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TREND DETECTION OF THE RAINFALL AND AIR TEMPERATURE DATA IN TAMIL NADU

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ABSTRACT
The present study is mainly concerned with the changing trend of rainfall and temperature of southern part of India viz., Tamil Nadu. This phenomenon has a time depending complex dynamics and hence, needs an integrated long time study. In this study, trend detection of these variables was used in annual and seasonal time scales in five Districts of Tamil nadu namely, Chennai, Coimbatore, Nagapattinam, Vellore, Kanyakumari using data pertaining to 30 years period (1980-2009). Parametric tests including t-test and linear regression and Non parametric tests of Mann Kendall, Mann Whitney and Spearman's rho was used for trend detection in the time series of data. Results indicated that there are not any linear and nonlinear significant trends among rainfall time series both annual and seasonal scale in districts of Tamil nadu State. But there are linear (results of t-test and linear regression) and nonlinear significant trends (results of Mann Kendall, Mann Whitney and Spearman's rho tests) in the most time series of selected stations. These trends in air temperature are mainly positive and show increase in air temperature in the study area. Thus it is required to have a comprehensive study of impact assessment in this region especially its impacts on the water supply systems and agriculture sector.

Keywords: *Time Series, p-value, Trend, Non Parametric*

INTRODUCTION
Climate change is one of the main challenges in the world that is being studied by scientists and researchers. This phenomenon has impact on human life both directly and indirectly. Scientific research has shown that surface air temperature increased about 0.2 till 0.6°C during last century (Abaurrea and Cerian, 2001) and studies indicate that this parameter may increase about 1.5 to 4.5°C by 2100 (IPCC, 2004). It should be considered that this rate may vary in different geographical regions (Colin *et al.*, 1999).
Global warming can affect land ecosystems especially water cycle. Rainfall is a key input in management of agriculture and irrigation projects and any change in this variable can influence on sustainable management of water resources, agriculture and ecosystems. Mainly, studies of climate change science are focused on the probable changes in the annual series of a variable such as rainfall or temperature and variability of these is important. There are physical and empirical methods for climate change detection. Physical methods use climate model for change detection whereas a statistical method uses empirical approach. There are numerous studies that use trend analysis for climate change and global warming. Climate data may be used directly (Van Belle and Hughes, 1984; Xie and Cao, 1996; Zhao and Dirmeyer, 2003; Yue and Hashino, 2003) or indirectly (Douglas *et al.,* 2000; Knowles *et al.*, 2007). Proedrou *et al.*, (1997) in a study of winter air temperature in Creek found that this variable had decreasing trend during 1951 till 1993 but showed upward trend in the summer seasons. Kampata *et al.*, (2008) have evaluated trend analysis in the rainfall of Zam bezi river basin in Zambia using Mann Kendall test using data from 5 rain gauges. Results indicated that there is a slow decrease in this variable that it is not statistically significant.
A study on the trend condition of rainfall in Vellore and Chennai districts showed that drought intensity has decreased in the central region compared with the past during 1980 till 2010. Also variability of annual rainfall in study area is related to some large scale fluctuations of annual rainfall (Lebel and Ali, 2009). Mann Kendall test for trend detection in monthly, seasonal and annual scale of rainfall in the Kerala state of India for data obtained during 1871 till 2005 showed that there is a significant descent in

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monsoon rainfall in the northwest region but it got an upward direction after this phenomenon. Also there was not any trend in the winter and summer seasons (Krishnakumar *et al.,* 2009). Kumar and Jain (2010) studied trend detection in seasonal and annual rainfall and rainy days using Mann Kendall test in Kashmir valley. Results imply that there was an upward trend of rainfall and rainy days in one station but other stations showed decreasing trend for both variables. Annual and monthly data of rainfall and temperature in England was evaluated by Perry (2006) in a grid net of 5 km resolution for data obtained from 1914 to 2004. He indicated that there was a significant trend in the rainfall. Summer rainfall has decreased but winter rainfall has increased in the north and western parts of the study area t-test method for trend detection was used by Ghahreman (2006) who used this test for trend detection of mean annual air temperature in 34 stations of Iran and found that 50% of stations showed positive trend while 41% of station had negative trend. Local and temporal changes in rainfall of Iran were studied by Asakerh (2007) who noted that 51.4% of Iran area was faced by rainfall changes that has high rate changes in mountains area and western part of Iran. Minimum of this change is -15.7 mm in Sarab station and its maximum is 29.6 mm in the Kouhrang station. Tamil Nadu is located in the southern part of India and has an important role in the socio economic development of India which is one of the major rice producers of the country. This region is prone to drought phenomenon. In the other words, this region can be confronted by water supply stress. Thus for better management and programming, suitable studies related to rainfall and temperature are necessary for this region. These results can be used for local and regional programming of water resources sections and helps governors for selecting optimum strategies related to water management. In fact the goal of the study is determining trend of rainfall and temperature series that results is suitable of water supply organizers for better water management in the State.

MATERIALS AND METHODS

Study Area

Tamil nadu is located in the southern part of arid lands of India with area of 4334 km^2. There are some mountainous regions in the west (Western Ghats) but plains and playas are the main feature of the geomorphology in the east section. So there is not a unit climate in this area. The average annual of precipitation in this area is over 1000 mm with high variability coefficient. There are 5 climatology stations taken into account that have longer period of data record; that was used in this study. The time period for this study is considered 30 years from 1980 to 2009.The rainfall data and the temperature for 5 districts month wise is given in tables 5 and 6.Average temperature for different seasons and annually are calculated and average rainfall of different seasons is also calculated for comparisons.

Methods

In this study, statistical method was used for trend detection in the rainfall and temperature series. Parametric tests of t-test and linear regression and nonparametric tests of Mann Kendall, Spearman's rho , Kendall's tau and Mann Whitney were used for trend detection in the time scales of annual and seasonal.

t-test

In the parametric test such as t student, a linear regression is considered between random variable of (Y) during time of (X). Regression coefficient of b1 (Pearson correlation coefficient) is calculated by data and t statistics is determined by the following equation:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = \frac{b_1}{s/\sqrt{ss_x}} \qquad (1)$$

In this equation, t-student distribution has freedom degree of n-2 that n is sample size, s is residual standard deviation and SS_x is sum square of dependent variable (time in trend analysis). Null hypothesis (H_0 : $\rho = 0$ (or $\beta_1 = 0$)) and H1 hypothesis (H_1: $\rho \neq 0$ (or $\beta_1 \neq 0$) are determined in the significant level of α. ρ and β1 are correlation coefficient and regression coefficient respectively. Lack of trend hypothesis can reject when the calculated t is more than its critical amount (t α/2) or p-value is lower than significant level (for example 0.01%) (Yue and Pilon, 2004).

