International journal of Advanced Biological and Biomedical Research
ISSN: 2322 - 4827, Volume 1, Issue 5, 2013: 547-555
Available online at http://www.ijabbr.com

Investigation of Trend of Precipitation Variation Using non-parametric Methods in Charmahal o Bakhtiari Province

Pezhman Alahbakhshian Farsani [a*], Mahmoud Habibnejad Roshan [b], Ghorban Vahbzade [c], Karim Solaimani [d]

[a] M.Sc Student Department of Watershed Management, Sari Agricultural Sciences and Natural Resources of University, Sari, Iran.

[b] Associate Professor of Department of Watershed Management, Sari Agricultural Sciences and Natural Resources of University, Sari, Iran.

[c] Assistant professor of Department of Watershed Management, Sari Agricultural Sciences and Natural Resources of University, Sari, Iran.

[d] Professor of Department of Watershed Management, Sari Agricultural Sciences and Natural Resources of University, Sari, Iran.

ABSTRACT

Climatic parameters in time and space scales of change are for many reasons of Changes and how they should be based on observations using a statistical method to be determined. Analysis of the most widely used statistical methods that assess potential climate change on hydrological time series, such series of precipitation, temperature and flow rate used. This study of 11 synoptic,rain gage and climatology stations with 30 years during the years 1979 to 2009 period is Charmahal o Bakhtiari province.Mann-Kendall non-parametric and sen estimate tests were used for the purpose of the study.The results showed that 11 stations were the only station in sepid dasht 95 and 99 percent had significant levels decline and changes in the slope is negative and other gage stations does not have significant trends. The results of this study can be in the long-term planning for water resources management, irrigation scheduling and prediction of future droughts in the province can be used.

Keywords: Precipitation Changes, Mann-Kendall Test, Sen Estimate Test, Charmahal o Bakhtiari

INTRODUCTION

The phenomenon of climate change has been occurred as result of increasing greenhouse gases concentration and human activities in atmosphere causes to change temporal and spatial of water resources in watersheds in twenty one century (Kanzvis et al., 2007). The capacity of vapor sustenance in atmosphere increases with climate warming. So, the water returns to hydrological cycle rapidly which potentially increase the frequency of hydrological events

