A Study Of Temperature And Rainfall Trends In Buldana District Of Vidarbha, India

D. T. Deshmukh, H. S. Lunge

Abstract: - The temperature and rainfall trends are analysed for meteorological data of Buldana district in Vidarbha, India over approximately last three decades stretching between years 1975 to 2005. The long–term change in temperature and rainfall has been assessed by linear trend analysis. The increasing trend in mean of maximum (MMAX) temperature and total mean rainfall (TMRF) is confirmed by Mann-Kendall trend test. It is observed that in Buldana district of Vidarbha region, the December MMAX temperature has increased by 2.6939^{0}C and annual MMAX temperature has increased by 1.3206^{0}C whereas the highest decrease in TMRF occurs in November, by 25.079 mm, and annual TMRF has increased by 12.137mm, during the last 31 years. Annual MMAX temperature shows increasing trend which is statistically significant at 5% level of significance whereas annual TMRF shows increasing trend which is statistically insignificant at 5% level of significance.

Keywords: - Global Warming, maximum temperature, rainfall, linear trend, Mann-Kendall test.

1 INTRODUCTION

Climate change has brought in unexpected changes not only in India but all over the regions across the world. Emergence of global warming due to climate change is the new and most talked subject of today's world as it being the most threatening issue for very existence of life on the earth. One of the consequences of climate change is the alteration of rainfall patterns and increase in temperature. According to Intergovernmental Panel on Climate Change (IPCC,[5]) reports, the surface temperature of the earth has risen by 0.6 ± 0.2^0C over the 20th century. Also in the last 50 years, the rise in temperature has been 0.13 ± 0.07^0C per decade. As the warming depends on emissions of GHGs in the atmosphere, the IPCC has projected a warming of about 0.2^{0}C per decade. Further, surface air temperature could rise by between 1.1^{0}C to 6.4^{0}C over 21st century. In case of India, the climate change expected to adversely affect its natural resources, forestry, agriculture, and change in precipitation, temperature, monsoon timing and extreme events (M. H. Fulekar, R.K. Kale,[2]). Due to global warming, precipitation amount, type and timing are changing or are expected to change because of increased evaporation, especially in the tropics (Ritter,[12]). The pattern and amount of rainfall are among the most important factors that affects agricultural production. Agriculture is vital to India's economy and the livelihood of its people. Agriculture is contributing 21% to the country's GDP, accounting for 115 of total export, employing 56.4% of the total workforce, and supporting 600 million people directly and indirectly (Beena Shah[1]).

- Asso. Professor, Department of Statistics, Brijlal Biyani Science College, AMRAVATI (M.S.)- 444605, INDIA (Email:dtdeshmukh.1721@gmail.com)
- Asso. Professor, Department of Statistics, Shri Shivaji Science College, AMRAVATI (M.S.)- 444603,INDIA (Email: hariharlunge@rediffmail.com

The analysis of rainfall records for long periods provides information about rainfall patterns and variability (Lazaro et. al., [8]). The main objective of this paper is to analyse the 1975 to 2005 rainfall and temperature records obtained from India Meteorological Department (IMD), Pune for Buldana district as a basis on sustainability of crop production.

2 LITERATURE REVIEW

Karl *et.al*.[15] analysed monthly mean maximum and minimum temperatures from countries comprising 37% of the global landmass and found that the minimum temperature increased over the period 1951-1990 by 0.84^{0}C compared to only 0.28^{0}C increase in maximum temperatures. Hasanean[3] investigated the trends and periodicity of surface air temperatures series from eight meterological stations in the east Mediterranean using different correlation tests. Shafiqur Rehman *et.al*.[14] analysed extreme temperature trends for a meteorological data collection station in Jeddah, Saudi Arabia over four decades during 1970 and 2006. Del Rio *et.al.* [13] presented the analysis of mean, minimum and maximum temperatures data from 171 stations in Spain on monthly, seasonal, and annual time scales and they observed that mean, minimum and maximum temperatures increases in all months of the year. Julius M.Huho et. al.[7] examined the changing rainfall pattern during the main growing season (March, April and May) and associated effects on subsistence agriculture in Laikipia East District of Kenya and observed rainfall intensities declined in March but increased in April and May. Jestinos Mzezewa et.al.[6] analysed 23 years(1983 to 2005) of rainfall data in order to study the basic statistical rainfall characteristics at the University of Venda ecotope and found that the distribution of daily rainfall was highly skewed with high frequency of occurrence of low rainfall events.