Linear Regression

Linear regression is a parametric test and it assumes that data has normal distribution and it evaluate existence of linear trend between time variable (X) and desire variable (Y). Slop of regression line is calculated by following equation:

$$a = \bar{Y} - b\bar{X} \quad (2)$$

$$b = \frac{\sum_{i=1}^{n}(X_i - \bar{X}) - (Y_i - \bar{Y})}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \quad (3)$$

And S statistics can calculate by:

$S = b/\delta$

S statistics has freedom degree of n-2 and it assumes data with normal distribution and errors are independent with the same distribution (normal) and has mean of zero:

$$\sigma = \sqrt{\frac{12\sum_{i=1}^{n}(Y_i - a - bX_i)}{n\,(n-2)\,(n^2-1)}} \quad (4)$$

Mann Kendall Test

A single variable statistics of Mann Kendall is defined for a special time series (Z_k, K = 1, 2,..., n) by following relation:

$$T = \sum_{j<i} \operatorname{sgn}\,(Z_i - Z_j) \quad (5)$$

And

$$\operatorname{sgn}\,(x) = \begin{cases} 1,\ldots\ldots \text{if} \ldots x > 0 \\ 0,\ldots\ldots \text{if} \ldots x = 0 \\ -1,\ldots \text{if} \ldots x < 0 \end{cases}$$

If there is not relationship between variables and the series has not trend, it would have (Onoz and Bayazit, 2003):

E (T) = 0 and Var (T) = n (n-1) (2n+5)/18

Spearman's Rho Test

This is a sequential nonparametric test. For data sets of {Xi, i = 1,2,…n} the null hypothesis is assumed that all Xi are independent and have the same distribution. But H0 hypothesis is assumed that Xi decrease or increase corresponding to I and it means there is a trend in the data series. Test statistics of D is defined as:

$$D = 1 - \frac{6\sum_{i=1}^{n}\,[R\,(X_i) - i]^2}{n\,(n^2-1)} \quad (6)$$

where, R (X_i) is i th order of X_i observed data and n is sample size regard to null hypothesis, D has normal distribution symmetrically and its average and variance are (Sneyers, 1990):

E (D) = 0 V (D) = 1/n-1

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Mann-Whitney Test

This is a kind of nonparametric test that is used for trend detection in data and can compare two independent and accidental variables. U statistics is calculated as following:

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum_{i=n1+1}^{n2} R_i \qquad (7)$$

Where n_1 and n_2 are sample size of two variables and R_i is their rank.

RESULTS AND DISCUSSION

Results

Plots of data series versus time are represented in Figure 1 and in Figure 2. Data sets should have normal distribution in the parametric test, thus normality test was carried out using Kolmogrov Smirnov method. Kolmogrov Smirnov test is a nonparametric test that can use for detection normal distribution of data. This test compares the observed cumulative distribution function for a variable with a specified theoretical distribution like normal distribution. The power of this test is detection departures from the hypothesized distribution. For using data in parametric tests, data should have normal distribution and we can check type of data distribution for these kinds of test using Kolmogrov Smirnov test. All data distribution was controlled by this test.

Table 1: Results of t-test for data of rainfall and temperature data set

Station	Period	p-value
Chennai	Annual	0.31
	Winter	0.06
	Pre monsoon	0.12
	Monsoon	0.01
	Post monsoon	0.99
Vellore	Annual	0.03
	Winter	-1.01
	Pre monsoon	0.02
	Monsoon	1.11
	Post monsoon	0.03
Nagapattinam	Annual	2.56
	Winter	2.31
	Pre monsoon	2.10
	Monsoon	2.3
	Post monsoon	0.05
Kanyakumari	Annual	-1.26
	Winter	0.38
	Pre monsoon	-0.61
	Monsoon	0.89
	Post monsoon	0.76
Coimbatore	Annual	0.78
	Winter	-0.60
	Pre monsoon	-0.004
	Monsoon	0.83
	Post monsoon	0.66

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Table 2: Results of linear regression test for the rainfall and temperature data

Station	Period	b	a	S
Chennai	Annual	0.05	8.8	6.3
	Winter	0.03	6.4	3.6
	Pre monsoon	0.07	20.3	6.7
	Monsoon	0.04	11.5	3.8
	Post monsoon	0.08	41.4	3.4
Vellore	Annual	0.09	50.3	-3.8
	Winter	0.001	40.7	-2.6
	Pre monsoon	-1.6	45.2	3.4
	Monsoon	-1.03	42.3	5.9
	Post monsoon	0.03	45.2	0.19
Nagapattinam	Annual	0.01	26.6	0.89
	Winter	0.03	21.2	-0.76
	Pre monsoon	0.04	24.3	1.7
	Monsoon	0.13	11.3	5.9
	Post monsoon	0.04	35.2	3.7
Kanyakumari	Annual	-o.08	19.6	3.7
	Winter	0.69	70.4	-o.84
	Pre monsoon	0.43	82.3	2.5
	Monsoon	0.25	26.3	-16.8
	Post monsoon	0.06	54.7	52.9
Coimbatore	Annual	-1.07	23.5	149.5
	Winter	0.006	19.3	-1.9
	Pre monsoon	0.01	82.4	2.5
	Monsoon	0.53	13.8	23.6
	Post monsoon			

Linear Regression Method

Results of regression test indicate that the statistic S has maximum of 3.89 and minimum of -0.83.Though there are fluctuations the comparability of rainfall with temperature does not show any significant trend .Both are positive or negative simultaneously or in other words they are positively proportionate to each other conforming Mann-Kendall’s test.

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Table 3: Results of Mann-Kendall's test and Sen's slope estimator of rainfall and temperature data set

Station	Period	Rainfall p-value	Rainfall MK Stat	Temp p-value	Temp MK Stat	Sen's slope (RF)	Sen's slope(Temp)
Chennai	Annual	.982	-.007	.0001	.561	-4.645	.31
	Winter	.335	.132	.000	.488	.14	.078
	Pre monsoon	.402	.113	.025	.297	1.618	.073
	Monsoon	.075	-.236	.003	.388	-18.428	.11
	Post monsoon	.724	-.049	.015	.323	-9.276	.084
Vellore	Annual	.515	.089	.063	-.246	92.409	-.271
	Winter	.894	-.020	.046	-.266	0	-.056
	Pre monsoon	.075	.236	.216	-.165	50.102	-.067
	Monsoon	.926	-.015	.276	-.146	-20.765	-.066
	Post monsoon	.185	.177	.721	-.050	96.958	-.015
Nagapattinam	Annual	.004	-.379	.115	-.210	-454.753	-.176
	Winter	.652	-.062	.598	.073	-8.552	.017
	Pre monsoon	.540	.084	.195	-.174	19.078	-.033
	Monsoon	.0001	-.527	.377	-.120	-197.116	-.044
	Post monsoon	.025	-.296	.105	-.219	-186.696	-.039
Kanyakumari	Annual	.211	.167	.293	-.141	297.605	-.085
	Winter	.985	-.005	.666	.060	-1.311	.011
	Pre monsoon	.066	.249	.338	-.129	177.33	-.028
	Monsoon	.515	.089	.536	-.084	76.341	-.031
	Post monsoon	.485	.102	.027	-.302	41.05	-.05
Coimbatore	Annual	.003	.415	.311	.136	595.556	.173
	Winter	.424	.108	.260	.152	6.002	.03
	Pre monsoon	.130	.202	836.	-.030	74.623	-.013
	Monsoon	.240	.158	.001	.428	217.902	.16
	Post Monsoon	.048	.261	.302	-.139	298.551	-.05

Table 4: Results of Spearman's rho and Kendall's tau for data set of rainfall and temperature

Station	Period	SP Test	Kendall's tau test
Chennai	Annual	0.599	0.568
	Winter	0.625	0.733
	Pre monsoon	0.564	0.605
	Monsoon	0.001	0.002
	Post monsoon	0.04	0.058
Vellore	Annual	0.509	0.522
	Winter	0.045	0.029
	Pre monsoon	0.134	0.169
	Monsoon	0.025	0.027
	Post monsoon	0.816	0.800
Nagappattinam	Annual	0.886	0.922
	Winter	0.579	0.045
	Pre monsoon	0.021	0.033
	Monsoon	0.112	0.099
	Post monsoon	0.543	0.471
Kanyakumari	Annual	0.573	0.634
	Winter	0.748	0.754
	Pre monsoon	0.830	0.854
	Monsoon	0.681	0.621
	Post monsoon	0.021	0.021
Coimbatore	Annual	0.187	0.241
	Winter	0.915	0.965
	Pre monsoon	0.097	0.075
	Monsoon	0.592	0.528
	Post monsoon	0.497	0.586

