International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; SP6: 97-103

Banashree B
University of Agricultural Sciences, Dharwad, Karnataka India

Maraddi GN
University of Agricultural Sciences, Raichur, Karnataka, India

Shanwad UK
University of Agricultural Sciences, Raichur, Karnataka, India

Correspondence
Banashree B
University of Agricultural Sciences, Dharwad, Karnataka, India

(Special Issue -6)
3rd National Conference
On
PROMOTING & REINVIGORATING AGRI-HORTI, TECHNOLOGICAL INNOVATIONS
[PRAGATI-2019]
(14-15 December, 2019)

Trend analysis of weather variables of Raichur district of Karnataka: A time series framework

Banashree B, Maraddi GN and Shanwad UK

Abstract
Trend analysis is a special case of regression analysis where the dependent variable is the variable to be forecasted and the independent variable is time. First step in assessing a trend is to plot the actual and observed data by year (or some other time period deemed appropriate). For the present study, the annual rainfall, annual maximum temperature and the annual minimum temperature of Raichur district for the year 1901 to 2015 was considered to examine the trend in the rainfall, maximum temperature and minimum temperature. The data is collected form IMD, India. The summary statistics and regression analysis revealed no significant trend in rainfall and temperature. In Regression analysis of rainfall data linear model was found to be the best fitat 5% level of significance, in case of maximum temperature cubic and quadratic model (5% level of significance) were found to be best and for minimum temperature cubic model (5% level of significance) found to be the best fit.

Keywords: Weather variables, time series framework

1. Introduction

Climate change is probably the most complex and challenging environmental problem facing the world today. During the last few decades, cyclic patterns between drought and flooding have become more frequent, while the intensity and spatial distributions have also changed, with severe impacts. The phenomenon and direction of trends in weather and climate events has become increasingly deviant from normal, with warmer and fewer cold days and nights, also warmer and more frequent hot days and nights over most land areas (Anonymous, 2007) [1]. Similarly, heavy precipitation events over many areas have become more frequent and brought more severe consequences. The impacts of these changes have manifested in decreased crop yields, increased pest outbreaks, rampant soil erosion and waterlogging. Drought-affected areas have become vulnerable to land degradation, crop damage or failure and increased livestock deaths due to dehydration and lack of forage. Studies by various authors show that, in general, the frequency of more intense rainfall events in many parts of Asia has increased whereas the number of rainy days and total annual precipitation has decreased. An increase in intense rainfall events leads to more severe floods and landslides. (Dash *et al*. 2007 [2]. Goswami *et al.* 2006 [3]. Lal, 2003) [4]. Using high resolution daily gridded rainfall data for the period 1951–2003, Goswami *et al.* 2006 [3]. Showed that there were significant rising trends in the frequency and magnitude of extreme rain events over central India during the monsoon season. They also found significant decreasing trend in the frequency of moderate events during the same period, thus leading to no significant trend in the mean rainfall. In Karnataka the magnitude of trend in temperature has increased during the period of 1941 to1980 and it extended its severity during the period of 1981-2002.

Analysis also showed that increase in trend for annual mean temperature was correlated with an increase in latitude (Madolli *et al.* 2015) [5].

Understanding meteorological conditions is essential to any agricultural work. If we know the status of the climate today and the differences between this and recent past, we can begin to plan. Hence a study was undertaken to examine the trend in the rainfall, maximum temperature and minimum temperature of Raichu district by using 114 years' time series data with different models such as linear, Exponential, growth, logistic, cubic, power, compound, logarithmic, Inverse, Quadratic and S curve.

