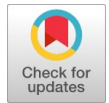


Spatio -Temporal Long-Term Variability and Trend Analysis of Precipitation and Temperature Series in the Ghataprabha (K3) Sub basin of Krishna Basin

Nagendra, Nagraj S. Patil, Nataraja M., Kulkarni Shashikanth



Abstract: Changing Climate is one of the most significant ecological issue, with the implications for agricultural production, water resource, energy and some other aspects of human well-being. Analysis of changing climate is important to assess climate-induced changes through the analysis of variability of climatic parameters such as temperature, precipitation, runoff and groundwater to suggest feasible adaptation strategies. This paper aims the long-term variability of rainfall and temperature using gridded daily data obtained from India Meteorological Department with 0.25° resolution from 1901-2016 for precipitation and 1° resolution from 1969-2005 for temperature (re-gridded to IMD 0.25° gridded location) in Ghataprabha sub basin (K3) of Krishna basin. The analysis of variability and trend in precipitation and temperature carried out by using coefficient of variation (CV), rainfall and temperature anomaly and also Mann-Kendall (MK) test was used to detect the time series trend. Statistical analysis of variability and trend in annual, Indian Summer Monsoon (ISM) rainfall and temperature observed that i) there is an intra and inter annual variability of precipitation in the sub basin ii) test results revealed that the annual and ISM trend appears to be increased by 0.12 & 0.14, iii) the Mann-Kendall trend test also analysed for annual minimum, mean and maximum temperature over the K3 sub basin (1969-2005) shows increasing trend by 0.06, 0.21 and 0.40. This analysis revealed that, there is an increasing trend in annual rainfall and temperature observed over the study region.

Keywords: Co-efficient of Variability, Ghataprabha Sub basin (K3), Mann-Kendall Trend Test, Rainfall, Temperature.

I. INTRODUCTION

The earth's atmosphere is experiencing a warming process due to global warming [1, 2, 3], this gradual increase in temperature of our planet is due to the increased anthropogenic greenhouse effect, which is considered to be a focal factor considerably affecting hydrological cycle and on the effectiveness of agricultural production systems with increased extreme events of rainfall and temperature [3, 4, 5]. Precipitation is the important variable which affects the crop productivity in general and rain-fed crops in particular. Agricultural productivity in India mainly depends on the spatial and temporal distribution of monsoon rainfall.

However, there is an uneven distribution of rainfall and +also becoming more erratic which may cause frequent draughts and floods. Temperature is another important variable which plays a significant role in the evaporation, transpiration and water demand, and hence considerably affects both the availability and requirement of water [6]. Over the past hundred years (1901-2007) the warming trend in India was observed to be 0.51°C with the enhanced warming of 0.21°C per decade since 1970 [7]. To know the variability in the extent and magnitude of climate change, rainfall and temperature are considered as the most significant variables in the field of climate studies and hydrology [8]. Understanding of current and past climate change evidence that the global climate is changing [9, 10], and has received more attention on the assessment of long term changes in the hydro-meteorological variables (rainfall and temperature) in perspective of climate change, mainly in the regions, where agriculture is mainly depends on rainfall, which emphasis to know climate-induced changes and recommend possible adaptation strategies [11].

II. STUDY AREA

To determine the spatio-temporal variation of rainfall and temperature, Ghataprabha (K3) sub basin was selected and is located in the Krishna river basin, India. The catchment area of the Ghataprabha sub basin (Fig. 1) is lies between northern latitudes 15° 45' and 16° 25' and 70° and 75° 55' eastern longitudes. The river rises from the Western Ghats in Maharashtra at an altitude of 884m, and flows 60km towards the east through the Sindgudurga and Kolhapur districts of Maharashtra. Catchment area of the river is 8829 km², out of which 6815.98 km² (77.2%) lies in Karnataka and rest 2013.01 km² (22.8%) falls under Maharashtra. Study area has a semiarid conditions, receives maximum rainfall in the monsoon season and the pattern of the rainfall varies from 5000mm (in a small portion of Western Ghats) to 600 mm in a eastern part [16]. Temperature (annual mean) of the basin varies from 25.1 to 26.6 °C.

