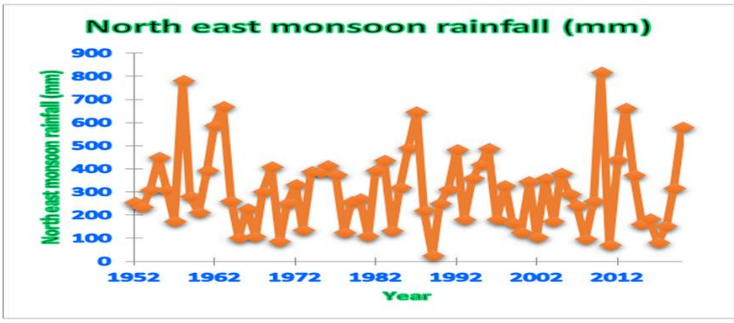

Fig. 17. Trend of NE monsoon period over 69 years (1952-2020).

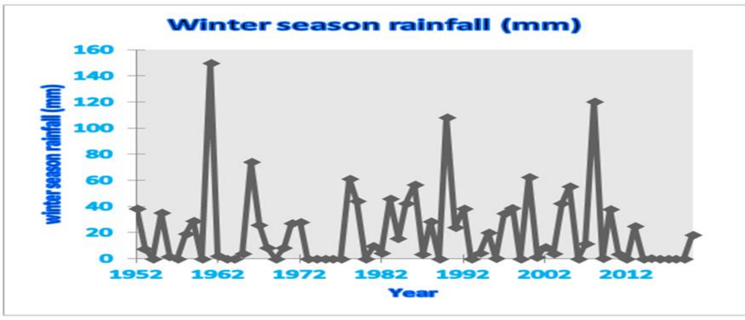

Fig. 18. Winter season rainfall trend over 69 years (1952-2020).

CONCLUSIONS

The annual and pre monsoon (March-May) rainfall of Anakapalle for 69 years is in increasing trend, where as monsoon rainfall (both South West & North East) is in decreasing trend. Thus trend analysis is highly useful in understanding the monsoon pattern of a district and for its effective use in crop planning in future and for decision making for policy makers.

FUTURE SCOPE

Decreasing monsoon rainfall are already a major concern for farmers, policy makers and society at large and in such situation, the findings of this study are very imperative. Adaptation and mitigation strategies are required to deal with these changing precipitation patterns.

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Conflict of Interest. None.

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