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Research Article

Investigation of Climate Change Anomaly by Using Nonparametric Test for Navsari District of South Gujarat

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ABSTRACT

Navsari district of rainfall was shows highest increasing rainfall trend obtained September and negative January, July, October, November and December. The regression slope of the yearly time series is about 12.35 mm/36 years. Maximum temperature shows the highest increasing trend in month October, followed by December and August. The month highest decreasing trend was noticed that January, followed by February and July. The regression slope of the yearly time series is about 0.025°C/36 years. Minimum temperature highest values of the slope (0.109°C/36 year) with high value of regression Slope of determination (0.111°C), the annual Kendall's tau statistic (0.492°C/36 year), the Kendall Score (310). All the month January to December shows increasing trend. The highest increasing trend found that November, followed by March and July, respectively. This finding shows that all the month shows increasing trend with the range between 0.308°C to 0.390°C. In case of RH-I the highest increasing trend shows September, followed by April and June. Similarly decreasing trend was found that January, followed by February and October, respectively. Relative humidity-II increasing trend was found only at the September month 0.084%, the increasing trend was detected in January to August and October to December, respectively. The strongest trend in the Bright sunshine hour's decline of all month's average daily sunshine hours was for the Navsari district. No significant trends were detected in all months and seasons for all weather elements. A similar trend was found in Sen's slope and regression slope all the months for all the weather elements.

Keywords: *Mann Kendall Test, Tmax, Tmin, RH-I, RH-II and Bright Sunshine Hour.*

INTRODUCTION

The year 2003 was the year of heat and cold waves across the world. The European Union (EU) suffered to a large extent due to heat wave that occurred in summer 2003.

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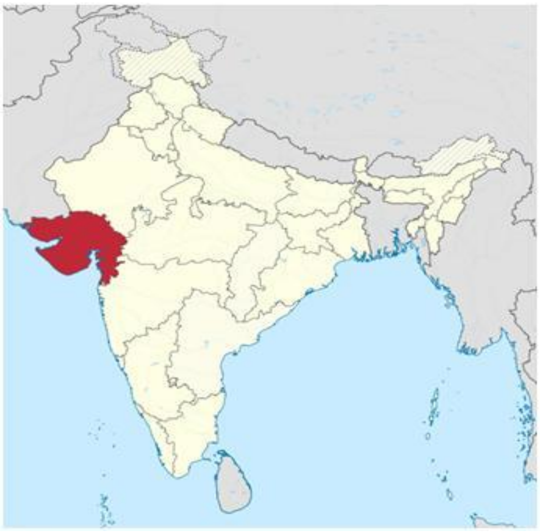
In India Uttar Pradesh, Bihar, West Bengal, Orissa and Andhra Pradesh are the States that experienced summer heat waves. When the EU suffered heat wave during the summer in 2003, India experienced severe cold wave from December 2002 to January 2003. Some parts of Jammu, Punjab, Haryana, Himachal Pradesh, Bihar, Uttar Pradesh and the North Eastern States experienced unprecedented cold wave. The crop yield loss varied between 10 and 100% in the case of horticultural crops and seasonal crops. The fruit size and quality were also adversely affected in horticultural crops. However, temperate fruits like apple, perch, plum and cherry gave higher yield due to extreme chilling. The damage was more in low-lying areas where cold air settled and remained for a longer time on the ground (Samra et al., 2004). High temperature in March 2004 adversely affected crops like wheat, apple, mustard, rapeseed, linseed, potato, vegetables, pea and tea across the State of Himachal Pradesh in India. The yield loss was estimated between 20% and 60% depending upon the crop. Wheat and potato harvest was advanced by 15-20 days and the flowering of apple was early by 15 days. The optimum temperature for fruit blossom and fruit set is 24^0C in the case of apple while it experienced above 26^0C for 17 days. The entire region recorded between 2.1 and 7.9^0C higher maximum temperature against the normal across the State of Himachal Pradesh in March 2004 (Prasad & Rana, 2006). The Mean Sea Level (MSL) rise is likely to be slightly less than one mm/year along the Indian coast. Sea level rise may lead to disappearance of low-lying areas of coastal belt in addition to changes in ocean biodiversity. It threatens health of corals and polar bear population. Greater number of high surges and increased occurrences of cyclones in post-monsoon period, along with increased maximum wind speed, are also expected. This phenomenon of sea level rise threatens the area of land available for farming.