III. DATA AND METHODS

A. Data

Long-term variability and trend in precipitation in the Ghataprabha sub basin is determined by using high-resolution 0.250 gridded data which is obtained from India Meteorological Department (IMD) from 1901-2016. In case of temperature, data is available at 10 x 10

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resolution (downloaded from: <https://swat.tamu.edu/software/india-dataset/>) obtained from IMD from 1969-2005 is regridded to IMD 0.25° gridded locations using two-dimensional linear interpolation technique (using Matlab) to make consistent with 0.25° precipitation grid locations. Specifically, from Fig. 1 it is observed that 35 grids covering in and around the subbasin (K3) is considered for the determination of variability and trend in the precipitation and temperature. The data of each individual grids are available on daily scale used to assess the variation and trend on annual, monthly and seasonal basis. Whereas, the seasonal period is considered for the Indian Summer Monsoon Rainfall (ISMR) period, which gives a higher understanding of the changing climate and its impacts on monsoon rainfall. Methods.

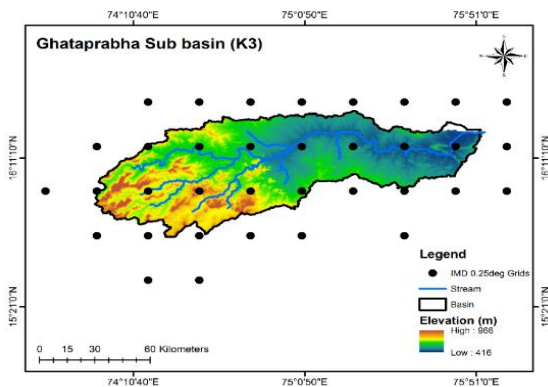


Fig. 1. Ghataprabha (K3) sub basin

B. Methods

Co-efficient of Variability (CV), Anomalies and Mann-Kendal (MK) trend tests were the methods used to know the long-term variability, anomalies and trends in rainfall (annually and during ISMR season) and temperature (mean, maximum and minimum,) for the Ghataprabha sub basin. Rainfall variability is determined by the statistical test coefficient of variation. A higher value of Co-efficient of Variation is the indicator of larger variability and contrariwise and is calculated with the following equation (1).

$$CV = \frac{\sigma}{\mu} \times 100 \quad (1)$$

Where,

CV - co-efficient of variation; σ - standard deviation and μ - mean precipitation. Based on the results, degree of variability of the rainfall events will be classified as, less ($CV < 20$), moderate ($20 < CV < 30$) and high ($CV > 30$) [11].

Similarly, anomalies in rainfall have been done to determine the dry and wet years to measure frequency of rainfall and severity of droughts and to identify the nature of trends [11, 12, 13, 14, 15] as eq. (2):

$$Z = \frac{(x_i - \bar{x}_i)}{s} \quad (2)$$

Where,

‘ Z ’- rainfall anomaly; ‘ x_i ’- annual rainfall of particular year; ‘ \bar{x}_i ’ - long term annual mean rainfall over a period of observation and ‘ s ’ - is a standard deviation of annual rainfall over the period of observation. Drought severity

classes are extreme drought ($Z < -1.65$), severe drought ($-1.28 > Z > -1.65$), moderate drought ($-0.84 > Z > -1.28$) and no drought ($Z > -0.84$) [14]. Rainfall and temperature anomalies results over the basin are presented based on average of all the individual grids. Further, the trend in rainfall and temperature (annually, ISMR) is tested by using the Mann-Kendal method. The non- parametric MK trend test was first proposed by Mann (1945) and it was further developed by Kendall (1975), which is generally used to know the monotonic trends in time series of climate or hydrological data [11].

The MK trend test determined on annual and seasonal basis. Specifically, study area receives rainfall during ISMR (June to September), these four months’ monthly trends have been analyzed separately. The trend is detected by comparing with each data value: i) for the data value from later time period is higher than a data value from an earlier time period, the statistic ‘S’ is incremented by ‘1’ ii) ‘S’ decremented by ‘1’ when the data value from a later time period is lower than a data value sampled earlier, the statistic. The results of all such increments and decrements gives the final trend value ‘S’. The trend statistic calculated based on [17, 18, 19] in detail discussed by [13]. In this analysis the long-term trend in rainfall and temperature (annually and during ISMR) is presented over the basin based, the test carried out by using Matlab.

