

RESEARCH PAPER

# Assessment of Climate Variability in Least and Highly Vulnerable Districts of Karnataka

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## ABSTRACT

Karnataka is the second largest drought prone area in the country next only to Rajasthan and water availability is one of the major concerns in the state. The present study was conducted in eight districts based on the composite climate vulnerability index. Climatic data on rainfall, relative humidity, wind speed, minimum temperature, maximum temperature and average temperature from 1981 to 2018 were collected. The results revealed that in least vulnerable districts (LVD) shift in precipitation was significant and not homogeneous from 1990. Whereas, precipitation in highly vulnerable districts (HVD), both Pettitt's test and Buishand test were not rejected and intensity of rainfall pattern has not changed over years from 2010. Wind speed in LVD was not homogeneous from 2000 and similar results were found for the HVD. Shift in relative humidity was statistically significant according to Buishand's test in LVD and not homogenous from 2015. In HVD results were found to be not significant. Maximum temperature in LVD is homogeneous since the null hypothesis for the Pettitts test was not rejected at 5 per cent level of significance and it was not statistically significant. Whereas, in highly vulnerable districts, it was found to be significant according to Buishand's test and not homogenous from 2001.

## HIGHLIGHTS

- This paper focuses on relationship between climate vulnerability and variability in different districts of Karnataka.

**Keywords:** Vulnerability, Exposure, Sensitivity, drought, least and highly vulnerable

The concern about climate change and its variability has gained greater attention from the scientists and academicians all around the world in the recent years in view of its evil impacts on our ecosystem, food production and on human livelihood. Farming is persistently and directly influenced by rainfall, temperature and other climatic variables. Climate change and environmental vulnerability pose a great hazard to the world's agricultural and natural resource frameworks (Sagar, 2016). Climate change is a continuous phenomenon and over hundreds of years, the atmosphere has changed considerably around the world. However, the pace and pattern of changes in climatic factors in recent decades have turned into a matter of concern. Especially, since it

is very hard to comprehend the effect of change in climatic factors at the small scale level even, say, at block or district levels (Raju *et al.* 2017). The Inter governmental Panel on Climate Change (IPCC), in its second evaluation report (Anonymous, 1996), characterizes vulnerability as the degree to which environmental change may harm or damage a system. It infers that vulnerability not only depends on a system of sensitivity, but also in addition, on its capacity to adjust to new climatic conditions, the

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level of economic development and institutions. The climate change varies across the locations due to differences in the level of exposure and vulnerability of various systems, be it ecosystems, economic sectors, or social groups. For the above reasons, assessment of the vulnerability of a system is one of the critical steps to identify adequate adaptation measures to adapt to the risks of climate change. Agricultural economy in Karnataka is largely influenced by agroclimatic factors, water and other resource endowments of farmers, technology, infrastructure, tradition, social capital as also the market forces of demand and supply. This research attempts to understand the changes taking place in climatic variables like temperature, rainfall and relative humidity which are important from agriculture point of view.

## MATERIALS AND METHODS

### Selection and description of the study area

Karnataka state having second largest area under drought prone in the country next only to Rajasthan and water availability is one of the major concerns in the state. The present study was conducted in eight districts of Karnataka state *viz.*, Bidar, Koppal, Kolar, Chitradurga, Davanagere, Shivamogga, Udupi and Dakshina Kannada by covering all three

meteorological sub divisions *viz.*, North Interior, South Interior and Coastal Karnataka. The study area was purely selected based on the composite climate vulnerability index (Table 1).

For easy comparison, districts were classified as least vulnerable and highly vulnerable using below mentioned criteria.

The arithmetic mean ( $\bar{X}$ ) and standard deviation (SD) of composite vulnerability index were calculated in order to demarcate boundaries between least and highly vulnerable districts.

**Least vulnerable districts:** Mean minus standard deviation ( $\bar{X}-SD$ ) of composite vulnerability index to demarcate least vulnerable districts (0.440 to 0.528).

**Highly vulnerable districts:** Mean plus standard deviation ( $\bar{X}+SD$ ) of composite vulnerability index to demarcate the highly vulnerable districts (0.628 to 0.677).