As per the United Nations Report of FAO, India stands to lose 125 million tonnes equivalent to 18% of its rainfed cereal production from climate change by 2015. Agriculture production is directly dependent on climate change and weather. Possible changes in temperature, precipitation and CO2 concentration are expected to significantly impact crop growth. The overall impact of climate change on worldwide food production is considered to be low to moderate with successful adaptation and adequate irrigation (IPCC, 1998). Global agricultural production could be increased due to the doubling of CO2 fertilization effect. Agriculture will also be impacted due to climate changes imposed on water resources (Gautam & Kumar 2007; & Gautam, 2009). India will also begin to experience more seasonal variation in temperature with more warming in the winters than summers (Christensen et al., 2007; & Cruz et al., 2007) India has experienced 23 large scale droughts starting from 1891 to 2009 and the frequency of droughts is increasing. Climate change is posing a great threat to agriculture and food security. Water is the most critical agricultural input in India, as 55% of the total cultivated areas do not have irrigation facilities. It is clear that the occurrence of floods and droughts, heat and cold waves are common across the world due to climate change. Their adverse impact on livelihood of farmers is tremendous. It is more so in India as our economy is more dependent on Agriculture. Interestingly, weather extremes of opposite in nature like cold and heat waves and floods and droughts are noticed within the same year over the same region or in different regions and likely to increase in ensuing decades. The human and crop losses are likely to be heavy. The whole climate change is associated with increasing greenhouse gases and human induced aerosols and the imbalance between them may lead to uncertainty even in year-to-year monsoon behavior over India. Therefore, there should be a determined effort from developed and developing countries to make industrialization environment friendly by reducing greenhouse gases pumping into the atmosphere. In the same fashion, awareness programmes on climate change and its effects on various sectors viz., agriculture, health, infrastructure, water, forestry, fisheries, land and ocean biodiversity and sea level and the role played by human interventions in climate change need to be taken up on priority basis. In the process, lifestyles of people should also be changed so as not to harm earth atmosphere continuum by pumping greenhouse gases and CFCs into the atmosphere. From the agriculture point of view, effects of extreme weather events on crops are to be documented on regional scale 26 so that it will be handy to planners in such re-occurrence events for mitigating the ill effects. Also, there is need to guide farmers on projected impact climate change and sensitize them on probable mitigation and adaptation options to minimize the risk in Agricultural sector.

India is home to 16% of the world population, but only 4% of the world water resources. Agriculture is directly dependent on climate, since temperature, sunlight and water are the main drivers of crop growth. While some aspects of climate change such as longer growing season and warmer temperatures may bring benefits in crop growth and yield, there will also be a range of adverse impacts due to reduced water availability and more frequent extreme weather conditions. These impacts may put agricultural activities at significant risk. Climate change has already caused significant damage to our present crop profile and threatens to bring even more serious consequences in the future (WHO, 1992). Wheat yields are predicted to fall by 5-10% with every increase of 1°C and overall crop yields could decrease up to 30% in South Asia by the mid-21st century (IPCC, 2001). India could experience a 40% decline in agricultural productivity by the 2080s (IPCC, 2007). In the present study, series of monthly maximum (Tmax) and minimum (Tmin) air temperatures, maximum (RH-I) and minimum (RH-II) relative humidity, and precipitation (P) were analyzed. The weather data included daily values of the above mentioned parameters averaged over each month. The full weather datasets were collected from weather stations Navsari (1980-2015).

MATERIALS AND METHODS

In south Gujarat one location were chosen for assessment of rainfall intensity and frequency, trend of temperature, relative humidity and bright sunshine hours for Navsari (23.15°N and 69.49°E, Altitude 11.0 m). Fig 1-2. The historical monthly and annual rainfall, temperature, relative humidity and bright sunshine hours data Navsari were used of 35 years (1980-2015). The data were subjected to find out long term trends. A linear rend line was added to the series for simplify the trends. To support the trends in annual and seasonal shifts in rainfall, temperature and humidity and bright sunshine hours were also analyzed.