IV. RESULT AND DISCUSSION

A. Variability Analysis

The co-efficient variation (CV) of rainfall is assessed for annual and seasonal (ISMR) periods for the K3 sub basin from 1901-2016, which shows moderate variation for annual rainfall events and moderate to higher variability in the ISMR seasonal events. Further, it is observed that the co-efficient of variability shows less in minimum, mean and maximum temperature over the K3 sub basin from 1969-2005.

B. Trend Analysis

In order to know the trend in climate variables (rainfall and temperature) over K3 sub basin, the non-parametric MK trend test is applied to time-series data from 1901-2016 (rainfall) and 1969-2005 (temperature). Fig. 2 shows the spatial distribution of MK trend tau value for the annual rainfall, ISMR rainfall, daily average minimum and maximum temperature over the K3 sub basin. Fig. 3 shows the long-term ISMR rainfall and annual from 1901-2016 with MK trend tau value over the K3 sub basin.

The analysis of trend in annual rainfall and seasonal ISMR shows increasing by 0.12 and 0.14. Specifically, from Table I, tau value of the rainfall shows increasing trend in the month of June (early stage of monsoon rainfall) and followed by the month of September (ending stage of monsoon rainfall). Then, the rainfall anomaly for the K3 sub basin shown in Fig. 4. Similarly, long-term changes in mean maximum and minimum, temperature over the K3 sub basin shown in below Fig. 5. Finally, the temperature anomalies



over the K3 sub basin shown in Fig. 6 respectively. In detail, the variability and trend in rainfall and temperature over the K3 sub b

