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Innovative Trend Analysis (ITA) of Rainfall for Kadiri Watershed Area

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ABSTRACT

Precipitation (Rain fall) is an important parameter of the hydrological cycle; drought and floods are really pertinent with variability of rain fall. Long-term changes in hydrological processes are referred the climate change for an area. Enormous increase in the population, urbanization, industrialization, and release of green house gases like Chlorofluorocarbon (CFC) gases are having negative effects on the environment. It is very essential to study of trends in the long term from climatic change and socioeconomic perspectives. Changes in rainfall pattern and distribution have an important effect on the amount of water available in watershed. Hence, it is required to analyze the rainfall pattern over time. This study employs the Innovative trend analysis (ITA) method to assess the long-term (1982–2020) temporal trends of annual rainfall in different seasons (*Kharif, Rabi, and summer*) for the Kadiri watershed division of the Anantpur district in Andhra Pradesh state. The ITA technique is a highly effective tool for finding patterns in rainfall time series data since it can provide results in graphical form. This technique is also used to detect trends as 'low,' 'medium,' and 'high,' which needs to be considered in upcoming research on drought and floods. According to the outcome of the analysis, the bottom cluster exhibits a negative trend, the middle cluster exhibits a positive trend and no trend, and the higher cluster exhibits a positive trend during the annual analysis. During this time, average seasonal analysis took into account the pre, post, and monsoon seasons. The investigation showed that while the average seasonal rainfall during the monsoon season is close to the yearly average, it is lower during the post-monsoon and pre-monsoon seasons. The average rain fall values observed as 161.8, 111.60 and 435.69 mm during pre, post and monsoon seasons respectively. This study will helps as a scientiûc foundation for expecting and mitigating the effect of climate change on the natural resources to lowering the risk of weather conditions.

Keywords: *Climate change, Hydrological cycle, Innovative trend analysis and Long-term trend.*

The most important climatic variables are rainfall and temperature in terms of climate change impacts (Pingale *et al.* 2014). Urbanization, population growth, and industrial growth are having negative effects on the environment (Mehta & Yadav 2021b). Challenges associated with changes in climate are growing more severe as growth in urbanization, as more pervious areas become impervious, resulting in decreased foliage cover and higher temperatures (Pingale *et al.* 2016). Rainfall is an important aspect of the hydrologic cycle, and variations in its pattern have a direct impact on the region's water resources (Goyal & Surampalli 2018). Agriculture accounts for 17–18% of India's overall GDP (Banda *et al.* 2021). Agriculture is the most common occupation, with 60% of the population operating in it (Alashan 2018;

Bouklikha *et al.* 2021). The agro-economy in nations such as India is heavily reliant on precipitation patterns and also on irrigation. One of the most serious worries about climate change is that total, Spatio-temporal changes in precipitation will increase in many regions of the world (Kundzewicz *et al.* 2019). A poor or low monsoon has always been seen as a major setback to India's economy, resulting in a fall in the country's GDP levels (Singh *et al.* 2021). In its ûfth assessment synthesis report, the Intergovernmental Panel on Climate Change (IPCC) made it absolutely clear that the climate system is warming, and numerous the observed changes since the 1950's were unexpected (Jain *et al.* 2013; Caloiero *et al.* 2020).

In the IPCC's fourth assessment report, it was also noted that the current evidence of actual melting of ice and snow, rises in global average ocean temperatures, and rising global sea levels amply demonstrate that the climate system is warming (Singh *et al.* 2021). Lack of water is a major threat to both humans and nature, especially in arid and semiarid regions (Aher & Yadav 2021).

Trend analysis is also most prominent approaches for assessing the variation of hydro-meteorological variables over the previous couple of decades, and it has been widely used by researchers (Caloiero *et al.* 2020). Analyzing long-term rainfall distribution and variability is helpful for long-term natural resources maintenance (Caloiero *et al.* 2018). Analyzing long-term rainfall distribution and variations is critical for long-term natural resources management (Malik *et al.* 2019). Furthermore, Von Storch *et al.* 1995 documented that the existence of positive serial correlation increases the probability that the MK test detects a trend when no trend exists. Despite the MK test's wide- spread use in hydrology trend analysis, previous research has shown that the presence of autocorrelation can interfere with the ability to detect trends using Mann-Kendall and Sen's slope (Thomas and Prasanna kumar 2016). Some studies use a trend- free pre-whitening method to eliminate the autocorrelation in the data series. However, according to a number of studies, pre-whitening may not be effective if serial correlation persists after the ûrst-order autoregressive process and the sample size is large. It can also remove a portion of the actual trend.

