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Assessment of Long Term Spatio-temporal Variability in Temperature over the Kalaburgi District, North Eastern Region of Karnataka, India

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ABSTRACT

In recent days observed extreme variations in the climate and weather events are increasingly being recognized as key aspects of climate change. ln this study we assessed the spatial-temporal variability of average temperature over the Kalaburgi district of Karnataka, India for the period 1981-2018, using gridded data with 0.5-degree resolution obtained from National Aeronautics and Space Administration prediction of worldwide energy resource (NASA POWER) project. Trend detection and quantification in the temperature evaluated using the non-parametric Mann-Kendall (MK) test and Sen's slope estimator. The overall average temperature data and Sen,s estimate showed the increasing trend in series for the last 38 years. The aveT from 1981 to 2018 for last 38 years observed spatially distributed over the entire study area in the range of 26.17 to 26.89 ºC.

KEYWORDS

Mann Kendall Test, Sen's estimator, Spatial analysis, Interpolation

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INTRODUCTION

Climate change is a change in annual, seasonal variation of weather conditions, or in the time variation of weather within the context of longer-term average conditions (IPCC, 2007). It has now proved that global and regional climate change is varying due to the increase of concentration of greenhouse gases in the atmosphere. It is also observed that the global mean surface temperature increased by 0.74 °C ± 0.18 °C from 1906 to 2005 (Trenberth *et al*, 2007). Intergovernmental Panel on Climate Change (IPCC) predictions indicate that average global surface temperature expected to rise by 1.4 to 5.8 °C by 2100 under different greenhouse gas emission scenarios (IPCC, 2007). Indian Network for Climate Change Assessment (INCCA) constituted by the Ministry of Environment and Forest, Government of India to assess the implications of climate change through scientific research and its impact assessments. According to (INCCA, 2010), the annual mean surface air temperature of Indian subcontinent is projected to rise by 1.7 °C and 2.0 °C in the 2030s. In the present century, climate change had become a significant concern, and atmospheric temperature is the dominant climatic factor that indicates the changes in both global and regional scales.

The study carried out by (Kothawale *et al*, 2010) to find out recent trends in pre-monsoon daily temperature extremes over India using daily data on maximum and minimum temperatures over a well-distributed network of 121 stations for the period 1970–2005. The time series of extreme temperature events have constructed for India as a whole and seven homogeneous regions, viz., Western Himalaya (WH), Northwest (NW), Northeast (NE), North Central (NC), East Coast (EC), West Coast (WC) and Interior Peninsula (IP). The results showed that during the pre-monsoon season, for India as a whole, the frequency of hot days and nights has increased. The number of cold days and nights reduced over the period. The trend in the frequency of cold days is significant at 5 per cent level.

The group of scientist analysed annual, seasonal and monthly trends in mean temperature, maximum temperature and minimum temperature at Florida, USA (Martinez *et al*, 2012). Data procured from United States Historical Climatology Network (USHCN) for the periods 1895-2009 and 1970-2009 for the state of Florida. The significance and magnitude of station trends determined using the non-parametric Mann-Kendall test and Sen's slope, respectively. Study revealed no significant differences for maximum and minimum temperature trends in the 1895–2009 and 1970–2009 periods respectively. Shen *et al* (1960) examined that spatio temporal change of temperature extremes in China from 1960 to 2011. Daily maximum and minimum temperature data collected from 437 weather stations were used to determine linear regression and Mann-Kendall statistical test. They revealed the temporal patterns of coldest day and night temperature different from the changes in corresponding mean temperatures. They also confirmed the nonlinear relationship between extreme temperature and corresponding mean temperature.The long-term spatial and temporal trends of meteorological data col-

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lected from 54 weather stations of North China District (NCD) from 1960–2015 analysed (Ti *et al*, 2018) . They applied Mann-Kendall (M-K) test and Sen's slope method for trend analysis. Study concluded annual average air temperatures (Tmin and Tmax) strong north to south increasing trends throughout the North China District.