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Table 5: Results of Mann-Whitney test for the data set

Station	Period	P-Value
Chennai	J-F	0.31
	MAM	0.26
	J-S	0.96
	O-D	0.34
	ANNUAL	0.76
Vellore	J-F	0.90
	MAM	0.96
	J-S	0.39
	O-D	0.051
	ANNUAL	0.002
Nagapattinam	J-F	0.49
	MAM	0.002
	J-S	0.35
	O-D	0.01
Kanyakumari	ANNUAL	0.24
	J-F	0.19
	MAM	0.32
	J-S	0.15
	O-D	0.003
	ANNUAL	0.02
Coimbatore	J-F	0.96
	MAM	0.88
	J-S	0.44
	O-D	0.001
	ANNUAL	0.35

Discussion

This study was focused on the trend detection of annual and seasonal time series of rainfall and temperature at 5 stations in the Tamil Nadu, viz. Chennai, Vellore , Nagapatinam, Kanyakumari and Coimbatore for a 30 years period. Parametric tests of “t-test and linear regression” were used for linear trend detection and non parametric tests of “Mann Kendall, Mann-Whitney and spearman’s rho” were used for nonlinear trend of date sets. Plots of rainfall data show irregular fluctuations in different time scale, but these fluctuations are smaller with clear trends in temperature time series. Results of different test are presented as follows:

t-test Method

Normality test of data indicated that all data have normal distribution with confidence level of 95%. t-test was performed for two separated groups with 30 sample sizes and each significant difference means existence of trend in data.

Results indicated that there is no significant trend for both seasonal and annual scales with confidential level of 95 %.From the above table, though there are significant trends in some seasons over all the risk of removing them to null hypothesis is less than that it has to be counted. In other words, in the seashore regions, they are directly proportional and in the offshore regions it slightly differs. But this change is not of a considerable amount.

Linear Regression Method

Results of regression test indicate that the statistic S has maximum of 3.89 and minimum of -0.83.Though there are fluctuations the comparability of rainfall with temperature does not show any significant trend .Both are positive or negative simultaneously or in other words they are positively proportionate to each other conforming Mann-Kendall’s test.

Mann-Kendall Test

In the non-parametric Mann – Kendall test, trend of rainfall and temperature for 30 years in 5 districts of Tamilnadu has been calculated for annual and the four Indian seasons together with Sen's slope estimation for these period.

Results of Mann-Kendall test and Sen's slope estimator are shown in Table 1. Minimum value of Mann – Kendall statistic for rainfall and temperature are 0.0001 (in winter, Chennai), 0.004 (annual, Nagapattinam) 0 .000 (in winter, Chennai) respectively.

There is an evidence of rising trends in rainfall in Chennai during winter (J-F), pre monsoon(MAM), in Vellore during annual (J-D), pre monsoon (MAM), post monsoon (O-D), in Nagapattinam during pre monsoon (MAM), in Kanyakumari during annual, pre monsoon, and post monsoon and in Coimbatore during all the seasons. In other seasons it is negative.

There is an evidence of raising trend of temperature in Chennai during annual and all seasons, in Vellore there is no positive trend, in Nagapattinam during winter (J-F), in Kanyakumari during winter (J-F) and in Coimbatore during winter (J-F) and monsoon (J-S).

As far as, for a healthy trend, the trend with respect to rainfall and temperature should be uniform i.e. if both are negative or positive then it is balancing otherwise the cause for rising trend may be global warming. The cause of rise in rainfall may be due to due to different geographical conditions that influence the variation.

Sen's slope is also calculated for the same five districts in Tamilnadu .Its values are also presented in Table 1 from the table there is no change for the winter season of Vellore is identified i.e., '0'otherwise the Sen's slope results are not significant with the Mann-Kendall's .

The places or seasons showing different trends with respect to rainfall and temperature are

Chennai – winter, Pre monsoon, post monsoon seasons

Vellore – annual, Pre monsoon, post monsoon seasons

Nagapattinam – winter, pre monsoon seasons

Kanyakumari – annual, winter, monsoon, Pre monsoon, post monsoon seasons

Coimbatore - Pre monsoon, post monsoon seasons

If both the trends move simultaneously ie., either increasing or decreasing then the climate will be normal. The variations may be due to air pollution, glaciers melting on poles, green house gases etc.

Therefore we can conclude that there is evidence of some change in the trend of precipitation in the specific regions in 30 years period. Hence, further study in this region finding the cause and other aspects may help better irrigation in the State.

Mann-Whitney Test

Nonparametric test of Mann-Whitney was performed on the rainfall and temperature series of 5 districts of Tamil Nadu for the period of 30 years. Results in Table 3 indicate that the rainfall and temperature are closely related to each other i.e. in test the risk of rejecting the null hypothesis is lower than 10 % in each case. Hence, it emphasises that the rainfall and the temperature are influencing each other.

During winter seasons, a positive trend exists in almost all the places.

Spearman's Rho Test

The Spearman's Rho test and Kendall's Tau test for different seasons of 5 districts of Tamil Nadu are shown in table 2.Results of Spearman's rho test indicate there is no significant trend in many seasons. In Chennai during monsoon and post monsoon seasons, it is negative. In Vellore during monsoon it is negative. In Kanyakumari during post monsoon, in Nagapattinam during monsoon the negative trend occurs. The result of Kendall's tau simulates almost the same trends as in Spearman's rho test.

Stability of rainfall variables and lack of positive trend in annual and seasonal scales in Chennai and in Vellore, it is expected that evaporation rate has increased due to warming of study area and this can cause stress on the water supply systems and limits agriculture practices. Matouq (2008) mentioned in his work that increasing air temperature caused increasing of evaporation. Increasing of air temperature and diminishing rainfall can influence a lot on water systems (Yasin, 2009). Also this positive trend of temperature can influence on the hydrologic cycle and it can impact on change of snowmelt time of

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upstream region and it may initiate problems in water supply system and extended irrigation networks in the downstream of this basin. Thus it is necessary that policy makers make an attempt to solve this problem and introduce proper programs in the regional and local scales toward diminishing negative impacts of the global warming.