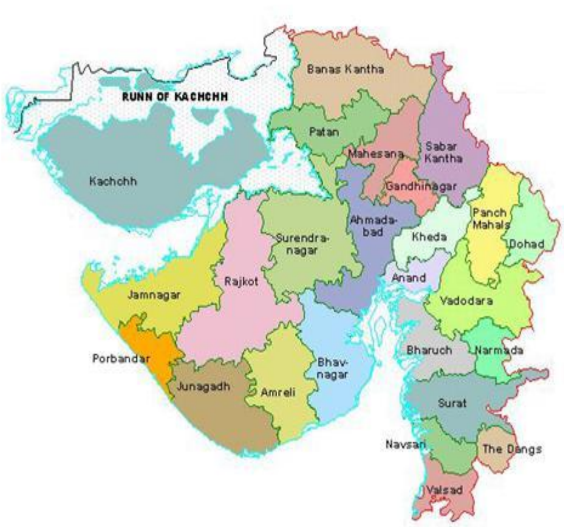


Fig. 1-2: Location map

Trend Analysis

Mann-Kendall Test

The trend analysis and estimation of Sen's slope are done using Kendall (1975) and Sen (1968) method, respectively for the given data sets. Man-Kendall test is a non-parametric test for finding trends in time series. This test compares the relative magnitudes of data rather than data values themselves (Gilbert, 1987). The benefit of this test is that data need not to confirm any particular distribution. In this test, each data value in the time series is compared with all subsequent values. Initially the Mann-Kendall statistics (*S*) is assumed to be zero, and if a data value in subsequent time periods is higher than a data value in previous time period, *S* is incremented by 1, and *vice-versa.* The net result of all such increments and decrements gives the final value of *S*. The Mann-Kendall statistics (*S*) is given as:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_j - x_i)$$

Where, $sign\ (x_j\text{-}x_k) = 1$, if $(x_j\text{-}x_k) > 0$; 0, if $(x_j\text{-}x_k) = 0$; -1 if $(x_j\text{-}x_k) < 0$.

A positive value of *S* indicates an increasing trend, and a negative value indicates a decreasing trend. However, it is necessary to perform the statistical analysis for the significance of the trend. The test procedure using the normal approximation test is described by Kendall (1975). This test assumes that there are not many tied values within the dataset. The variance (*S*) is calculated by the following equation:

$$Var\ (S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p-1)(2t_p+5)\right]$$

Where, n is the number of data points, g is the number of tied groups and t_p is the number of data points in the p^{th}group.

The normal Z-statistics is computed as:

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}, & if\ S>0 \\ 0, & if\ S=0 \\ \frac{S+1}{\sqrt{Var(S)}}, & if\ S>0 \end{cases}$$

The trend is said to be decreasing if Z is negative and the computed Z-statistics is greater than the z-value corresponding to the 5% level of significance. The trend is said to be increasing if the Z is positive and the computed Z-statistics is greater than the z-value corresponding to the 5% level of significance. If the computed Z-statistics is less than the z-value corresponding to the 5% level of significance, there is no trend.

Sen's Slope Estimator

Simple linear regression is one of the most widely used model to detect the linear trend. However, this method requires the assumption of normality of residuals (McBean & Motiee, 2008). Viessman et al. (1989) reported that many hydrological variables exhibit a marked right skewness partly due to the influence of natural phenomena and do not follow a normal distribution. Thus the Sen (1968) slope estimator is found to be a powerful tool to develop the linear relationships. Sen's slope has the advantage over the regression slope in the sense that it is not much affected by gross data errors and outliers. The Sen's slope is estimated as the median of all pair-wise slopes between each pair of points in the dataset (Thiel, 1950; Sen, 1968; & Helsel & Hirsch, 2002). Each individual slope (m_{ij}) is estimated using the following equation:

$$m_{ij} = \frac{(Y_j - Y_i)}{(j-1)} \qquad ...(2)$$

Where, i= 1 to n-1, j = 2 to n, Y_j and Y_i are data values at time j and i ($j > i$), respectively. If there are n values of Y_j in the time series, there will be $N=n(n-1)/2$ slope estimates. The Sen's slope is the median slope of these N values of slopes. The Sen's slope is:

$$m = m_{\left[\frac{N+1}{2}\right]}, \ if \ n \ is \ odd$$

$$m = \frac{1}{2}\left(m_{\left[\frac{N}{2}\right]} + m_{\left[\frac{N+2}{2}\right]} \right), \ if \ n \ is \ even$$

Positive Sen's slope indicates rising trend while negative Sen's slope indicates falling trend.