They (Larbi *et al*, 2018) examined the trends in temperature extremes between 1985 to 2016 over the Vea catchment in Ghana. Trend detection and quantification in the extreme temperature indices were analysed using the non-parametric Mann–Kendall (MK) test and Sen's slope estimator. The results show that a very high seasonal correlation coefficient (r = 0.99), Nash–Sutcliff efficiency (0.98) and percentage bias (4.4 per cent and −8.1 per cent) between the stations and the gridded data. They concluded that spatial distribution analysis shows temperature extremes uniformly distributed over the catchment. The present study is undertaken to investigate the long term Spatio-temporal variability of average temperature and analysis of its trend in the Kalaburgi District, North Eastern Region of Karnataka, India.

MATERIALS AND METHODS

DESCRIPTION OF STUDY AREA

Location

The area selected for the present study comes under the north eastern dry zone of agro climatic condition of Karnataka state, India (Figure 1). The entire district located on Deccan plateau and altitude ranges from 300 to 750 m above Mean Sea Level (MSL). Most of the area is covered with black soil and to some extent red soil as well. The study area lies between 17°12′ and 17°46′ N latitude and 76º 04′ and 77°54′ E longitude.

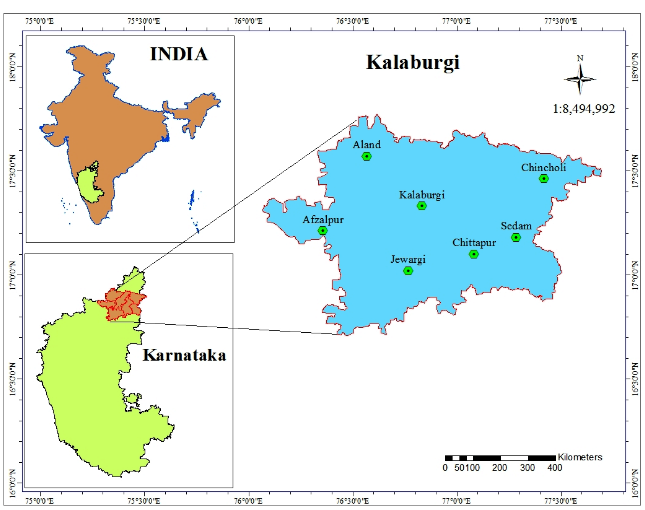

Fig. 1: Location of the study area

Climate

The climate of the district is generally dry with, temperature ranging from a minimum of 8 ºC to a maximum of 45 ºC and annual rainfall is about 750 mm. May is the hottest month with an average maximum temperature of 40 °C and December is the coldest month with an average minimum temperature of 15.9 °C. During peak summer, temperature shoots up to 45 ºC, average wind speed is 5.5 ms^{-1}, average day length varies from 10-12 hours and relative humidity varies from 26 per cent during summer to 62 per cent during rainy and winter season.

Data collection

In the present study data pertinent to study were collected and used for modelling as well as statistical analysis.

Temperature data

The long-term data of average temperature (°C) obtained from the National Aeronautics and Space Administration prediction of worldwide energy resource (NASA POWER) project. Historical data collected for 7 weather stations viz. Aland, Afzalpur, Chincholi, Chittapur, Kalaburgi, Sedam and Jewargi, for the periods of 1981-2018.

Statistical analysis

Statistical analysis of average temperature executed. For statistical data analysis spreadsheet package of MS Excel was used. The data analysis was carried out by using Mann-Kendall Test, Sen's slope estimator.

Trend Analysis

Long term temperature data from 1981 to 2018 were collected from the National Aeronautics and Space Administration prediction of worldwide energy resource (NASA POWER) project (https://power.larc.nasa.gov / data-access-viewer/), these data available freely worldwide in gridded form with 0.5 degree resolution. Trend analysis of temperature carried out to assess the long-term variability and trend slope of average temperature by Mann-Kendall test and Sen's slope estimator.

