International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Trend Analysis of Winter Precipitation over Kashmir valley from 1980 – 2016

Mifta ul Shafiq[1], Pervez Ahmed[1], Abaas Ahmad Mir[1], Himayoon Hassan[2]

[1]*Climate and Cryosphere Group,*

Department of Geography and Regional Development, University of Kashmir, Srinagar, India

[2]*Directorate of School Education, J&K Govt. Srinagar, India*

ABSTRACT

Kashmir valley forms an important and environmentally fragile part of North western Himalayas. It has some of the important glaciers which hold a huge significance in most of the sectors like agriculture, domestic consumption, hydropower generation. Climate variability and change is altering the timing and intensity of precipitation. The study focuses on trend analysis and characteristics of winter precipitation in Kashmir valley from 1980 – 2016. Kashmir valley receives most of its solid precipitation during winters and has been subjected to large changes during recent decades. Mann Kendall test and Sen's slope estimator was used for quantifying the trend and rate of change respectively. There was overall decrease of -1.1 mm/year in Kashmir valley with Gulmarg station recording maximum decrease of -4.8 mm/year. The decrease in winter precipitation over Kashmir valley was statistically insignificant.

Keywords: Climate variability, Kashmir valley, Mann Kendall, Precipitation, Trend analysis

1.INTRODUCTION

Global surface temperature has significantly risen during the last century and will continue to rise unless greenhouse gas emissions are drastically reduced [3]. The international panel on climate change (IPCC) predicts that the average global surface temperature will increase by between 2 and 4.5ºC and that there will be major changes in seasonal precipitation patterns by 2100 [2]. Changes in the distribution of precipitation would also be likely to occur with serious consequences in some parts of the world [3]. Ever increasing attention is devoted by climatologists to the study of precipitation trends, because, owing to possible variations or changes in the climate, the geographic distribution of rainfall frequency and intensity could be subjected to substantial modifications [4]. The study of rainfall variability is essential for climate change and water recourse management.

In some regions, such as parts of Asia and Africa, the frequency and intensity of droughts have been observed to increase in recent decades. Though each and every part of the world is more or less susceptible to natural calamities, the Himalaya due to its complex geological structures, dynamic geomorphology, and seasonality in hydro meteorological conditions experience natural disasters very frequently, especially water induced hazards [5]. Negative impacts of climate change on society and ecosystems are mostly expected to arise due to large scale variability of crucial meteorological parameters especially in the mountainous areas having fragile ecosystems.

Topography coupled with the Western Disturbances decides the orographic precipitation over the Himalayan region [6, 7, 8, 9]. There are eastward-moving low pressure synoptic weather systems that originate over the Mediterranean Sea or mid-Atlantic Ocean and travel eastward over Iran, Afghanistan, Pakistan and Northwest, take their southernmost tracks during winter and pass over Northwestern India [10]. The Indian monsoon air masses, which bring significant rainfall on the southern margin, penetrate infrequently across the Himalayas. However, the precipitation in these northern ranges is concentrated in winter and spring months [11]. The winter precipitation provides the principal source for accumulation on Western Himalayan glaciers in the greatest area of perennial ice outside the Polar Regions.

In order to identify the spatial and temporal trend and pattern in annual and seasonal precipitation various statistical methods are put into use like nonparametric Mann-Kendall (MK) statistical test [12, 13], and Theil-Sen approach (TSA). In order to quantify the implication of trends in hydro-meteorological time series, the frequently used statistical test is MK test [14, 15, 16, 17, 18, 19]. Further, in order to quantify the magnitude of trend another nonparametric test known as Theil-Sen approach is used. This approach is more fruitful than least-square method in terms of slope estimation because this very approach is much more insensitive to extreme values or outliers and also, even for normal distribution of data it stands well compared to simple least squares [20, 21]

2.STUDY AREA

The valley of Kashmir (Fig. 1) lies between 32^{o} 22' to 34^{o} 43' N latitude to 73^{o}52' to 75^{o}42' E longitudes. Kashmir is a meso-geographical region with an area of around 15948 square kilometers. Topographically the valley depicts an elliptical bowl shaped character, encapsulated between mighty Pir-Panjal range in its south and south west and the great Himalayan range in the north and east [22]. The mountain ranges rise to the height of about 5550 meters in the north-east and dip down to a height of 2770 meters in south. Kashmir valley has achieved a discrete geographical and distinct physiographic personality within the Himalayas. The valley can be divided into four broad physiographic divisions; the mountains, the foot hills, the Karewa's and the valley floor with two, one, two and one meteorological stations respectively.