3 DATA AND METHODOLOGY

The data used in this paper are the monthly averages of total mean rainfall, minimum and maximum atmospheric temperatures during 1975-2005. The yearly averages were calculated from the monthly readings which are provided by the India Meteorological Department, Pune. The time series is made up of four components known as seasonal, trend, cyclical and irregular (Patterson,[11]). Trend is defined as the general movement of a series over an extended period of time or it is the long term change in the dependent variable over a long period of time (Webber and Hawkins,[18]). Trend is determined by the relationship between the two variables as temperature and time, rainfall and time. The statistical methods such as regression analysis and coefficient of determination R^2 (Murray R. Spiegel, Larry J. Stephens,[10]) are used. The magnitudes of the trends of increasing or decreasing maximum temperatures and total mean rainfall were derived and tested by the Mann-Kendall (M-K)[9] trend test and slope of the regression line using the least squares method.

4 STUDY AREA

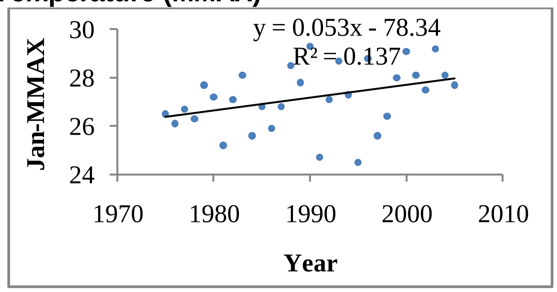
Recently, Vidarbha region has become infamous for a large number of farmer suicides occurring. Buldana district is one of the six distressed districts of Vidarbha for which the Government of India and Government of Maharashtra State have announced the package of relief for the farmers. Vidarbha's economy is primarily agricultural and it is less economically prosperous as compared to the rest of Maharashtra. Vidarbha is the eastern region of Maharashtra State made up of Nagpur division and Amravati division. Nearly 89% of cultivated area of Vidarbha is under rain fed farming. Buldana is the district comes under Amravati division. Buldhana district has an area of 9,680 sq. km and is located in Amravati division of Maharashtra, located in central India. It is around 500 km from the state capital, Mumbai. Cotton, sorghum and other cereals, oil seeds, soybean, sunflower, and groundnuts are the predominant crops grown in the district. The world largest hyper-velocity meteorite impact crater in basaltic rock named the Lonar crater is located in Buldhana district. The district has the population of 2,232,480 of which 21.20% were urban (2001 census).The male population is 1,144,314 and the female population is 1,082,014.The literacy rate 0f the district is 76.14 percent. The world heritage site of Lonar crater is located in Buldhana district. it is the second big crater in world The boundary latitude are : 19.51Â° to 21.17Â° N and longitude are : 75.57Â° to 76.59Â° E.

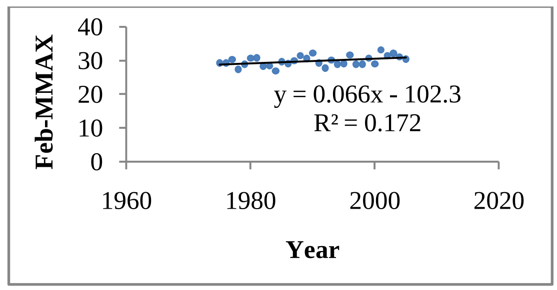
Table1. Statistical summary of monthly mean of MMAX temperatures.