Corresponding Author E-mail : allahbakhshian2412@gmail.com

(Hangtigton, 2006). The rate of stored water in water resources changes in different times of hydrological cycle because of the increasing precipitation variations and increasing temperature (Hejen and Van, 2010). Indeed, the existence of trend in temporal series of meteorology is due to the gradual natural change and climate change or the effects of human activities (Bayersen et al., 2005; Jiang et al., 2007; Vesmaket and Bern, 1997). The identification of the variations in long duration series of hydrological data is a most important problem which persuades researchers to provide basal maps of water resources and prohibit from flood risk in future (Zdenek and Milada, 2008). The plans usually form based on stationary hypothesis in hydrological series which the previous data of precipitation are used to predict future (Kundzewicz and Robson, 2008). The analysis of the temporal hydrological trend is important to help researches and management of water resources to understand the climate change and its effect on water resources (Becker et al., 2006; Burn and Hag Elnur, 2002; Kahya and kalayci, 2004; Xu et al.,2007). The trend analysis is used to evaluate the effect of potential of climate change and its variability on temporal hydrological series in different region of the world (Khaled and Hamed, 2008). The determining of trends in hydrology, climate, water quality and other natural temporal series has been more attended in three recent decades. In recent years the extensive researches have been done about climate change and its variability which more attention has focused on determination of trend. For example Carbajal et al. (1993) in Aconcagua river basin investigated the temperature and precipitation using Mann-Kendall test. This study didn't show the significant trend in precipitation whereas there was significant increasing trend in temperature. Kampata et al. (2008) in Zambezi River Basin in Zambia investigated the long term precipitation data collected from 5 rain gauge stations to determine the temporal series have same regime or significant trend. The Mann-Kendall test was used to determine the trend. each 5 stations show the decreasing trend but these trends were not significant. An investigation was conducted by zangxu et al. (2010) in Tarim river basin in North West of china in a 50-year statistical period. Results showed that the mean annual temperature and annual precipitation had increasing trend whereas the annual discharge had an increasing and decreasing trend. The upward of mountainous region had increasing trend and downward decreasing. Fisher et al. (2010) conducted a study in watershed of Zhujing river in south of china in a statistical period 1961-2001. Results showed that a positive significant trend (significant at probability level of 90%) in annual temperature of warm days and without rainfall within the watershed especially in western and coastal parts, whereas there is negative trend in cold days and moist periods. Although there wasn't significant trend in maximum precipitation and mean annual but, lengthens of dry period and shorten of moist period can be observed by the reduction of rainy days. In recent years several researches about trend variations of hydrological and meteorological parameters was carried out in Iran. Sohrabi et al. (2009) in a study investigated the annual precipitation of 23 stations in Hamedan province from 1982-2006 using Mann-Kendall test. Results showed that there was significant increasing trend (at probability level of 5%) in Aghajanblaghy, Toiserkan and Ghahavand and for other it was stable. In some stations there was significant trend with increasing and decreasing trend. Hejam et al. (2008) investigated the variations of seasonal and annual rainfall in several selected stations in central basin of Iran using non-parametric methods. Results indicated that the Mann-Kendall method and Sen Estimator method are same in analysis of the trend of seasonal and annual rainfall. The performance of Sen Estimator method is better than Mann-Kendall method in observation analysis which the number of zero data (lack of rainfall) is high. The results of this research shows the significant decreasing trend in both of applied test on some temporal series, but there was no significant increasing trend for both of tests. They concluded that it cannot possible to consider an especial trend for seasonal and annual rainfall in region because of the insufficient number of series with significant trend as compared to without trend series. The objective of this study was to determine the trend of precipitation variations in Chaharmahal O Bakhtiari province in a 31-year time period (1979-2009) using Sen Estimator method and Mann-Kendall method. Results of this study can be used in scheduling water resources management and drought zoning in future.

MATERIALS AND METHODS

Description of the study area

Chaharmahal O Bakhtiari province with an area 16532 km^2 is located between the 31° 9´ to 32° 48´ northern latitude and 49° 28´ to 51° 25´ eastern longitude. This province is located in central parts of Zagros mountain between the within mountains and Esfehan province. It is limited to Esfehan province in north and east direction, Khozestan province from west and Kokuloyeh O Boier ahmad from south and Lorestan from west.

Figure 1. The geographical position of Chaharmahal O Bakhtiari province in Iran

Precipitation including rain and snow are two main resources of Karoon and Zayandehrood rivers and watersheds of these two rivers with an area of 13800 and 2720 km^2. The elevations of Zagroos form the watersheds of Dez, Karkheh, Karoon and Zayandehrood rivers. These areas provide 45 to 50 percent of water resources according to volume of precipitation, low evaporation and suitable condition of geology.

Rainfall data

The annual rainfall of 11 synoptic station, rain gauge and climatology with 30-year statistical period from 1979-2009 was used in this study. The homogenous condition of data was investigated using linear regression method and duplicate mass method. The stations were used in this study had missed data lower than 5% in total periods. In cases which there were significant and acceptable relationship among stations with defect data the missed data was estimated using linear regression.