The climate of Kashmir is governed by altitude, insolation and amount of rainfall. The valley has an average altitude of 1545 meters, and experiences temperatures varying from -9°C in winter to 38°C in summer. Winters are generally severe while the month of July becomes oppressively warm. Spring though wet, is pleasant with fresh green tints. The summer is hot with the roses and flowers in full bloom, while the autumn is dry and invigorating. The average mean maximum and minimum temperatures of Kashmir valley are 19.27°C and 7.29°C respectively while as the average rainfall is 84 cm [23].

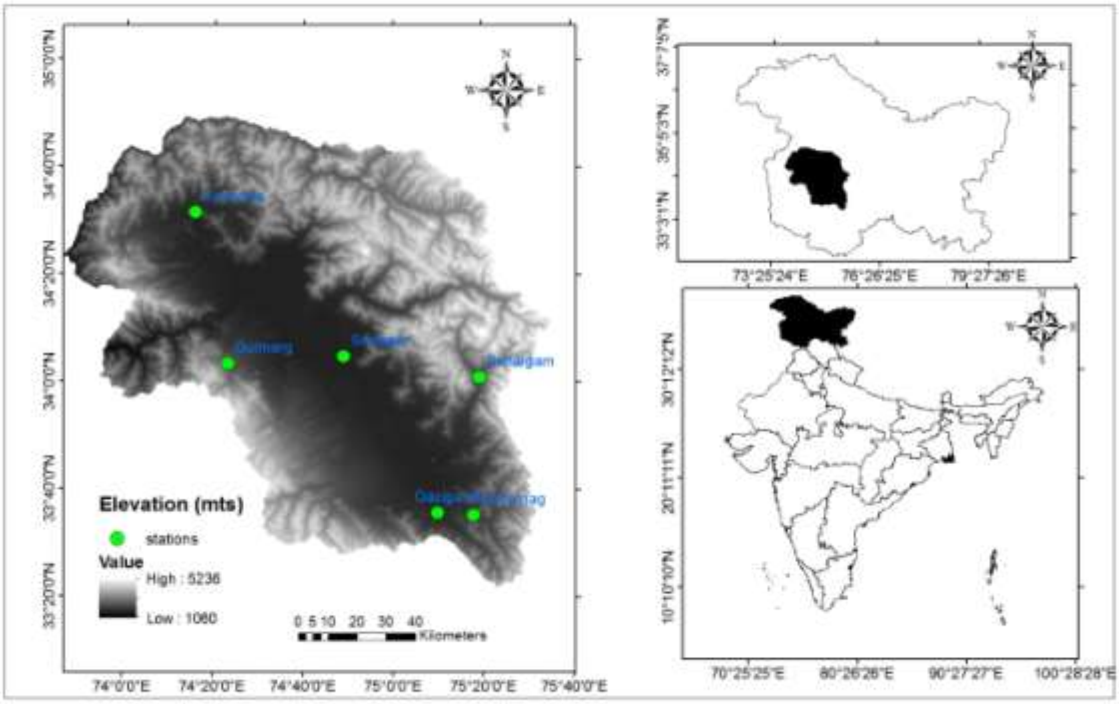


Fig 1: Location map of study area with IMD stations.

3. DATA AND METHODOLOGY

3.1DATA:

To study the variability of climate over a specific region, the observational data represents the best picture. Precipitation along with temperature forms the base for these studies. In this paper, time series analysis of the precipitation is attempted by taking the in situ precipitation data of 6 meteorological stations of Indian Meteorological Department (IMD) from 1980-2016. These are situated in different topographical zones of the Kashmir valley. The monthly precipitation data was summed up to obtain the winter seasonal precipitation datasets. Kashmir valley owing to its peculiar climate has four distinct seasons as follows: Winter (December, January, February), Spring (March, April, May), Summer (June, July, August) and Autumn (September, October, November).

Table 1: List of Meteorological stations used in the study.

