*__Original Research Article__*

# Trend Analysis of Historical and Future Projections of Rainfall in the Lower Godavari Basin, India


## Abstract

Changes in evaporation and precipitation in the climate are precursors to changes in the water cycle due to the increase in temperatures due to climate change. In recent years, enormous changes in precipitation patterns have led to an increase in extreme rainfall events, reflecting flash floods in smaller areas. To understand this, you must study the rainfall patterns of the district and the smaller watersheds. In the present study, we have observed the trend of rainfall in the lower Godavari basin, which was part of the Godavari River from 1970 to 2019, using IMD 0.25X0.25 ° gridded rainfall data. According to the study, during the winter season and before the monsoon, there is no significant increasing or decreasing trend. In the post-monsoon season they are showing a negative and decreasing trend with a magnitude of 4 mm/year. But in the monsoon season, one end (the right end near the river mouth) of the basin or watershed is showing an increasing trend, while the left part is showing a significantly decreasing trend. In addition to that, future projections of the CMIP5 two scenarios data from 2000 to 2100 to understand the precipitation patterns in future projections. Lower Godavari basin from 2020–2040 and 2040-20100 with the RCP 4.5 and RCP 8.5 scenarios. With the RCP 4.5 scenario, the first 40 years (2020–2040) of the future projected mean seasonal rainfall are 4.5 mm/year higher in the western part of the sub-basin than in the eastern and river mouth regions.



**Keywords:** Rainfall, River basin, Climate change, Trend, Future projections.




## INTRODUCTION

The increased concentrations of greenhouse gases in the atmosphere have been attributed to global warming and further to climate change (IPCC, 2007). The change in precipitation and temperature patterns caused by global warming has been studied and discussed in several regions of the world. Precipitation is an important climate variable as it determines types and distribution of natural vegetation and availability of water to meet the needs of agriculture, industrial, and hydroelectric power sectors. The spatial and temporal variability in trends of precipitation has been studied for interannual and interseasonal periods during the past few decades throughout Asia. The changes in rainfall patterns may lead to floods and drought situations (Srivastava et al., 2015). Hence, there is an absolute need for regular monitoring of rainfall changes in the temporal and spatial regions for food security and productivity (Kumar et al., 2010). Various researchers have contributed to the study of climate change (Dessens and Bucher, 1995; Serra et al., 2001; Marengo, 2004) with long-term data. A study of different time series data has shown that the trend is decreasing or increasing, both in the case of temperature and rainfall. Human interference also leads to climate change by changing land use due to the impact of agricultural and irrigation practices (Kalnay and Cai, 2003). The geographical location of India receives almost 80% of its rainfall during monsoons (June to September). They (monsoons) ensure a decrease in the number of rainfall days and an increase in the intensity of rainy events during the seasons, which results in a serious threshold on water availability (Jain, S.K. and Kumar, V. 2012). A proper understanding of the long-term variability in rainfall trends will provide key indicators of water availability and its management. To address these concerns, many studies have conducted rainfall data analysis. Guhatakurtha and Rajeevan have observed that there is no clear long-range trend in average annual monsoon rainfall. Kumar et al. (2010) found large variations in spatial and temporal regions with respect to rainfall in India. Gosain and A.K. Rtal (2006) ensured that a decrease in precipitation closely affected the decline of freshwater availability in many Indian River basins. Partahsarthy B. and Dhar O.N. (1976) found that there is an increasing trend in monsoon rainfall in the Ganga, Indus, Brahmaputra, Krishna and Cauvery basins. S. Bera (2015) studied the rainfall trends across the entire Ganga basin and found that there will be large spatial and temporal variability in the annual and seasonal rainfall trends in the Godavari basin. Gajbhiye et al. (2015) studied the trend analysis of the Sindh River basin and reported the increasing trend in annual and seasonal rainfall. A.K. Taxak et al. (2014) studied the long-term temporal and spatial rainfall trends in the Wainganga basin, which is one of the subbasins of the Godavari river basins, for the period 1901–2012. They revealed upward trends in rainfall during 1901–1948; however, they reversed during the period 1949-2012. Kalpesh Borse 2019 analysed the long-period rainfall data from 1901 to 2002 in the regions of the upper Godavari basins using the MK test and Sen's slope estimator. A.Sravani et al.2021. In the present study, we have seen the rainfall trend analysis and future trend analysis for the lower Godavari basin using the linear trend analysis, Man-Kendall test, and Sens slope estimator methods. To understand the distribution of rainfall, future rainfall probabilities, and flood situations, we studied the future projection of rainfall destruction using the data from the CMIP5 model. The sub-basins play an important role in the seasonal

Understand the changes in the rainfall pattern by district and sub-basins and the strategies required to deal with climate change conditions, especially near the mouth of the river and the catchments, which are more prone to disasters.