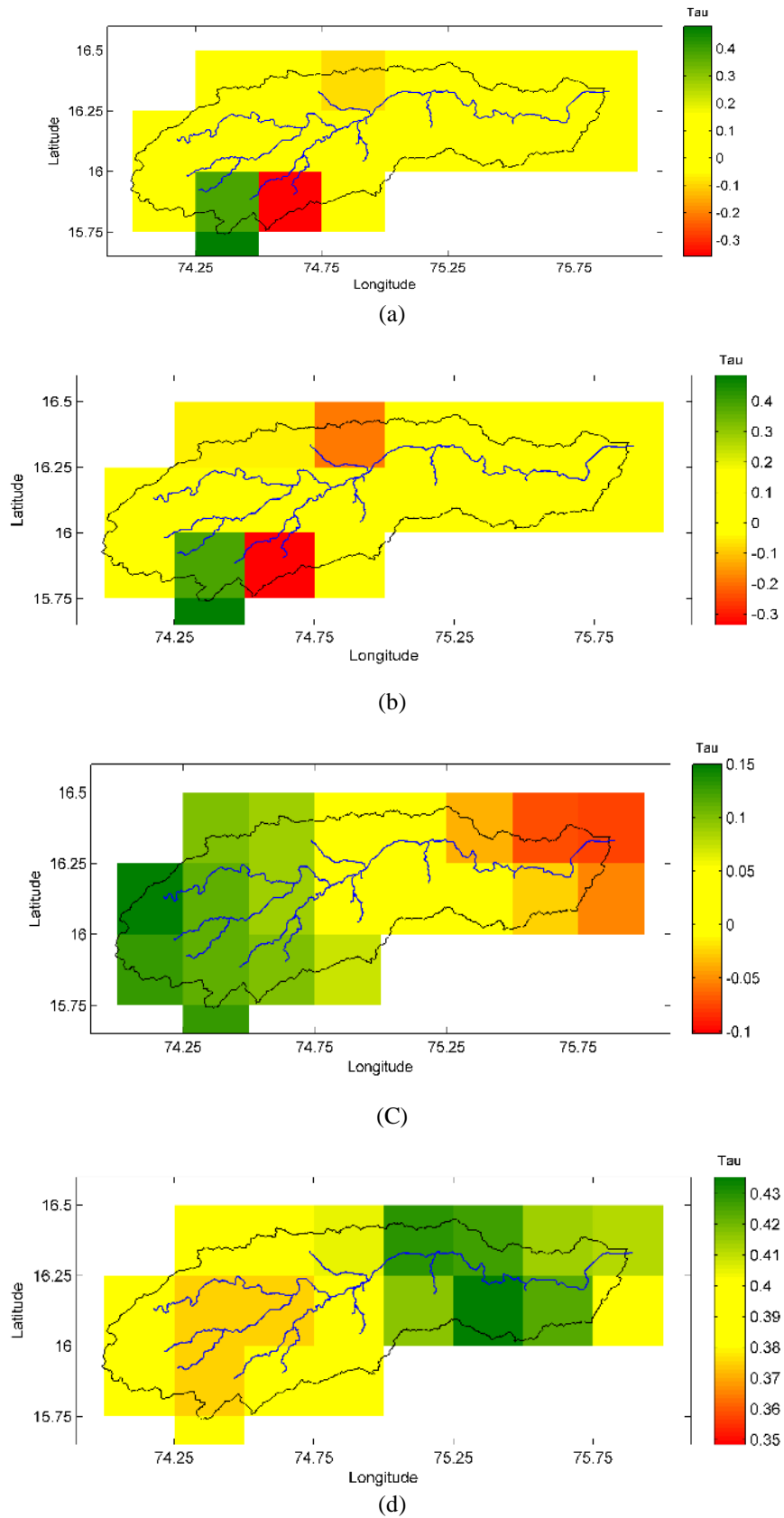


Fig. 2. Spatial distribution map of MK trend tau value over the Ghataprabha sub basin for annual rainfall (2a), ISMR rainfall (2b), daily average minimum temperature (2c) and daily average maximum temperature (2d).

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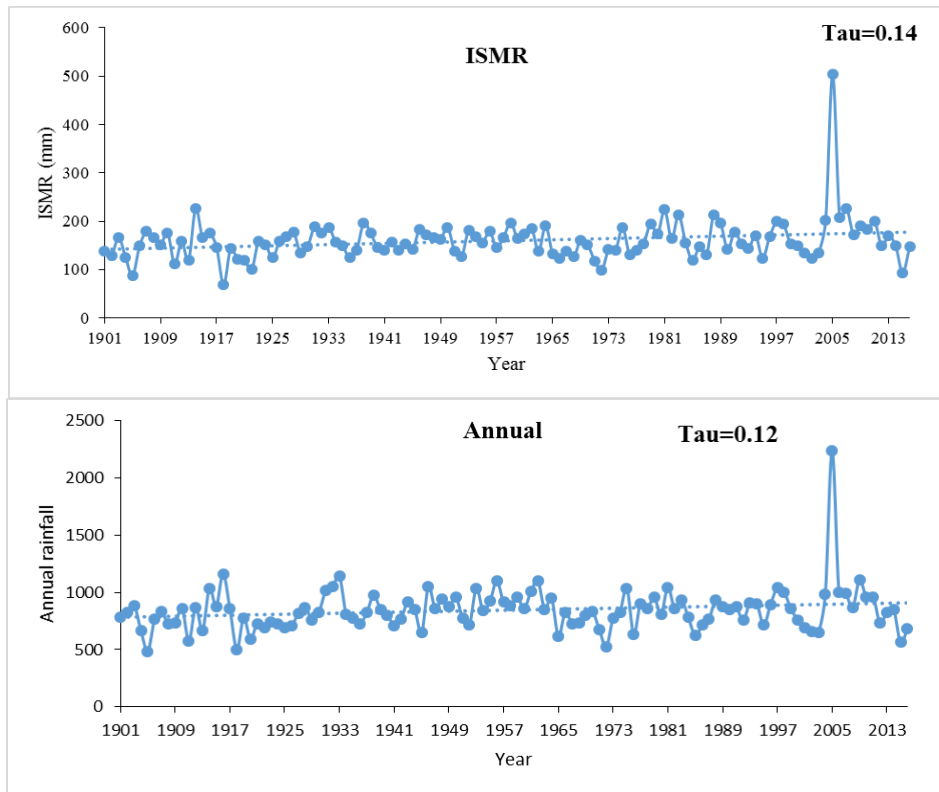


Fig. 3. ISMR and annual Rainfall pattern of K3 sub basin (1901-2016) with MK trend tau value