The data for the study was collected from multiple sources. Climatic data on rainfall, relative humidity, wind speed, minimum temperature, maximum temperature and average temperature from 1981 to 2018 was collected from Karnataka State Natural Disaster Monitoring Centre and All India Coordinated Research Project on Agrometeorology, University of Agricultural Sciences, GKVK,

**Table 1:** Composite index of vulnerability for different districts of Karnataka

Sl. No.	Districts	Composite index	Sl. No	Districts	Composite index
1	Bidar	0.677	16	Chamarajanagar	0.579
2	Kolar	0.658	17	Mysuru	0.574
3	Yadgir	0.638	18	Tumakuru	0.573
4	Koppal	0.636	19	Hassan	0.571
5	Raichur	0.628	20	Bengaluru rural	0.558
6	Chitradurga	0.628	21	Mandya	0.557
7	Kalaburagi	0.625	22	Belagavi	0.555
8	Ramanagara	0.604	23	Ballari	0.543
9	Vijayapura	0.602	24	Bengaluru urban	0.538
10	Gadag	0.599	25	Chikkamagaluru	0.531
11	Dharwad	0.596	26	Uttara kannada	0.530
12	Kodagu	0.594	27	Dakshina kannada	0.528
13	Chikkaballapur	0.593	28	Udupi	0.486
14	Bagalkot	0.590	29	Davanagere	0.486
15	Haveri	0.580	30	Shivamogga	0.440

Average = 0.577

Source: Shivakumara and Murthy, 2019.

Bengaluru. The data were subjected to validation and missing values were filled using NASA Satellite Power DATA sources for the same period and location. The data period of 1981 to 2018 was used based on availability of data pertaining to relative humidity and wind speed.

**Analytical tools and technique employed**

**Temporal variability of climate parameters**

Information on weather parameters such as annual rainfall, minimum temperature, maximum temperature and relative humidity were analyzed for the period 1981-2018 to determine the trend and behavior of climate variables and were subjected to homogeneity tests. Homogeneity tests were performed to analyze the exact time series data change or split. The Pettitt test and the Buishand test were used to check the homogeneity with following null and alternate hypotheses.

$H_0$ : Data are homogeneous

$H_a$ : There is a break in the series of data related to rainfall, temperature and relative humidity

**(a) Pettitt’s test**

The Pettitt’s test is a non-parametric test and is commonly used in time series data for finding a single break point. Also the test is more effective to detect breaks in any sequence in the centre. Pettitt’s experiment was first developed and published by Pettitt in 1979.

The ranks from  $t_1, \dots, t_n$  of the  $Y_1, \dots, Y_n$  are used to calculate the statistics.

$$X_k = 2 \sum_{i=1}^k t_i - r(n+1)$$

Where,

$t_i$  = Time period

$r$  = Distribution function

$n$  = Sample length

The statistic is maximal or minimal near the year  $k$ , if a break occurs in year  $k$

$$X_k = \max_{1 \leq k \leq n} |X_k|$$

The critical value ( $X_{\alpha}$ ) or the statistical significance (for probability level) at  $\alpha$  is given as below,

$$X_{\alpha} = \sqrt{\frac{-\ln \alpha (n^3 + n^2)}{6}}$$

Where,

$\alpha$  = Confidence level

If the value of  $X_k$  is greater than  $X_{\alpha}$  at specified level of  $\alpha$ , the null hypothesis will be rejected.

**(b) Buishand test**

Buishand test is also a non-parametric test used in the long-term climate data analysis to verify the break or change. In the earlier and later part of the data sets, the test is also more sensitive to breaks. Buishand test was first used to analyze rainfall data in Netherlands during the year 1982. The adjusted partial sums are defined in this test as,

$$s_j^* = \sum_{i=1}^j (Y_i - \bar{Y})$$

$$S_0 = 0 \quad j = 1, 2, \dots, n$$

Where,

$s_j^*$  = Adjusted partial sum

$Y_i$  = Sample observations

$\bar{Y}$  = Mean of the observations

The values of  $s_k$  will fluctuate about zero when a series is homogeneous, because there will be no systematic variations of the  $Y_i$  values with respect to their mean. If there is a break in the year, then  $S_k^*$  can reach a maximum (negative shift) or minimum (positive shift) close to the year  $k = n$ . The sense of the change can be measured with the rescaled modified range  $R$ , which is the difference between the maximum and minimum values of the  $S_k^*$  multiplied by the normal sample deviation, but it is more prone to breaks in the middle of a time series.