MATERIAL AND METHODS

STUDY AREA

Present study area of Kadiri watershed is located in between 78Ú 9¹ 32º N, and 14Ú 6¹ 49º E, having an extent of 239 km^2 which includes 15 villages. The extent of villages varies from 1.22 km^2 to 86.96 km^2. The average elevation of study area was 620 m above the Mean Sea Level (MSL) with highest value of 830 m and lowest valve of 409 m. The average annual rainfall in this area varies between 600 mm to 700 mm in which 60%, 35% and 5% of total rainfall occurs in S-W, N-E and in summer seasons respectively. Major crops grown in the study area were Bengal gram, ground nut, maize, mango and paddy. Watershed program was initiated from the year 2012-13 and completed in 2019-2020 during in this period different soil conservation measures as well as construction of structures were carried out, these tends to changes in parameters like water bodies, water table, cropped area, runoff and erosion. The location map of study area shown in Fig.1

Daily rainfall data collected from Agricultural Research Station, Kadiri (ANGRAU) for the period of 1982 to 2020. In addition to performing an annual, seasonal, and monthly average analysis, innovative trend analysis (ITA) was also done.

The various parameters and requirements to carryout ITA at selected watershed as well as flow process of methodology are shown in Fig.2 and Fig.3 respectively.

Sen (2012) put forth the ITA methodology, in which none are included limiting assumptions like those frequently seen in the Mann Kendall trend test and Spearman's rho test. Additionally, this method enables a graphic evaluation of a parameter's low, moderate, and high values. With reference to underlying principle, if a pair of time series coincides, then their scatter points will almost always fall along the line 1:1 (45°). First, two equal parts of the hydrometeorological time series are split apart and arranged separately in increasing order. The earlier half is plotted on the X-axis, and the remaining half is plotted on the Y-axis. A 1:1 (45°) straight line splits the space into two similar triangular parts, wherein the growing (decreasing) trend element is shown by the higher (lower) triangular region. The hydrometeorological observations do not show a trend if the scattering locations are on or near the 1:1 (45°) straight line. However, it is possible to confirm an escalating (declining) trend in the time series if the points are above (below) the 1:1 straight line (45°). (Sen 2012, 2014). For "low," "medium," and "high" precipitation data, the graph might show possible partial trends. As the dispersion of the points is non-parametric, the serial correlation coefficient does not become effective in this trend study.

RESULTS AND DISCUSSION

ITA of annual average rain fall

In this analysis it is observed that, in lower cluster negative trend, in middle it shows both positive as well as no trend and in higher cluster it is in positive trend. Also analysis revealed that positive trend is continuously appearing in middle and upper clusters, this indicates that new conservative measures must be planned according to the middle and upper trends will provide better results. The Fig.4 shows the ITA of annual average rainfall of study area.

Post-Monsoon season (November to February) average rain fall analysis

It is stated that, during this season maximum contribution was from November month, less average during this season indicated that draught or below average rain fall years. There is no significant contribution during in the moths of January and February. Also observed that the gap between annual trend line and average trend line of November is widening from 1982 to 2020. It is clearly indicates climate change impact is more on rainfall pattern and quantity**.** The Fig.5 shows graphical representation of post-monsoon average rain fall analysis.

Monsoon season (July to October) average rain fall analysis

It is stated that, during this season rain fall contribution was almost uniformly happened in September and October followed by August and July. There is similar trend in between annual average rain fall and seasonal average rain fall. The Fig.6 shows graphical representation of Monsoon season average rain fall analysis.

Pre-monsoon season (March to July) average rain fall analysis

It is stated that, during this season there is significant contribution from March and April months, Major contribution from June followed by May. There is a significant contribution in April and March during from the years having excess annual rain fall. The Fig.7 shows graphical representation of Pre-Monsoon season average rain fall analysis.