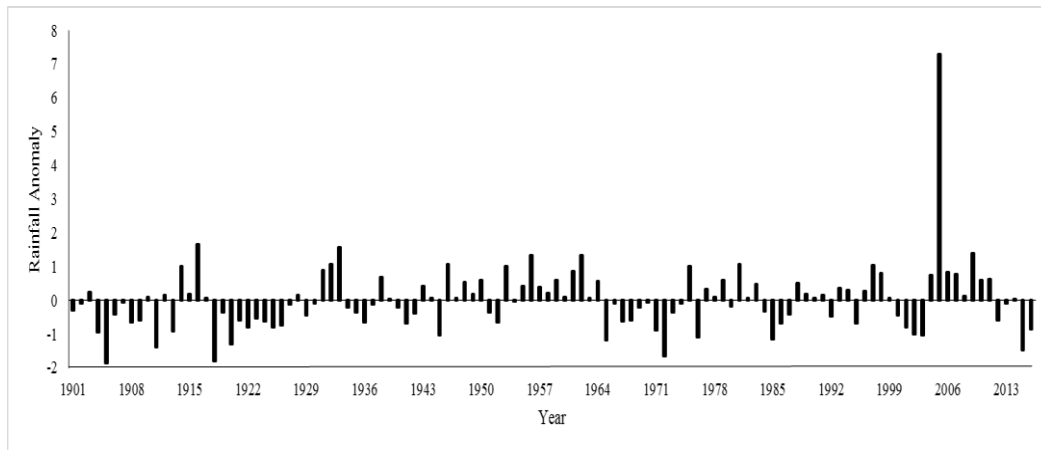
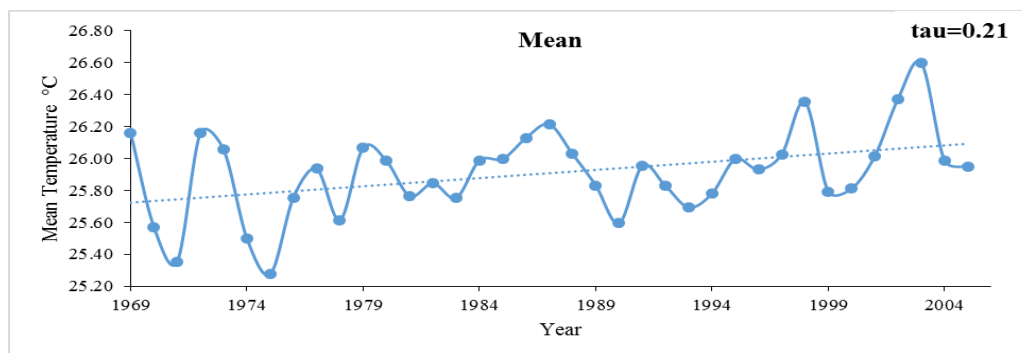


Fig. 4. Rainfall anomalies of K3 subbasin (1901-2016)