2. Methodology

2.1 Study area

Raichur district is situated in the North Eastern part of the Karnataka state between 15°09' and 16°34' North latitude and 75°46' and 76°35' East longitude. The average altitude above mean sea level is 393.3 meters. It is interesting to note that Two major Rivers, Krishna and Tungabhadra flow north and south of Raichur respectively. The district is bound on the north-east by Mahaboobnagar district of Telangana, on the north by Yadgir district. The total geographical area of the district is 8, 35,843 ha, out of which, total cropped area is 6, 62,620 ha. The area under horticultural crops is 1,063 ha. The district is bestowed with varied soil resources comprising 57.6 per cent black and42.4 per cent red soils. The Southwest monsoon period stretches from June to end of September. The post monsoon period extends from October to November. Traditionally crops like Green gram, Red gram, Groundnut, Sunflower, Bajra *etc.* are grown underrainfed situation in *kharif* season while under irrigated situation, the district is known for intensive cultivation of paddy and cotton. During *rabi* season, crops like Jowar, Chickpea, Safflower, Sunflower, Chilli *etc.* Are grown extensively. The major horticultural crops are Lemon, Pomegranate, Mango, Papaya and Sapota. For the present study, the annual rainfall, annual maximum temperature and the annual minimum temperature of Raichur district for the year 1901 to 2015 was considered to examine the trend in the rainfall, maximum temperature and minimum temperature. The data is collected form IMD, India.

2.2 Statistical models

Following statistical models were used in the study to analyse the data

2.2.1 Trend models

Trend analysis

Trend analysis is carried out to understand the Pattern or structure of the data setor time series under consideration. Broadly speaking, trends occur in two ways: agradual change over time that is consistent in direction (monotonic) or an abrupt shift at a specific point in time (step trend). For time series trend analysis the dependent and independent variable are need to define. Usual for a time series data, the time is considered as independent variable and time series under consideration as dependent variable.

Procedure of selecting a trend model

1. Choose one or more curve estimation regression models.
2. Plotting of data
3. If the variables appear to be related linearly, use a simple linear regression model.
4. If variables are not linearly related, then try for transforming your data. When a transformation does not help, then one is need to go for complicated model. For trend analysis following models are popular used as these are from family of regression models (Motulsky and Christopoulos, 2004 [7]. Montgomery and Peck, 1982). [6].

2.2.1 A: Linear model

The series values are modeled as a linear function of time.

$$Y = b_o + (b_1 * t) \qquad \text{………………} (1)$$

Where,
Y is dependent variable or time series under consideration
b_0Is intercept of the model
b_1Is the first regression coefficient
t is the time period

2.2.1 B: Logarithmic Model

The series values are modeled as a linear function of logarithmic values time.

$$Y = b_o + (b_1 * ln(t)) \qquad \text{…………………} (2)$$

Where,
Y is dependent variable or time series under consideration
b_0Is intercept of the model
b_1 Is the first regression coefficient
ln is natural log
T is the time period

2.2.1 C: Inverse Model

The inverse model is as follows

$$Y = b_o + (b_1/t) \qquad \text{……………….. } (3)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1Is the first regression coefficient
T Is the time period

2.2.1 D: Quadratic Model

quadratic model can be used to model a series that "takes off" or a series that dampens.

$$Y = b_o + (b_1 * t) + (b_2 * t^2) \qquad \text{………….. } (4)$$

Where,
Y is dependent variable or time series under consideration
b_0Is intercept of the model
b_1The first regression coefficient
b_2Is the second regression coefficient
T is the time period

2.2.1 E: Cubic Model

$$Y = b_o + (b_1 * t) + (b_2 * t^2) +) + (b_2 * t^3) \qquad \text{………….. } (5)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1Is the first regression coefficient
b_2Is the second regression coefficient
T is the time period

2.2.1 F: Power Model

$$Y = b_o * (t^{b_1}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1 Is the first regression coefficient
T *is* the time period

2.2.1 G: Compound Model

$$Y = b_o * ({b_1}^t) \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1 Is the first regression coefficient
T is the time period

2.2.1 H: S-curve Model:

$$Y = exp^{(b_0} + b_1/t) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1 Is the first regression coefficient
T is the time period
Exp is the exponential value

2.2.1 I: Logistic Model

$$Y = \frac{1}{(\frac{1}{u} + (b_0 * ({b_1}^t)))} \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1 Is the first regression coefficient
T is the time period
U is the upper boundary value.
After selecting Logistic, specify the upper boundary value to use in the regression equation. The value must be a positive number that is greater than the largest dependent variable value.