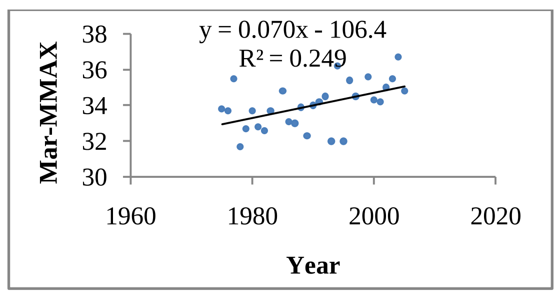
Month	Mean	s.d.	Mean Dev.	C.V. %
Jan	27.17	1.29897	1.0524	4.7801
Feb	29.88	1.45298	1.196	4.8631
Mar	34.01	1.30245	1.0416	3.83
Apr	37.43	1.31173	1.0856	3.5045
May	38.38	1.0841	0.9393	2.825
Jun	33.94	1.80746	1.5337	5.3256
July	28.81	1.11074	0.8742	3.8558
Aug	27.16	0.9617	0.7539	3.5415
Sep	28.97	1.10586	0.8656	3.8172
Oct	30.53	1.49526	1.1302	4.8976
Nov	28.87	1.48787	1.2147	5.1545
Dec	27.31	1.32145	1.0388	4.838

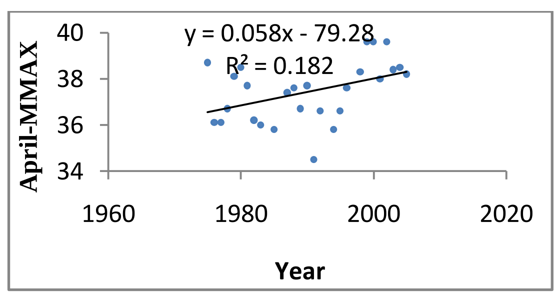
The coefficient of variation for MMAX temperature is highest in the month of June and it is observed as 5.32% whereas it is lowest in the month May and it is 2.82% for the Buldana district. This means that maximum temperature is most stable in the month of May and least stable in the month of June for the Buldana district.

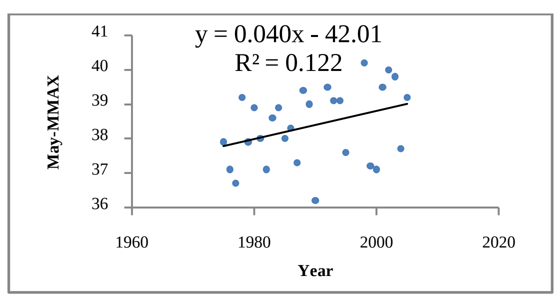
4.1 Trend Analysis of Monthly Mean of Maximum Temperature (MMAX)

