The trend of seasonal and annual precipitation stations Orumieh lake basin using the Mann Kendall

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Abstract: The main aim of the current research was to investigate the seasonal and annual rainfall trends in the Orumieh Lake Basin. The most data sequences are observed as climatic series having non-linear behavior which do not follow a normal distribution. Consequently, a Mann- Kendall non-parametric statistical method was applied to analyze all data at hand. For this purpose eight major synoptic and climatic stations' observations (from 1970 to 2009, exactly 40 years) have been analyzed using different sort of graphic and analytic techniques. The final results show that, there are some negative significant decreasing trends in the most of the time series. It is also distinguished that the beginning of changes, regarding the all time series at the study area, started at 1990s. Since, significant trends cannot be detected in all stations data; the related spatial distribution maps were not created.
[Kheshtkary Sani, sayyad. **The trend of seasonal and annual precipitation stations Orumieh lake basin using the Mann Kendall.** *Researcher* 2014;6(5):23-26]. (ISSN: 1553-9865). http://www.sciencepub.net/researcher. 5

Key words: dynamic simulation; model; composting; domestic solid waste

1. Introduction

One of the common methods to analyze time series of precipitation is consideration of presence or absence of the Statistical tests. Existence of significant trends in a time series of rainfall alone cannot be conclusive evidence of the occurrence of climate change in the region, but also to reinforce the assumption that event (Serrano et al, 1999). It is caused by multiple factors control the climate. Several methods have been proposed to analyze the environmental variables, such as the normal condition for nonparametric data distribution is proposed; therefore, most studies have been conducted using a non-parametric method.

Using non-parametric Mann- Kendall test trend analysis by the World Meteorological Organization Hydrometheology series recommended (Mitchell et al, 1966). Several studies on the precipitation process are performed using nonparametric methods. (Yue and Hashino, 2003) to examine the monthly and annual rainfall of Japan and the majority of stations showed a significant negative trend). Partal and Kahya, 2006) To determine the long-term trend in annual average total monthly precipitation for 96 stations in Turkey in the period from 1929 to 1993 Kendall and t age I used nonparametric (Longobardi and Villani, 2009). To study the seasonal and annual precipitation at 211 meteorological stations surveyed in southern Italy in the period 1999-1918, and the last 30 years have demonstrated a significant trend.

Zahedi et al (2007) using the linear regression method and mann - Kendal North West began to study the temperature changes. Modarresi (2007) Rainfall trends in arid and semi-arid country on mann - Kendall way reviewed. Research showed that a seasonal shift in the focus of a major climate change in total precipitation occurred but has not been done in this area. Azizi and Roshani (2008) examined the possible deviation of temperature and humidity of the southern coast of the Caspian Sea, which normally deals with data indicating onset more abrupt changes of both trends and fluctuations. Hejam et al (2008) Seasonal changes and annual rainfall of 48 stations in the central area of Iran in the period 1971 to 2000, using two non-parametric test me, Kendall and Sen. 'S estimator studied.

In the present study, the importance of the phenomenon of climate change and its relationship with local variations, the review will examine the rainfall, the rainfall as a random variable has a significant spatial and temporal variations. To analyze trends in seasonal and annual rainfall in the catchments of Lake nonparametric test Mann - Kendall used. The main objective of this study was to evaluate seasonal and annual time series of rainfall and lake basin in a relatively long-term process of detection statistics.

Materials and Methods:

A - Geographical characteristics Area

Orumieh Lake Basin area of 51,460 square kilometers between Lake coordinates 7 and 44 to 53 and 47 east longitudes and 40 north latitudes and 35 to 30 and 38 is located. The basin is located in northwestern Iran and the north of the Aras River Basin, East River catchments Sefidrud, south of the West Basin Sefidrud and Sirwan and Zab River Basin has been limited. This basin is a closed basin, the mountains and the lake basin runoff flows (Integrated Water Resources Management, 2006).

B - Data and Methods

In this study, precipitation data from all synoptic

stations and lake basin were collected among them eight stations with long-term data on the forty-year period ranging from 1970 to 2009 were analyzed. The reason for these stations completeness of the data and distributes them across a geographical area is a good place. To reconstruct the statistical errors of the correlation between the stations and the normal ratio method was used to ensure homogeneity of rainfall statistics were performed on the test data, test thigh. For each series of seasonal and annual rainfall stations were extracted and finally 40 time series were created. Geographical location of the lake basin and the spatial distribution of the stations are listed in Figure 1.