2.2.1 J: Growth Model

$$Y = e^{(b_0 + (b_1 * t))} \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1 Is the first regression coefficient
T is the time period
Exp is the exponential value

2.2.1 K: Exponential Model

$$Y = b_0 * (exp^{(b_1 * t)}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Where,
Y is dependent variable or time series under consideration
b_0 Is intercept of the model
b_1 Is the first regression coefficient
T is the time period
Exp is the exponential value
The regression coefficient *b* explains the amount of or unit of changes in dependent variable as a result of per unit of changes in independent variable.

2.2.3 Coefficient of determination (R^2)
Coefficient of determination explains the variation in the prediction variable (y) by independent variables through the fitted regression equation which is computed as follows

$$R^2 = \frac{RegSSq}{ErrorSSq} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

In trend analysis R^2 is used to identify the goodness of fit of the model or to identify the best model among the considered models.

3. Results:
3.1 Trend analysis of various weather parameters of climate change
3.1.1 Trend analysis of rainfall of Raichur district for the year 1901 to 2015
For the current study, the annual rainfall (mm) of Raichur district for the year 1901 to 2015 is considered to examine the trend in the rainfall. The data is collected form IMD, India. The time series plot of above dataset has been exhibited in Fig. 1. The summary statistics of rainfall data is given in Table 1 and it indicates that the data is highly heterogeneous as the coefficient of variation is 25.24 per cent.
Trend analysis of the rainfall series is presented in table 2. Based on the R2 value obtained one can depict that among the various models used, linear model (.061) is fitting best for this data set. The regression co efficient of linear model *b1* = 1.078indicates for every one unit change in present rainfall depends on every 1.078 unit changes in its lag (earlier years).In rainfall data the linear (.008) model is significant at 5per cent level of significance. The model fitting is also represented through graphic alre presentation which is presented in Fig. 2 which indicates that the above discussed model is fitting best among all the models used in the study.
Based on the overall result obtained for trend analys is of annual rainfall (mm) of Raichur district, none of the model is fitted correctly as the R^2 value is very low. The reason may be due to presence of set is highly nonlinear, complex and unidentified patterns in the series. The above results were in line with the findings of Rachel *et al.* (2014).

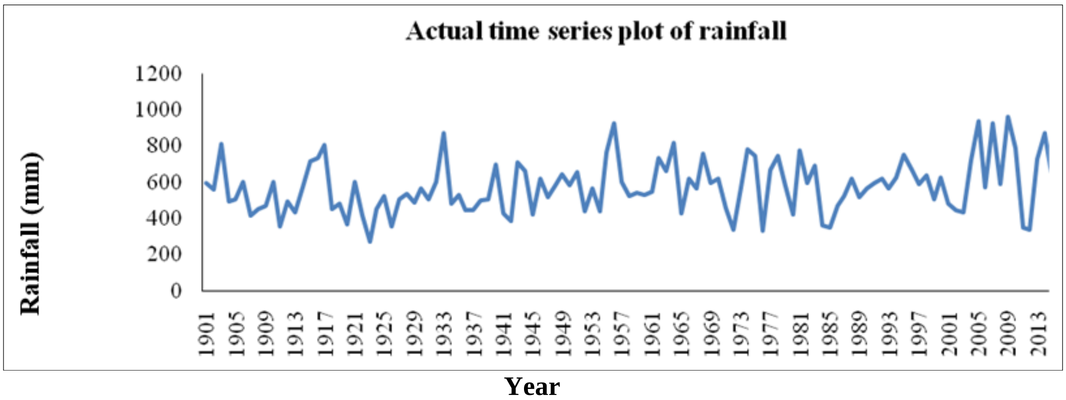

Fig 1: Actual time series plot of rainfall (Raichur district)

Table 1: Summary statistics of rainfall series (Raichur district)

Statistic	Series	Statistic	Series
Observation	115	Variance	21201.70
Mean	576.73	Standard Deviation	145.60
Median	569.87	Kurtosis	-0.025
Maximum	962.3	Skewness	0.50
Minimum	273.47	Coefficient of Variation (%)	25.24

