



Decadal Trends in Climate Change in Central Tamil Nadu, India: Implications for Climate Resilient Agriculture

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJAEES/2023/v41i92047

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/102504>

Original Research Article

Received: 28/04/2023

Accepted: 30/06/2023

Published: 06/07/2023

ABSTRACT

A temporal rainfall analysis of Central Tamil Nadu was carried out for 12 decades for the purpose of examining the Climate Change. The detailed statistical analysis of annual as well as season-wise rainfall data showed that there was a drastic climate change over the years, under the study. The mean annual rainfall was 862.10 mm but there was a wider range in the distribution of rainfall seasonally as well as annually as high as 874.98 mm and the annual rainfall exhibited a very high variance of 28,094.69 mm. The coefficient of variation observed was also higher ranging from 31.95 to 104.60. An analysis of Kurtosis showed Platykurtic distribution (negative kurtosis with lighter tail) of rainfall for the first 6 decades of the 19th century (1900-1960), whereas, it was Leptokurtic distribution (positive kurtosis with heavier tail) for the rest of the 6 decades. (1961-2021). Hence, drastic climate change was clearly visible in Kurtosis analysis, when it turned from Platykurtic distribution to Leptokurtic distribution. The results suggested that there were more number of extreme events in the later decades. These facts clearly portrayed the profound effect of climate change in Central Tamil Nadu, in the years studied. Therefore, it is recommended that

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efficient climate resilient policy options: building resilience in soil, rainwater harvesting and recycling, water saving technologies, adapter cultivars and cropping systems, crop contingency plans, livestock and fishery intervention, weather based agro advisories and other institutional interventions should be put in place so as to increase the resilience of agricultural production to climate change in the central Tamil Nadu.

Keywords: Climate change; annual rainfall; seasonal rainfall; climate resilience; kurtosis.

1. INTRODUCTION

Climate change is an undisputed reality with severe impacts on the natural environment, human lives, economic assets and activities. Changes to earth's climate driven by increased human emissions of heat-trapping greenhouse gases are already having widespread effects on the environment. The glaciers and ice sheets are shrinking, river and lake ice is breaking up earlier, plant and animal geographic ranges are shifting and plants and trees are blooming sooner. Some changes (such as droughts, wildfires, and extreme rainfall) are happening faster than scientists previously assessed. In fact, according to the Intergovernmental Panel on Climate Change (IPCC) modern humans have never before seen the observed changes in our global climate, and some of these changes are irreversible over the next hundreds to thousands of years [1,2].

1.1 Climate Change in India

India is one of the countries that are more vulnerable to climate change. The Coupled Model Intercomparison Project (CMIP) 5 projections for India showed that the average climate would likely to be warmer by 1.70 to 2.00 C for 2030s and by 3.30 – 4.80 C by 2080s compared to the pre-industrial times. Precipitation is likely to increase by 5 to 6 per cent and 6 to 14 per cent, for 2030s and 2080s, respectively [3-5]. Agriculture, being a biological production process, is obviously affected by climate and hence the projected change in climate will have implications to sustainability of agricultural production and of livelihoods of those dependent on agriculture. As climate change aggravates all other problems such as land degradation, market volatility, rising input costs, slowing response to added inputs that hinder agricultural growth. Climate change is recognized as a potent threat to the sustainability of agriculture. Developing countries such as India, with their relatively higher dependence on agriculture for livelihoods, are more likely to

suffer from such an impending climate change [6-8].

The trends in climate change and the yearly variability of monsoon rainfall has been studied by many researchers [9-11]. Sinha Ray and Srivastava [12] have reported a declining trend in rainfall over most parts of the country except over northwest India and a few stations in northern India. Joshi and Rajeevan [13] observed an increasing trend in monsoon rainfall over the west coast and northwest India. A preliminary analysis by Ray et al. [14] using 40 years of data for Gujarat found that mean seasonal rainfall has increased over Saurashtra and south Gujarat region (along the west coast) and has remained more or less the same over the north Gujarat region and adjoining Kutch. Singh [15] while analysing seasonal and annual rainfall series in Maharashtra during the past 118 years observed significant decreasing trends of winter and pre-monsoon rainfall in the districts of Maharashtra. Rangarajan [16] analysed the spatial and temporal variability of precipitation in the southern part of Tamil Nadu.