Linear Regression Analysis

Linear regression analysis is a parametric model and one of the most commonly used methods to detect a trend in a data series. This model develops a relationship between two variables (dependent and independent) by fitting a linear equation to the observed data. The data is first checked whether or not there is a relationship between the variables of interest. This can be done by using the scatter plot. If there appears no association between the two variables, linear regression model will not prove a useful model. A numerical measure of this association between the variables is the correlation coefficient, which range between -1 to +1. A correlation coefficient value of ± 1 indicates a perfect fit. A value near zero means that there is a random, nonlinear relationship between the two variables. The linear regression model is generally described by the following equation:

$$Y = m.\ X + C \qquad \ldots(3)$$

Where, Y is the dependent variable, X is the independent variable, m is the slope of the line and C is the intercept constant. The coefficients (m and C) of the modal are determined using the Least-Squares method, which the most commonly used method. t-test is used to determine whether the linear trends are significantly different from zero at the 5% significance level.

RESULTS AND DISCUSSION

Navsari

The Mann-Kendall test and Sen's slope estimator were applied to the time-series 1980–2015 for the six meteorological variables: Rainfall, Maximum temperature, Minimum temperature, Relative humidity-I, Relative humidity-II and Bright Sunshine hours. Each of trend methods is implemented.

Rainfall trend

Regression analysis was used to establish linear trends of rainfall amounts and number of events at Navsari stations with 36 years of record. Annual rainfall was further split into months of amounts and events, and similar analysis was performed on these variables.

The slopes of the regression analysis (linear trend) for the amount of rainfall and the number of rainfall events, averaged across the district, are shown in Table 1 and 2. The rainfall trend obtained during the months of the year, February, March, April, May, June August and September, was positive and January, July, October, November and December, was negative.

Sen's slope estimator were the rainfall trend obtained during the months of the year, January, February, March, April, May, June August, September, October, November and December was positive. Similarly highest

Sen's slope was found that September 9.493 mm followed by August 3.268 mm and June 0.744 mm. July month shows negative Sen's slope -0.131 mm. Similar result were found (Kumar & Patel 2012; & Kumar, et al., 2015a; 2015b).

Maximum temperature

A number of warm weather events, including the most severe ones such as heat-wave conditions, occur over most parts of the country during May and June. Table 1 for Navsari district shows a increasing Mann-Kendall trend in Maximum temperature obtained during the months of the year, March, April, May, June, August, October, November and December, was positive, similar decreasing trend was noticed January, February, July and September. The month highest decreasing trend was noticed that January -0.178°C followed by February -0.146°C and July -0.145°C, respectively.

The highest Sen's slope was found that October 0.052°C followed by March 0.019°C and November, December 0.013°C, respectively. The negative Sen's slope noticed January, February, July and September, viz, -0.026°C, -0.031°C, -0.012°C and -0.03°C, respectively, shows table 2.

Minimum temperature

Vinnikov and Grody (2003), Results have shows that the Earth's surface air temperature has increased by 0.6˚C - 0.8˚C during the 20th century, along with changes in the hydrologic cycle. Temperatures in the lower troposphere have increased between 0.13˚C and 0.22˚C per decade since 1979, according to satellite temperature measurements.