## 2.1. DATA & METHODOLOGY

## Geographical area of the study:

Figure 1 (a, b) shows the geographical area of the study region(Lower Godavari basin).lower Godavari sub basin is one of the tributaries of river Godavari. The beneficiary regions of the river Godavari spread in the states of Maharashtra (152199 sq km) (48.6%), Andhra Pradesh (73201 sq km) (23.4%), Madhya Pradesh (65255 sq km) (10.0%), Chhattisgarh (10.9%), Orissa (17752 sq km) (5.7%) &Karnataka (4405 sq km) (1.4%) and Pondicherry (Yanam) through its extensive network of tributaries. This river basin receives maximum rainfall during the south-west monsoon season. The quantum of rainfall has a significant association with depressions and low pressure systems formed in the Bay of Bengal. The Lower Godavari sub-basin receives the maximum of rainfall in the months of July and August in the monsoon season. In the post-monsoon season also receives the rainfall due to the formation and land falling the trocal systems in the Bay of Bengal. While in the crossing the tropical systems in the east coast, the lower Godavari sub-basins receive the intense rainfall and flood situations are also. Almost two to three floods occurred every year.

## Data Used:

The India Meteorological Department, Government of India (Pai et al. 2014) and the Climate Research Unit (CRU) of East Anglia, UK (Harriset al. 2014) provide observed gridded climatology data for temperature and rainfall. Temperature data are further downscaled to 1 km resolution by adjusting temperatures in relation to a high-resolution digital elevation model (Gerlitz et al. 2014, Farr et al. 2007, and Reuter et al. 2007).IMD's gridded rainfall data have a much finer spatial resolution, i.e. 0.25 ° x 0.25 °. (Pai et al., 2014). This high-resolution observed rainfall dataset (1970–2019). Future projections for four Representative Concentration Pathways (RCP) scenarios are provided in global climate models. In this study, we used the RCP scenarios RCP4.5 and RCP8.5. RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5 are the four RCP scenarios.

## Methodology

### Trend Analysis

Trend is defined as the overall movement of a series over time (Webber and Hawkins, 1980). It is also the long-term change in the dependent variable over time. The connection between the two variables of temperature and rainfall, as well as their temporal resolution, determines the trend. For the importance of temperature and rainfall trends, statistical methods such as regression analysis and coefficient of determination R2 are applied. The trend was produced and evaluated using the Mann-Kendall (M-K) trend test and the slope of the regression line was calculated using the least squares technique. To investigate the link, the mean, standard deviation (SD), and coefficient of variation (CV) of rainfall and temperatures were calculated.

Mann-Kendall test

The MK test is a non-parametric statistical test that is commonly used to analyze trends in climatological and hydrological time series data. Mann proposed the test in 1945, and it has been widely used in environmental time series. There are two benefits to using this test. First, it is a nonparametric test, which means that the data does not have to be distributed regularly. Second, the test exhibits limited sensitivity to sudden interruptions caused by inhomogeneous time series. The null hypothesis (H0) of this test implies that there is no trend. This is compared to the alternative hypothesis H1, which believes that there is a trend. The MK statistic is calculated as follows.

$$S = f(z) = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn(xj - xk)$$

The trend test is used for a time series Xk, which is ranked from k = 1,2,3,…,n-1, and ranked from j = i + 1, i + 2, i + 3..... n. Each of the data points xj serves as a reference point.

$$sgn(xj-xk) = \begin{cases} 1 & \text{if } xj-xk > 0 \\ 0 & \text{if } xj-xk = 0 \\ -1 & \text{if } xj-xk < 0 \end{cases}$$

Sen's Slope Estimator Test

Sen's estimate (Sen, 1968) is a non-parametric approach for determining the amplitude of a trend in a time series. Sen's non-parametric technique is used to determine the real slope of an existing trend, such as the amount of change every year, and the test is carried out in R software. A positive value of Sen's slope indicates an upward or growing trend, whereas a negative value shows a downward or declining trend in the time series.

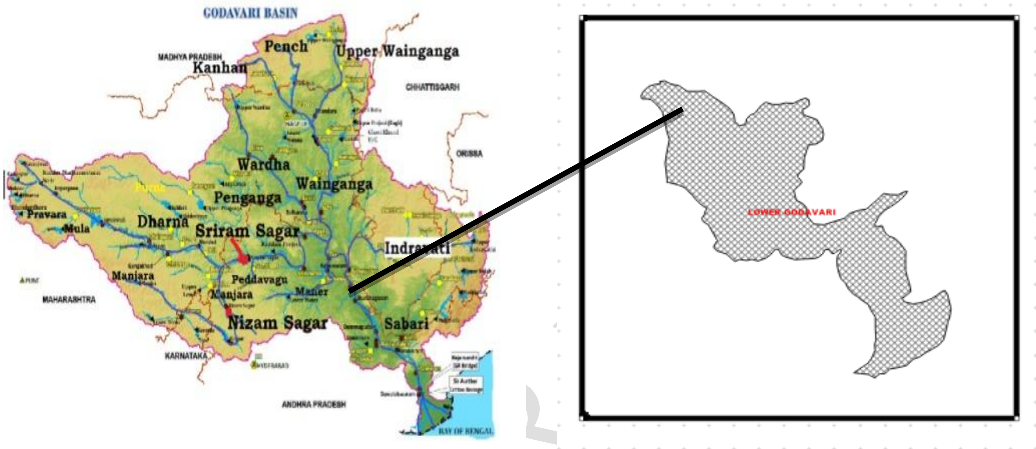


**Figure (1) Area of the study of the lower Godavari sub-basin**

## 3.1. Results and Discussions

The sub-basin rainfall analysis is important to understand the seasonal fluctuations and distribution of water inflow in the river sub-basin. Many rivers in India are showing a declining trend in sediment discharge due to the impact of climate change as well as human interference.According to (Sravani et al.2021), there is a significant Increasing trend in the upper Godavari (G1), Manjira(G4), middle Godavari(G5),Maneru(G6) and lower Godavari (G10) sub-basins in the river Godavari basin.  Figure 1 shows the variability and trend of rainfall in the lower Godavari basin for the past 40 years (1970–2019). It indicates that there will be an increasing trend in rainfall in the lower Godavari basin.