$$Q = \max |s^*|$$

$$R = (\max s_k^* - \min s_k^*)/s$$

Buishand gives critical values for  $R/\sqrt{n}$

**RESULTS AND DISCUSSION**

Temporal variability of key climate parameters such as rainfall, temperature, wind speed and relative

humidity was analysed. The homogeneity test was used to assess the change (increase or decrease) or break point in long-term weather parameters. In terms of assessment of precipitation, the total annual rainfall was considered and in case of temperature, monthly maximum and minimum temperatures over the years, yearly data on wind speed and relative humidity from the year 1981 to 2018 was considered for analysis.

### Variability in precipitation

The homogeneity test was carried out for the data to identify the shift in precipitation received over the years. Two tests such as Pettitt’s test and Buishand test were employed in the homogeneity test analysis. The tests which are proved to be significant statistically were presented and interpreted in this section. The precipitation data pertaining to LVD and HVD was analysed by employing homogeneity test for the period 1981 to 2018. Table 2 shows the results of the homogeneity tests for LVD and HVD.

**Table 2:** Homogeneity test to identify the shift in precipitation

	LVD		HVD	
	Pettitt’s test	Buishand’s test	Pettitt’s test	Buishand’s test
t	2014	1990	2010	2010
p-value (Two-tailed)	0.577	0.051	0.572	0.150

Based on these results, precipitation in LVD is homogeneous since the null hypothesis for the Pettitts test was not rejected at 5 per cent level of significance and it was not statistically significant from 2014. According to Buishand test, shift in precipitation was significant and not homogeneous from 1990 (Fig. 1). Whereas, with reference to precipitation in HVD both Pettitt’s test and Buishand test were not rejected and intensity of rainfall pattern has not changed over years from 2010 (Fig. 2). These findings are in confirmatory with the results of the Dourte *et al.* (2015) and Rani *et al.* (2014). The results of which revealed that there was no change in the amount of annual rainfall.

### Variability in Wind speed

Table 3 depicts the results of homogeneity test conducted to identify the shift in wind speed

for LVD and HVD for the period 1981 to 2018. According to Pettitt’s and Buishand’s test wind speed in LVD was not homogeneous from 2000 and 2001 respectively, since the null hypothesis for both tests were rejected at 5 per cent level of significance.

**Table 3:** Results of homogeneity test conducted to identify the shift in wind speed

	LVD		HVD	
	Pettitt’s test	Buishand’s test	Pettitt’s test	Buishand’s test
t	2000	2001	2000	2001
p-value (Two-tailed)	0.002	0.004	0.002	0.004

Similar results were found for the HVD, i.e., both tests were significant and not homogenous from 2000 in Pettitt’s test and 2001 in Buishand’s test. The results are in line with findings of Molina *et al.* (2014).

### Variability in relative humidity

The results of the homogeneity tests to identify the shift in relative humidity for least vulnerable and HVD for the period 1981 to 2018 has been presented in the Table 4.

**Table 4:** Homogeneity test to identify the shift in relative humidity

	LVD		HVD	
	Pettitt’s test	Buishand’s test	Pettitt’s test	Buishand’s test
t	2002	2015	2010	2010
p-value (Two-tailed)	0.330	0.016	0.631	0.084