S.no	Station	Physiography	Latitude (North)	Longitude (East)	Elevation (mts)	Time Span
1.	Srinagar	Flood Plain	34^{o} 05'	74^{o} 50'	1588	1980-2016
2.	Qazigund	Foot hills	33^{o} 35'	75^{o} 05'	1690	1980-2016

3.	Pahalgam	Mountain	34° 02'	75° 20'	2310	1980-2016
4.	Gulmarg	Mountain	34° 03'	74° 24'	2705	1980-2016
5.	Kupwara	Karewa's	34° 25'	74° 18'	1609	1980-2016
6.	Kokernag	Karewa's	33° 40□	75° 17□	1910	1980-2016

3.2METHODOLOGY:

The purpose of a trend analysis/test is to determine general (or overall) behavior of the variable under consideration as a function of time. Such a method of data analysis confirms the presence of suspected trends, presents unknown trends and assesses the detected trends. Several methods of estimating linear trends and their significance are used in climatological studies.

Further for detecting the trends within the datasets, a nonparametric statistical test, the Mann-Kendall trend test [24, 25], has been used. The Mann-Kendall rank statistics test is an effective method for testing monotonic trends and abrupt time series changes [26. 27]. This test detects the significant trends in the time series by analyzing the correlation between ranks within dataset values and the time series. This test is a two-sided test and is sensitive to the null hypothesis that there is no significant trend within data series. If the null hypothesis is rejected, then there is an indication of a significant trend within the time series which may be positive or negative, as described by its score. This test is not dependent on the distribution of the dataset and does not vary with the outliers. In this method, H0 represents distribution of random variables and H1 represents possibility of bidirectional changes. The test statistic S is given by

$$S = \sum_{i=1}^{n-1} \sum_{k=i+1}^{n} sgn(xk - xi)$$

in which xk and xi are the sequential data values, n is the length of the data set, and

$$sgn(\theta) = \begin{Bmatrix} +1, & \theta > & 0 \\ 0, & \theta = & 0 \\ -1, & \theta < & 0 \end{Bmatrix}$$

In particular, if the sample size is larger than 10, the statistic S is nearly normally distributed.

If a linear trend is present in a time series, then the true slope of trend can be estimated by using a simple non-parametric procedure developed by Theil and Sen [28, 29]. The slope estimates is computed by

$$Q_i = Median\left(\frac{x_i - x_k}{j - k}\right) \bigvee k < j$$

Where *xj* and *xk* are data values at times *j* and *k* (*j* > *k*) respectively. The median of N values of *Q*i is Sen's estimator of slope. If N is odd, then Sen's estimator is computed by

$$Q_{med} = Q\left(\frac{N+1}{2}\right)$$

and if N is even, then Sen's estimator is computed by

$$Q_{med} = \left[Q\frac{N}{2} + Q\frac{(N+2)}{2}\right]/2$$

Finally, *Qmed* is tested by two-sided test at 100 (1-α) % confidence interval and, the true slope may be obtained by the non- parametric test.

4.RESULTS AND DISCUSSIONS

Mann-Kendal test is used for winter time series precipitation trend analysis in six meteorological stations of Kashmir Valley viz., Srinagar, Gulmarg, Kokernag, Kupwara, Pahalgam and Qazigund. The winter averages have been carried out by taking the averages of December, January and February over the last 37 years that is from 1980-2016. Mann–Kendall test (MK) and Theil–Sen approach (TSA) test were utilized to see the trend and slope of the datasets. The results for winter season showed that winter precipitation decreased at -1.1 mm/year as shown by Sen's slope estimator with a MK value of -0.90. The results of the statistical analysis have been shown in table 1. Figure 2 clearly shows that there is a decreasing trend in winter precipitation.

Table 2: Result of statistics for winter seasonal time series of precipitation over Kashmir valley from 1980-2016.

Time Series	Z	Q	Significant
Winter Season	-0.90	-1.185	NS

Z: Statistics for MK test, Q: Slope of Theil-Sen approach (mm/year)