Figure 2 shows the monthly average rainfall of the lower Godavari basin. The line graph shows that the rainfall is slowly increasing in the month of May, the maximum rainfall peak is in the months of July and August, which indicates the monsoon season, is the major rainfall season, with the secondary maximum rainfall in the month of October. The season variation of the rainfall for the period of 41 years is shown in Figure. 3. In Figure. 3 (a), shows the linear trend analysis of the seasonal rainfall in the lower Godavari basin. In the winter season, the rainfall trend is showing a decreasing trend, while in the pre-monsoon season, there is no significant increasing or decreasing trend. In the monsoon season, which is the main rainfall season, the trend is showing a slight increase. The post-monsoon season (October to December) also shows a downward trend in rainfall. Figure 4 shows the spatial distribution of the mean seasonal rainfall of the Lower Godavari basin, which ranges between 150 and 2000 mm and varies from G1 to G30. Maximum (80%) rainfall occurred in the months of June to September (monsoon season). During the monsoon season, rainfall ranges from 1500-2000mm to a maximum of 2110mm. Values are less in the eastern part than in the western part because the eastern part is connected to the Eustery(River Mouth) region, which connects to the ocean, and backwater will come and inundate the inland areas near the river mouth region, followed by the post-monsoon season, which contributes 10% of rainfall with a range of 250-450mm in the pre-monsoon season, which is from March to May, and 4% of rainfall in the winter season. Figure 5 shows the rainfall covariance of the Lower Godavari basin. Covariance is a measure of the relationship between two random variables and the degree to which they change together. The figures show that the monsoon season has a high covariance in the upper part of the basin rather than the lower.

For a deep understanding of the hydrological distribution, we have carried out a trend analysis of the 30 points of the grid that fall in the entire Lower Godavari basin. Tables (1-4) for trend analysis, the MK and Sens slope estimator method is used.

**Significance of the Trend:**

The entire sub-basin is covered by 30 grid points (G1-G30).The seasonal and trend analysis is shown in tables (1-4). Tables 1-2 show that during the premonsoon and winter seasons, during the winter season, there is no significant increasing or decreasing trend, but in the premonsoon season, grids 1 and 3 show a significant increasing trend with 3.6 mm/yr. The monsoon season is the main rainy season for the Lower Godavari basin. During the monsoon season, the G1 and G8 grid points showed a significant decreasing trend of -3.5mm/year. The last G21 to G30 shows an increase, indicating that the river mouth region is on the rise, implying that floods are more common in the western part of the sub-basin. In the post-monsoon rainfall,, lower Godavari will get the maximum rainfall occurrence due to the passage of the systems, in the post-monsoon season, 25 grid points (55%) are showing that a negative and decreasing trend with the magnitude of 4 mm/year. The monsoon is the significant rainfall season, and the G1-G6 grids are showing a decreasing trend with 95% significance, respectively, have been identified as the two poles in the lower Godavari basin.

The time series and regression analysis for the monsoon seasons in Figure 6 resulted in the time series analysis and statistical forecast for the next 5 years.

Figure 7 shows the projected future values of the mean average rainfall for the lower Godavari basin. from 2020–2040 and 2040–2100 with the scenarios RCP 4.5 and RCP 8.5. With the RCP 4.5 scenario, the first 40 years (2020-2040) of future projected mean seasonal rainfall are 4.5 mm/year higher over the western part of the sub-basin than in the eastern and river mouth regions. In the second part, 2041-2100, the projected mean seasonal rainfall for the future is 4.7 mm/year higher in the western and southwestern parts of the sub-basin than in the eastern and river mouth regions. The projected mean rainfall is different with other scenarios; with RCP8.5, the projected rainfall is higher than with RCP4.5. With RCP8.5, the first 40 years (2020-2040) and the second part (241-2100) of the projected future mean seasonal rainfall are 30.5mm/year higher in the river mouth region than in the western part. With both scenarios, it shows that there will be a significant increase in rainfall over the Lower Godavari basin.

**Summary and conclusions:**

The current study examined the trend and homogeneity of trends for annual and seasonal rainfall series for the Lower Godavari basin from 1970 to 2019 using IMD 0.25X0.25 ° gridded rainfall data. From the study, it is concluded that annual and monsoon rainfall is increasing in the Lowe Godavari basin during the period 1970–2019. There has been an increasing trend in the basin during the period 1970–2019. There has been a general decrease (2.20%) in annual rainfall in the basin during the period 1970–2019. It is also found that the trends are homogeneous across the basin. It has also been discovered that there will be a significant increase in the future. Projections are also important.