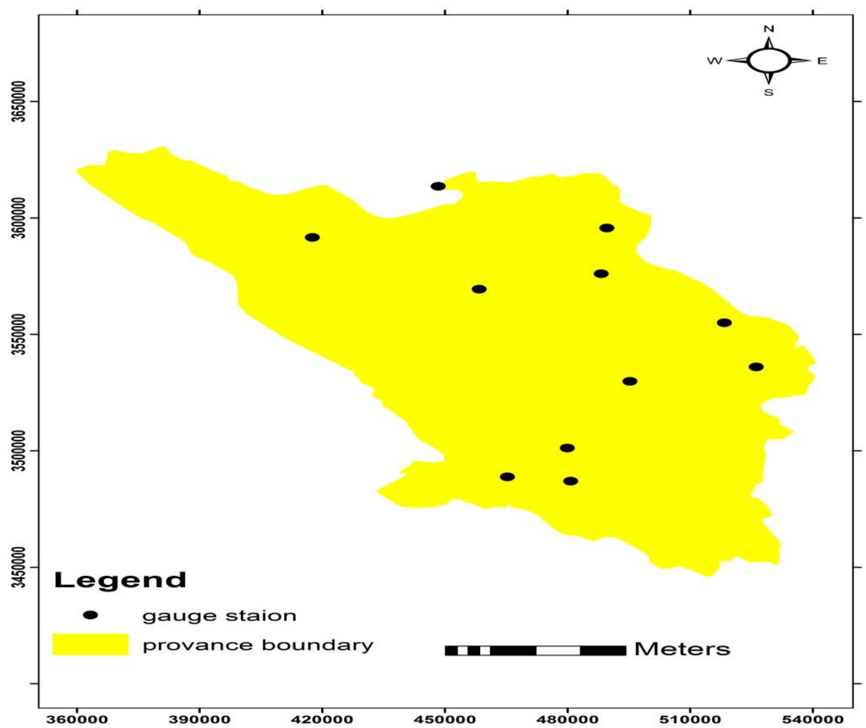

Figure 2. Spatial distribution of stations

Analysis Method

Hydrological process is usually recognized as stationary process. There is evidence which showed many of temporal hydrological series had long term trend and variability. This may due to the effects of human activities and natural system of earth climate.

Mann-Kendall test

Many studies show that the Mann-Kendall test is as effective technique in evaluating even variation in temporal series in time (Brooks and Carrthers, 1982). Mann-Kendall test is based on the difference (x_i-x_k) in years having rainfall in temporal periods (X_i,…,X_N) . S is calculated based on total signs (it is always between -1, 0 and 1). In cases which N>10 the standard Z is calculated as following:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k) \qquad [1]$$

Which:

$$\operatorname{sgn}(x_j - x_k) = \begin{cases} +1 & if \quad x_j > x_k \\ 0 & if \quad x_j = x_k \\ -1 & if \quad x_j < x_k \end{cases} \qquad [2]$$

n is sample size. The S has approximately normal distribution When $n \geq 10$ and the mean and variance is as following:

$$E(S) = 0 \qquad [3]$$

$$V(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{n} t_i i(i-1)(2i+5)}{18} \qquad [4]$$

Which t_i is the number of the snarl with a size of *i*. Standard Z for one limit test is as equation [5]:

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}} & S > 0 \\ 0 & S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} & S < 0 \end{cases} \qquad [5]$$

Which positive value of Z shows the increasing trend and negative value shows decreasing trend. If $|Z| > 1.960$ and $|Z| > 2.576$ the zero hypothesis of lacking trend is rejected.

Sen Estimator method

There is quantitative trend to estimate true gradient (variation per year). Non-parametric of Sen is used (Sen, 1998). This test is used in cases which the hypothesis for trend is as linear. This means that the F(t) in equation [6] is as:

$$F(t) = Q_t + B \qquad [6]$$

In this equation the Q is a gradient and B is constant value. At first the gradient of all pair values must be calculated to estimate gradient in equation [7]:

$$Q_i = \frac{Xj - Xk}{j-k}, \; j > k \qquad [7]$$

If n to X_j values be in temporal series the number of estimated gradient will calculate by $N - \frac{n(n-1)}{2}$ (Khaliq et al., 2009). the estimated gradient of sen test is the median of the N numbers of Q_i. A two side confidence distance in limit of gradient estimation can be calculated using this non-parametric technique based on normal distribution. In this study the confidence distance was calculated at both level of X=0.01 and X=0.05. At first the C_α is calculated as following:

$$C_\alpha = Z_{1-\alpha/2} \sum VAR(s) \qquad [8]$$

Which $Z_{1-\alpha/2}$ was obtained from normal standard distribution. Then $M1 = (N - C\alpha)/2$ and $M2 = (N + C\alpha)/2$ are calculated. The Q_{min} and Q_{max} are the lower and higher rate of confidence distance. M_1 is largest and (M_2+1) is larger than N estimated gradient arranged Q_i. The differences of x_i-Q_t are calculated to estimate B in equation [6]. The median of these values will be an estimation of B for different confidence distance (Sen, 1998). The positive rate of gradient shows the increasing trend and negative rate of gradient shows the decreasing trend (Xu et al., 2008).