Table 6: Monthly Rainfall data of 5 districts in Tamil Nadu

CHENNAI												
year	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1980	2				8	124.1	501.9	547.7	31.2	429.9	1850.6	750.8
1981			2.7	35	88.2	22	356.2	247.3	521	815.8	372.3	382.8
1982	6.6			2.2	8.2	311	381.3	410.6	275	641.4	583.7	0
1983					25.2	205.7	312.3	1144.7	153.3	1265.4	239.6	1174.3
1984	94.3	1106.2	3	5.7		204.8	338.8	58	712.8	393.6	1209.9	332.8
1985				69.4	23.7	232.4	247.7	328.4	366.2	438.1	2013.4	266.6
1986	270.1	45.8	0		5.2	51.8	45.2	203.6	138.3	645.3	317.4	226.3
1987	18.6		52	23.5	1	230.4	82.8	357	154.8	816.1	765.4	1034.7
1988	10.7	37.4	0	9.7	81.3	65.2	484.4	868.7	586.2	234.3	1322.9	337.8
1989	18.6	0	43.8	0	23.2	322.6	574.4	160.1	287.6	327	910.1	380.8
1990	12.5	0	27.6	0	0							
1991	0	0	0	0	0	495.7	152.3	203.8	351.7	598.6	911.2	3
1992	24.3	0	0	80.5	102.5	16.3	173.3	331.4	153.7	167.6	1065.9	0
1993	0	0	12	0	112.1	82.1	136.2	204.3	110.1	499.3	642.5	565.7
1994	0	0	0	0	144	106.3	0	205.5	76.6	804.6	1102.3	450.5
1995	345.2	0	0	0	608.5	37.8	206.2	513.5	373.3	496.9	542.9	0
1996	0	0	0	34.1	15	1424.3	117.9	0	0	0	330.3	891.4
1997	19.3	0	0	109.3	0.6	102.3	97	182.2	345.1	594.1	1641	1344.2
1998	5.6	0	4.5	29.9	37.4	77.7	217.1	216.6	131.3	378.7	656.7	375.9
1999	14.4	0.2	0	21.1	18.5	202.5	175.4	357.1	334.3	636.2	307.6	98.4
2000	0	381.5	0.6	31.8	31.2	186.4	197.2	119.7	244.4	295.8	341	90.8
2001	1.4	0	0	152.4	35.6	51	512.5	98.9	257.5	812.4	757	543.9
2002	78.1	9.6	0	0	29.4	67.7	141.5	174.5	246.9	658.4	1037.3	51.9
2003	0.1	0	6.2	0	0.5	26.9	180.6	220.1	265.1	272.6	152.5	165.4
2004	72.5	0	0.2	2.4	353.6	28.8	50.6	47.1	246.5	285.3	280.2	6.8
2005	2	5.2	0	210	84.9	57.1	353.2	132.7	180.4	2387.8	1394.4	989.5
2006	3.5	0	39.5	14.1	39.2	86.4	158.1	289.8	360.9	1371.9	530	31.6
2007	0	12.6	0	0.2	0.1	205.2	588.9	487.9	411.7	708.9	211	659.3
2008	118.2	16	307.4	35.9	0.3	293.4	68.6	297.2	243.4	787.9	1109.6	29.7
2009	43.1	0	2	0	24.2	34.5	72.8	148	171.8	149.8	1317.6	595.2
2010	15.2	0.4	0	0	437	433.7	446	630.5	277.7	326.2	493	268.1
VELLORE												
year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	68	0		97.5	953.1	264.8	1627.1	2849.2	1016	1154.8	2089	849.7
1981	96.6	0	746.5	455.4	1424	1090.5	3320.2	3575.5	3964	4235.4	1096.4	1158.5
1982	0	0	129.5	186.7	1457	1437.4	1093.5	906.8	2634	1774.3	4758.3	14.9
1983	0	0	165.8	229.5	1499	2144.7	2999.1	5250.9	6994	2213.8	681.4	3772.3
1984	*164*	*2530*	*1261*	*585*	*416*	*289*	*6185*	*271.1*	*3495*	*3121*	*2443.9*	*1442*
1985	675.9	0	96.2	478.8	610.5	2226.3	3460.8	3514	3356	2684.8	5684.8	597.8
1986	1555	424.5	0	360.8	1070	1093.3	1279.3	1824.7	4347	1970.8	2262.4	276.7
1987	79.2	2	576.6	483.5	567.9	1825.6	983.1	2581.3	2310	3559.9	2646.1	3981.7
1988	0	0	213.3	2145	1587	277	3156.7	5678.5	4199	1619.6	1060.1	1638.9
1989	0	0	232.1	59.2	802.5	1251.6	6206.4	352.2	3785	1913.4	2707.5	769.8
1990	327.5	148.9	713.5	559.5	0	0	0	0	0	0	0	0
1991	0	0	0	423.8	0	3664	735.7	3103.1	3637	6117.6	6869.3	20.6
1992	192.2	0	0	176.4	832.5	770.3	1537	1282.5	2418	3392.2	4284.2	0
1993	0	56	46.6	49.2	959.8	2035	1597.6	2390.7	5282	3626.7	1283.4	2987.6

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1994	58.3	5	0	136.4	1806	849.3	0	3423.7	2674	3794.4	3602.7	177.1
1995	619.7	63.9	0	29.8	5546	2827.4	2785.9	5684.5	2595	2356.3	870.8	0
1996	0	0	1196	538.8	4871	1490.4	1490.4	3875.7	6100	3326.7	1858	6716.6
1997	179.5	0	141.4	891.1	963.6	1956	50.8	1478.3	358.8	2542.2	4628.6	2447.8
1998	0	0	0	423.4	432.2	453.7	1867.5	3886	4253	3124.6	3925.3	2565.8
1999	80.3	0	0	1306	1380	1090.2	784.1	1958.2	1181	2757.4	2401.2	1523.6
2000	1024	0	0	504.8	1431	1559.7	1957	4061.6	4405	4521.4	2481.6	1523.2
2001	78.8	0	82.6	1678	1619	630.1	4418.2	1353.9	6183	6349.4	1195	2041.9
2002	143	1	0	154.2	1721	1772.6	496.8	1468	2616	3817.5	1440.3	682.7
2003	0	0	965.3	288.4	394.2	1767.7	5618.4	4204	2639	3793.2	736.1	265.4
2004	156.4	0	6.1	572.3	5834	751.8	1897.4	193.5	4755	2746.8	2660.4	8.5
2005	0	24.8	512.5	2109	1827	1369.9	1851.7	2288.5	3856	7800.4	5034.9	3654.3
2006	110.5	0	734.5	642.5	1103	2755.5	715.8	1852.2	4348	4717.8	2390.8	1142.4
2007	0	63.8	0	1443	1929	2155.3	4164.2	4153.4	2862	4521	1431.9	5350.4
2008	284.8	154.3	2090	196.8	2270	1399	1874.3	2381.3	3644	2877.3	6325.2	269.1
2009	46	0	33.6	268.8	1756	1367.9	694.2	2715.7	4992	645.8	4265.6	1927.4
2010	150.4	0.2	0	488.7	2507	2570.7	5824.6	2530.2	2671	3397.3	2664.37	3224.9