Table 2: Model summary and parameter estimates

Model	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.061	7.330	1	113	0.008	514.216	1.078		
Logarithmic	0.031	3.615	1	113	0.060	473.187	27.440		
Inverse	0.001	0.066	1	113	0.798	578.210	-31.888		
Quadratic	0.064	3.822	2	112	0.025	532.359	0.147	0.008	
Cubic	0.064	2.527	3	111	0.061	534.487	-0.068	0.013	-0.000026
Compound	0.051	6.112	1	113	0.015	505.453	1.002		
Power	0.026	2.982	1	113	0.087	473.862	0.044		
S	0.000	0.010	1	113	0.920	6.327	-0.022		
Growth	0.051	6.112	1	113	0.015	6.225	0.002		
Exponential	0.051	6.112	1	113	0.015	505.453	0.002		
Logistic	.051	6.112	1	113	.015	.002	.998		

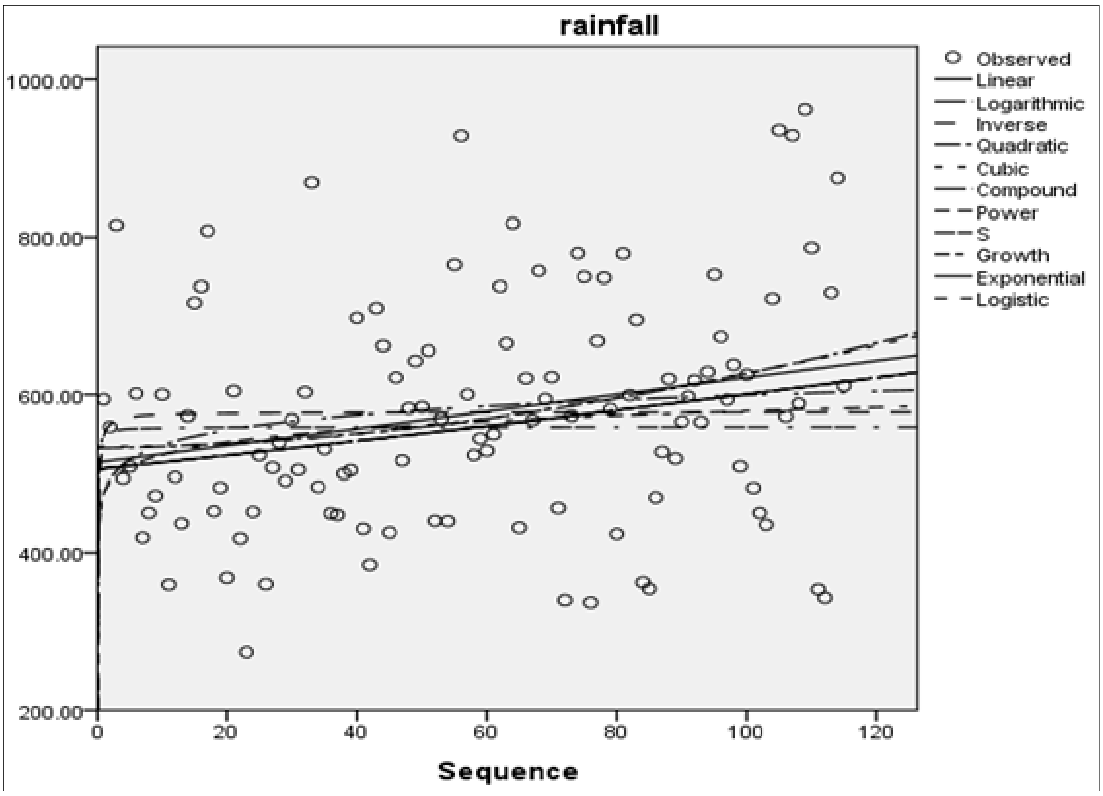

Fig 2: Actual v/s Fitted plot (Raichur district)

3.1.2 Trend analysis of maximum temperature of Raichur district for the year1901 to 2014

For the present study, the annual maximum temperature of Raichur district for the year 1901 to 2014 is considered to examine the trend in the maximum temperature. The data is collected from MARS, Raichur and IMD, India. The time series plot of above dataset has been exhibited in Fig. 3 The summary statistics of temperature data is given in Table 3 and it indicates that there were 114 observations with mean temperature of 32.63 ^{0}C and maximum temperature of 35.16 ^{0}C and minimum of 31.51 ^{0}C with coefficient of variance of 2.15 per cent.