Long term time series of annual minimum temperature has been compiled and analyzed. There is a clear indication that climate change has occurred in Navsari. Statistically significant abrupt changes and trends have been detected. The analysis of the annual minimum temperature showed a not very significant cooling trend during the period ranging from 1980 to 2015 for Navsari. A significant warming trend was furthermore observed for the period after the year 1980 to 2015 for NAU, Navsari observatory where presented the highest values of the slope (0.109°C/36 year) with high value of regression Slope of determination (0.111°C), the annual Kendall's tau statistic (0.492°C/36 year), the Kendall Score (310). Similarly all the month January to December shows increasing trend. The highest increasing trend found that November 0.469°C followed by March 0.390°C and July 0.371°C, respectively. This finding shows that all the month shows increasing trend with the range between 0.308°C to 0.390°C.

Relative humidity-I

Water vapor plays a major role in the dynamics of the atmosphere's circulation as well as in radiation exchange within the atmosphere. A large portion of the energy transferred between the surface and the free atmosphere is in the form of latent heat. The output of the analyzed RH maximum series was summarized in Table 1. On the monthly time scale, the increasing trends were found in March to September and November months. On the monthly time scale, the decreasing trends were found in January, February, October and December months. The highest increasing trend shows September 0.262% followed by April 0.252% and June 0.104%, respectively. Similarly decreasing trend was found that January -0.279 followed by February -0.193 and October -0.032%, respectively.

Relative humidity-II

Results of the applied Mann-Kendall and Sen's slope estimator statistical tests for monthly annual Relative humidity-II (RHmini) over the period 1980–2015 are presented in Table 1. As shown, the majority of the trends in the monthly and annual RHmini series were not significant, while the increasing trend was found only at the September month 0.084%. On the months time scale, the increasing trend was detected in January to August and October to December. Similarly month wise decreasing trend varied January to December -0.012% to -0.220%, respectively. A similar trend was found in Sen's slope and regression slope all the months.

Bright Sun Shine hours

No significant trends were detected in all months. Similarly month wise decreasing trend varied January to December -0.060 hrs/ 36 years to -0.651 hrs/ 36 years, respectively. A similar trend was found in Sen's slope and regression slope all the months, table 2.

Table 1: Mann-Kendall trend analysis of rainfall, T Max, T Mini, RH-I, RH-II and BSS at Navsari, from 1980 to 2015