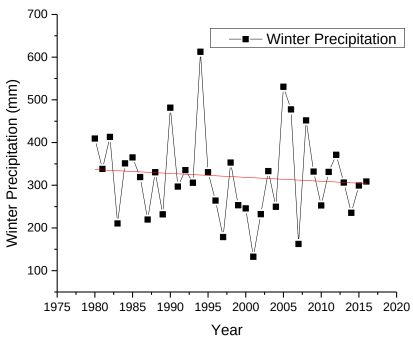


Fig 2: Winter Precipitation over Kashmir valley from 1980 – 201

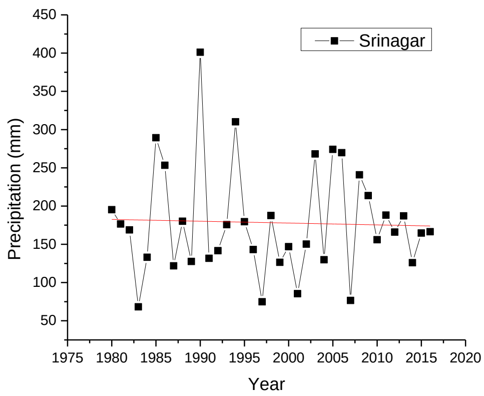
4.1Station wise winter season analysis:

Winter precipitation in Kashmir valley is received mainly in the form of solid precipitation under the influence of western disturbances. MK test revealed that on seasonal basis Kashmir valley has recorded a negative trend in winter precipitation during last 37 years. The trend recorded by MK test has been found to be insignificant. Seasonally among six meteorological stations, three stations viz: Srinagar, Pahalgam and Kupwara have registered positive trend in precipitation which are all statistically insignificant. On the other hand, Kokernag, Gulmarg and Qazigund have negative trend on MK test which are also insignificant except Gulmarg which have statistically significant decreasing trend with -4.8 mm/year at 90% confidence interval. The range of trend magnitude when analyzed on Sen's slope estimator in winter season varied from -5 and 1 mm/season per year. The statistical analysis has been presented in table 3. Figures 3 shows the variability of precipitation among various meteorological stations as a function of time.

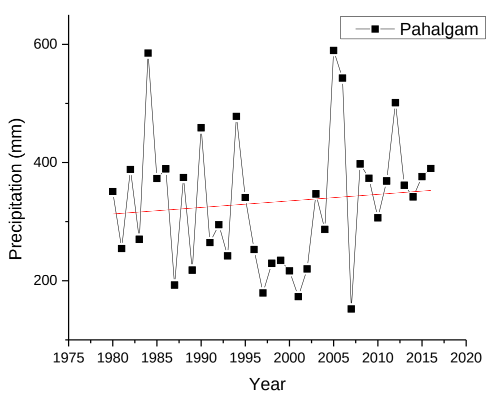
Table3: Winter Seasonal Calculations of precipitation at different stations in Kashmir Valley

Station	Z	Q	Significance
Srinagar	0.04	0.125	NS
Pahalgam	0.56	0.900	NS
Kokernag	-0.30	-0.520	NS
Kupwara	0.17	0.305	NS
Gulmarg	-1.77	-4.827	S (95%)
Qazigund	-0.64	-1.429	NS

Z: Statistics for MK test, Q: Slope of Theil-Sen approach (mm/season)



(a)



(b)