RESULTS

The rate of precipitation and the water potential can be measured in each geographical region through measuring annual rainfall. The mean annual precipitation in of Chaharmahal O Bakhtiari province was 528.86 mm. So, according to province area (16532 km^2) it can expect to discharge 8743.27 MCM of moisture potential of air. Figure 3 shows the name of selected stations as well as the values of mean annual precipitation and standard deviation of data from 1979 to 2009. According to Figure 3 the mean annual precipitation in Brojen and Kohrang stations were 244.3 and 1422.3 mm, respectively which were the minimum and maximum rate of precipitation in selected stations of Chaharmahal O Bakhtiari province. The analysis result of the trend variation in annual precipitation using Mann-Kendall test in selected stations of Chaharmahal O Bakhtiari province and Sen Estimator method has been illustrated in Figure 4. Results indicates that the Sepid dasht station had decreasing trend at probability level of 95% and 99%, whereas other studied stations had no significant trend at probability level of 95% and 99%.

Table 1. The name of selected stations, annual precipitation and standard deviation of data

guage station	annual mean	Standard deviation
armand	587	281.5
ouregan	510.5	142.2
borojen	244	71.1
Pole zamankhan	349.5	113.9
sepiddasht	615	309.6
shahrekord	331	94.9
farsan	488	162
ghalesharokh	390	121.1
kohrang	1422	355.6
monj	566	157.6
lordegan	587.5	270.2

Table 2. Result of the Men-Kendal test in study stations

Station name	Station code	Z	Q	significant
armand	21-231	1.427	1.67	
ouregan	21-486	628	.85	
borojen	21-092	1.138	2.44	
Pole zamankhan	42-009	-.05	-.16	
sepiddasht	21-668	-4.334	-25.66	**
shahrekord	21-433	.016	.25	
farsan	21-440	.424	.45	
ghalesharokh	42-003	1.86	4.85	
kohrang	42-001	-.016	-.62	
monj	21-571	-.424	-1.34	
lordegan	21-235	-.764	-3.22	

** Significant trend at probability level of 99%

DISCUSSION AND CONCLUSIONS

According to the Mann-Kendall test more than 81% of stations had no significant trend at probability level 95 and 99% and only Sepid dasht station which has been located in eastern parts of province had significant trend at probability level of 95 and 99%. This result was in agreement with Sen Test and Hejam et al. (2008) about annual precipitation variations in some selected stations in central watersheds of Iran. Each of studied stations had no significant trend. Results of the Kampata et al. (2008) in investigation of the long term data of precipitation in 5 stations of Zambezi River Basin in Zambia showed that the trend was significant in each 5 stations. The precipitation is one of the most effective climate factors in hydrological studies in watersheds, so the temporal and spatial variation and stability and instability in temporal series must be determined using statistical tests to better decision making in management of watersheds. It is better for the researchers to do applicable researches on precipitation and other effective factors in control and utilization of water sources in Iran watersheds to prepare management programs in true direction.

REFRENCES

1. Becker, S., Gemmer, M., Jiang, T. (2006). Spatiotemporal analysis of precipitation trends in the Yangtze River catchment. *Stochastic Environmental Research and Risk Assessment*, 20: 435–444.

2. Belle, V.G., Hughes, J.P. (1984). Nonparametric tests for trend in water quality. *Water Resources Research*, 20 (1): 127–136.

3.Birsan, M.V., Molnar, P., Burlando, P., Pfaundler, M. (2005). Streamflow trends in Switzerland. *Journal of Hydrology*, 314: 312–329.

4. Brooks, C.E.P. and Carrthers, N. (1982). *Handbook of Statistical Method in Meteorology*, London, H.M.S.O, pp 412.

5. Burn, D.H., Hag Elnur, M.A. (2002). Detection of hydrologic trends and variability. *Journal of Hydrology*, 255: 107–122.