1.2 Climate Change in Tamil Nadu

In India, Tamil Nadu is one of the states most vulnerable to drought impacting agriculture and allied activities. In a study undertaken by Varadan [17] while examining climate change phenomena in all the districts of Tamil Nadu, concluded that Tiruchirappali District was the most vulnerable district in Tamil Nadu. Hence, Tiruchirappali District, the Central Tamil Nadu, has been chosen for the present study to make a detailed analysis of rainfall pattern for almost 120 years from which, the corresponding inferences were drawn and recommendations were made accordingly.

2. METHODOLOGY

Secondary data on rainfall, that is rainfall of Tiruchirappalli District, the central Tamil Nadu for the past 120 years in respect of South West

monsoon, North East monsoon, Winter and Hot Weather periods and annual rainfall were collected. The collected data were subjected to descriptive statistical analysis: mean, coefficient of variation, variance, skewness and kurtosis. Further, decadal trends in annual rainfall and seasonal rainfall were also analysed for observing changes in trends in climate change.

2.1 Mean

It is the measure of central tendency and first moment of distribution and arrived by the following formula:

$$\bar{x} = \frac{\sum_{i=1}^N x_i}{N}$$

2.2 Variance

In probability theory and statistics, variance is the expectation of the squared deviation of a random variable from its population mean or sample mean. Variance is a measure of dispersion, meaning it is a measure of how far a set of numbers is spread out from their average value [18].

$$\sigma^2 = \frac{\sum_{i=1}^N (X_i - \bar{X})^2}{N}$$

2.3 Coefficient of Variation

The coefficient of variation (CV) also known as relative standard deviation (RSD) is a standardized measure of dispersion of a probability distribution of frequency distribution. It is often expressed as percentage and is defined as the ratio of the standard deviation to the mean [19].

Coefficient of Variation= (Standard Deviation/ Mean) X 100

2.4 Kurtosis

Kurtosis is a measure of whether the data are heavy-tailed or light tailed relative to normal distribution. The data sets with high kurtosis tend to have heavy tails or outliers. Data sets with low kurtosis tend to have light tails.

$$Kurt = \frac{1}{N} \sum_{i=1}^N \left[\frac{(X_i - \bar{X})}{\sigma} \right]^4$$

3. RESULTS AND DISCUSSION

3.1 Annual Rainfall

A temporal analysis of annual rainfall in Tiruchirappalli District, the Central Tamil Nadu for the past 120 years revealed that the mean annual rainfall is 862.10 mm, but it exhibited a very high variance of 28,094.69 mm, with a lowest rainfall of 423.80 mm in the year 2016-17 and with a maximum rainfall of 1297.78 mm in the year 1988. The range observed was very wide, that is 874.98 mm and it exhibited a kurtosis of leptokurtic distribution with a positive tail.

Further, in order to capture the inter decadal variations in rainfall more clearly, the data is divided into four sub-sections, i.e., every 30 years constitute one sub-section as follows in Table 1.

The annual rainfall received during every three decades are analysed and presented in the following chart (Fig. 1).

From the above graph, it could be inferred that the that the annual rainfall received is considerably and conspicuously lower especially in the last 10 years compared to the rest of 110 years. This is a clear indication of profound Climate Change.

Table 1. Inter Decadal Rainfall Analysis

Years	Sub-Section of every 3 Decades
1901-1930	I
1931-1960	II
1961-1990	III
1991-2021	IV