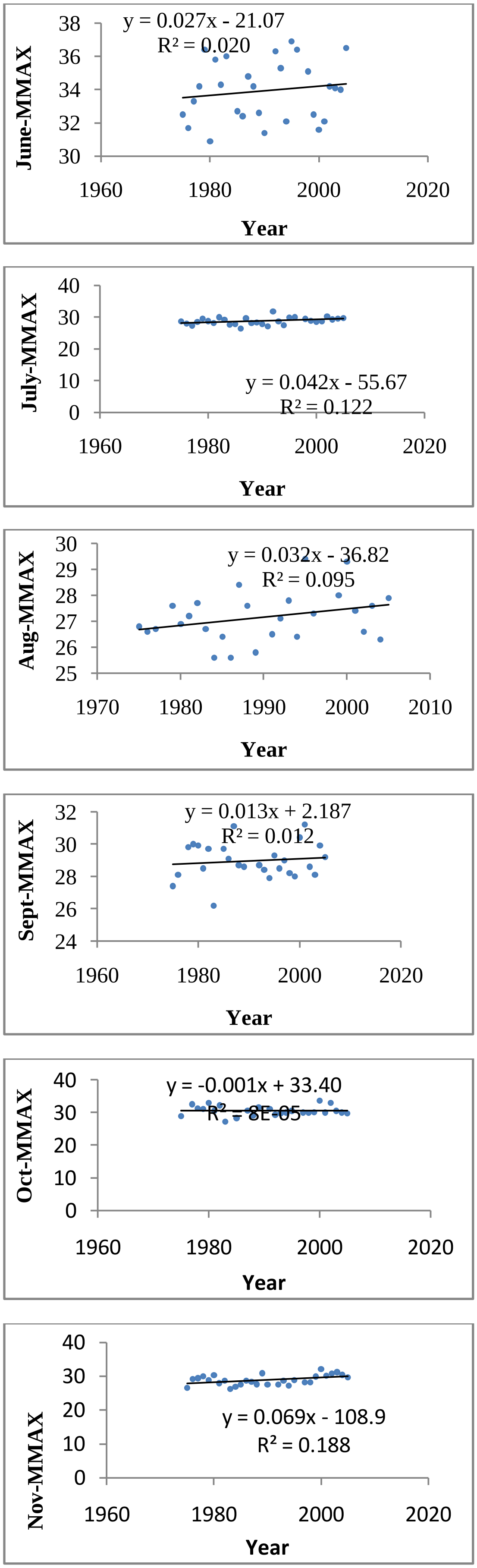












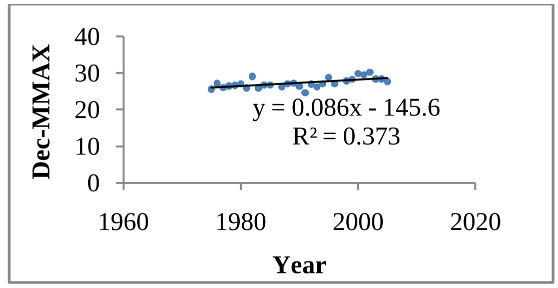


Figure1.Linear regression trends of monthly mean of maximum temperatures.

The trends of monthly mean of maximum temperatures over different years were obtained using linear regression best fit lines. The linear regression trends with their linear regression equations and coefficient of determinations for all the months from January to December are represented in **Figure1** and summarised in **Table2** below. It is evident from above figures that monthly mean of maximum (MMAX) temperatures have increased significantly for all the months except the month of October for which a very weak decrease in MMAX temperature is observed. This implies that in Buldana district the highest increase in MMAX temperature occurs in December (0.0869^{0}C) and has increased by 2.6939^{0}C during last 31 years.

Table 2. Linear regression equations of MMAX temperatures for all the months.

Month	Regression line	R^2
Jan	Y=0.053*X-78.344	0.1377
Feb	Y=0.0665*X-102.36	0.1729
Mar	Y=0.0706*X-106.48	0.2497
Apr	Y=0.0586*X-79.283	0.1822
May	Y=0.0404*X-42.013	0.1228
Jun	Y=0.0276*X-21.073	0.0207
July	Y=0.0425*X-55.67	0.1224
Aug	Y=0.0322*X-36.826	0.0956
Sep	Y=0.0135*X+2.1876	0.0129
Oct	Y= - 0.0014*X+33.406	8E-05
Nov	Y=0.0692*X-108.92	0.1889
Dec	Y=0.0869*X-145.61	0.373

4.2 Trend Analysis of Annual Mean of monthly maximum Temperature (MMAX)

The annual mean of monthly mean of maximum temperatures observed an increasing trend having an annual increase of 0.0426^{0}C per year, as represented in **Figure2.** This implies that in Buldana district annual MMAX temperature has increased by 1.3206^{0}C during the last 31 years.

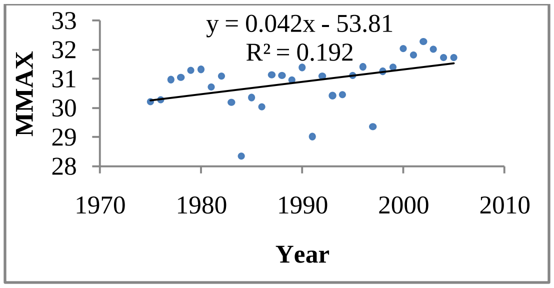


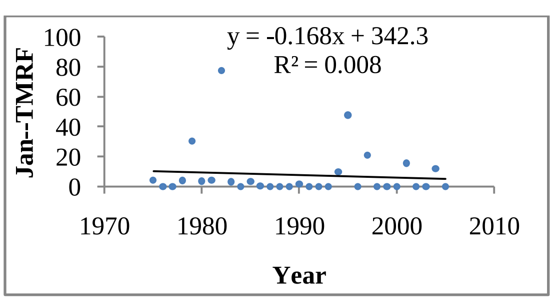
Figure2. Trend of annual mean of monthly maximum temperature.