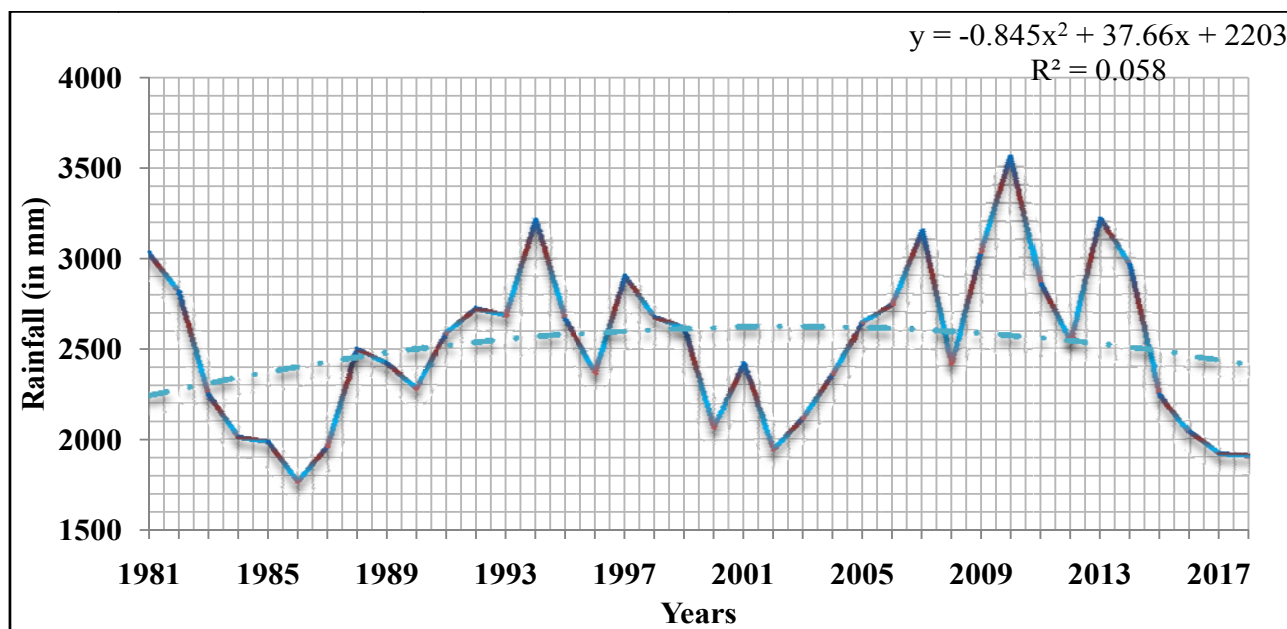
Shift in relative humidity was statistically significant according to Buishand’s test in LVD and not homogenous from 2015 (Fig. 3), whereas according to Pettitt’s test, it was not statistically significant. In HVD results were found to be not significant (Fig. 4) in both Pettitt’s test and Buishand’s test. These results are in line with the results of Tudorache *et al.* (2017).

### Variability in temperature

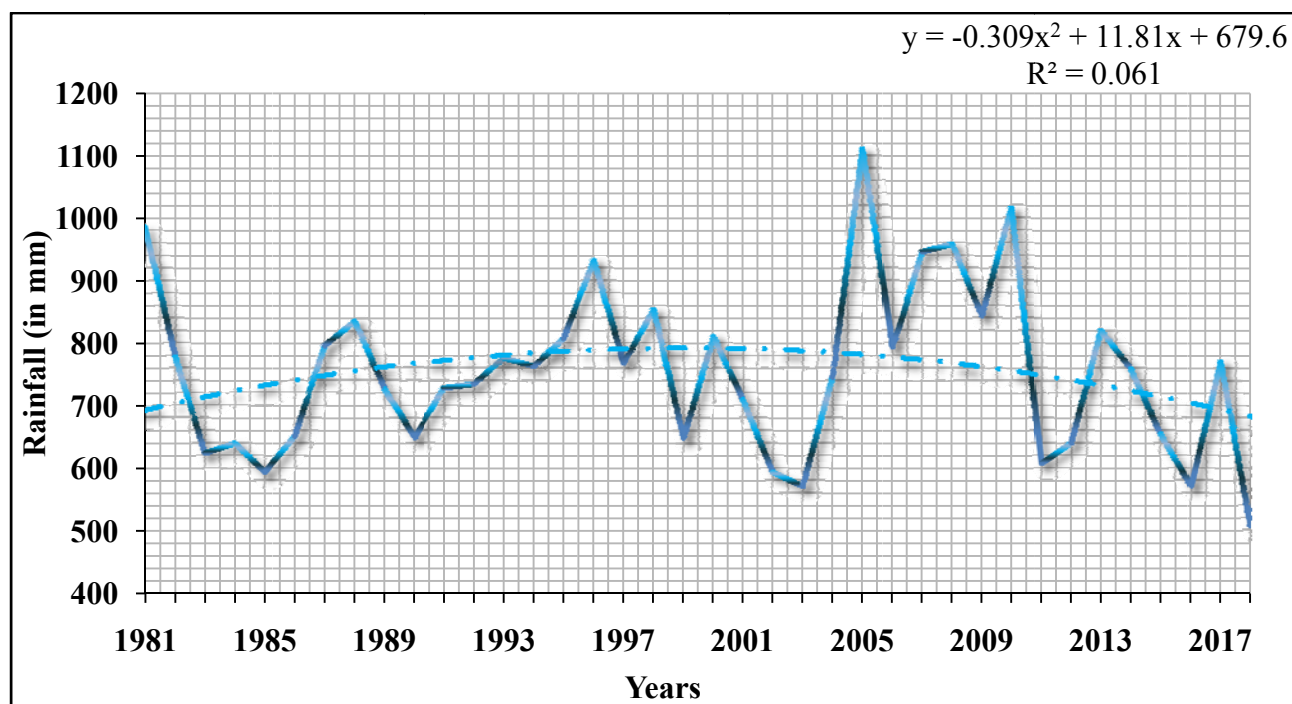
The temperature data was analysed from 1981-2018 for least vulnerable and HVD by employing homogeneity test. The analysis was carried out for different parameters like maximum and minimum