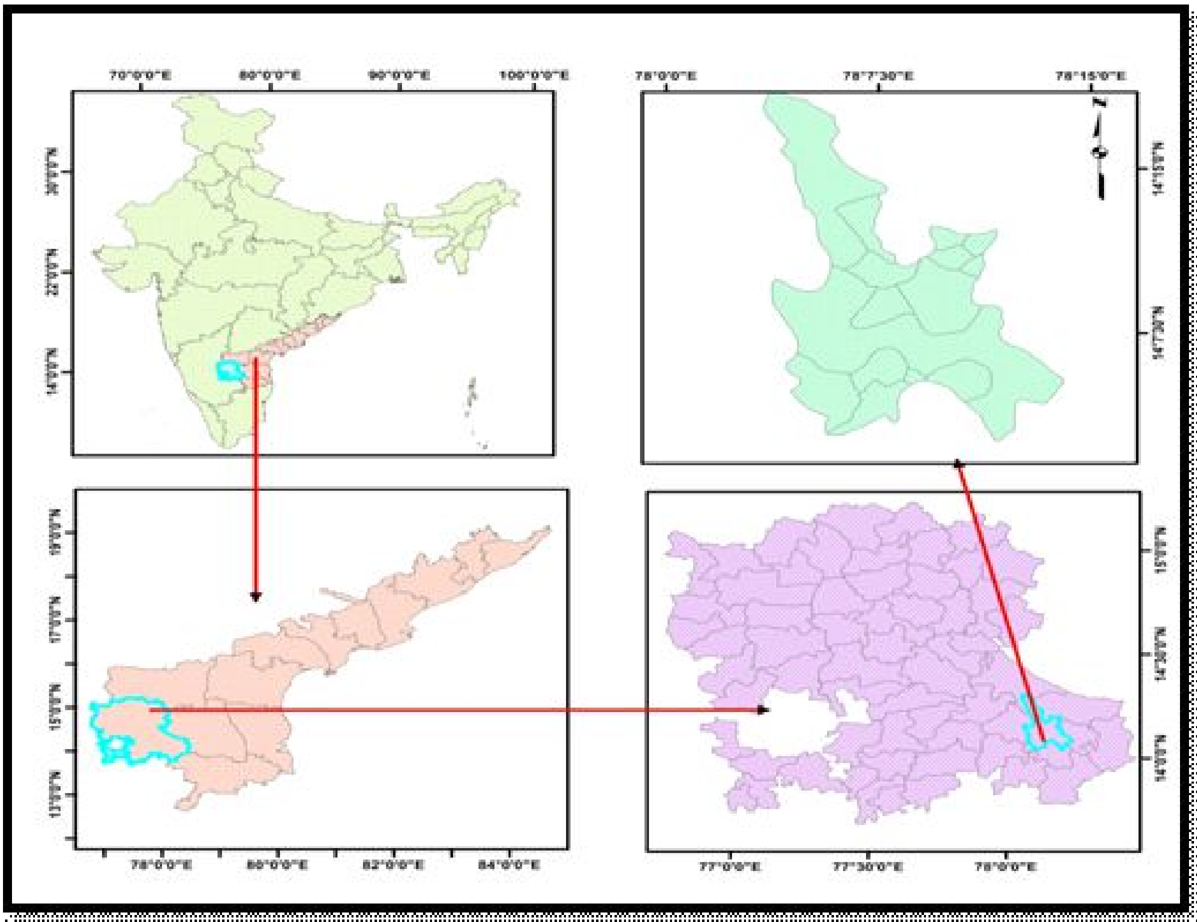

Fig 1. Location map of Kadiri watershed of Anantapur District

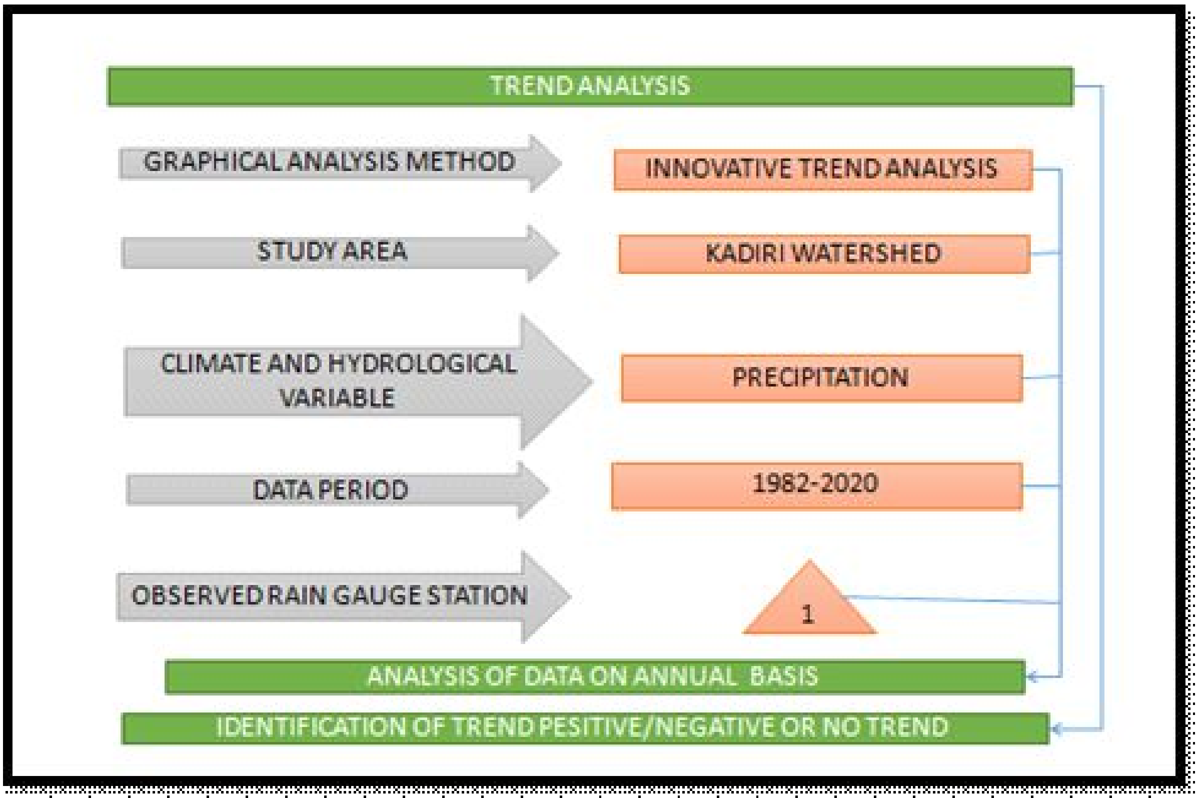

Fig 2. Parameters required for ITA Method

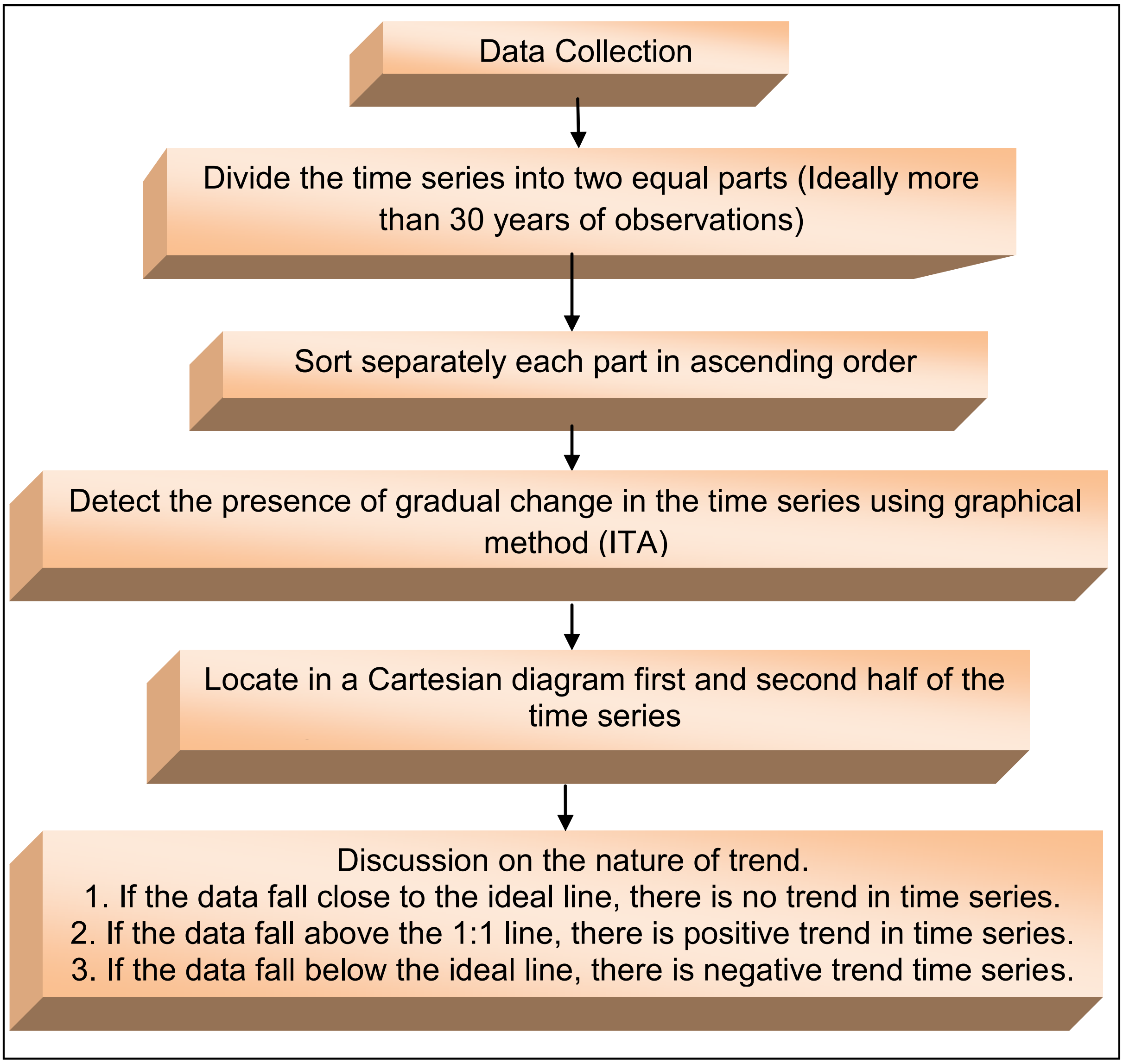

Fig 3. Flow chart for process of methodology

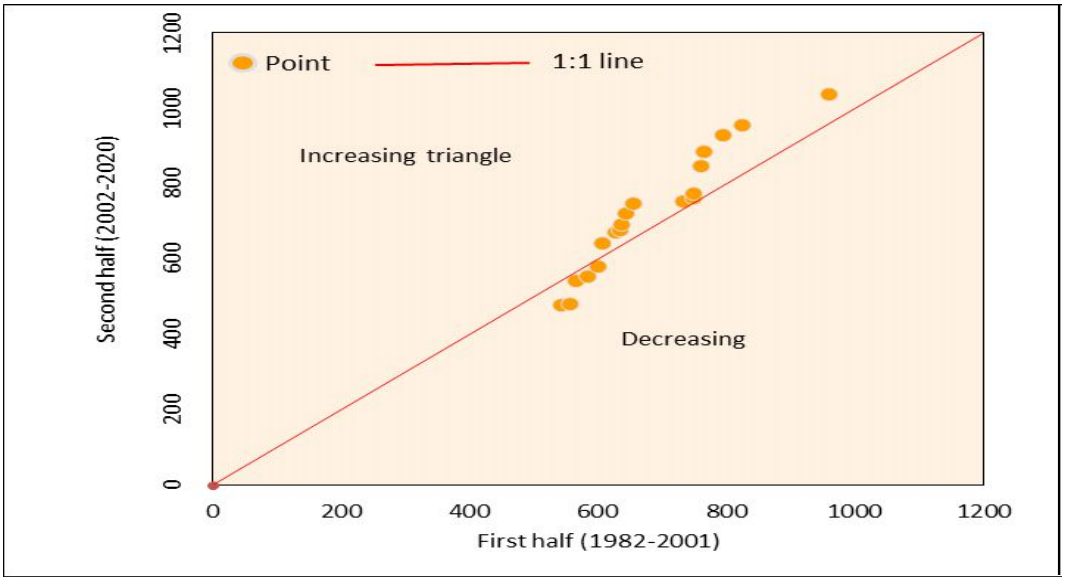

Fig 4. ITA of annual average rainfall of study area

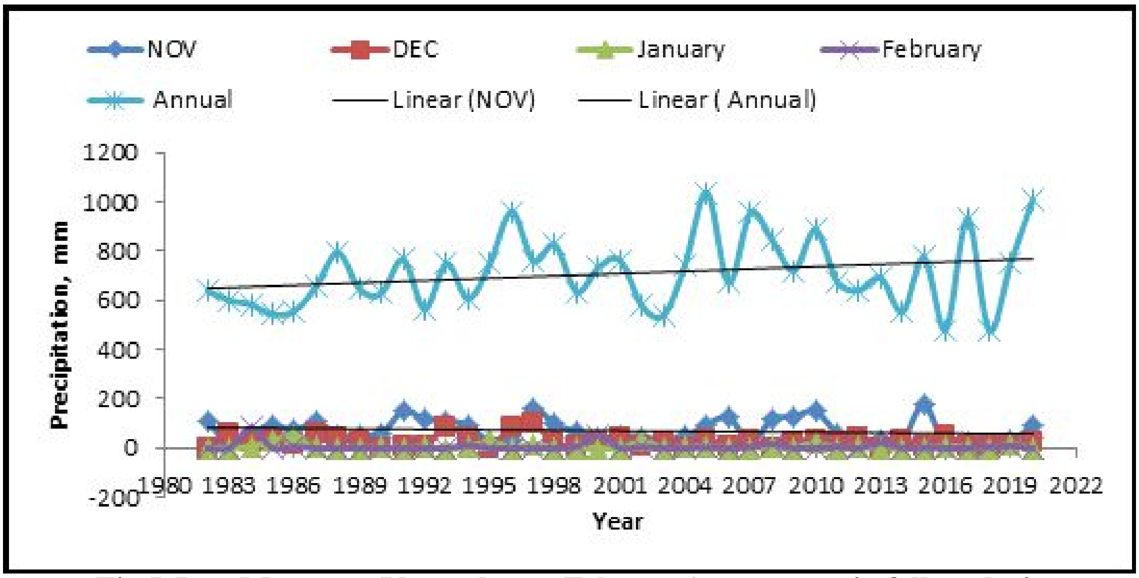

Fig 5. Post Monsoon (November to February) average rain fall analysis

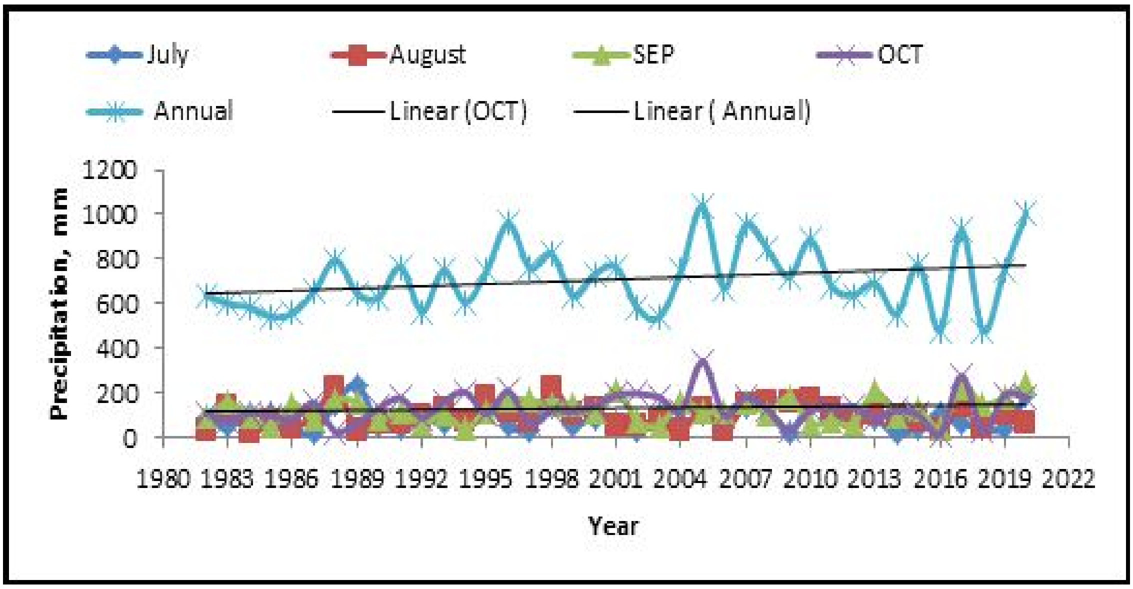

Fig 6. Monsoon season average rainfall analysis of study area