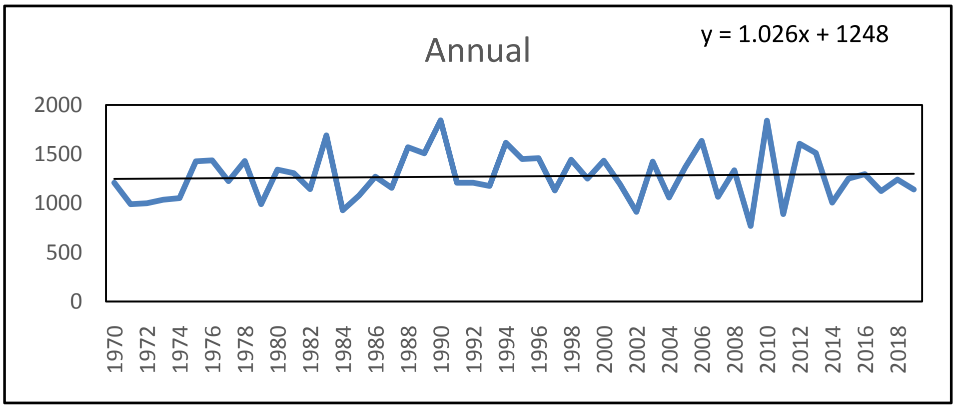

**Fig.2. Shows the time series (1970-2019) of annual rainfall in the Lower Godavari basin.**

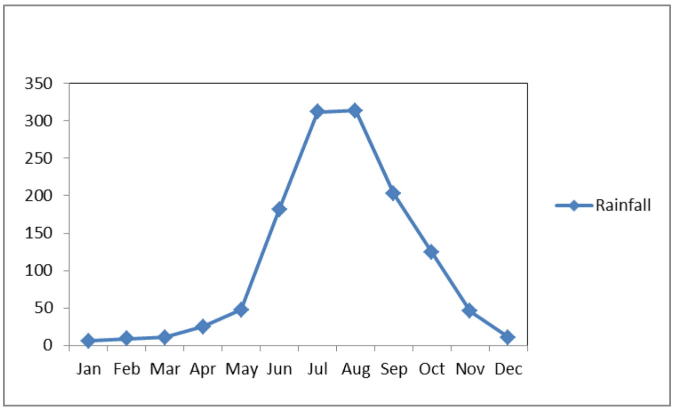


**Fig3. Shows the mean monthly rainfall of the lower Godavari basin.**

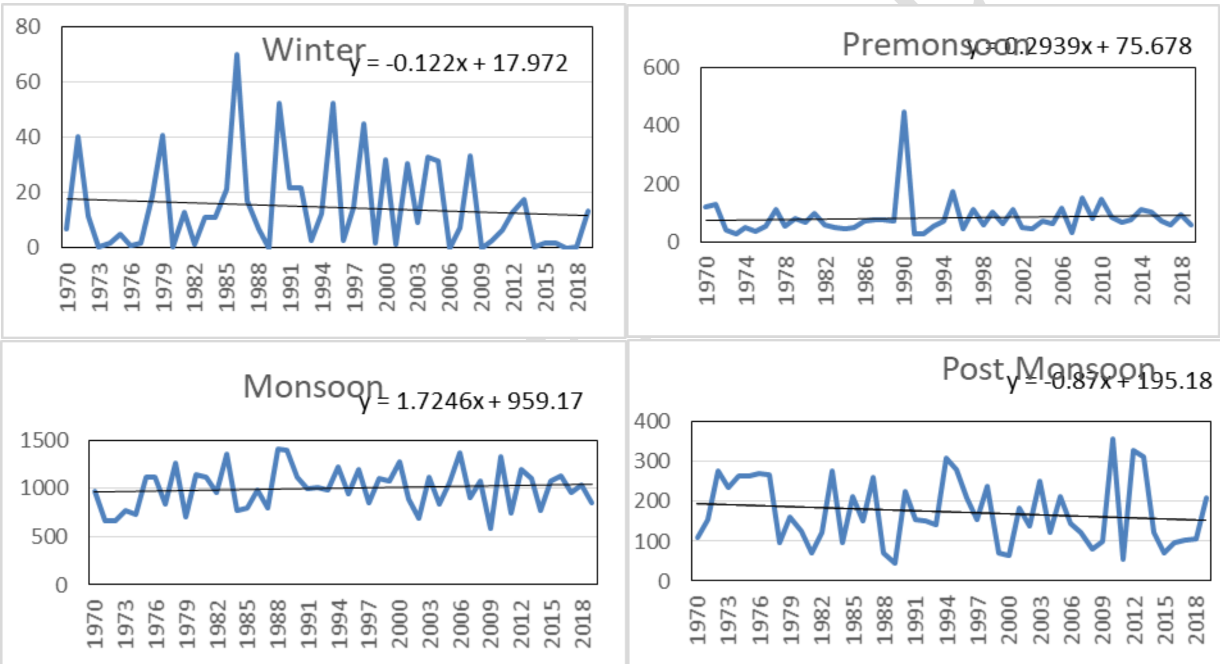


**Fig4. Shows the time series (1970-2019) of Season-wise rainfall over lower Godavari basin**

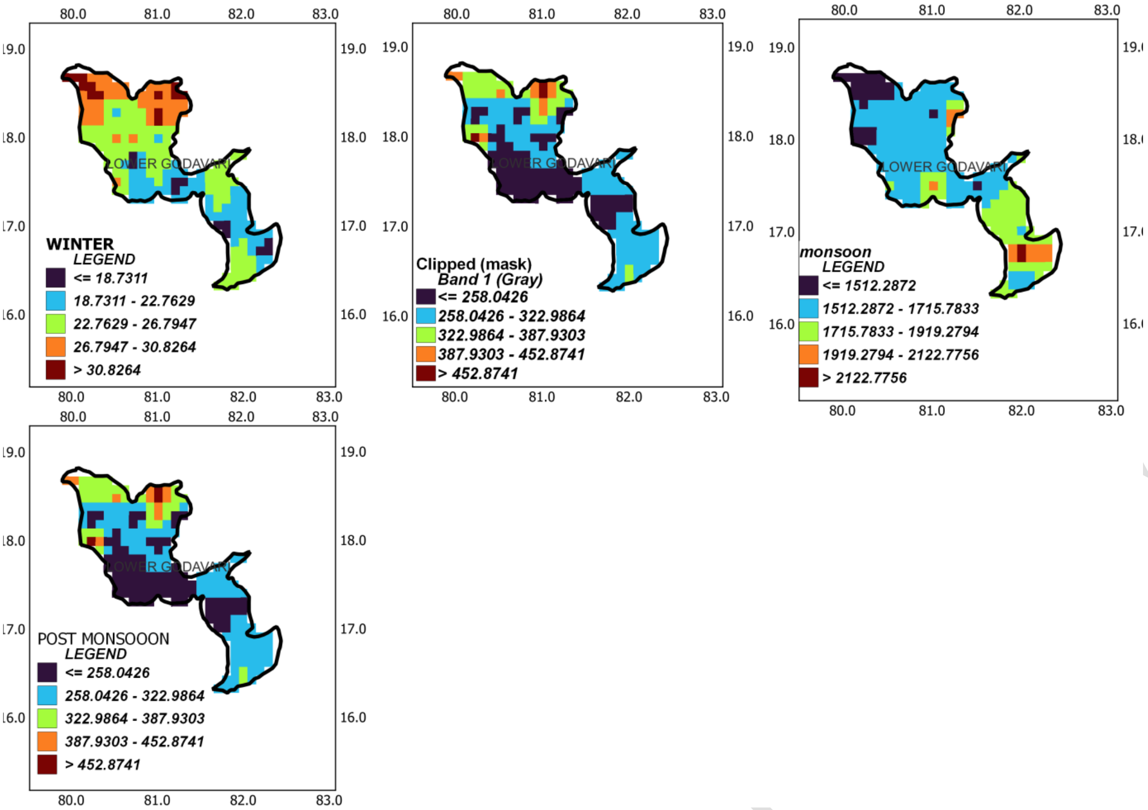


**Fig5 shows the spatial distribution of the mean seasonal rainfall for the lower Godavari basin**

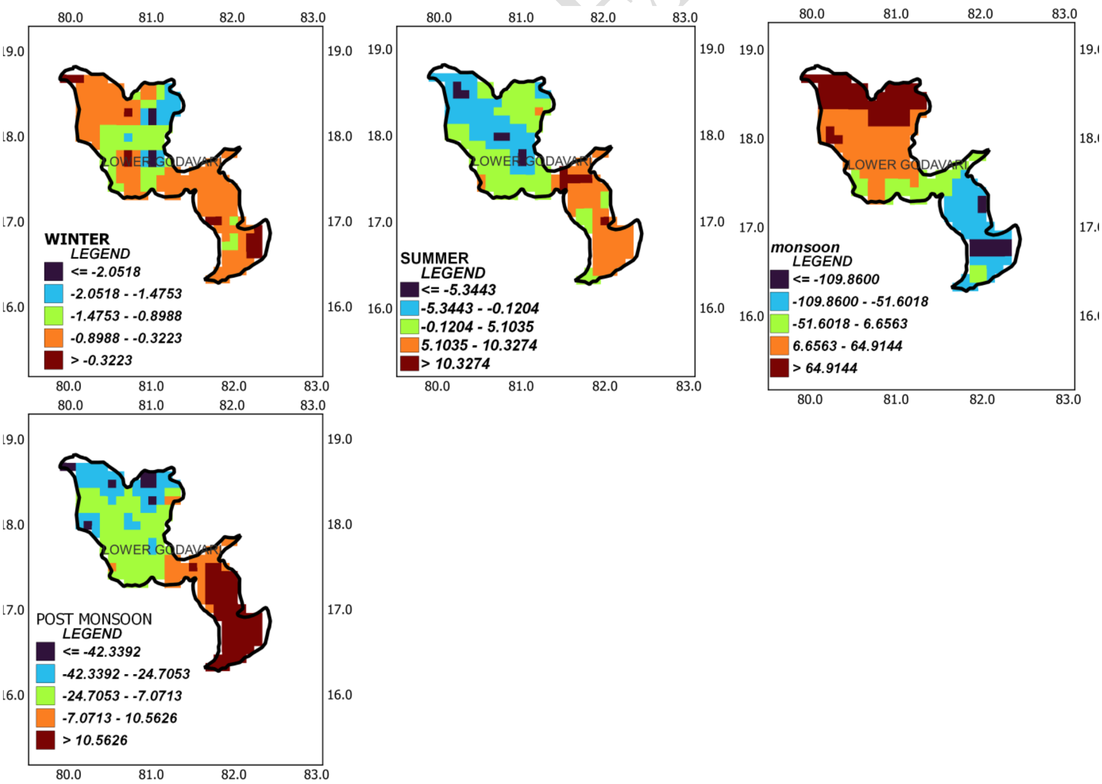


**Figure 6 shows the rainfall covariance of the lower Godavari basin.**

| | GRID NO. | Z VALUE | P VALUE | Sen's SLOPE | Trend |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | G1 | 3.086741 | 0.001012 | 0.040168 | ↑ |
| 2 | G2 | 1.455485 | 0.072767 | 0.018736 | no |
| 3 | G3 | 0.384783 | 0.350199 | 0.004494 | no |
| 4 | G4 | 3.580159 | 0.000172 | 0.047718 | ↑ |
| 5 | G5 | 1.631204 | 0.051424 | 0.03089 | no |
| 6 | G6 | 2.241782 | 0.012488 | 0.035056 | ↑ |
| 7 | G7 | 1.530823 | 0.062907 | 0.022142 | no |
| 8 | G8 | 1.714856 | 0.043186 | 0.023527 | ↑ |
| 9 | G9 | 1.564283 | 0.058876 | 0.028828 | no |
| 10 | G10 | 4.559007 | 2.57E-06 | 0.074749 | ↑ |
| 11 | G11 | 3.889795 | 5.02E-05 | 0.057482 | ↑ |