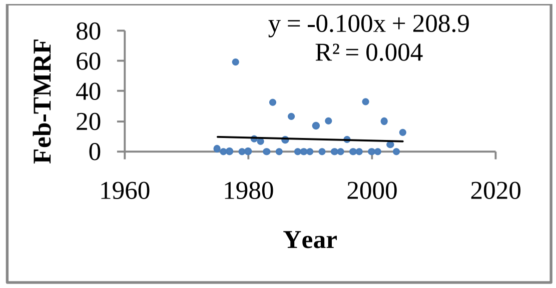
Table2. Statistical summary of monthly mean of total mean rainfall (TMRF):

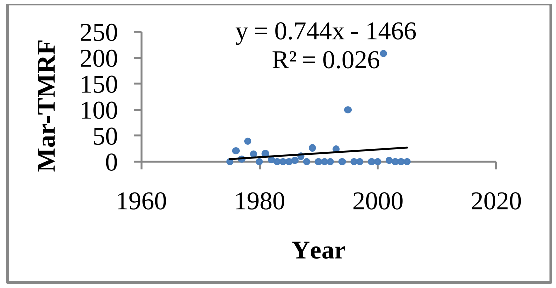
Month	Mean	s.d.	Mean Dev.	C.V. %
Jan	7.6742	16.68	10.31	217.36
Feb	8.2161	13.65	9.791	166.12
Mar	15.787	41.6	21.73	263.51
Apr	5.3	12.22	7.462	230.64
May	15.938	30.11	18.98	188.92
Jun	173.31	77.58	58.11	44.762
July	189.58	57.62	42.05	30.392
Aug	213.76	118.5	87.05	55.43
Sep	120.14	89.66	69.13	74.634
Oct	75.804	65.11	48.85	85.897
Nov	22.713	35.88	26.27	157.96
Dec	6.8448	13.4	9.682	195.74

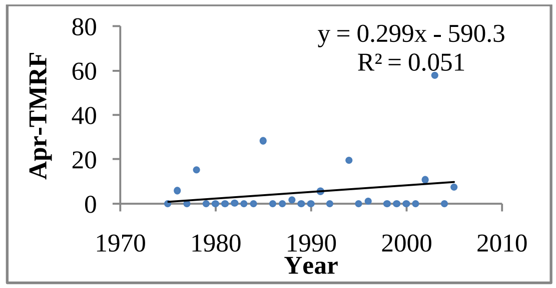
The coefficient of variation for TMRF observed highest in the month of March and it is 263.51% whereas coefficient of variation is minimum for the month of July and it is 30.39% for the Buldana district. This shows that rainfall is more stable in the month of July and is more variable in the month of March for the Buldana district.

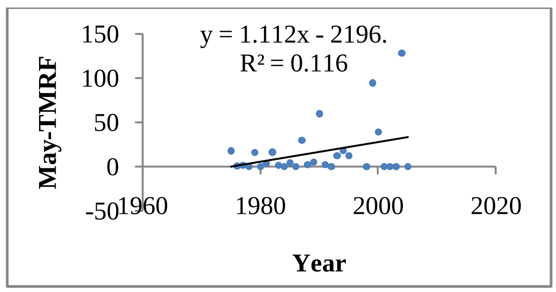
4.3 Trend Analysis of Monthly Mean of Total Mean Rainfall (TMRF)