Mann- Kendall Test

Mann Kendall test (non -parametric test), is one of the commonly used tools for examining climatic and hydrologic time series data. Non-parametric methods focus on the location of the probability distribution of the sampled population, rather than specific parameters of the population. The outcome of the test is not determined by the overall magnitude of the data points, but it also depends on the ranking of individual data points. The Mann- Kendall test is often used to identify a trend in a series. The test is of non-parametric trend test is proposed by (Mann, 1945), further studied by (Kendall, 1975) and improved by (Hirsch *et al*, 1993). The Mann-Kendall statistic (S) measures the trend in the data. Detail about Mann Kendall test given in (Siddharam *et al*, 2020).

Sen's slope estimator

Linear trend in a time series can be estimated using a simple non-parametric procedure developed by (Sen, 1968). Detail about sen's slope estimator given in (Siddharam *et al*, 2020)

Spatial analysis

A Spatial Analysis Tool in the ArcGIS V. xx software was used for investigating spatial patterns in data.

Spatial Interpolation

The Spatial Analysis Tool in the ArcGIS V. xx software used for interpolation creating and analysing the map of long term annual meteorological data. The Inverse Distance Weighting (IDW) interpolation technique used to create the map of weather parameters of the study area. We used this technique because IDW technique takes the less neighboring unknown location points and it will give more accurate than the kriging and spline or any other interpolation technique. The spatial interpolation by IDW performed with the assumption that the attribute value of an unknown location with weighted average of a known location by assigning values to the unknown location using values from known neighboring locations based on the concept of distance weighting (Po *et al*, 2017). The collected average temperature data analyzed from 1981-2018 using deterministic IDW interpolation technique available in ArcGIS V. xx software.

RESULTS AND DISCUSSION

Spatial variability analysis

The spatial variability maps of collected data prepared to display the spatial distribution of parameters in the study area. The spatial variability analysis of average temperature carried out in ArcGIS Vr.xx in spatial analyst tool by IDW interpolation technique.

Average temperature

The spatial distribution maps of average temperature (Henceforth aveT) from 1981 to 2018 over the district of Kalaburgi prepared and presented in Figure 2 (a to e).

1991 to 2000, c) 2001 to 2010, d) 2011 to 2018 and e) 1981 to 2018.

The spatial distribution of aveT from 1981-1990 Fig. 2 (a) observed higher aveT in Afzalpur, Jewargi and part of Kalaburgi between 26.38 to 26.83 ºC as compared to part of Aland, Chincholi, Chittapur and Sedam with a range of 26.10 to 26.38 ºC from 1981 to 1990. During1991 to 2000 Fig. 2 (b) the spatial distribution of aveT observed slightly higher to the previous decade. Similar to previous decade the aveT also observed higher in Afzalpur, Jewargi and some part of Kalaburgi between 26.46 to 26.80 ºC and Aland, Chittapur, Chincholi and Sedam were lower temperature having with a range of 26.06 to 26.26 ºC. The spatial distribution of aveT between 2001 to 2010 Fig. 2 (c) in Kalaburgi, Jewargi and Afzalpur found in the range of 26.45 to 26.88 ºC and part of Aland, Chittapur, Chincholi and Sedam in between 26.13 to 26.45 ºC. The spatial variability of aveT from 2011 to 2018 Fig. 2 (d) observed warmer than last three decades with aveT in Afzalpur, Jewargi and Kalburgi, Aland, Chincholi and Chittapur with a range of 26.45 to 27.18 ºC. In the last four decades Fig. 2 (a to d) observed 0.4 ºC rise in the aveT. The aveT of last 38 years from 1981 to 2018 Fig. 2 (e) observed spatially distributed over the study area in the range of 26.17 to 26.89 ºC. The soil of Kalaburgi, Afzalpur and Jewargi is black colour, which absorbs the more heat from the incoming solar radiation, which influences the more temperature in these regions. The part of Aland, Chincholi, Chittapur and Sedam having black as well as red soil, because red soil reflect the incoming solar radiation more compared to black soil.

Time series analysis

Long term trend analysis of average temperature carried out for seven weather stations from study area for the period of 38 years.