NAGAPPATINUM

year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	39.4	0	20.1	758.9	297.6	629	777	608.7	1359	3266.1	5107.3	2512.8
1981	743.9	0	57.2	102.7	1437	62	2732.2	1028.4	3385	6036.2	5375.4	3241
1982	0	0	31.1	392.7	606.3	759.7	482.7	1047.3	875.2	1837.3	6959.3	2094.2
1983	0	0	0	0	1262	503.9	1346	3313.1	2584	2516.3	3393.9	16164
1984	2206	6479.8	1332	1243	2	352.9	3619.6	769.5	3571	1903.3	6258.8	2548.2
1985	4447	67.4	16	444.6	213.3	1859.3	1180.4	2646.5	1507	4090.5	12876.9	3038.2
1986	3617	1090.1	912.9	305.8	848.1	193	1088.2	2449.4	1799	3828.6	4925.9	7190.6
1987	657.8	60.4	887.7	19	836.3	1264.8	372.6	2068.4	2215	7568.6	2811.1	7188.5
1988	14.4	0	337.7	2286	140.1	480.5	1246.4	2853.8	2404	1112.7	10459.3	1581.3
1989	285.2	0	85.5	14.8	489	363.8	2994.5	1193.4	2060	3064.2	9288.9	2794.5
1990	2387	295.7	1160	180	1848	275.5	727	2543	4103	6690.9	3752.4	2656.7
1991	1270	56.7	0	26.9	23.8	2295.3	407	1060.2	1981	5711.5	11556.6	2132.6
1992	63.4	0	0	246.8	869.6	491.5	887.9	1265.5	2422	3540.4	7969.9	3531.7
1993	0	135.6	209.4	135	503.6	877.1	1230.2	1549.3	1607	6253.4	10186.4	10087
1994	342	2213.7	8	246.2	717.8	60.4	798.4	584.1	685.4	2901.4	9516.8	2594.4
1995	1371	96.1	0	434.7	3390	1299.5	2024.4	1088.1	2111	4754.3	6321.6	1026.8
1996	0	0	0	490.9	508.5	3602.6	677.7	3266	4039	3129.3	9346	483.9
1997	592.1	0	0	358.3	741.9	808.7	2263.5	911.4	2180	4079.4	16128.9	6812.3
1998	243.5	113.5	0	0	1990	148.3	1154.4	3334.1	1942	2299.3	7354.4	9562.2
1999	159.4	1272.5	6.3	1117	955.3	184.4	397.5	1006.7	813.8	5060.5	9918.5	2084.1
2000	3994	2223.1	51.3	633.5	485.8	219	400.9	794.6	3346	3198.2	7614.8	3841.4
2001	278.8	104.6	0	1251	1466	978.4	1689.8	1077.1	2272	4568.8	5195.3	5562.9
2002	509.2	2600.5	0	0	339.6	469.6	253.3	227.1	602.9	2493.4	2694.4	1060.5
2003	62.3	1.2	130.1	154	372.6	452.8	731	1194.1	469.1	1917.8	4534.5	544.5
2004	147.2	14.2	116.5	0	2881	148.9	235.8	869.3	2417	6399.4	4549.4	635.5
2005	17.4	5.5	24.1	1954	395.8	7.2	274.1	538.3	1207	1546.5	8260.1	1138.8
2006	354.3	0	308.5	337.9	441.4	112.4	60.3	594.3	997.7	4970.3	4151.6	970.7
2007	0	259	0	205.3	95.5	285.7	597.3	1904.6	795.5	5054.2	1468.7	4052.9
2008	585.2	153.8	3218	176.2	303.3	251.6	151.4	690	460	2614.4	8047.1	1867.6
2009	534.7	68	1686	830.7	406.5	84.7	48	984.1	426	78.6	7008.3	4733
2010	562	0	0.6	63.4	1175	1002.3	484.1	1871.6	1148	1195.1	5646.2	4065.1

KANNIYAKUMARI

year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	0	0	1107	3687	2232	5807.4	2314.6	2534.7	2296	4605.7	7144.9	4518.6
1981	230.3	169.3	1213	2813	2709	10752	2201.1	5344.8	5489	9160.1	5168.3	519.8
1982	8	0	854.7	2635	6248	10076	4911.4	2393.1	964.3	7575.6	6227.2	494.8

1983	1	86.3	154.1	1328	3956	4428.5	2402	3888.5	3168	4261.3	7244.6	4698.3
1984	1083	3283.2	4164	4527	1332	6125.3	3496.3	608.6	4576	14918	3897.3	173.7
1985	3702	746.8	949.1	2180	3653	9754.6	1328.6	1541.6	2576	6631.1	7478.9	1598.5
1986	388.5	2829.2	476.2	3138	2660	2395	1862.4	5903.9	2822	5454.8	4647.1	260
1987	339.1	13.2	1706	4016	5775	4324.1	688.5	4823.6	7207	12555	9100.2	4859.9
1988	49.6	1420.5	3894	6756	1012	8309.6	4539.8	3183.7	9987	1700.2	7544.8	701.6
1989	26.2	0	1619	3526	2404	11186	6075.1	1855.7	5876	7807.8	6831.4	492.2
1990	452.5	92.1	1965	1576	0	0		0	0	0	0	0
1991	0	1108.7	0	4873	0	24483	8424.7	1667.8	386.1	11719	4080.9	154.6
1992	443.3	0	0	2684	7049	7977.3	5651.9	2192.9	3827	12607	16403	0
1993	0	556.2	1083	1980	3245	5783.5	5406.3	1135.4	2659	12057	1774.1	4507.6
1994	30.2	163.7	967.1	3389	4213	5330.6	6111.7	4760.4	3097	14272	6973.6	393.6
1995	1433	12.5	0	3866	11484	3764	3988.5	3342.8	3457	7292.8	8748.2	12.3
1996	198.4	466.2	0	5308	725.1	6784.1	5110.9	1526.2	4423	11088	5434.4	4632.7
1997	262.2	98.7	0	3898	3952	4941.5	3374.8	3776.4	12467	8244.7	9856.1	2654.8
1998	0	56.6	151.5	2544	5063	6398.4	3266	2707	9686	16592	11582.5	7332.1
1999	433.5	1290	820.5	3900	10994	10465	5861.4	944	2207	14825	4348.2	662.1
2000	261.6	6682.5	976.2	2647	950.8	8336.8	1513	13803	4869	4850.9	5439.1	2777.7
2001	1780	641.5	661.2	9758	3420	4830.5	5320.1	2881.4	8610	8092.7	7339.8	569.3
2002	227	707.2	1551	4268	5459	2878.8	908	3107.7	1020	14362	10367.4	202.7
2003	4.2	312.2	1437	3218	1570	4120.7	2041.3	1045.9	414.9	11275	3887.7	395.4
2004	241.3	96.4	1077	4355	9953	7327.8	2990.6	2082.3	7129	7123	3606	286
2005	420.8	626.6	1403	9112	4267	5032.3	8853.3	1337.3	4904	7092.9	9420.8	4850.9
2006	901.7	58.1	4568	1210	6006	4357.2	3968.4	2183	10111	11945	7440.9	183.2
2007	31.3	205.1	516.8	4960	3812	7623.7	6677.3	3926.6	7509	10530	5018.8	664
2008	3.4	2292	8635	3225	949.6	1059.2	7857.4	4927.4	5026	12699	6044.8	952.3
2009	37.2	0	2811	2595	4265	5011.6	4179	2169.8	4431	4582.2	9730.5	2186.4
2010	2257	0	1020	3421	6715	5053.8	5451.3	2771.3	3475	12008	14398.9	9463.8