Trend analysis of the maximum temperature series is presented in table 4.Based on the R2 value obtained one can depict that among the various models used quadratic (0.705) and cubic (0.717) are best for this data set. In maximum temperature data the quadratic (0.000) and cubic (0.000) models are significant at 5 per cent level of significance. The model fitting is also represented through graphical representation which is presented in Fig. 4 which indicates that the above discussed models are fitting among all the models used in the study. The above results were like the findings of Rachel *et al.* (2014) [8].

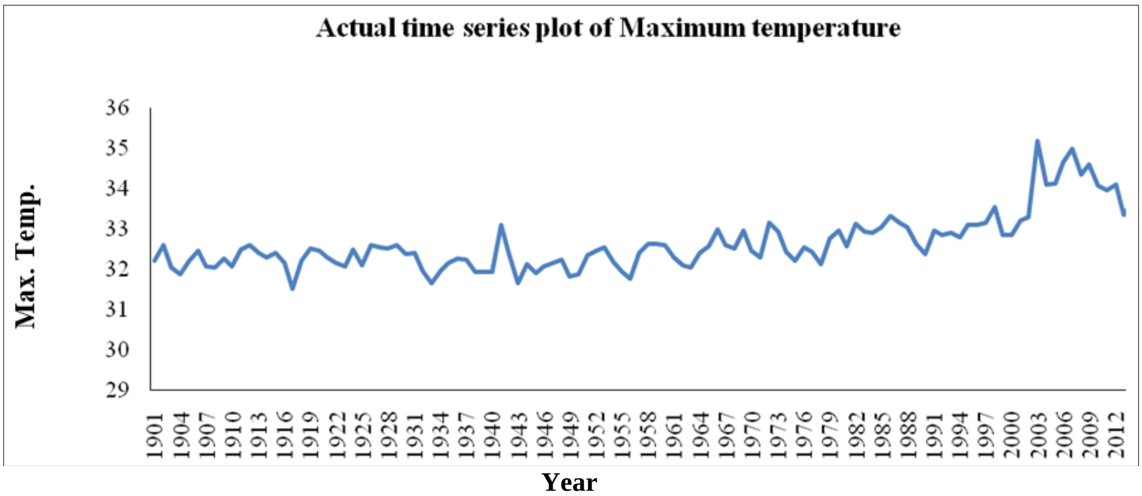

Fig 3: Actual time series plot of Maximum Temperature (Raichur district)

Table 3: Summary statistics of Maximum Temperature series (Raichur district)

Statistic	Series	Statistic	Series
Observation	114	Variance	0.50
Mean	32.63	Standard Deviation	0.70
Median	32.46	Kurtosis	2.37
Maximum	35.16	Skewness	1.47
Minimum	31.51	Coefficient of Variation (%)	2.15

Table 4: Model summary and parameter estimates

Model	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.513	118.022	1	112	0.000	31.760	0.015		
Logarithmic	0.256	38.467	1	112	0.000	31.203	0.381		
Inverse	0.035	4.089	1	112	0.046	32.693	-1.192		
Quadratic	0.705	132.766	2	111	0.000	32.465	-0.021	0.0001	
Cubic	0.717	92.732	3	110	0.000	32.256	0.0003	0.00045	0.000003
Compound	0.516	119.580	1	112	0.000	31.775	1.000		
Power	0.258	38.899	1	112	0.000	31.241	0.012		
S	0.036	4.126	1	112	0.045	3.487	-0.036		
Growth	0.516	119.580	1	112	0.000	3.459	0.002		
Exponential	0.516	119.580	1	112	0.000	31.775	0.006		
Logistic	0.516	119.580	1	112	0.000	0.031	1.000		