| 12 | G12 | -0.10875 | 0.456702 | 0.013496 | no |
| 13 | G13 | 0.82815 | 0.203793 | 0.010411 | no |
| 14 | G14 | 2.384068 | 0.008561 | 0.034925 | ↑ |
| 15 | G15 | 0.744498 | 0.228288 | 0.013496 | no |
| 16 | G16 | -1.34679 | 0.089024 | -0.01948 | no |
| 17 | G17 | 1.137621 | 0.127639 | 0.018512 | no |
| 18 | G18 | -0.22586 | 0.410656 | -0.00395 | no |
| 19 | G19 | 0.125477 | 0.450073 | 0.002915 | no |
| 20 | G20 | 0.711038 | 0.23853 | 0.00786 | no |
| 21 | G21 | -1.73159 | 0.041674 | -0.03044 | ↓ |
| 22 | G22 | -2.85252 | 0.002169 | -0.05731 | ↓ |
| 23 | G23 | 2.25867 | 0.011952 | 0.034176 | ↑ |
| 24 | G24 | 0.192398 | 0.423715 | 0.003429 | no |
| 25 | G25 | 2.936168 | 0.001661 | 0.038228 | ↑ |
| 26 | G26 | -0.82815 | 0.203793 | -0.0161 | no |
| 27 | G27 | -1.74832 | 0.040205 | -0.03015 | ↓ |
| 28 | G28 | 2.049462 | 0.020208 | 0.031023 | ↑ |
| 29 | G29 | 2.016001 | 0.0219 | 0.027254 | ↑ |
| 30 | G30 | 2.534641 | 0.005628 | 0.035981 | ↑ |

Table 1. is the analysis of the rainfall trends for the winter season.

| S.NO. | GRID NO. | Z VALUE | P VALUE | Sen's SLOPE | Trend |
|---|---|---|---|---|---|
| 1 | G1 | -0.31402 | 0.376754 | 0 | no |
| 2 | G2 | -0.54484 | 0.292933 | 0 | no |
| 3 | G3 | 0.337784 | 0.367763 | 0 | no |