**Table 5:** Homogeneity test to identify the shift in temperature

	LVD				HVD			
	Maximum Temperature		Minimum Temperature		Maximum Temperature		Minimum Temperature	
	Pettitt's test	Buishand's test	Pettitt's test	Buishand's test	Pettitt's test	Buishand's test	Pettitt's test	Buishand's test
t	2011	2001	2001	2001	2010	2010	2008	2008
p-value (Two-tailed)	0.242	0.015	0.015	0.038	0.431	0.243	0.149	0.564



**Fig. 1:** Precipitation during 1981 to 2018 in least vulnerable districts



**Fig. 2:** Precipitation during 1981 to 2018 in highly vulnerable districts

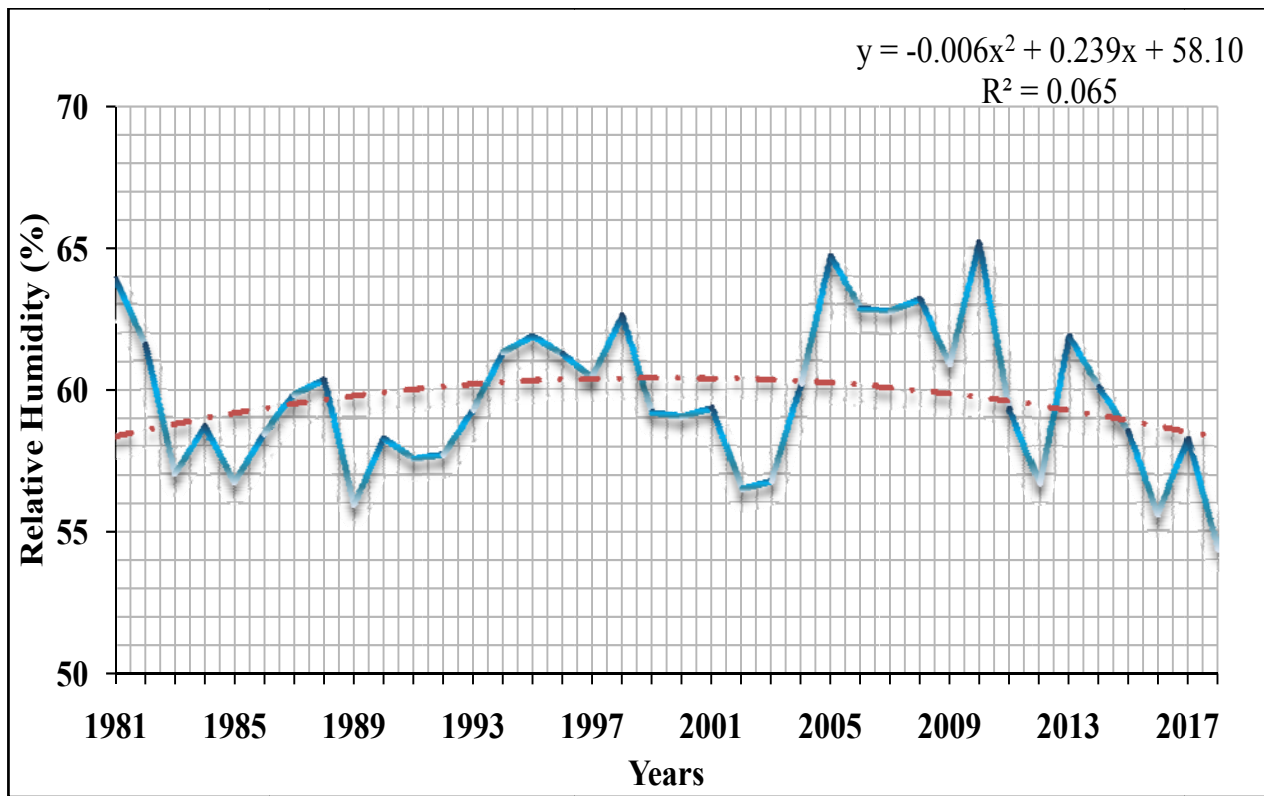


Fig. 3: Relative humidity during 1981 to 2018 in least vulnerable districts

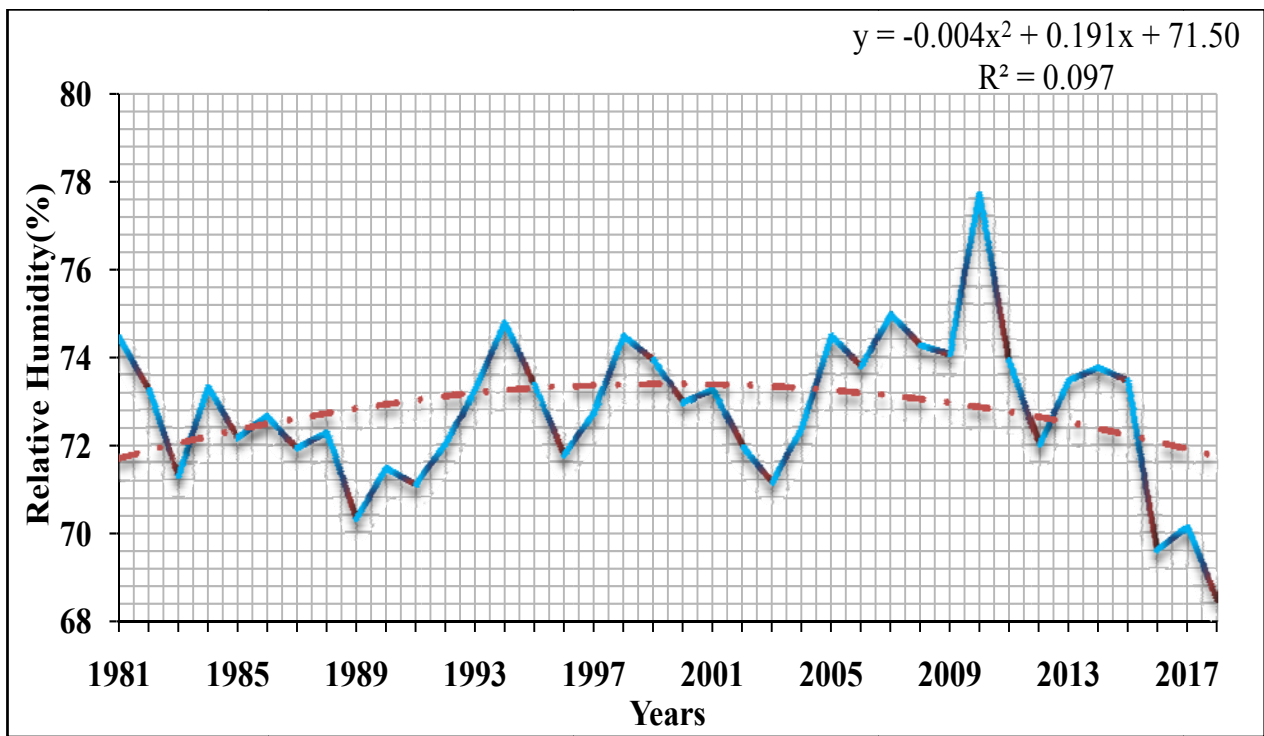


Fig. 4: Relative humidity during 1981 to 2018 in highly vulnerable districts