COIMBATORE

year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	0	0	1272	2093	5630	7370.3	9871	5394.3	2999	5961.8	6071	548.7
1981	39	17	1790	1339	4675	10405	6097.1	7138.7	8681	7181.1	2063.4	1195
1982	2	0	428.3	1037	4989	4684.8	6548.2	5363.7	2713	4854.3	6606.7	514.7
1983	0	23.4	241.9	278.3	4307	7122.1	7378.9	6751.3	3118	5205.9	4873.1	3999.7
1984	555	1664.3	3577	1427	1376	7448	8004.1	3505.9	4175	7830.1	2221.1	2007.3
1985	2563	70.2	134.2	2235	1582	11382	4781.9	5560.8	3903	2913.6	4205.9	1258.2
1986	520.4	1703	530.7	820.6	2547	7628.6	5268.5	8131.1	3632	5101.8	3420.3	397.4
1987	78.9	114.5	1214	747.4	2968	5008.8	3015.5	5221	3613	9558.2	5381.3	7130.5
1988	0	287	1031	5477	4122	4678	10093	7174.7	6666	2701.1	1721.9	298
1989	21.2	0	2082	2474	3037	5639.3	11501	4285.9	5198	6244.4	3447.1	529.1
1990	2911	1	1526	2061	1860	800.1	854.7	907.8	316.2	5447.1	3903.1	768
1991	573.7	20.7	475.2	2344	1796	9427.8	10723	5457.9	1958	4541.8	2277.4	153.6
1992	3	63	0	527.2	3775	10027	11024	4874.2	7476	3432.1	10484.1	535.5
1993	0	639.2	790.4	565.6	2761	4368	7615.9	5500.7	2006	8809.9	11032.9	2145.6
1994	485.9	522.5	86.8	3926	2645	9032.9	2990.5	3438.1	4523	10608	7273.3	5.5
1995	1	0	0	0	3779	4179	7606.1	6171.2	4283	3353.9	3871.2	0
1996	67	130	284.2	4956	1500	19222	7018.9	3336	2228	2244	43340.5	4795.4
1997	49	19	0	1640	920	3953.1	8910.2	6640	3550	9716.4	10623	2909.5
1998	17	0	115.6	1212	2311	6970.7	10497	6242.3	4741	5584.7	9641.4	6700.1
1999	0	318.8	12	3364	4709	3529.8	9141.8	4046.7	2692	16364	4851.2	902.5
2000	390.6	1964	73	2166	2129	7216.3	4486.7	12401	7130	1452.6	3788.6	2539.6
2001	363.7	328.3	840.5	4285	2093	6496.7	7492.9	3778.9	3081	6046.1	5373.6	1172.2
2002	66.4	331.7	1388	653.4	2807	4610.7	2900.1	6854.8	1767	10596	2519	915
2003	0	899.9	3763	2247	1372	4798.7	6361.1	5381.9	1427	10739	3517.4	557.3
2004	346	14.4	1007	2387	7163	9532.1	5320.9	7403.6	6171	8564.2	5835.3	33.9

2005	536.1	341.3	1129	6874	4592	5624.4	14196	7679.9	7461	7895.7	9476.7	4073.1
2006	668.7	18	2646	1839	7131	6065.4	7454	5558.5	6958	6045.6	11386.9	66.3
2007	234.2	105.7	1	3597	3023	11355	16059	9321.4	7816	10886	1885.7	6470.8
2008	171.6	1330.9	5201	880.1	1620	6348.7	8674.7	7828.8	4767	11421	2276.1	2184.6
2009	25.5	0	2156	1166	4152	4198.1	15208	4921.8	7327	4839.4	10625.2	1333.3
2010	361.7	90	429	1678	2685	7008.8	9259	5556	4099	8302.2	13050.9	2222

Table 7: AVERAGE MONTLY TEMPERATURE DATA OF TAMIL NADU

CHENNAI												
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1980	26.9	27.3	28.4	27.9	29.9	32.4	30.7	29.5	30.5	28.4	25.9	24.7
1981	24.8	25.4	28	31.2	32.2	32.9	30.6	29.6	28.6	28	26	24.8
1982	24.5	26	27.5	30.4	31.8	32.1	30.7	30.2	29.9	28.4	27	25.4
1983	24.5	27.5	28.9	30.2	32.6	33.1	30.9	30	29.2	28.3	26.3	25.2
1984	25.6	25.8	27.8	30.3	32.6	32.9	29.3	31.3	29.6	28.5	25.7	24.9
1985	25	26.2	28.6	31	32.7	31.4	29.5	30	29.7	28.2	25.2	25.1
1986	24.2	26.1	28	29.8	32.9	32.7	32	30.4	30.4	28	26.9	26.2
1987	25.5	25.2	27.7	30.6	31.6	33.1	31.9	30.2	30.7	28.4	26.9	25.4
1988	25	26.5	29.4	30.4	33.6	33.4	30.5	29.4	29.4	29	25.9	25.8
1989	25	26	26.8	30.2	32.6	31.6	29.1	30.5	29.5	28	26	25
1990	24.7	27.2	29.3	31	30	31.8	30.5	30.1	29.9	27.9	26.7	25.9
1991	25.7	26.7	28.4	30.9	32	30.5	30.6	30	30.1	28.5	26.3	25.4
1992	24.5	26.8	27.9	29.9	31.7	32.5	31.4	30.2	29.1	28.6	26.5	25.2
1993	24.9	26.3	28.7	30.2	32	32.2	31.2	30.3	29.8	28.1	26.5	25
1994	25.4	26.9	28.6	30.7	32.7	32.9	30.7	30	30.5	28.3	25.5	24.5
1995	24.8	26.6	28.5	30.5	31	32.8	30.5	30	30.2	28.1	27.2	25.4
1996	25.2	26.3	27.7	30.4	33.3	30.7	30.5	30	30	28	26.9	24.8
1997	24.8	26.3	28.6	30.5	31	32.1	31.9	31.1	29.2	28.1	26	26.6
1998	26.6	28.1	29.3	31	33.3	33.7	31.4	29.9	30.2	38.2	27.4	25.7
1999	25.1	27	29.3	31.3	31.9	32	31.2	30.3	30.1	29.3	27	25.4
2000	25.8	27.3	28.4	31.1	32.8	31.5	30.3	29.75	30.5	28.6	27.2	25.5
2001	25.7	27.5	29.3	29.9	33.7	32.7	31.8	30.6	30.2	28.4	26.7	25.1
2002	25.8	26.2	28.6	31	33.6	30.9	32.1	30.2	30.8	28.3	26	25.2
2003	25.4	27.1	28.5	30.9	28.7	33.8	30.3	29.9	30.8	29.9	27.1	25.4
2004	25.2	25.8	28.5	31.4	31.1	32	31.2	32.15	29.5	28.15	26.65	25.7
2005	26.2	27.1	29.4	30.3	32.4	33.5	31.5	31.2	30.4	28.3	25.9	25.2
2006	25.7	26.4	29.0	31.2	32.4	32.4	32.1	31.05	30.2	28.6	26.75	31.1
2007	25.9	26.8	28.5	30.6	34.1	31.5	30.7	29.7	30	28.8	26.75	25.9
2008	25.7	27.1	28.1	30.4	33.8	32.3	31.6	30.55	30.2	28.5	27.15	26.1
2009	25.5	27	28.8	31.0	32.7	33.5	31.5	30.1	31.2	32.5	29.6	28.6
2010	24.5	24.9	28.4	32.2	32.9	32	32.1	29.7	29.9	28	26.3	24.2
VELLORE												
YEAR	**JAN**	**FEB**	**MA**	**AP**	**MA**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DE**