| 4 | G4 | -0.9226 | 0.178107 | -0.00055 | no |
| 5 | G5 | -0.14389 | 0.442793 | 0 | no |
| 6 | G6 | 0.294475 | 0.384198 | 0 | no |
| 7 | G7 | 0.228535 | 0.409615 | 0 | no |
| 8 | G8 | -0.23157 | 0.408437 | 0 | no |
| 9 | G9 | 0.411692 | 0.340282 | 0 | no |
| 10 | G10 | 0.05925 | 0.476377 | 0 | no |
| 11 | G11 | -0.17086 | 0.432168 | 0 | no |

| | | | | | |
|---|---|---|---|---|---|
| 12 | G12 | -0.15324 | 0.439106 | 0 | no |
| 13 | G13 | 0.317335 | 0.375495 | 0 | no |
| 14 | G14 | -0.50827 | 0.305633 | 0 | no |
| 15 | G15 | -0.85131 | 0.197299 | 0 | no |
| 16 | G16 | -1.03024 | 0.151448 | -0.00068 | no |
| 17 | G17 | -0.18794 | 0.425461 | 0 | no |
| 18 | G18 | -0.52317 | 0.300427 | 0 | no |
| 19 | G19 | 0.008577 | 0.496578 | 0 | no |
| 20 | G20 | -0.37589 | 0.353501 | 0 | no |
| 21 | G21 | -1.5609 | 0.059274 | -0.00351 | no |
| 22 | G22 | -2.09798 | 0.017954 | -0.00499 | ↓ |
| 23 | G23 | -0.67072 | 0.251198 | -0.00044 | no |
| 24 | G24 | -0.17594 | 0.430172 | -0.0002 | no |
| 25 | G25 | -0.91708 | 0.179551 | -0.00097 | no |
| 26 | G26 | -1.74388 | 0.04059 | -0.0064 | ↓ |
| 27 | G27 | -0.37082 | 0.355385 | 0 | no |
| 28 | G28 | -0.72479 | 0.23429 | -0.00036 | no |
| 29 | G29 | -1.94079 | 0.026142 | -0.0072 | ↓ |
| 30 | G30 | -0.68745 | 0.245901 | 0 | no |