Decades	Months	Kendall's tau	S- Statistics	P Value	Trend	Trend at 5% Significant level
Rainfall	January	-0.055	-22.000	0.693	Falling	No
	February	0.083	24.000	0.564	Rising	No
	March	0.079	23.000	0.581	Rising	No
	April	0.255	74.000	0.067	Rising	No
	May	0.053	24.000	0.700	Rising	No
	June	0.019	12.000	0.882	Rising	No
	July	-0.003	-2.000	0.989	Falling	No
	August	0.089	56.000	0.457	Rising	No
	September	0.324	204.000	0.005	Rising	No
	October	-0.012	-7.000	0.934	Falling	No
	November	-0.053	-24.000	0.700	Falling	No
	December	-0.071	-25.000	0.613	Falling	No
Maximum Temperature	January	-0.178	-112.000	0.131	Falling	No
	February	-0.146	-92.000	0.217	Falling	No
	March	0.067	42.000	0.579	Rising	No
	April	0.046	29.000	0.703	Rising	No
	May	0.030	19.000	0.806	Rising	No
	June	0.032	20.000	0.797	Rising	No
	July	-0.145	-91.000	0.220	Falling	No
	August	0.089	56.000	0.457	Rising	No
	September	-0.013	-8.000	0.925	Falling	No
	October	0.216	136.000	0.066	Rising	No
	November	0.087	55.000	0.462	Rising	No
	December	0.092	58.000	0.441	Rising	No
Minimum Temperature	January	0.331	197.000	0.005	Rising	No
	February	0.331	197.000	0.005	Rising	No
	March	0.390	246.000	0.001	Rising	No
	April	0.308	194.000	0.008	Rising	No
	May	0.352	222.000	0.002	Rising	No
	June	0.346	218.000	0.003	Rising	No
	July	0.371	234.000	0.001	Rising	No
	August	0.256	161.000	0.029	Rising	No
	September	0.344	193.000	0.004	Rising	No
	October	0.358	201.000	0.003	Rising	No
	November	0.469	263.000	< 0.0001	Rising	No
	December	0.365	205.000	0.002	Rising	No
Decades	**Months**	**Kendall's tau**	**S- Statistics**	**P Value**	**Trend**	**Trend at 5% Significant level**
Relative Humidity-I	January	-0.279	-166.000	0.019	Falling	No
	February	-0.193	-115.000	0.106	Falling	No
	March	0.013	8.000	0.921	Rising	No
	April	0.252	150.000	0.034	Rising	No
	May	0.042	25.000	0.735	Rising	No
	June	0.104	62.000	0.386	Rising	No
	July	0.059	35.000	0.632	Rising	No
	August	0.025	15.000	0.842	Rising	No
	September	0.262	156.000	0.028	Rising	No
	October	-0.032	-19.000	0.800	Falling	No
	November	0.000	0.000	1.000	Rising	No
	December	-0.002	-1.000	1.000	Falling	No
Relative Humidity-II	January	-0.106	-63.000	0.382	Falling	No
	February	-0.172	-102.000	0.151	Falling	No
	March	-0.220	-131.000	0.065	Falling	No
	April	-0.121	-68.000	0.321	Falling	No
	May	-0.050	-28.000	0.689	Falling	No
	June	-0.012	-7.000	0.930	Falling	No
	July	-0.118	-66.000	0.335	Falling	No
	August	-0.034	-19.000	0.791	Falling	No
	September	0.084	47.000	0.498	Rising	No
	October	-0.087	-49.000	0.480	Falling	No
	November	-0.045	-25.000	0.724	Falling	No
	December	-0.137	-77.000	0.262	Falling	No
Bright Sun Shine hours	January	-0.584	-368.000	< 0.0001	Falling	No
	February	-0.651	-410.000	< 0.0001	Falling	No
	March	-0.568	-358.000	< 0.0001	Falling	No
	April	-0.622	-392.000	< 0.0001	Falling	No
	May	-0.330	-208.000	0.004	Falling	No
	June	-0.194	-122.000	0.100	Falling	No
	July	-0.352	-222.000	0.002	Falling	No
	August	-0.060	-38.000	0.617	Falling	No
	September	-0.384	-242.000	0.001	Falling	No
	October	-0.267	-168.000	0.022	Falling	No
	November	-0.432	-272.000	0.000	Falling	No
	December	-0.524	-330.000	< 0.0001	Falling	No

Table 2: Sen's slope estimator of rainfall, T Max, T Mini, RH-I, RH-II and BSS at Navsari, from 1980 to 2015

Decades	Months	Sen's Slope	Trend	Confidence limits for slope at 5% Significance Level		Regression Slope
				Lower Limit	Upper Limit	
Rainfall	January	0.000	Rising	0.000	0.000	0.020
	February	0.000	Rising	0.000	0.000	0.025
	March	0.000	Rising	0.000	0.000	0.041
	April	0.000	Rising	0.000	0.000	0.017
	May	0.000	Rising	0.000	0.000	0.062
	June	0.744	Rising	-1.354	2.182	2.261
	July	-0.131	Falling	-1.565	2.141	0.219
	August	3.268	Rising	1.164	4.711	3.174
	September	9.493	Rising	7.359	9.973	8.427
	October	0.000	Rising	0.000	0.000	-1.692
	November	0.000	Rising	0.000	0.000	-0.028
	December	0.000	Rising	0.000	0.000	-0.049
Maximum temperature	January	-0.026	Falling	-0.031	-0.020	0.004
	February	-0.031	Falling	-0.043	-0.021	-0.055
	March	0.019	Rising	0.003	0.035	0.042
	April	0.004	Rising	-0.001	0.009	0.006
	May	0.003	Rising	-0.004	0.009	0.030
	June	0.008	Rising	-0.006	0.021	0.061
	July	-0.012	Falling	-0.016	-0.007	-0.007
	August	0.011	Rising	0.004	0.022	0.045
	September	-0.003	Falling	-0.011	0.009	0.028
	October	0.052	Rising	0.042	0.065	0.083
	November	0.013	Rising	0.008	0.018	0.033
	December	0.013	Rising	0.005	0.020	0.027
Minimum Temperature	January	0.067	Rising	0.059	0.082	0.067
	February	0.068	Rising	0.057	0.081	0.053
	March	0.084	Rising	0.077	0.097	0.080
	April	0.062	Rising	0.055	0.070	0.068
	May	0.060	Rising	0.047	0.068	0.087
	June	0.055	Rising	0.046	0.064	0.095
	July	0.042	Rising	0.035	0.047	0.044
	August	0.043	Rising	0.035	0.050	0.057
	September	0.051	Rising	0.043	0.059	0.079
	October	0.082	Rising	0.069	0.089	0.103
	November	0.115	Rising	0.100	0.130	0.118
	December	0.077	Rising	0.067	0.083	0.063