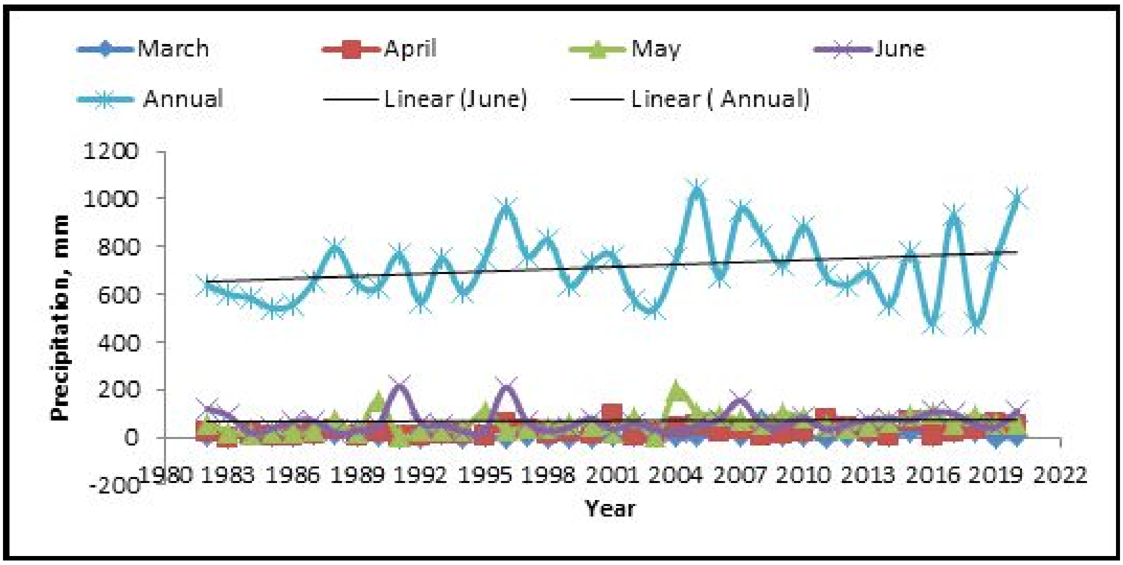

Fig 7. Pre-Monsoon season average precipitation analysis of study area

CONCLUSION

In this research study, seasonal average precipitation analysis and annual trends of rainfall over the Kadiri watershed of Anantapur district for the period of 1982 to 2021 (30 years) were assessed by ITA. Climate change has a detrimental effect on the rainfall pattern in the study area, and the entire water supply. The precipitation trend reported that the study area may implies that certain changes are more pronounced than others. The ITA application of annual precipitation indicated that in lower cluster negative trend, in middle it shows both positive as well as no trend and in higher cluster it is in positive trend. Also analysis revealed that positive trend is continuously appearing in middle and upper clusters, this indicates that new conservative measures must be planned according to the middle and upper trends will provide better results. Also observed that the gap between annual trend line and average trend line of November is widening from 1982 to 2020. It is clearly indicates climate change impact is more on rainfall pattern and quantity. During November to February maximum contribution was from November month and less average during this season indicated that draught or below average rain fall years. From July to October rain fall contribution was almost uniformly occured in September and October followed by August and July. Where as in between March to June there is significant contribution of rainfall from March and April months, Major contribution from June followed by May. Furthermore, the use of graphical techniques, such as the ITA method, is new in that it overcomes issues such as the independent structure of the time series, normality of the distribution, and data length, all of which may arise when evaluating a large range of data scale. The results of this research will be beniûted to policymakers in the systematic development of present water resources. The above information may be used to make qualitative predictions about when the rainy season will start and how long it will last for the respective watershed.

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