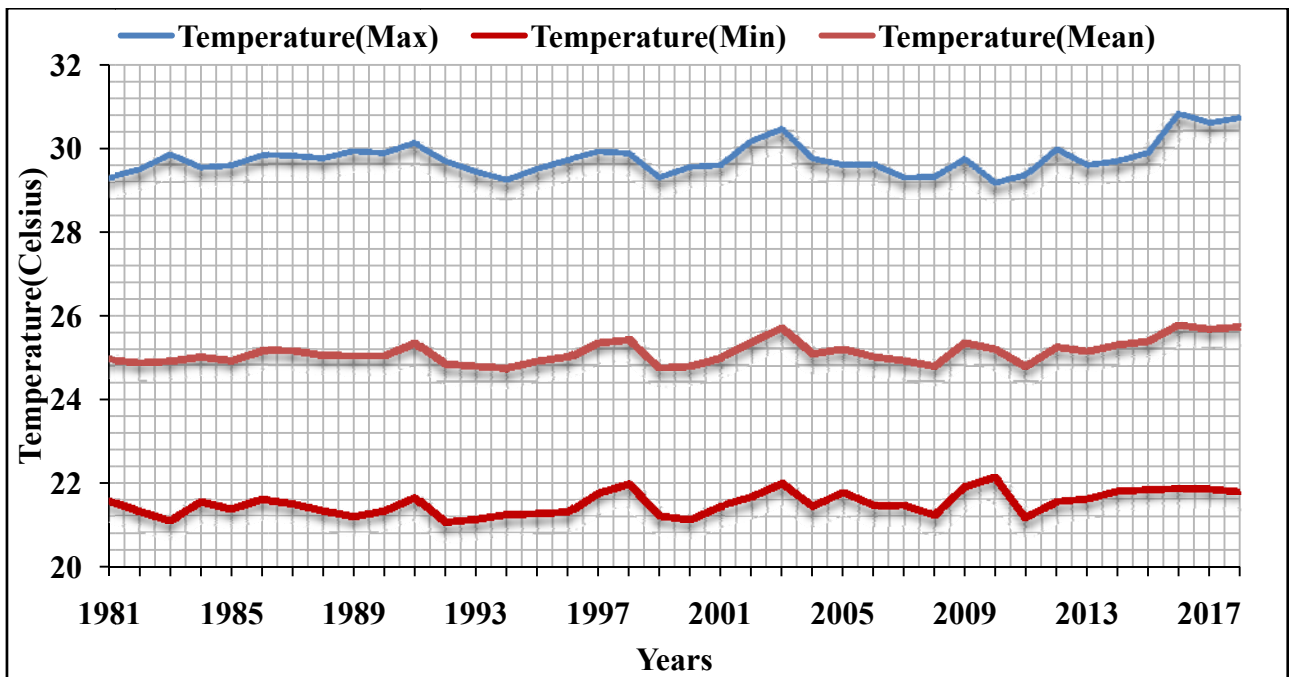


Fig. 5: Temperature during 1981 to 2018 in least vulnerable districts

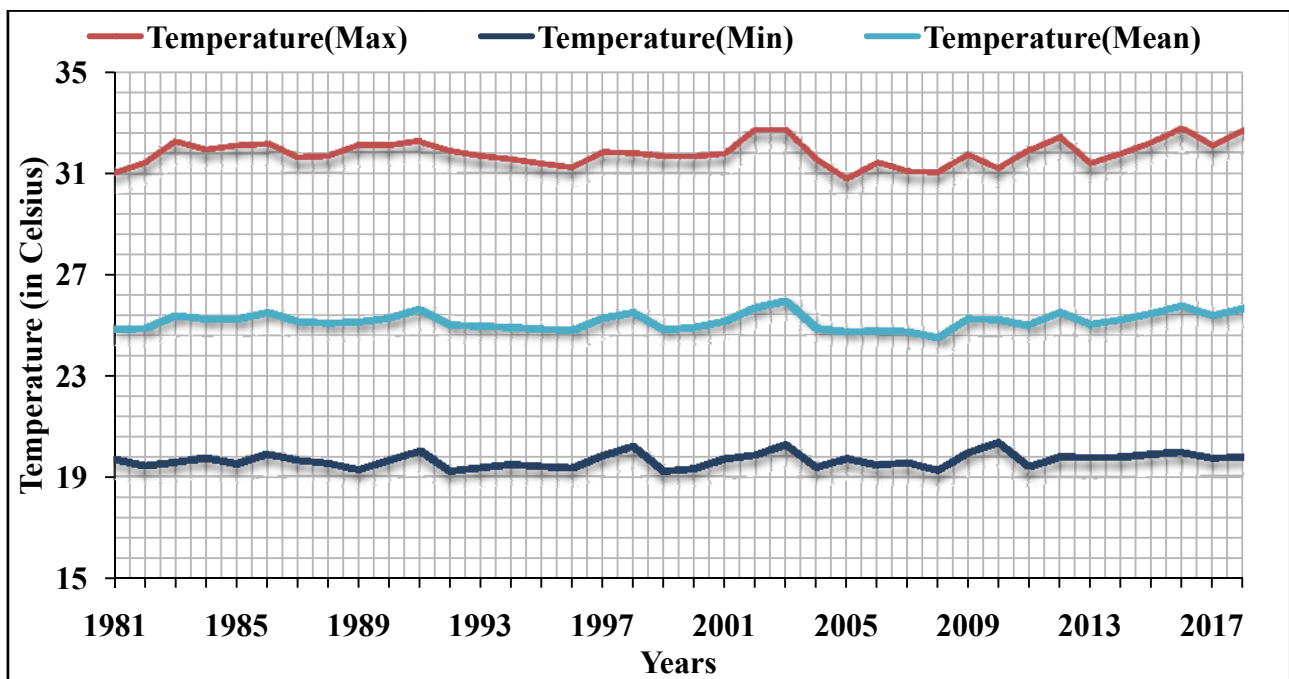


Fig. 6: Temperature during 1981 to 2018 in highly vulnerable districts

temperatures for the period 1981-2018. Table 5 shows the results of the homogeneity tests for Maximum temperature and minimum temperature for least vulnerable and HVD.

Based on the results, maximum temperature in LVD is homogeneous since the null hypothesis for the Pettitt's test was not rejected at 5 per cent

level of significance and it was not statistically significant (Fig. 5). It was found to be significant according to Buishand's test and not homogenous from 2001. In the case of minimum temperature, both Pettitt's test and Buishand's test were rejected and not homogeneous since from 2001. Whereas, in HVD, both the test results for maximum and

minimum temperature were found to be not statically significant (Fig. 6). These results are in confirmatory with the findings of Welch (2010) and Meehl *et al.* (2007).

## CONCLUSION

In least vulnerable districts (LVD) shift in precipitation was significant and not homogeneous from 1990. Whereas, precipitation in highly vulnerable districts (HVD), both Pettitt's test and Buishand's test were not rejected and intensity of rainfall pattern has not changed over years from 2010. Wind speed in LVD was not homogeneous from 2000 and similar results were found for the HVD. Shift in relative humidity was statistically significant according to Buishand's test in LVD and not homogenous from 2015. In HVD results were found to be not significant. Maximum temperature in LVD is homogeneous since the null hypothesis for the Pettitts test was not rejected at 5 per cent level of significance and it was not statistically significant. Whereas, in highly vulnerable districts, it was found to be significant according to Buishand's test and not homogenous from 2001. Now a day's climate change is one of the serious threats to the socio-economic growth of the country as well as state. Adapting to the present and future change in the climate is highly crucial to ensure hard won gains and also increase resilience of vulnerable communities through proper assessment of least and highly vulnerable regions and establishment of climate smart practices.

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