Decades	Months	Sen's Slope	Trend	Confidence limits for slope at 5% Significance Level		Regression Slope
				Lower Limit	Upper Limit	
Relative Humidity-I	January	-0.187	Falling	-0.222	-0.145	-0.207
	February	-0.165	Falling	-0.202	-0.133	-0.210
	March	0.008	Rising	-0.025	0.027	0.012
	April	0.134	Rising	0.111	0.167	0.121
	May	0.046	Rising	-0.004	0.087	0.075
	June	0.063	Rising	0.027	0.102	0.108
	July	0.032	Rising	0.007	0.049	0.023
	August	0.027	Rising	-0.007	0.052	0.086
	September	0.103	Rising	0.085	0.121	0.136
	October	-0.023	Falling	-0.049	0.012	0.088
	November	0.000	Rising	-0.037	0.051	0.027
	December	-0.001	Falling	-0.058	0.036	-0.02
Relative Humidity-II	January	-0.135	Falling	-0.204	-0.054	-0.392
	February	-0.255	Falling	-0.338	-0.168	-0.541
	March	-0.282	Falling	-0.333	-0.204	-0.564
	April	-0.242	Falling	-0.325	-0.165	-0.376
	May	-0.090	Falling	-0.152	0.000	-0.168
	June	-0.020	Falling	-0.086	0.033	-0.108
	July	-0.065	Falling	-0.089	-0.045	-0.063
	August	-0.033	Falling	-0.103	0.017	0.004
	September	0.083	Rising	0.024	0.107	0.031
	October	-0.106	Falling	-0.154	-0.061	-0.148
	November	-0.053	Falling	-0.120	0.006	-0.103
	December	-0.207	Falling	-0.282	-0.118	-0.288
Bright Sun Shine hours	January	-0.082	Falling	-0.088	-0.077	-0.080
	February	-0.056	Falling	-0.060	-0.052	-0.070
	March	-0.069	Falling	-0.074	-0.064	-0.063
	April	-0.071	Falling	-0.075	-0.069	-0.065
	May	-0.030	Falling	-0.034	-0.027	-0.034
	June	-0.045	Falling	-0.053	-0.031	-0.045
	July	-0.064	Falling	-0.070	-0.053	-0.054
	August	-0.012	Falling	-0.019	-0.001	-0.012
	September	-0.067	Falling	-0.073	-0.058	-0.072
	October	-0.052	Falling	-0.058	-0.046	-0.030
	November	-0.067	Falling	-0.073	-0.061	-0.058
	December	-0.062	Falling	-0.068	-0.056	-0.053

CONCLUSIONS

The rainfall trend obtained during the months of the year, February, March, April, May, June August and September, was positive and negative January, July, October, November and December. Sen's slope estimator were the rainfall trend obtained during the months of the year, January, February, March, April, May, June August, September, October, November and December was positive in Navsari district. Navsari district Maximum temperature shows a increasing the months of the year, March, April, May, June, August, October, November and December. Decreasing trend was noticed January, February, July and September. Monthly highest trends shows October 0.216°C, followed by December 0.092°C and August 0.089°C, respectively. The month highest decreasing trend was noticed that January -0.178°C followed by February -0.146°C and July -0.145°C, respectively. Sen's slope estimator shows highest Sen's slope was found that October, followed by March and November, December, respectively. The negative Sen's slope noticed January, February, July and September, respectively. The regression slope of the yearly time series is about 0.025°C/36 years. Navsari district all the month January to December shows increasing trend. The highest increasing trend found that November, followed by March and July, respectively. This finding shows that all the months shows increasing trend with the range between 0.308°C to 0.390°C. The decreasing trend in winter season RH-I series was found that the highest increasing trend shows September, followed by April and June, respectively. Similarly decreasing trend was found that January, followed by February and October, respectively. Similarly Sen's slop as well as regression slop parallel trend was found for all the month. Relative humidity-II increasing trend was found only at the September month 0.084%. The increasing trend was detected in January to August and October to December, respectively. No significant trends were detected in all months. The similar trend was found in Sen's slope and regression slope all the months and seasons. All month average daily sunshine hours were for the Navsari district, No significant trends were detected in all months. A similar trend was found in Sen's slope and regression slope all the months and seasons.