Table2 is the trend analysis of rainfall for the pre-monsoon season

| S.NO. | GRID NO. | Z VALUE | P VALUE | Sen's SLOPE | Trend |
|---|---|---|---|---|---|
| 1 | G1 | -3.68054 | 0.000116 | -0.44117 | ↓ |
| 2 | G2 | -3.39613 | 0.000342 | -0.65506 | ↓ |
| 3 | G3 | -3.64708 | 0.000133 | -0.53901 | ↓ |
| 4 | G4 | -4.28281 | 9.23E-06 | -0.55229 | ↓ |
| 5 | G5 | -3.49651 | 0.000236 | -0.85944 | ↓ |
| 6 | G6 | -3.86456 | 5.56E-05 | -0.59571 | ↓ |
| 7 | G7 | -1.53913 | 0.061886 | -0.12818 | no |
| 8 | G8 | 0.669189 | 0.251688 | 0.061548 | no |
| 9 | G9 | 0.936864 | 0.174414 | 0.073075 | no |
| 10 | G10 | -0.71938 | 0.235954 | -0.06635 | no |
| 11 | G11 | -2.77713 | 0.002742 | -0.32124 | ↓ |
| 12 | G12 | -0.75284 | 0.225774 | 0.103741 | no |
| 13 | G13 | 0.803026 | 0.21098 | 0.062863 | no |
| 14 | G14 | -1.05397 | 0.145948 | -0.09354 | no |
| 15 | G15 | 1.020513 | 0.153743 | 0.103741 | no |
| 16 | G16 | 1.321648 | 0.093143 | 0.133063 | no |
| 17 | G17 | 4.232618 | 1.15E-05 | 0.421048 | ↑ |
| 18 | G18 | 3.111727 | 0.00093 | 0.274853 | ↑ |
| 19 | G19 | 2.593106 | 0.004756 | 0.199105 | ↑ |
| 20 | G20 | 1.371837 | 0.085057 | 0.123184 | no |
| 21 | G21 | 1.923917 | 0.027182 | 0.179989 | ↑ |
| 22 | G22 | 2.877511 | 0.002004 | 0.245386 | ↑ |

| | | | | | |
|---|---|---|---|---|---|
| 23 | G23 | 4.450104 | 4.29E-06 | 0.378185 | ↑ |
| 24 | G24 | 4.767969 | 9.30E-07 | 0.476771 | ↑ |
| 25 | G25 | 5.32005 | 5.19E-08 | 0.547653 | ↑ |
| 26 | G26 | 5.219671 | 8.96E-08 | 0.543369 | ↑ |
| 27 | G27 | 3.914753 | 4.52E-05 | 0.406476 | ↑ |
| 28 | G28 | 4.68432 | 1.40E-06 | 0.447345 | ↑ |
| 29 | G29 | 5.554266 | 1.39E-08 | 0.58895 | ↑ |
| 30 | G30 | 2.459268 | 0.006961 | 0.288829 | ↑ |

Table 3. is the trend analysis of rainfall for the Monson season.

| S.NO. | GRID NO. | Z VALUE | P VALUE | Sen's SLOPE | Trend |
|---|---|---|---|---|---|
| | | | | | |
| 1 | G1 | 0.694307 | 0.243745 | 0.0231475 | - |
| 2 | G2 | 0.510274 | 0.30493 | 0.0193032 | - |
| 3 | G3 | 0.610656 | 0.270714 | 0.0226716 | - |
| 4 | G4 | 1.480632 | 0.069352 | 0.0554505 | - |
| 5 | G5 | 1.631204 | 0.051424 | 0.0692449 | - |
| 6 | G6 | 1.915619 | 0.027707 | 0.072624 | ↑ |
| 7 | G7 | 1.831968 | 0.033478 | 0.0782386 | ↑ |
| 8 | G8 | -1.78178 | 0.037393 | -0.0459465 | ↓ |
| 9 | G9 | -1.27987 | 0.100296 | -0.0345056 | - |
| 10 | G10 | 0.27605 | 0.391255 | 0.010801 | - |
| 11 | G11 | 0.82815 | 0.203793 | 0.0273141 | - |
| 12 | G12 | -1.81524 | 0.034744 | -0.0657785 | ↓ |
| 13 | G13 | -1.21295 | 0.112575 | -0.0292455 | - |
| 14 | G14 | -1.17949 | 0.119102 | -0.0359094 | - |
| 15 | G15 | -2.33388 | 0.009801 | -0.0657785 | ↓ |
| 16 | G16 | -3.88979 | 5.02E-05 | -0.1165946 | ↓ |
| 17 | G17 | -1.53924 | 0.061873 | -0.0357791 | - |
| 18 | G18 | -1.86543 | 0.031061 | -0.041145 | ↓ |
| 19 | G19 | -0.3597 | 0.359535 | -0.0096131 | - |
| 20 | G20 | -2.26696 | 0.011696 | -0.0457818 | ↓ |
| 21 | G21 | -4.7765 | 8.92E-07 | -0.1667198 | ↓ |
| 22 | G22 | -4.49209 | 3.53E-06 | -0.1788658 | ↓ |
| 23 | G23 | -4.09056 | 2.15E-05 | -0.2705587 | ↓ |
| 24 | G24 | -4.49209 | 3.53E-06 | -0.2682623 | ↓ |
| 25 | G25 | -4.29132 | 8.88E-06 | -0.2906275 | ↓ |
| 26 | G26 | -3.52173 | 0.000214 | -0.1699552 | ↓ |
| 27 | G27 | -3.82287 | 6.60E-05 | -0.1626151 | ↓ |
| 28 | G28 | -3.97345 | 3.54E-05 | -0.1901434 | ↓ |
| 29 | G29 | -4.27459 | 9.57E-06 | -0.2108459 | ↓ |
| 30 | G30 | -0.00837 | 0.496663 | -0.0002295 | - |