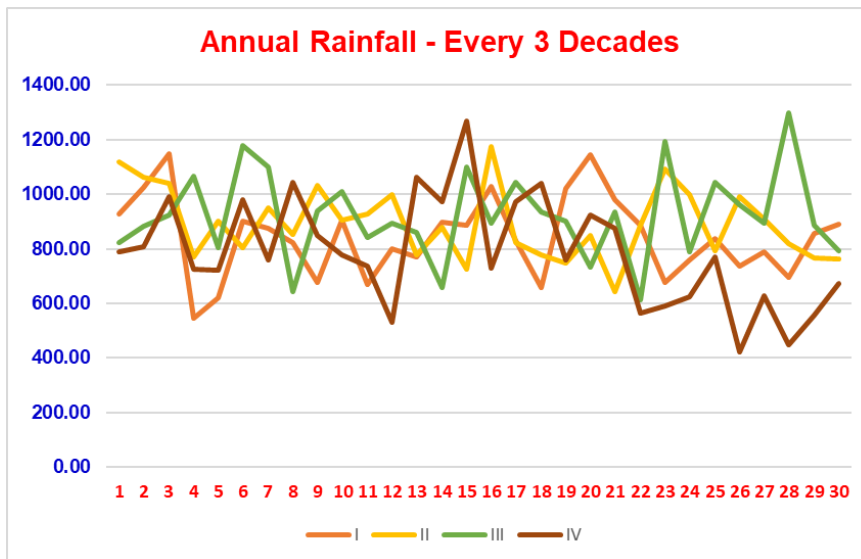


Fig. 1. Annual Rainfall in mm (Every 3 Decades)

3.2 South West Monsoon Rainfall

An analysis of the South West Monsoon rainfall data of Tiruchirappalli District for the past 120 years revealed that there was a wider variation in the rainfall received over years exhibiting a maximum range of 904.32 mm, with some years as low as 114.10 and in some years as high as 1018.42. As per the IMD classification, the former was a severe meteorological drought and the latter was severe flood and both are extreme events to climate change and not

congenial for a good crop [20]. The mean rainfall is 317.83 mm with a CV of 34.05 percent. The variance of the rainfall is 11,709.20 mm. Further, the analysis of Kurtosis showed Leptokurtic distribution (a positive kurtosis of 14.15 with a heavier tail) suggesting the more number of outliers, namely, the extreme events.

The Inter-Decadal variations in South West monsoon are analysed and presented in the following Chart.

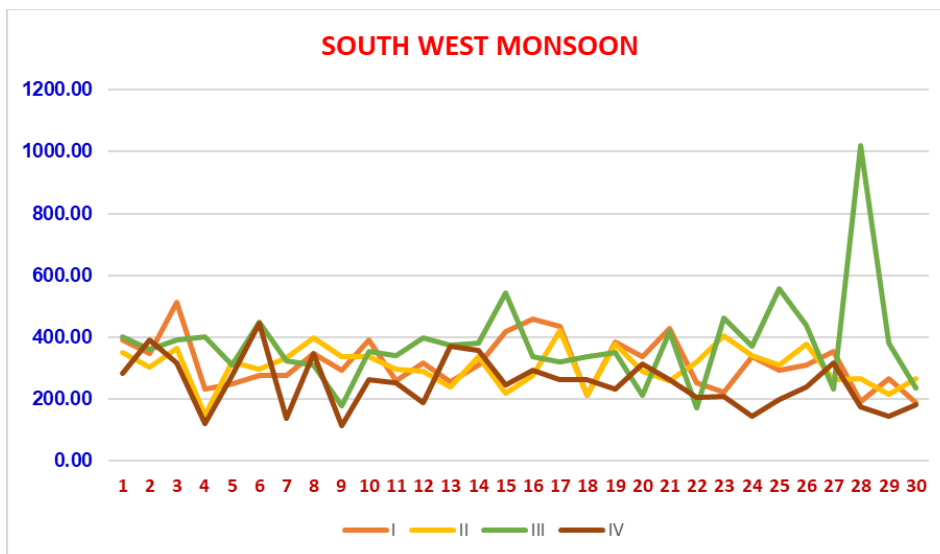


Fig. 2. Inter-Decadal rainfall variations in South West Monsoon (in mm)

- It is quite obvious from the graph that the rainfall received during the South West monsoon period is consecutively lower in the last 3 decades compared to the rainfall received in the first 9 decades of 19th century.
- This is also another indication of profound Climate Change.