REFERENCES

Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., & Gao, X. (2007). Regional Climate Projections. In: Climate Change. The Physical Science Basis. *Cambridge University Press. Cambridge*, United Kingdom.

Cruz, R. V., Harasawa, H., Lal, M., Wu, S., & Anokhin, Y. (2007). Asia Climate Change Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Gautam, H. R. (2009). Preserving the future. In; Joy of Life- The Mighty Aqua". Bennett, Coleman & Co. Ltd., *The Times of India, Chandigarh*.

Gautam, H. R., & Kumar, R. (2007). Need for rainwater harvesting in agriculture. *J Kurukshetra, 55*, 12-15.

Gilbert, R. O. (1987). Statistical methods for environmental pollution monitoring. *Van No strand Rienhold Company*, Inc., New York.

Helsel, D. R., & Hirsch, R. M. (2002). Statistical methods in water resources. *U. S. Geological survey technique of water resources investigations*, book 4, chapter A3, 524.

IPCC, (1998). Principles governing IPCC work, Approved at the 14^{th} session of the IPCC.

IPCC, (2001). Climate Change Impacts, Adaptation & Vulnerability: Contribution of Working Group II to the Third Assessment Report of the IPCC. Cambridge University Press, Cambridge, UK.

IPCC, (2007). Summary for Policy-makers, Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IPCC. Cambridge University Press, Cambridge, United.

Kendall, M. G. (1975). Rank correlation methods. 4th edition, Charles Griffin, London.

Kumar, N., & Patel, J. G. (2012). Analysis of regional drought intensity and frequency over north Gujarat. *Journal of Agrometeorology, 14*(1), 95-96.

Kumar, N., Patel, S. S., Chalodia, A. L., Vadaviya, O. U., Pandya, H. R., Pisal, R. R., Dakhore, K. K., & Patel, M. L. (2015b). Markov Chain and Incomplete Gamma distribution analysis of weekly rainfall over Navsari region of South Gujarat. *Mausam, 66*(4), 751-760.

Kumar, N., Pisal, R. R., Shukla S. P., & Patel, S. S. (2015a). Analysis of climatic variability at heavy rainfall zone of South Gujarat. *Mausam, 66*(4), 850-856.

McBean, E., & Motiee, H. (2008). Assessment of impact of climate change on water resources. A long term analysis of the Great Lakes of North America. *Hydro/Earth Syst. Sci., 12*, 239-255.

Prasad, R., & Rana, R. (2006). A study on maximum temperature during March 2004 and its impact on *rabi* crops in Himachal Pradesh. *J. of Agrometeorology, 8*(1), 91-99.

Samra, J. S., Singh, G., & Ramakrishna, Y. S. (2004). Cold wave during 2002-03 over North India and its effect on crops. *The Hindu dated 10th January, 2004*. p. 6.

Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall's. *J. Am. Stat. Assoc., 63*, 1379- l389.

Thiel, H. (1950). A rank-invariant method of 1inear and polynomial regression analysis. Part 3, *Proceedings of Koninalijke Nederlandse Akademie van Weinens chatpen A. 53*, 1397-1412.

Viessman, W., Krapp, J. W., & Harbough, T. E. (1989). Introduction to Hydrology. *Third edition, Harper and Row Publishers lnc*., New York.

Vinnikov, K. Y., & Grody, N. C. (2003). Global Warming Trend of Mean Troposphere Temperature Observed by Satellites. *Science, 302*(5643), 269-272.