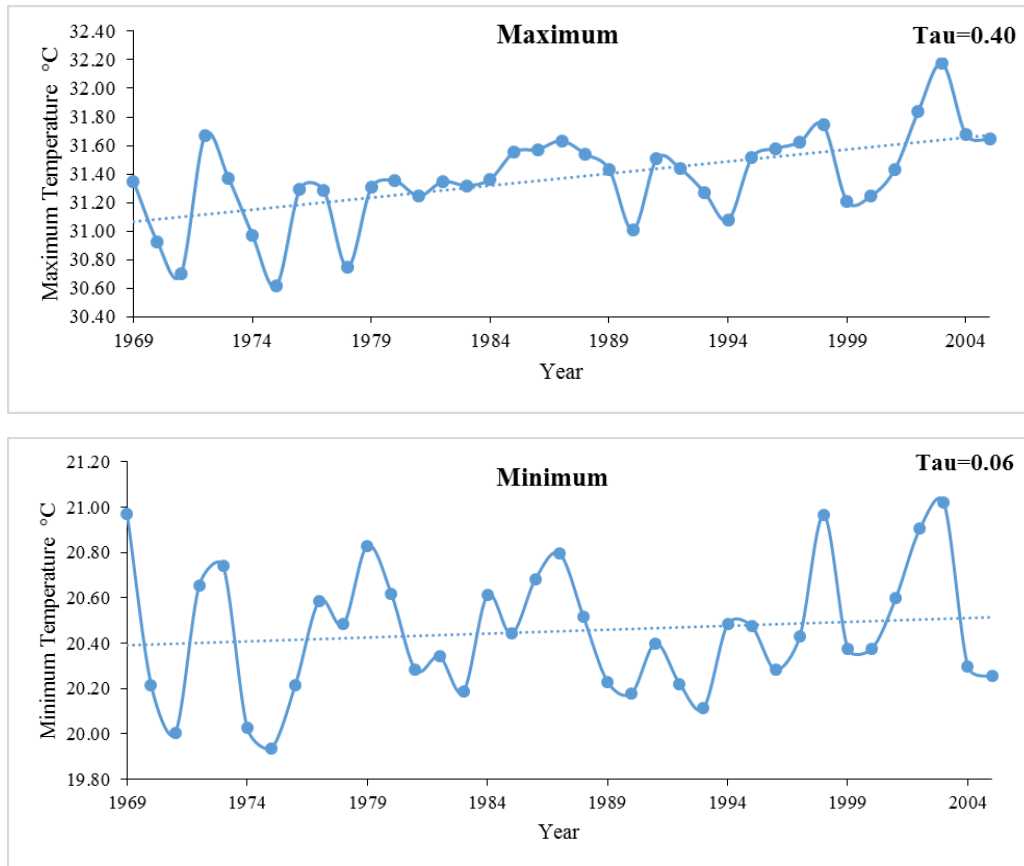


Fig. 5. Mean, Maximum and Minimum temperature pattern K3 sub basin (1969-2005) and MK trend tau value.

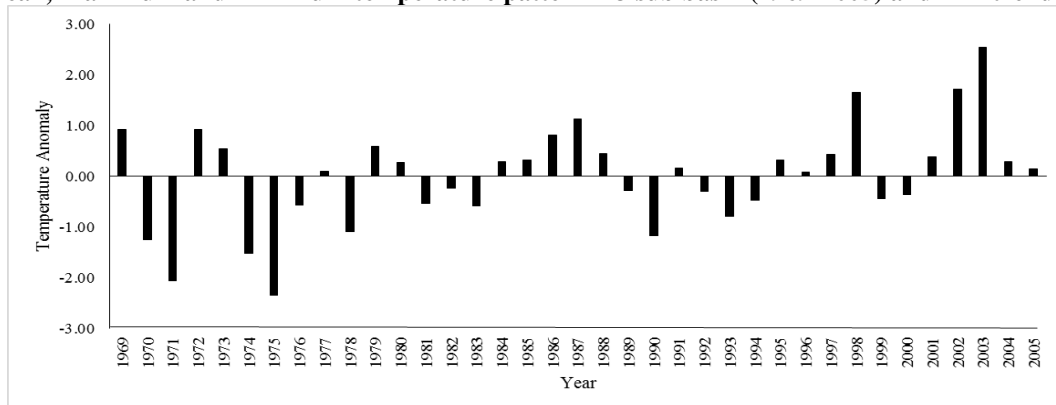


Fig. 6. Temperature anomalies of K3 sub basin (1969-2005).

Table-I: Rainfall and Temperature variability and trend in over K3 sub basin

Variable	Attribute	CV	Tau
Rainfall	Annual	22.68	0.12
ISMR	June	33.06	0.17
	July	38.68	0.03
	August	43.94	0.19
	September	43.05	0.003
Annual Temperature	Min.	1.38	0.06
	Mean	1.04	0.21
	Max.	1.02	0.40

V. CONCLUSION

Analysis of variability and trend in precipitation and temperature is a vital to understand under changing climate.

This paper aims to analyse the long-term variability of rainfall from 1901-2016 and temperature from 1969-2005 using gridded daily data obtained from India Meteorological Department in Ghataprabha sub basin (K3) of Krishna basin by using coefficient of variation (CV), rainfall and temperature anomaly and also Mann-Kendall (MK) test. Statistical analysis of variability and trend in annual, Indian Summer Monsoon (ISMR) rainfall and temperature observed that, there is a inter and intra annual variability of precipitation in the study area and from the trend test results, it is observed that the annual and ISMR trend appears to be increased by 0.12 & 0.14. Further, the trend in annual minimum, mean and maximum temperature over the K3 sub basin (1969-2005) shows increasing trend by 0.06, 0.21 and 0.40.



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This analysis is aimed at historical trend and variability analysis for time series data which gives a valuable information under changing climate over a historical period. It is recommended to extend this work by considering the future projected climate data to observe the future changes in the climate variables.

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Mr. Nagendra, completed his graduation in Civil Engineering and Post-graduation in Environmental Engineering, currently, he is a Research Scholar at Center for PG Studies, Visvesvaraya Technological University, Belagavi, Karnataka, India. His research areas include environmental engineering, waste water treatment, climate change, hydrological modelling, remote sensing and GIS, assessment of climate change impacts. He also attended a national and international conference.



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