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ISSN: 2319-8354

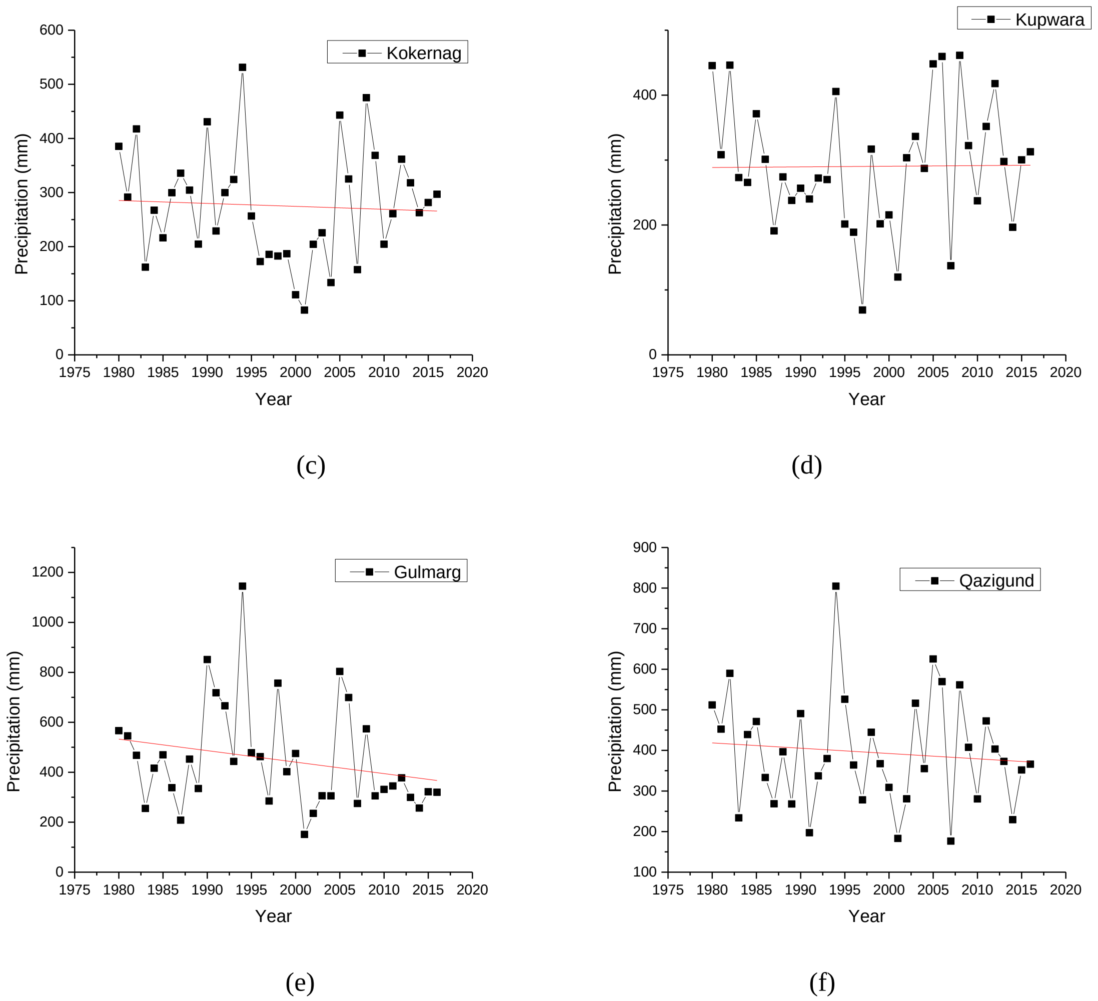

Figure 3: Time series analysis of precipitation among different stations from 1980 – 2016.

5.SUMMARY AND CONCLUSIONS

This study analyses the nature and behaviour of winter precipitation over Kashmir valley with six meteorological stations located in different topographies like mountains, Foot hills, Karewa's and Plains. The analysis has been carried out for 37 years from 1980 – 2016. The trends in the winter precipitation were analyzed using the non-parametric Mann Kendall test and the slope of the trend with Sen's slope estimator. The winter precipitation has shown a consistent decrease during the last 37 years at the rate of -1.1 mm which was statistically insignificant. The analysis when carried out on individual station basis showed that Gulmarg has shown the highest decrease of the order of -4.8 mm followed by Qazigund (-1.4 mm) and Kokernag (-0.5 mm) respectively. Srinagar (0.1 mm), Pahalgam (0.9 mm) and Kupwara (0.3 mm) stations have shown a positive trend in precipitation during the study period. There is a slight increase in these stations. The overall decrease in the precipitation will have negative impact on the regional hydrology and snow glacier environments of the valley which houses a large number of glaciers. The winter precipitation is received mainly in the form of snow which accumulates in the winter and then melts in the summer which helps in agriculture, irrigation, hydro power generation, and various other important sectors of economy. Any slight variability in the winter precipitation can prove detrimental for the fragile ecosystem of Kashmir valley.

REFERENCES

[1]. Houghton, J. T., Y. Ding, D. T. Griggs, M. Noguer, P. J.van der Linden, X. Dai, K. Maskell, and C. A.Johnson, (2001) Climate Change 2001: The Scientific Basis, Cambridge University Press.

[2]. IPCC (2007) "The Physical Science Basis. Contribution of Working Group 1 to the Fourth IPCC Assessment Report, Chapter 11" Regional Climate Projections, 2007

[3]. Mitchell, J.M., Jr. (1983) "An Empirical Modelling Assessment of Volcanic and Carbon Dioxide Effects on Global Scale Temperature" American Meteorological Society, Second Conference on Climate Variations, New Orleans, Louisiana

[4]. IPCC (1996) "Climate Change 1995: The Science of Climate Change) J.T. Houghton, L.B. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (Eds.). Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge.