6. Carbajal, L.R., Pellicciotti, F.,Molnar,P. (1993). Analysis of Hydro-climatic Trends in the Aconcagua river basin, central Chile. Institute of Environmental Engineering, Ethz Zurich, CH-8093, Switzerland.

7. Fischer, Thomas., Marco Gemmer, Liu Lüliu, Su Buda. (2010). Temperature and precipitation trends and dryness/wetness pattern in the Zhujiang River Basin, South China, 1961-2007. *Quaternary International* xxx: 1-11.

8. Heejun, C., Won, J. (2010). Spatial and temporal changes in runoff caused by climate change in a complex large river basin in Oregon. *Journal of Hydrology*, 388 :186–207.

9.Hejam,S.,khoshkho,Y.,shamsodinvandi,R. (2008). analaysis of annual and

Seasonal precipitations trend in the central iran basin using nonparametric methods. *journal of geoghraphycal researchs*,vol.64. Summer,157-168pp(in Persian).

10. Huntington, T.G. (2006). Evidence for intensification of the global water cycle: review and synthesis. *Journal of Hydrology*, 319: 1–4.

11. Jiang, Y., Zhou, C., Cheng, W. (2007). Streamflow trends and hydrological response to climatic change in Tarim headwater basin. *Journal of Geographical Sciences*, 7(1): 51–61.

12. Kahya, E., Kalayci, S. (2004). Trend analysis of streamflow in Turkey. *Journal of Hydrology*, 289: 128–144.

13. Kampata, J.M., Parida, B.P. and Moalafhi, D.B. (2008). Trend analysis of rainfall in the headstreams of the Zambezi River Basin in Zambia. *Physics and Chemistry of the Earth*, 33: 621–625.

14. Khaled H. Hamed. (2008). Trend detection in hydrologic data: The Mann–Kendall trend test under the scaling Hypothesis. *Journal of Hydrology*, 349: 350– 363.

15. Khaliq,M.N., Ouarda.T.B.M.J., Gachon,P., Sushama,L., St-Hilaire, A. (2009). Identification of hydrological trends in the presence of serial and cross correlations: A review of selected methods and their application to annual flow regimes of Canadian rivers. *Journal of Hydrology*, 368 : 117–130.

16. Kundzewicz, Z.W., Mata, L.J., Arnell, N.W., Doll, P., Kabat, P., Jimenez, B., Miller, K.A.,Oki, T., Se¿n, Z., Shiklomanov, I.A. (2007). Freshwater resources and their management. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 173–210.

17. Kundzewicz, Z.W.,Robson,A. (2004). Change detection in hydrological records – a review of the methodology. *Hydrological Sciences Journal*, 49: 7–20.

18. Lettenmaier,DP., Wood, EF., Wallis,JR. (1994). Hydro-climatological trends in the continental United States, 1948–1988. *Journal of Climate*, **7**: 586–607.

19.Sohrabi,M.M.,Marofi,S.,sabziparvar,A.,Maryanaji,Z.(2009). Investigation of existence of trend in annual precipitation of Hamedan province using mann-kendall method. *journal of water and soil conservation*, 16(3): 163-169, (in Persian).

20. Westmacott, J.R., Burn, D.H. (1997). Climate change effects on the hydrologic regime within the Churchill–Nelson river Basin. *Journal of Hydrology*, 202 (1–4): 263–279.

21. Xu, Z.X., Li, J.Y., Liu, C.M. (2007). Long-term trend analysis for major climate variable in the Yellow River basin. *Hydrological Processes*, 21: 1935–1948.

22. Zdenek, K. and Milada, M. (2008). Long-term Trends of Rainfall and Runoff Regime in Upper Otava River Basin. *Soil & Water Research*, 3 (3): 155–167.

23. Zongxue,X., Zhaofei,L., Guobin, F.,Yaning, C. (2010). Trends of major hydroclimatic variables in the Tarim River basin during the past 50 years. *Journal of Arid Environments*, 74: 256–267.