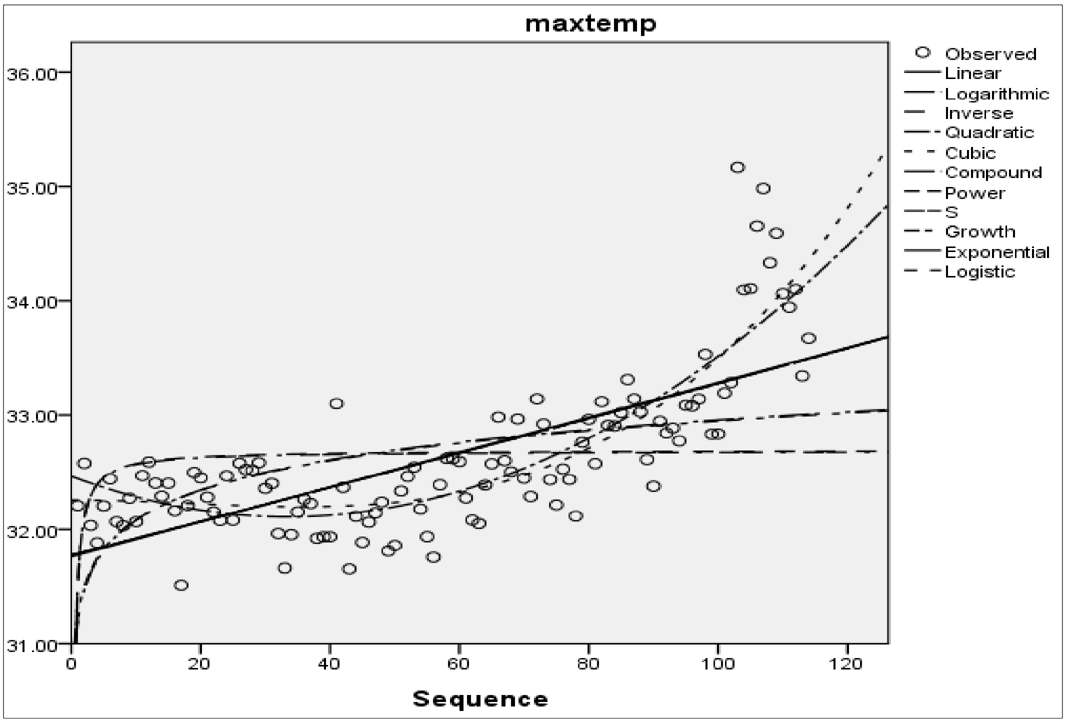

Fig 4: Actual v/s Fitted plot (Raichur district)

3.1.3 Trend analysis of minimum temperature of Raichur district for the year1901 to 2014

For the present study, the annual minimum temperature of Raichur district for the year 1901 to 2014 is considered to examine the trend in the minimum temperature. The data is collected from IMD, India. The time series plot of above dataset has been exhibited in Fig. 5. The summary statistics of temperature data is given in Table 5 and it indicates that there were 114 observations with mean minimum temperature of 20.73 ^{0}C and maximum temperature of 22.15 ^{0}C and minimum of 18.70 ^{0}C with coefficient of variance of 2.46 per cent.

Trend analysis of the minimum temperature series is presented in table 6.Based on the R2 value obtained one can depict that among the various models used cubic (0.283) is best for this data set. In maximum temperature data, the cubic (0.000) models are significant at 5 per cent level of significance. The model fitting is also represented through graphical representation which is presented in Fig. 6, which indicates that the above discussed model is fitting better among all the models used in the study. The above results were in line with the findings of Rachel *et al.*, (2014) [8].