[5]. Rawat P. K, Pant C. C, Tiwari P.C, Pant P. D. and Sharma A. K (2011) "Spatial variability assessment of river-line floods and flash floods in Himalaya: A case study using GIS" International journal of Disaster prevention and management, 21(2), 135-159

[6]. Bookhagen B. and Strecker M. R., (2008) Orographic barriers, high resolution TRMM rainfall and relief variations along the eastern Andes, *Geophys. Res. Lett.*, 35, 1–6

[7]. Dimri A.P., (2009) Impact of subgrid scale scheme on topography and landuse for better regional scale simulation of meteorological variables over the Western Himalayas, *Clim. Dyn.*, 32, 565-574

[8]. Dimri A.P. and Mohanty U.C., (2009) Simulation of mesoscale features associated with intense western disturbances over western Himalayas, *Meteorol. Appl.*, 16, 289-308

[9]. Medina S., Houze R. A. Jr., Kumar A. and Niyogi D., (2010) Summer monsoon convection in the Himalayan region: Terrain and land cover effects, *Quart. J. Roy. Meteor. Soc.*, 136, 593-616

[10]. Mohanty U.C. and Dimri A.P., (2004) Location specific prediction of probability of occurrence and quantity of precipitation over Western Himalayas, *Weath. Forecast*, 19(3), 520-533

[11]. Archer D.R. and Fowler H.J., (2004) Spatial and temporal variations in precipitation in the Upper Indus Basin, global teleconnections and hydrological implications, *Hydrol. Earth Syst. Sci*., 8, 47-61

[12]. Mann HB (1945) Nonparametric tests against trend. Econometrica 13: 124–259

[13]. Kendall MG (1975) Rank correlation methods. Griffin, London

[14]. Martinez, J.C., Maleski, J.J., Miller, F.M., (2012). Trends in precipitation and temperature in Florida, USA. J. Hydrol. 452–453, 259–281.

[15]. Modarres, R., Sarhadi, A., (2009). Rainfall trends analysis of Iran in the last half of the twentieth century. J. Geophys. Res. 114.

[16]. Modarres, R., Silva, V., (2007). Rainfall trends in arid & semi-arid regions of Iran. J. Arid Environ. 70, 344–355.

[17]. Tabari H, Somee BS, Zadeh MR (2011) Testing for long-term trends in climatic variables in Iran. Atmos Res 100(1):132–140. https://doi.org/10.1016/j.atmosres.2011.01.005

[18]. Sayemuzzaman Mohammad, Jha, Manoj K. (2013) Seasonal and annual precipitation time series trend analysis in North Carolina, United States Atmospheric Research; 137

[19]. Shafiq MU, Rasool R, Ahmed P, Dimri AP. (2018). Temperature and Precipitation trends in Kashmir valley, North Western Himalayas Theoretical and Applied Climatology https://doi.org/10.1007/s00704-018-2377-9

[20]. Hirsch, R.M., Slack, J.R., Smith, R.A., 1982. Techniques of trend analysis for monthly water quality data. Water Resour. Res. 18, 107–121.

[21]. Jianqing, F., Qiwei, Y., (2003). Nonlinear time series: nonparametric and parametric methods. Springer Series in Statistics.0387224327.

[22]. Shafiq MU, Rasool R, Ahmed P, Dimri AP. (2018). Temperature and Precipitation trends in Kashmir valley, North Western Himalayas Theoretical and Applied Climatology https://doi.org/10.1007/s00704-018-2377-9

[23]. Hussain M (1987) Geography of Jammu and Kashmir state. Rajesh Publication, New Delhi, pp 11–18

[24]. Mann HB (1945) Nonparametric tests against trend. Econometrica 13: 124–259

[25]. Kendall MG (1975) Rank correlation methods. Griffin, London

[26]. Kadiolgu M (1997) Trends in surface air temperature data over Turkey. Int J Climatol 17:511 520

[27]. Smadi MM, Zghoul A (2006) A sudden change in rainfall characteristics in Amman, Jordan during the mid-1950s. Am J Environ Sci 2(3): 84–91. https://doi.org/10.3844/ajessp.2006.84.91

[28]. Theil H. (1950) A rank-invariant method of linear and polynomial regression analysis. Nedal Akad Wetensch; 53:386–92.

[29]. Sen PK. (1968) Estimates of the regression coefficient based on Kendall’s tau. J Am Stat Assoc; 39:1379–89.