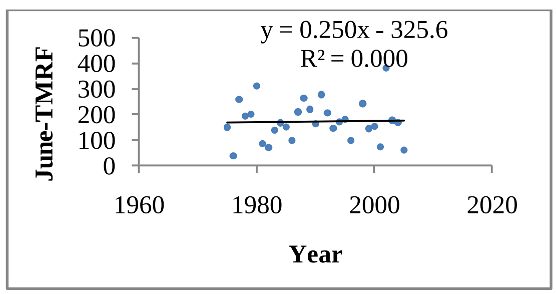


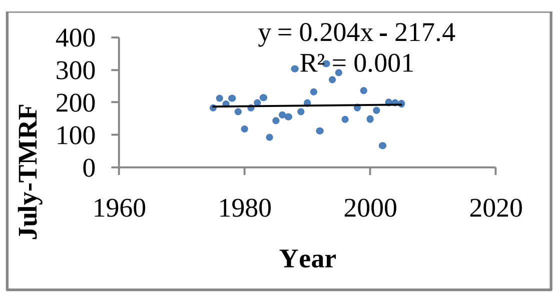












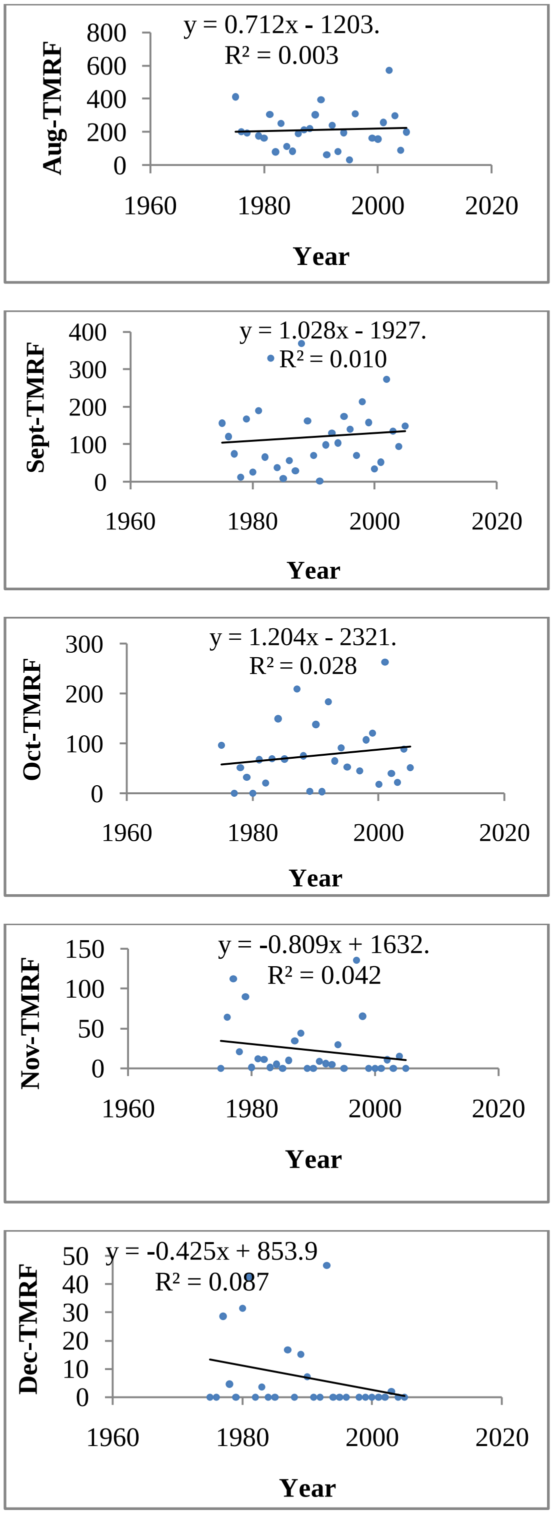


Figure3.Linear regression trends of monthly mean of total mean rainfall.

The trends of monthly mean of total mean rainfall over different years were obtained using linear regression best fit lines. The linear regression trends with their linear regression equations and coefficient of determinations for all the months from January to December are represented in **Figure 3** and summarised in **Table 4** below. It is evident from above figures that monthly mean of TMRF have increased significantly for the months March, April May, June, July, August, September, and October whereas it shows decreasing trend in January, February, November, and December for the Buldana district. This implies that in Buldana district the highest increase in TMRF occurs in October and has increased by 31.324 mm during the last 31 years. The highest decrease in TMRF occurs in November and decreased by 25.079 mm during 31years.