3.3 North East Monsoon Rainfall

With regard to North East monsoon rainfall, which contributes nearly 45 per cent of total annual rainfall, exhibited a still higher variance of 14563.95 mm, with the mean rainfall of 377.69 mm and with a CV of 31.95 per cent. The range observed was 715.11 mm with a minimum of 143.09 mm and a maximum of 858.20 mm. Here again, an analysis of Kurtosis revealed Leptokurtic distribution.

The Inter-Decadal variations in North East monsoon were analysed and presented in the following Chart (Fig.3).

- It could be inferred from the graph (Fig. 3) that the rainfall received during the North East monsoon period is considerably lower in the last 10 years (except one year) compared to the rainfall received during the past 110 years.

3.4 Winter Rainfall

As far as Winter rainfall is concerned, it exhibited a very high CV of 104.60 per cent with a mean rainfall of 23.86 mm. It was noted that in some of the years, there was absolutely no rainfall

received during winter (almost Zero) and the maximum rainfall received was 95.37 mm. The winter rainfall is the least contributing to the annual rainfall of Central Tamil Nadu.

3.5 Hot Weather period rainfall

In case of Hot Weather period, the mean rainfall is 149.42 mm with a CV of 40.30 per cent. Here again, in some of the years, there was absolutely no rainfall received during hot weather period (almost Zero) and the maximum rainfall received was 309.62 mm.

3.6 Inter Decadal Variance in Rainfall

The Variance in annual rainfall for every 3 decades were analysed and presented in the following chart (Fig. 4).

It has been observed that the Variance in Rainfall in Tiruchirappalli district, has been increasing every 3 decades and especially the Variance in the last 30 years (1991-21) is almost doubled when compared to variance in the first three decades of 19th century. (1901 -1930). This is again, a clear indication of profound Climate Change.

3.7 Inter Decadal Kurtosis

Apart from variance, another measure, namely, kurtosis will provide the meaningful insight about the phenomenon of Climate change. The inter-Decadal kurtosis is presented in the following chart (Fig. 5).

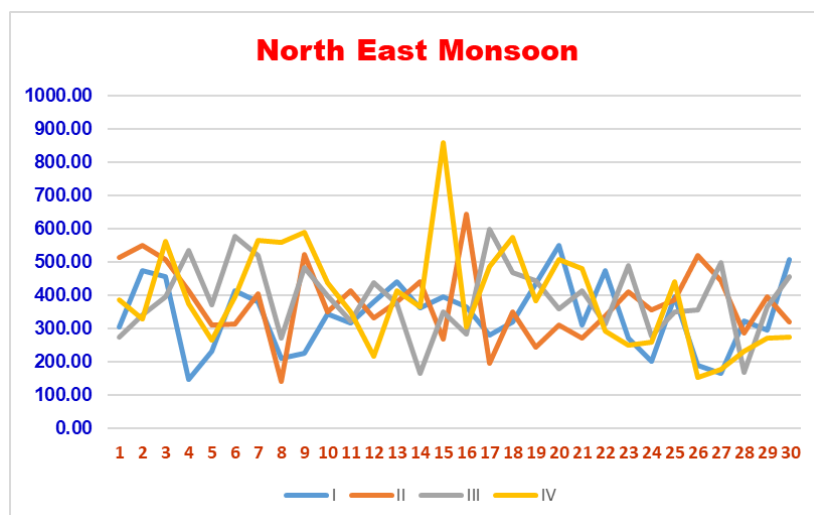


Fig. 3. Inter-Decadal Rainfall variations in North East Monsoon (in mm)