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			R	R	Y							C
1980	26	26.5	29.7	32.2	33.4	31.9	31.1	29.6	30.8	28.7	25.8	24.9
1981	25.2	26	29.3	32.4	33.2	31.5	30.5	29.2	28.6	27.7	25.5	23.6
1982	28.9	24.1	26.2	30.5	32.1	32.2	30.9	30.9	30.4	28.9	26.1	24.2
1983	24.6	28.4	30.7	31.9	32.2	31.9	30.7	29.4	28.2	28	25.2	24
1984	24.7	25.2	26.9	30	32.5	31.5	28.5	29.9	29.2	26.9	24.6	23.1
1985	24.2	25.9	28.7	32.7	33.3	30.4	28.8	29	28.8	27.2	24	24
1986	23.3	25.5	28.2	31.4	32.9	31.2	30.8	29.5	29.2	27.6	25.7	25.4
1987	24.5	24.9	28.4	32.2	32.9	32	32.1	29.7	29.9	28	26.3	24.2
1988	23.6	26.6	30.3	30.6	33.1	30.7	30.2	29.2	29	27.2	25	23.9
1989	23.8	24.6	28	30.9	31.8	31.1	28.4	29.5	28.8	26.6	24.4	23.4
1990	22.7	26.4	29.3	31.3	30	30.8	30.3	28.95	28.5	26.75	25.7	24.1
1991	25.2	26.2	29.5	32.2	33.8	30.8	29.9	29	29.2	27.4	24.8	23.9
1992	22.9	26.8	27.4	31.0	32.2	31.6	30.4	29.9	28.6	26.5	25.35	23.4
1993	24.2	25.4	29.1	31.3	33	31.2	30.5	30.2	28.3	27.05	25.05	23.3
1994	23.9	26.3	28.5	31.5	32.6	31	29.2	28.85	28.8	27.25	24.25	22.6
1995	23.4	26.1	28	31.0	32.1	30.7	28.7	28.3	27.9	27.05	25.65	22.7
1996	23.6	25.2	27.8	25.5	33.2	29.6	28.3	28.3	26.7	25.9	24.25	22.0
1997	23.0	25.2	28.6	30.3	32.7	31.2	30.2	29.3	28.8	27.6	25.95	25.4
1998	25.3	26.9	29.2	32.1	32.3	32.1	29.3	28	27.7	26.5	25	22.6
1999	21.9	24.5	27.8	30.5	30.4	29	29.2	28.2	28.8	25.95	23.9	22.7
2000	23.3	25.8	27.3	31.2	30.5	29.6	28.7	26.75	27.3	25.4	23.65	21.6
2001	23.7	26.6	29.9	30.7	33.1	31.5	29.5	29.15	29.1	28	26	23.2
2002	23.8	24.9	28.8	31.3	32.7	30.4	30.8	29.5	29.3	27.65	25.15	23.2
2003	24.7	27	29.9	32.4	34.3	30.6	30.7	28.25	28.5	27.65	24.95	23.9
2004	24.3	24.6	29.2	30.8	29.6	30.2	29.5	30.4	28.5	27.3	24.5	23
2005	24.3	26.5	29.8	30.7	32.3	31.8	30.8	30.1	29.3	28	24.9	24.3
2006	23.9	24.5	29.5	31.7	32	31.3	30.9	30.7	29	27.6	25.4	23.1
2007	23.6	25.7	29	31.2	32.4	30.1	29.6	28.7	29.3	28.7	25.9	22.5
2008	23.1	25.7	27.2	30.2	30.5	30.5	30.2	28.9	28.9	27.6	25.8	23.7
2009	23.5	25.5	28.7	30.7	30.5	32.2	31.7	30.5	29.6	28.4	25.4	24.2
2010	23.9	26.2	28.7	30.5	28.8	27.2	26.7	26.3	27.1	27.4	25.7	24.1

COIMBATORE

YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1980	24	26.3	28.7	29.5	28.5	26.7	26.3	26.2	27	26.6	25.6	24.3
1981	24.5	26.2	28.4	29	28.6	25.4	26.1	25.8	26.2	25.8	25.7	23.7
1982	23.9	26.2	28.7	30.5	28.8	27.2	26.7	26.3	27.1	27.4	25.7	24.1
1983	25	27.6	29.7	30.9	30.4	28.0	26.9	26.1	26.1	26.4	25.3	24.4
1984	24.3	25.3	17.9	27.8	30.3	26.2	25.8	26.2	26.7	25.3	25.3	23.9
1985	24.4	26.6	29.2	30.2	30.4	26	25.3	25.7	26.2	26	24.4	24.3
1986	24.2	26.9	29.1	31.3	29.7	27.6	27.3	26.6	27.4	27.4	25.7	26.2
1987	25.8	26.9	29	31.1	30.8	28.7	28.1	27.6	28.4	27.9	26.3	25.1
1988	24.8	28.2	30.2	29.9	29.4	27.3	27	27.3	26.7	27.7	26.8	27.8
1989	24.1	26.1	28.8	29.3	29.4	27.3	26.9	27.2	27.3	27.3	25.4	24.8

1990	24.3	27.1	29.5	30.1	28.3	27.4	26.5	26.7	27.6	27.6	25.7	24.4
1991	25.5	26.7	29.6	30.4	30.7	27.1	26.3	26.3	28	27	25.5	24.5
1992	24.1	26.2	28.6	30.7	29.6	27.7	26.4	26.5	26.9	26.6	25.4	23.1
1993	23.8	25.6	28.3	30.5	29.7	27.5	26.6	27.2	27.1	26.7	24.8	27.7
1994	24.5	26.9	28.7	29.1	29.2	27.1	26.8	26.3	27.4	27	27	27.5
1995	27.5	28	28.8	29.1	28.6	32.3	26.6	27.6	27.6	27.7	26.4	23.9
1996	24.9	26.6	28.7	29.4	28.9	27.6	26.8	26.7	27	26.3	26	23.8
1997	24.4	26.2	28.7	29.4	29.7	28.8	26.3	26.8	28.1	27.4	26	25.4
1998	25.6	27.3	29.6	31.5	30.4	28.2	27.2	27.6	26.2	27.1	25.9	24.3
1999	24.1	26.6	29.2	29.1	31.1	27.4	26.7	27.4	28.2	26.5	25.2	23.9
2000	24.8	26.7	28.3	29.6	29.7	27.2	27.1	26.5	26.2	26.6	25.9	23.8
2001	25.5	27.8	29.3	29.5	29.3	26.8	26.8	27	27.9	27.1	26.2	24
2002	25.3	26.1	34.1	30.9	30.1	28.1	27.6	26.9	27.9	32.3	25.9	24.5
2003	25.2	27.7	28.8	30	30.7	28.4	26.9	27.8	27.9	27.1	24.8	24.6
2004	25.6	26.7	29.7	30.7	37.6	29.7	29.4	30.1	28.8	26.7	25.8	26.1
2005	26.5	27.3	28.4	28.3	30	27.8	26.9	27.3	27.4	26.8	24.7	24.8
2006	24.4	25.4	28.6	29.4	28.5	27.4	27.3	26.2	26.6	26.8	25.5	24.1
2007	24.7	26.2	28.9	31.1	29.4	29.1	26.8	27.2	27.4	27.9	23.1	23.2
2008	24.4	25.9	25.2	30.4	28.6	28.3	27.7	26.9	27.1	25.4	23.5	23.3
2009	24.3	27.4	28.7	30.3	29.4	30.1	28.7	27.7	27.2	26.2	24.3	23.6
2010	24.7	25.2	26.9	30	32.5	31.5	28.5	29.9	29.2	26.9	24.6	23.1