Average Temperature (ºC)

Long term trend analysis of average temperature (henceforth, aveT) from 1981 to 2018 shown in Figure 3 (a to g), and Longterm average, yearly highest and lowest values of average temperature is presented in Table 1 for Aland, Afzalpur, Chincholi, Chittapur, Kalaburgi, Sedam and Jewargi respectively. The aveT in Aland observed highest with 27.08 ºC in 2003 and lowest with 26.28 ºC in 1990 shown in Fig 3 (a). The aveT with 26.23 ºC, Mann- Kendall test (Z) with 1.84 and Sen's slope (Q) with 0.013 found in the Aland (Table 1). In Afzalpur recorded aveT, highest with 27.75 ºC (2003) and lowest with 26.28 ºC (1990) presented in Fig 3 (b).

Also, observed aveT with average with 26.83 ºC, Mann-Kendall test (Z) with 2.06 and Sen's slope (Q) with 0.013. The aveT highest with 27.34 ºC in 2018 and lowest with 26.04 ºC in 1990 and also aveT with 26.47 ºC, and statistical results for Mann- Kendall test (Z) with 1.28 and Sen's slope (Q) with 0.010 observed in Chincholi presented in (Figure 3 (c)).

Table 1: Mann- Kendall trend (Z), Sen's slope value (Q), Long term average, yearly highest and lowest values of Average Temperatures

Places/ Indices	Average Temperature,°C				
	Z	Q	Highest	Average	Lowest
Aland	1.84	0.013	27.09	26.23	25.06
Afzalpur	2.06	0.013	27.75	26.83	26.08
Chincholi	1.22	0.008	27.34	26.47	25.81
Chittapur	1.28	0.010	27.34	26.47	25.81
Kalaburgi	1.58	0.011	27.63	26.79	26.16
Sedam	1.22	0.009	27.34	26.47	25.81
Jewargi	1.58	0.011	27.63	26.74	26.16

The aveT with 26.45 ºC, Mann- Kendall test (Z) with 1.28 and Sen's slope (Q) with 0.010 and highest with 27.40 ºC (2018) and lowest with 26.06 ºC (1990) observed in Chittapur exhibited in Fig 3 (d). In the Kalaburgi observed aveT highest with 27.54 ºC in 2018 and lowest 26.30 ºC in 1996 and aveT average with 26.80 ºC, Mann- Kendall test (Z) with 1.58 and Sen's slope (Q) with 0.011 shown in Fig 3 (e).The aveT average with 26.48 ºC, Mann- Kendall test (Z) with 1.28, Sen's slope (Q) with 0.010, highest with 27.35 ºC in 2018 and lowest with 26.08 ºC in 1990 observed in Sedam shown in Fig 3 (f). In the Jewargi aveT recorded highest with 27.58 ºC in 2018 and lowest with 26.29 ºC in 1990 shown in Fig 3 (g). Also, the aveT observed average with 26.80 ºC, Mann- Kendall test (Z) with 1.58 and Sen's slope (Q) with 0.011 for Jewargi in the last 38 years (Table 1). The aveT exhibited increasing trend