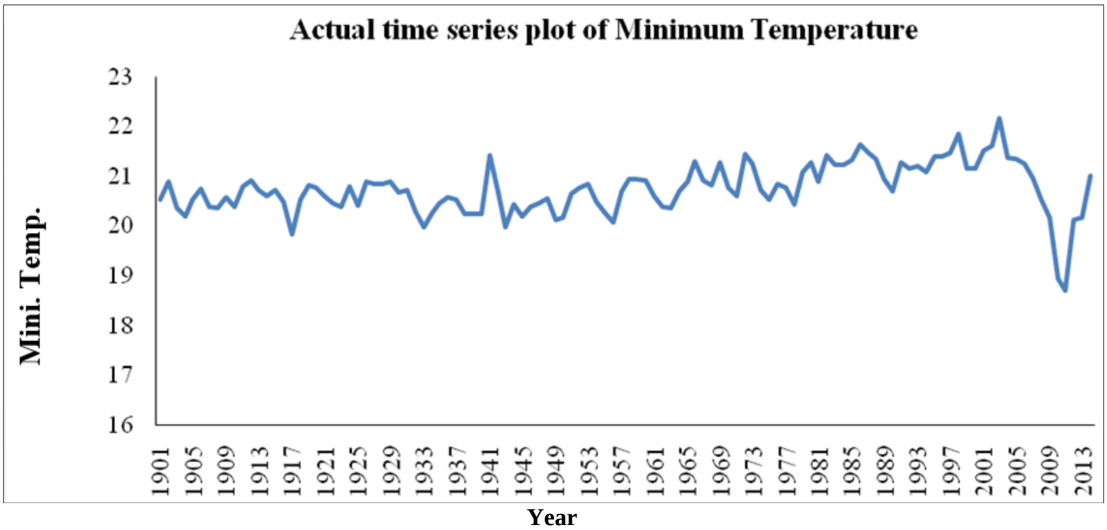

Fig 5: Actual time series plot of Minimum Temperature (Raichur district)

Table 5: Summary statistics of Minimum Temperature series (Raichur district)

Statistic	Series	Statistic	Series
Observation	114	Variance	0.26
Mean	20.73	Standard Deviation	0.51
Median	20.72	Kurtosis	2.45
Maximum	22.15	Skewness	-0.54
Minimum	18.70	Coefficient of Variation (%)	2.46

Table 6: Model summary and parameter estimates

Model	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	0.113	14.282	1	112	0.000	20.438	0.005		
Logarithmic	0.080	9.680	1	112	0.002	20.156	0.154		
Inverse	0.014	1.553	1	112	0.215	20.762	-0.539		
Quadratic	0.118	7.431	2	111	0.001	20.356	0.009	-0.000037	
Cubic	0.283	14.469	3	110	0.000	20.932	-0.049	0.001	-0.0000007
Compound	0.105	13.159	1	112	0.000	20.442	1.000		
Power	0.075	9.037	1	112	0.003	20.171	0.007		
S	0.013	1.458	1	112	0.230	3.033	-0.025		
Growth	0.105	13.159	1	112	0.000	3.018	0.000		
Exponential	0.105	13.159	1	112	0.000	20.442	0.000		
Logistic	0.105	13.159	1	112	0.000	.049	1.000		