KANYAKUMARI

YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1980	26.9	27.3	28.4	27.9	29.9	27.5	28.7	25.9	28	27.8	27.5	27
1981	27	27.5	29	29.6	29.9	27.1	28	26.7	27.2	27.8	27.2	26.8
1982	27.2	27.2	28.4	30	29.5	30.3	27.5	27.8	28	27.8	27.3	27
1983	27.6	28.1	29.1	29.9	30.1	28.8	28.2	27.2	27.6	28.3	27.5	27.2
1984	27.1	27	27.8	28.9	29.8	27.2	26.9	28.3	27.4	26.7	29.1	27.3
1985	27.1	28.2	28.9	30.1	29.3	25.5	27.5	27.3	27.1	27.4	26.5	27.1
1986	27.4	27.7	28.6	29.9	29.7	28.4	27.8	26.8	27	27.8	27.5	28
1987	28.1	28	29.2	29.8	30	28.7	28.8	27.2	28.4	27.6	27.6	27.5
1988	27.7	28.2	29.5	29.1	30.4	27.9	28.5	28.4	28	28.8	28	28
1989	27.4	27.4	28.2	27.8	30.2	26.9	26.9	27.2	27.2	27.4	27.7	27.5
1990	26.9	28.5	29.3	29.9	27.6	27.5	27.3	27.3	28.3	27.6	27.4	27.4
1991	27.3	27.7	29	30.1	30	26.9	26.9	27.2	28.3	27.4	27.2	26.8
1992	29.5	27.3	28.2	29.8	29	27.6	26.7	26.9	27.3	27.2	26.8	26.2
1993	26.4	27.4	28.5	29.2	29.3	26.6	24.9	27.2	27.6	27.1	26.7	26.4
1994	26.8	27.6	27.9	28.6	28.8	27.1	26.8	26.3	27.4	27	27	27.5
1995	27.7	28	28.8	29.1	28.6	27.7	27.5	27.2	27.6	27.5	27.1	28
1996	27.8	28.3	28.3	28.9	29.3	27.9	26.5	27.2	27.3	27.6	27.4	26.7
1997	27.5	27.6	29	29.4	29.6	27.9	28	27.4	27.3	27.7	27.1	27.7
1998	28	28.8	29.7	29.7	30.1	28.6	27.6	27.8	27.2	27.2	26.5	26.6
1999	27	28.6	29	29.4	29.3	26.9	27.2	27.4	27.6	27.1	27.9	27.3
2000	27.5	28.6	28.6	29.8	29.8	27.3	27.2	26.6	27.3	27.6	27.6	27.3

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Research Article

2001	27.7	27.6	28.9	28.7	29.6	30.9	31.5	30.9	29.7	28.4	27.3	25.6
2002	26.2	26.6	28.1	29.9	32.6	28.1	27.6	28	27.8	27.6	26.6	26.9
2003	27.6	28.3	28.9	28.5	30	28.9	28.1	28.3	27.9	27.8	27.5	27.7
2004	27.8	28.5	29.3	30	28.3	27.1	26.8	27.8	27.3	27.1	27.1	27.2
2005	27.7	28.5	29.7	29.3	29.8	28.1	27.3	27.9	26.9	27.9	26.8	26.9
2006	26.7	27.9	29.2	29.6	28.5	27.9	27.2	26.9	27	27	26.9	27.1
2007	27.2	27.5	28.5	29.2	28.9	28.5	26.8	27.5	28.2	26.9	27.9	25.9
2008	26.9	27.3	27.6	31.2	28.8	28.6	28.9	23.1	27.4	27	27.2	26.9
2009	27.6	27.2	28.3	28.1	28.7	28.7	27.8	24.1	26.7	27.1	27.2	26.8
2010	26.6	27.1	29.2	29.6	31.9	31.7	31.3	31.7	30	28.6	25.9	26.2
NAGAPPATTINUM												
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1980	25.3	25.6	28.5	30.6	31.9	32.4	31.8	30.8	30.4	27.7	26.8	26
1981	25.4	25.8	28.4	30.9	31.9	32.2	31	30.1	28.8	28.3	26.6	25.5
1982	25.6	26.5	28.1	30.2	31.3	31.7	31.7	31.4	30.5	28.8	27.3	26.2
1983	25.4	27.3	28.8	30.5	32.1	33.1	32	30.9	29.3	28.9	26.7	25.8
1984	25.95	26.2	27.7	29.9	31.9	32.4	30	30.7	28.8	28.5	26.5	25.7
1985	26	26.5	28.8	31.4	32.7	31.2	30.5	30.5	29.7	28.7	26.3	26.2
1986	25.3	26.5	28.2	30	32.5	32.5	31.8	30.3	32.2	30.2	27	26.4
1987	26.1	25.9	28	30.6	31.2	32.9	32	31.4	30.6	28.3	27.7	26.5
1988	25.8	26.9	29.5	29.7	33.7	32.3	31.3	30.8	30.5	29.8	26.3	26.4
1989	25.8	25.4	28.2	30.2	32.4	31.9	29.9	30.8	30.3	28.9	26.5	25.9
1990	24.9	27.6	28.7	30.4	27.8	32.1	31.6	30.3	29.8	28.3	27.4	26.5
1991	26.2	26.4	27.9	30.2	32.4	30.8	31.6	30.4	30.1	28.4	27	25.9
1992	24.9	25.6	25.8	29.7	31.2	32.3	31.3	31.2	34.9	28.3	27.4	25.7
1993	24.9	26.2	28.1	29.3	32.2	32.5	31.8	30.2	30.2	27.9	26.7	25.7
1994	25.7	26.7	27.7	30	32.2	32.6	31.5	31.2	30.7	28.6	26.3	24.9
1995	25.8	26.6	27.3	29.5	30.2	31.8	30.8	30.8	30.4	28.8	27.4	25.8
1996	25.5	26.2	27.7	29.3	32.6	30	30.8	29.7	29.1	28.4	26.9	25.6
1997	25.4	25.4	28	28.9	31.5	32.1	31.2	31.3	30.2	27.9	27.4	27.2
1998	27	27.5	28.3	30.8	31.7	32.9	31.6	29.9	30.2	28.8	27.7	25.7
1999	24.9	26.7	27.3	29.8	30.8	31.4	31.5	30.6	30.4	27.9	26.8	25.7
2000	25.7	26.7	27.3	30.2	32	31.4	31.1	29.8	29.6	28.5	27.3	25.5
2001	25.9	25.9	28.1	28.9	32.3	30.9	31.5	30.9	29.8	28.5	27.2	25.7
2002	26.2	26.6	28.1	29.9	32.6	31.5	32	31.5	31.2	28.7	26.7	25.9
2003	25.9	27.7	28.2	30.1	32	31.9	30.6	30.5	30.8	29	26.9	26.3
2004	25.9	26.5	28.5	30.7	30.3	31.2	30.7	31.3	23.8	27.9	26.7	26.1
2005	26.6	27.1	29.2	29.6	31.9	31.7	31.3	31.7	30	28.6	25.9	26.2
2006	25.6	26.2	28.7	30.4	31.5	31.7	32.1	31.1	29.1	28.5	27.2	26.7
2007	26.5	26.9	28.2	30.2	32.7	31.4	31.1	29.1	30.1	29.5	25.8	25.6
2008	25.9	26.1	26.2	30.9	30.1	31.2	31.3	30.6	30.9	23.8	26.9	25.7
2009	25.2	25.8	27.3	29.9	31.3	31.2	30.3	31.2	31.2	24.1	26.8	25.8
2010	27.2	27.2	28.4	30	29.5	30.3	27.5	27.8	28	27.8	27.3	27

Specified Districts in Tamil Nadu

In this study to access better results and comparison of the tests, not only Mann Kendall test that used by some researchers (Kampata *et al.*, 2008; Krishnakumar *et al.*, 2009; Kumar and Jain, 2010) but also other linear and nonlinear tests was used. Also some researchers have indicated that Mann Kendall test is a suitable test for trend detection (Montazeri and Ghayour, 2009; Yue and Pilon, 2004) but some work suggest other test like t-test, regression method, Spearman's rho, Kendall's tau are also can be used but Mann Kendall test is the best for trend detection and they indicated that the t-test has less power than the non-parametric test when the probability distribution is skewed.

Conclusion

Results above show that generally, t -student and linear regression are suitable parametric tests for linear trend detection and nonparametric tests of Mann Kendall, Man Whitney and Spearman rho have good capability for nonlinear trend detection especially in the climatology data series. It is recommended that several statistical tests are used for trend detection for a data series and it can decrease uncertainty of incorrect detection and interpretation compared with using a single test.

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