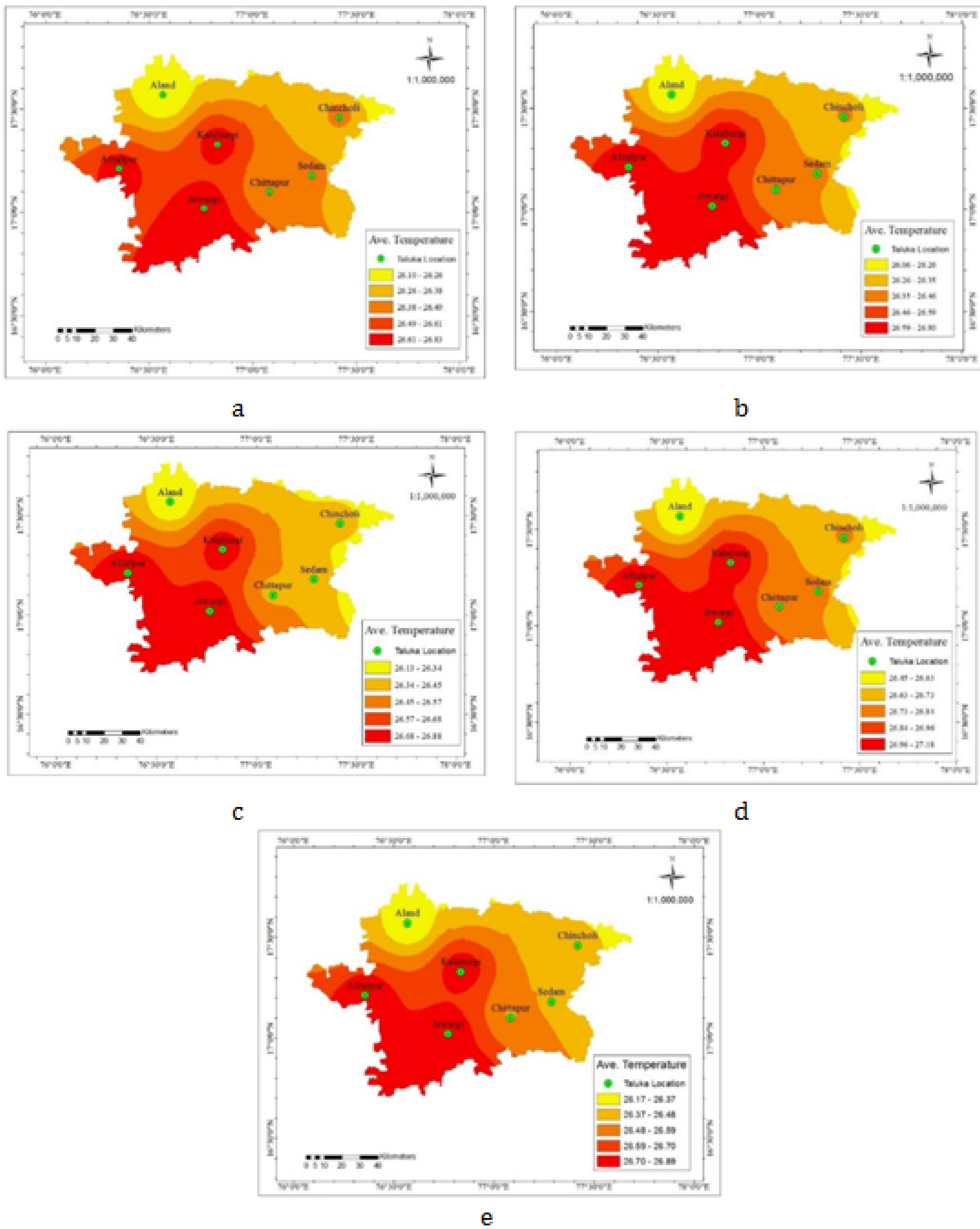

Fig. 2: Spatial variability maps of average temperature, ^{0}C, for a) 1981 to 1990, b)1991 to 2000, c) 2001 to 2010, d) 2011 to 2018 and e)1981 to 2018