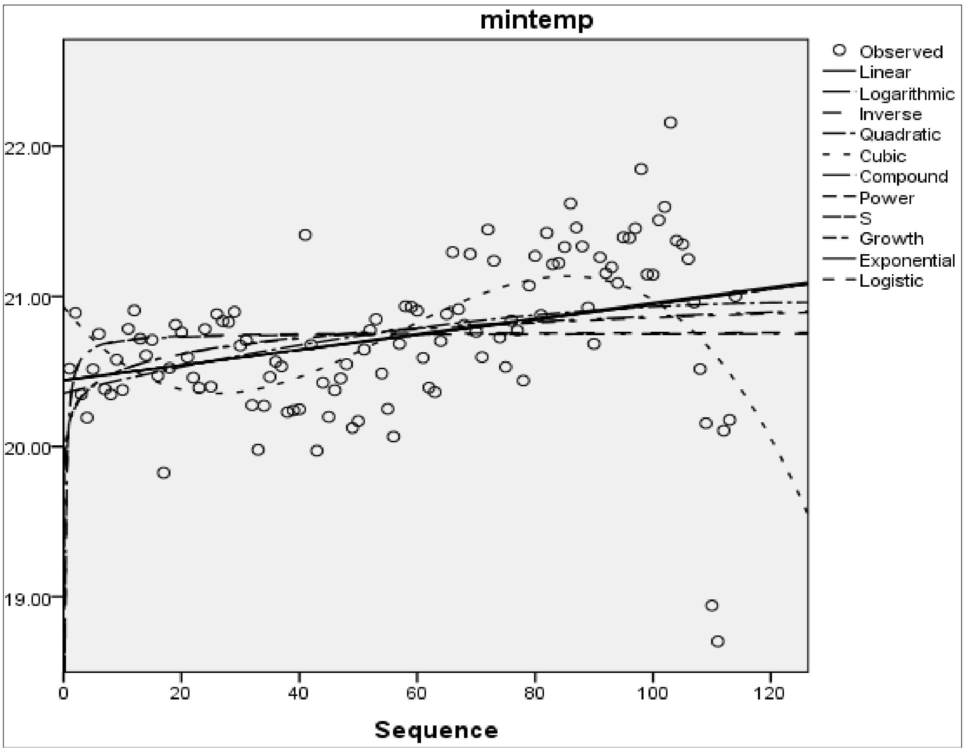

Fig 6: Actual v/s Fitted plot (Raichur district)

Conclusion

In trend analysis of rainfall of Raichur district for the year 1901 to 2015, Coefficient of variation of the rainfall data was 25.24 per cent which indicates that the rainfall is highly heterogeneous. In linear regression model the *b1* was 1.078 which means forevery one unit change in present rainfall depends on every 1.078 unit changes in it slag (earlier year's rainfall). In trend analysis of Raichur district maximum temperature, based on R2 value obtained cubic model and quadratic model were fitting best for the temperature dataset at 5 per cent level of significance. For cubic model *b1* was 0.00045 which means for every one unit change in present temperature depends on every 0.00045 unit changes in its lag (earlier years temperature). In trend analysis of Raichur district minimum temperature, based on R2 value obtained cubic model was fitting best for the temperature data set at 5 per cent level of significance. For cubic model b1 was -0.049 which means for every one unit change in present temperature depends on every -0.049 unit changes in its lag (earlier years temperature)

References

1. Anonymous Climate Change: Impacts, Adaptation and Vulnerability ML, Parry OF, Canziani JP, Palutikof PJ. Van der Linden and C. E. Hanson, Eds., Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, 2007.
2. Dash SK, Jenamani RK, Kalsi SR, Panda SK. Someevidence of climate change in twentieth-century India. Climatic Change. 2007; 85:299-321.
3. Goswami BN, Venugopal V, Sengupta D, Madhusoodanam MS, Xavier PK. Increasing trends of extreme rain eventsover India in a warming environment. Science. 2006; 314:1442-1445.
4. Lal M, Global climate change: India's monsoon and its variability. J. Environ. Stud. Policy. 2003; 6:1-34.
5. Madolli MJ, Kanannavar PS, Yaligar R. Spatial and temporal analysis of temperature for the state of Karnataka, India. International Journal of Agricultural Science and Research. 2015; 5(1):105-110.
6. Montgomery DC, Peck EA. Introduction to linear regession analysis. J. Wiley and Sons, New York, New York USA, 1982.
7. Motulsky H. Christopoulos A. Fitting Models to Biological Data Using Linear and Nonlinear Regression: A Practical Guide to Curve Fitting, Oxford University Press, 2004.
8. Rachel E, Aggarwal RK, Mahajan PK, Negi YS, Bhardwaj SK. Trend study of Meteorological Parameters and Crop Yield in Solan District of Western Himalayan State. Universal Journal of Environmental Research and Technology. 2014; 4(4):215-226.
9. Rosenzweig C, Parry ML. Potential impact of climate change on world food supply. Nature. 1994; 367:133-138.