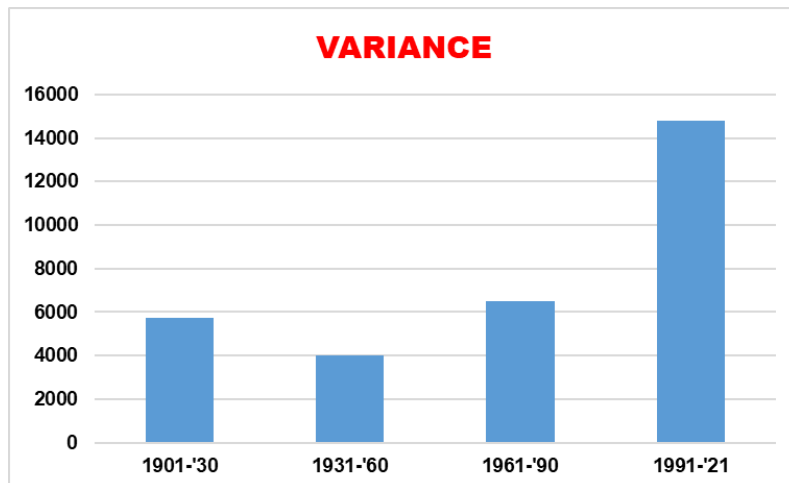


Fig. 4. Variance in annual rainfall (mm) over decades

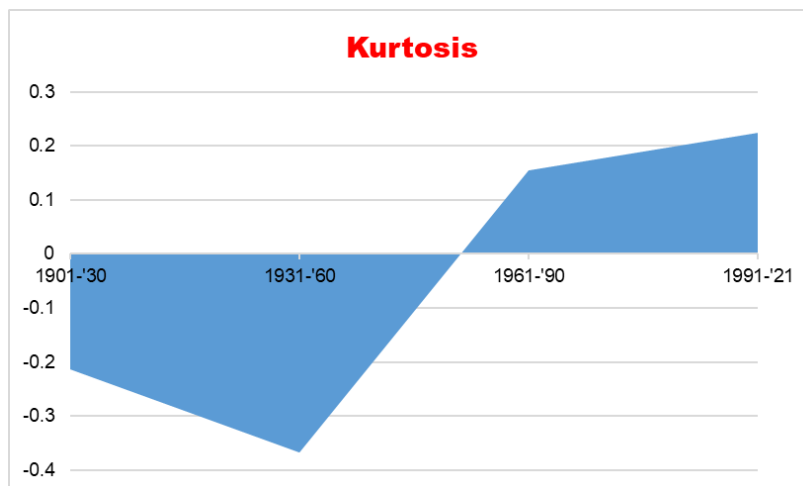


Fig. 5. Inter Decadal Kurtosis

Table 2. Number of extreme events in sub-section of every 3 decades

Sub-Section of every 3 Decades	No. of Extreme events
I	3
II	4
III	7
IV	8

An analysis of Kurtosis showed Platykurtic distribution (negative kurtosis with lighter tail) of rainfall for the first 6 decades of the 19th century (1900-1960), whereas, it was Leptokurtic distribution (positive kurtosis with heavier tail) for the rest of the 6 decades. (1961-2021). Hence, the drastic climate change is clearly visible in Kurtosis analysis, when it turns from Platykurtic distribution in to Leptokurtic distribution. This implies the probability of outlier namely extreme events will be more in the later decades.

- The number of Extreme Events is continuously rising decade after decade. It was 3 in the first three decades and 8 in the last three decades.

4. CONCLUSION

In this study, the detailed statistical analysis of annual as well as season-wise rainfall data of 12 decades showed very clearly that there was a drastic climate change over the years. The mean

annual rainfall was 862.10 mm but there was a wider range in distribution of rainfall seasonally as well as annually as high as 874.98 mm. The annual rainfall exhibited a very high variance of 28,094.69 mm. The coefficient of variation observed was also higher ranging from 31.95 to 104.60. An analysis of Kurtosis showed Platykurtic distribution (negative kurtosis with lighter tail) of rainfall for the first 6 decades of the 19th century (1900-1960), whereas, it was Leptokurtic distribution (positive kurtosis with heavier tail) for the rest of the 6 decades. (1961-2021). Hence, the drastic climate change was clearly visible in the Kurtosis analysis, when it turned from Platykurtic distribution to Leptokurtic distribution. The results suggested that there were more number of extreme events in the later decades. These facts clearly portrayed profound effects of climate change in Central Tamil Nadu. Therefore, it is imperative that efficient climate resilient policy options; building resilience in soil, rainwater harvesting and recycling, water saving technologies, adapter cultivars and cropping systems, crop contingency plans, livestock and fishery intervention, weather based agro advisories and other institutional interventions should be put in place in order to increase the resilience of agricultural production to climate change in Central Tamil Nadu.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:

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