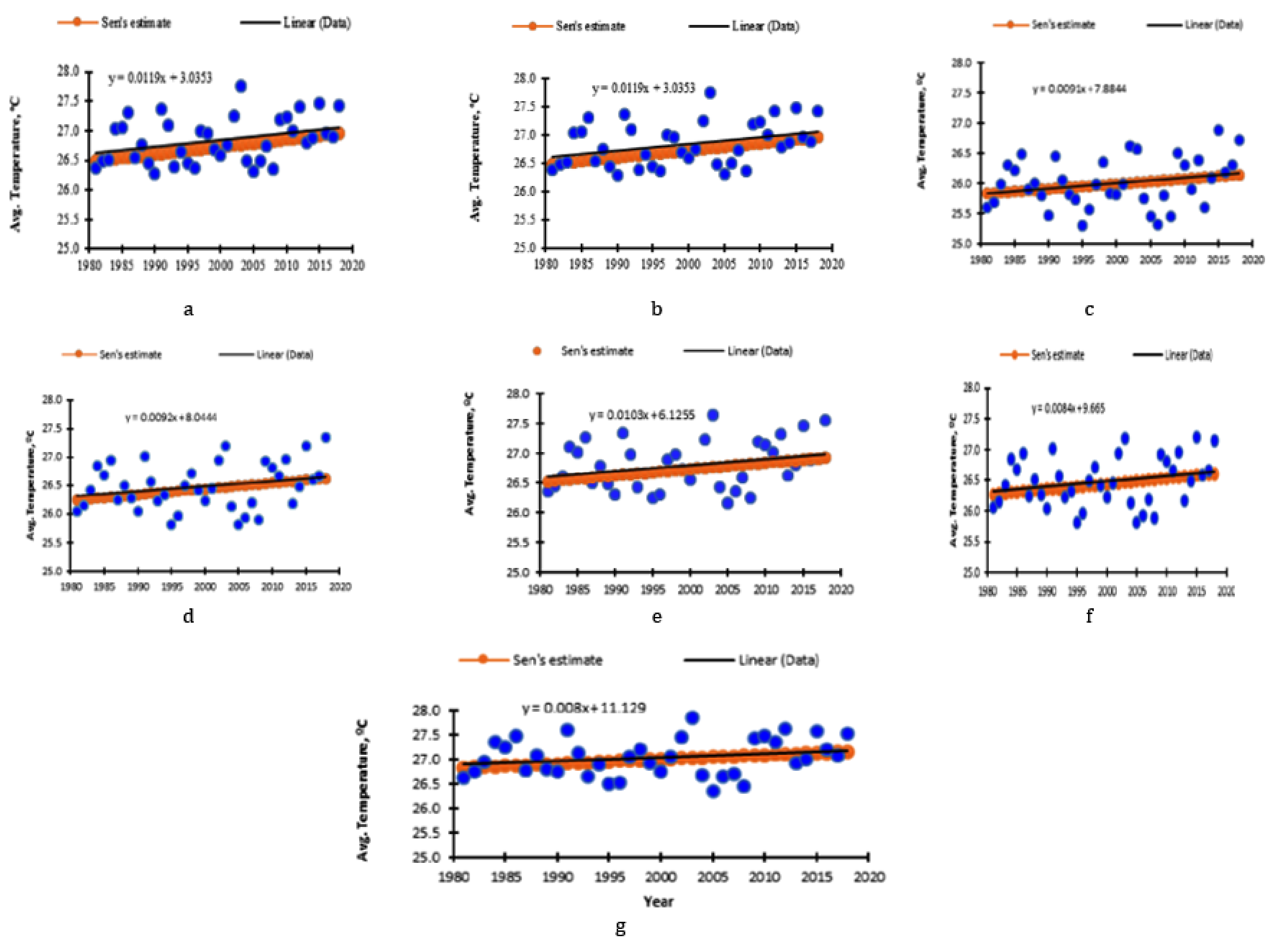

Fig. 3: Trend analysis of average temperature, °C, from 1981 to 2018 for a) Aland b) Afzalpur c) Chincholi d) Chittapur e) Kalaburgi f) Sedam and g) Jewargi

linearly in the long-term time series and Sen's estimate also observed similar trend. It was suggested by (Martinez *et al*, 2012) that significant decreasing trends in monthly precipitation in October and May for the 1895-2009 and 1970-2009 periods, respectively. Study revealed no significant differences for maximum and minimum temperature trends in the 1895–2009 and 1970–2009 periods, respectively.

CONCLUSION

The average, maximum temperature and minimum temperature is the most important climatic parameters which influence the agriculture in a given region. The non-parametric statistical methods Mann Kendall test and Sen's slope estimator were used to establish the trend in parameters.

The major conclusions drawn from the study are:

- The highest aveT is observed densely distributed over the Jewargi with a range of 24.74 to 26.68 ºC and all other places found sparsely distributed with range 19.98 to 23.50 ºC.
- The aveT from 1981 to 2018 for last 38 years observed spatially distributed over the entire study area in the range of 26.17 to 26.89 ºC.
- The aveT exhibited increasing trend linearly in the long-term time series and Sen's estimate.

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