Table4. Linear regression equations of TMRF for all the months.

Month	Regression line	R^2
Jan	Y=-0.168*X+342.3	0.008
Feb	Y=-0.100*X+208.9	0.004
Mar	Y=0.744*X-1466	0.026
Apr	Y=0.299*X-590.3	0.051
May	Y=1.112*X-2196	0.116
Jun	Y=0.250*X-325.6	0.000
July	Y=0.204*X-217.4	0.001
Aug	Y=0.712*X-1203	0.003
Sep	Y=1.028*X-1927	0.010
Oct	Y= 1.204*X-2321	0.028
Nov	Y=-0.809*X+1632	0.042
Dec	Y=-0.425*X+853.9	0.087

4.4 Trend Analysis of Annual Mean of total mean rainfall(TMRF)

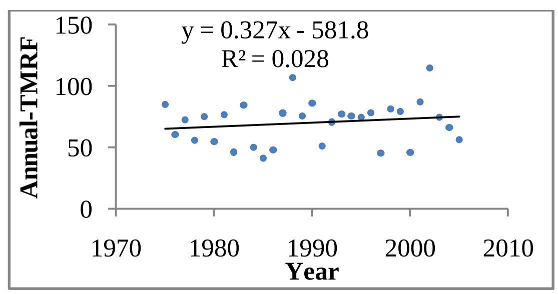


Figure4. Trend of annual mean of monthly total mean rainfall.

From the **figure4**, the annual mean of monthly mean of total mean rainfall observed an increasing trend having an increase of 0.327 mm per year. This implies that in Buldana district annual TMRF has increased by 10.137 mm during the last 31 years.

5 THE MANN-KENDALL TEST FOR TREND

The Mann-Kendall test is a non-parametric test for identifying trends in time series data. The test was suggested by Mann (1945) and has been extensively used with environmental time series (Hipel and McLeod, 2005). The test compares the relative magnitudes of sample data rather than the data values themselves.One benefit of this test is that the data need not conform to any particular distribution. Let X_1, X_2……… Xn represents n data points where Xj represents the data point at time j. Then the Mann-Kendall statistic (S) is given by

$S=\Sigma\ \Sigma$ sign $(Xj- X_k)$, j=2,3….n; k=1,2…..j-1

Where: sign (Xj-Xk) = 1 if Xj-Xk >
= 0 if Xj-Xk =0
= -1 if Xj-Xk <0

A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend.

For a sample size>10, a normal approximations to the Mann-Kendall test may be used.

For this, variance of S is obtained as,

$V(S) = [n (n-1) (2n+5) - \sum t_p(t_p-1)(2t_p+5)] /18$, p=1,2…..q

Where tp is the number of ties for the p^{th} value and q is the number of tied values.

Then standardized statistical test is computed by:

$Z=S-1/\sqrt{V(S)}$ if S>0,
=0 if S=0,
$=S+1/\sqrt{V(S)}$ if S<0

For annual MMAX temperature, the value of S obtained as 208, a very high positive value indicating increasing trend and is statistically significant that there is enough evidence to determine an upward trend as shown in figure 2 which is confirmed by the M-K trend test at 5% level of significance. For annual TMRF, the value of S obtained as 42, a positive value indicating increasing trend but is statistically insignificant that there is not enough evidence to determine there is an upward trend for TMRF shown in figure 4 and is confirmed by the M-K trend test at 5% level of significance.