Table 4. is the trend analysis of rainfall for the post-Monson season.

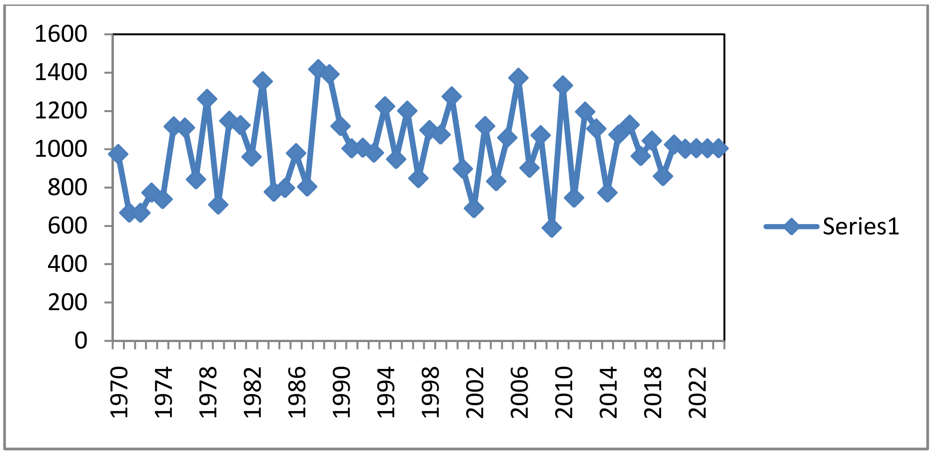


figure 7 :time series and regression analysis for the monsoon seasons, the time series analysis and the forecast for the next 5 years statistically.

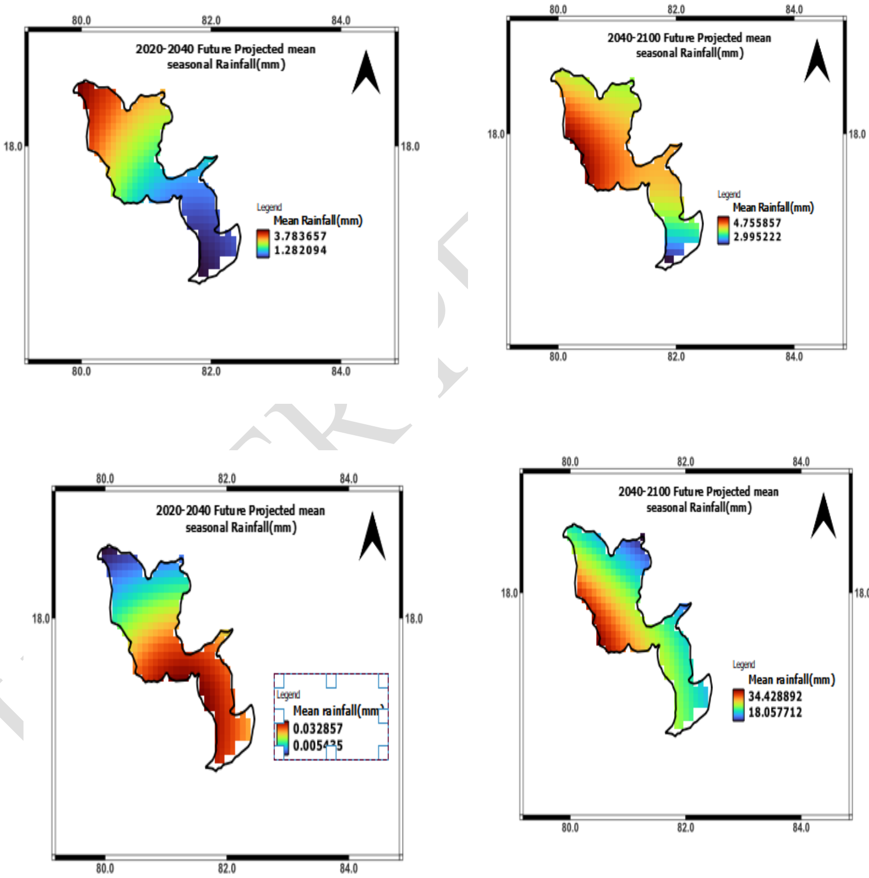


**Figure 8 shows future projects of the mean average rainfall for the lower Godavari basin from 2020-2040, 2040-2100 with RCP 4.5 and RCP 8.5 scenarios.**

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