6 CONCLUSION

It is observed that monthly mean of maximum (MMAX) temperatures have increased significantly for all the months except the month of October for which a very weak decrease in MMAX temperature is observed in Buldana district. The highest increase in MMAX temperature occurs in December by 0.0869^0C and has annually increased by 2.6939^0C during last 31 years. Annual MMAX temperature shows increasing trend which is statistically significant at 5% level of significance. Also monthly mean of TMRF have increased significantly for the months March, April May, June, July, August, September, and October whereas it shows decreasing trend in January, February, November, and December for the Buldana district. The highest increase in TMRF occurs in October and has increased by 31.324 mm whereas highest decrease in TMRF occurs in November and decreased by 25.079 mm during the last 31years. Annual TMRF shows increasing trend which is statistically insignificant at 5% level of significance.

7 REFERENCES

[1]. Beena Shah, “Global and National Concerns on Climate Change,” University News, Vol.48 No.24, June 14-20, 2010, 15-23.

[2]. Fulekar, M.H., Kale, R.K., “Impact of Climate Change: Indian Scenario,” University News, Vol.48 No.24, June 14-20,2010, 15-23.

[3]. H.M.Hasanean, “Fluctuations of Surface Air Temperature in the East Mediterranean,” Theorotical and Applied Climatology, Vol.68, No.1-2, 2001, pp.75-87.

[4]. Hipel, K.W. and McLeod, A.I., “Time Series Modelling of Water Resources and Environmental Systems,” Electronic reprint of our book orginally published in 1994. http://www.stats.uwo.ca/faculty/aim/1994Book/.

[5]. IPCC “Climate Change-A Synthesis Report of the IPCC,” Technical Report, Inter-governmental Panel on Climate Change 2007.

[6]. Jestinos Mzezewa, Titus Misi and Leon D van Rensburg (2009), “Characterisation of rainfall at a semi-arid ecotope in the Limpopo Province (SouthAfrica) and its implications for sustainable crop production,” available on website http://www.wrc.org.za

[7]. Julious M. Huho, Josephine K.W. Ngaira, Harun O.Ogindo and Nelly Masayi, “The changing rainfall pattern and the associated impacts on subsistence agriculture in Laikipia East District, Kenya,” Journal of Geography and Regional Planning Vol.5(7), pp. 198-206, 4 April, 2012.

[8]. Lazaro R, Rodrigo FS, Gutierrez L, Domingo Fand Puigdefafregas J (2001) “Analysis of a 30-year rainfall record (1967-1997) in semi-arid SE Spain for implications on vegetation,” J. Arid Environ. 48 373-395.

[9]. Mann, H.B. “Nonparametric tests against trend,” Econometrica, 1945 13, 245-259.

[10]. Murray R. Spigel, Larry J. Stephens,“SCHAUM’S outlines STATISTICS”, Third Edition, TATA McGRAW-HILL EDITION,2000.

[11]. Patterson, P.E. “Statistical Methods”, Richard D. Irwin INC, Homewood, IL,1987.

[12]. Ritter ME (2006), “The physical environment: an introduction to physical Geography,” available online at: http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/title_page.html.

[13]. S.Del Rio, R.Fraile, L. Herrero and A.Penas, “Analysis of Recent Trends in Mean Maximum and Minimum Temperatures in a Region of the NW of

Spain (Castillay Leon)," Theorotical and Applied Climatology, Vol.90, No.1-2, 2007, pp. 1-12. doi:10.1007/s00704-006-0278-9.

[14]. Shafiqur Rehman, Luai M. Al-Hadhrami, "Extreme Temperature Trends on the West Coast of Saudi Arabia" Atmospheric and Climate Sciences, 2012,2,351-361.doi:10.4236/acs.2012.23031 Published Online July 2012 (http://www.SciRP.org/journal/acs).

[15]. T.R.Karl, P.D.Janes, R.W.Knight, J.Kukla, N.Plummer, V.Razuvayev, K.P.Gallo, J.Lindesay, R.J.Charlson and T.C.Peterson, "A Symmetric Trends of Daily Maximum and Minimum Temperatures: Empirical Evidence and Possible Causes," Bulletin of the American Mathematical Society, Vol.74, No.6, 1993, pp.1007-1023.

[16]. Vidarbha- Wikipedia, the free encyclopedia.

[17]. Webber, J. and Hawkins, C. "Statistical Analysis Applications to Business and Economics", Harper and Row, New York, 1980.