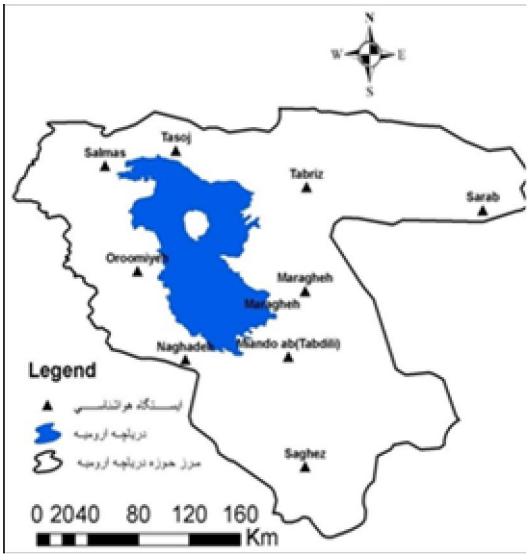

Figure 1 - Geographical location of the studied stations

The changes in annual and seasonal rainfall time series of total stations were examined using Kendall's nonparametric test me. This test to determine if there are significant and they are, in addition, this method provides information on starting the process of abrupt climate change (Karaca et al, 1995).

Mann- Kendall test summarize as follows:

Ranked data and statistics ti (relative rank i rather previous rank) is calculated and then, statistics and cumulative frequency ti) $\sum ti$) is obtained.

Expectation Ei, the variance Var and U index is as follows:

$$t = \sum_i ni$$

$$E(t) = \frac{n(n-1)}{4}$$

$$u(t) = \frac{[t - E(t)]}{\sqrt{\text{var}(t)}}$$

$$\text{var}(t) = \frac{n(n-1)(2n+5)}{72}$$

n, respectively, when the test dataset t (relative rank i to rank pre-high). The index is normally distributed. Therefore, the normal curve table can be used to identify significant.

If U> 0 is positive, if U <0 is negative and if it is U = 0 is the neutral trend Confidence level (± 1.96) $\%95$, is considered (Ezber, 2007).

Results:

A - Analysis Test Mann- Kendall on seasonal and annual precipitation data:

For all time series studied in the first Mann - Kendall test calculated this statistic significant at the 95% confidence level and 99% were tested the results in Tables 1 and 2 are insertion.

As these tables comes from the series of quarterly and annual data, the most significant trend was confirmed in 99% of the data fall was observed that 25 percent of the stations studied were significantly increased. Spring rainfall at all stations has been decreasing, the most significant trend was confirmed in 99% of the cash station with -2.88 and 95% at the two stations, respectively -2.09 and -2.01 are Urmia and Tabriz. Miandouab stations with a decreasing trend this season had the lowest -1.5. In the summer between data sets at 95% and 99%, there was no significant trend in any station.

Data autumn showed increasing trend in most of the stations. Miandouab and Sarab stations with 3.08 and 3.03 the most significant trends in the levels of 99% and Maragheh station with 2.28 most significant trends at the 95% level are shown. In this chapter, Urmia -0.97 had the highest decline. In winter, the station of Tabriz, was significantly 2.09 Top trends showed a significant increase in the level of 95%. In this season, Ouromieh and Salamas stations were no trends this season. The results of the analysis of annual series of rainfall data also showed a decreasing trend at all stations, but this trend was significant only at the 95% level station in Tabriz. Among the lowest in the series, Sarab station showed a decreasing trend.

B- Analysis test Mann - Kendal test to determine when to change

First, Mann - Kendal test using components u and u 'for all stations were plotted on a scale of seasonal and annual. Accordingly, the test characteristics change over time was determined graphically. An example of this is given in the following charts:

Table 1: Results of Mann - Kendall, * there are 95% - 99% level ** trend

Station	Spring	Summer	Fall	Winter	Annual
Orumieh	* -2.09	0.94	-0.97	0	-1.47
Tabriz	*-2.01	0.63	1.20	**-2.76	*-2.11
Sarab	-1.72	1.85	**3.03	**2.38	-0.8
Miandouab	-1.5	0.68	**3.08	1.58	-0.34
Saghez	-1.68	1.03	-0.08	1.01	-1.63
Maragheh	-1.78	0.5	*2.28	*2.09	-1.21
Salmas	-1.81	0.24	1.17	0	-1.22
Naghadeh	**-2.88	0.05	-0.66	-1.11	-1.79

Table 2: Percentage Breakdown of stations with a significant trend of significant levels

significant level	Spring	Summer	Fall	Winter	Annual
95%	37.5	0	37.5	37.5	12.5
99%	12.5	0	25	12.5	0

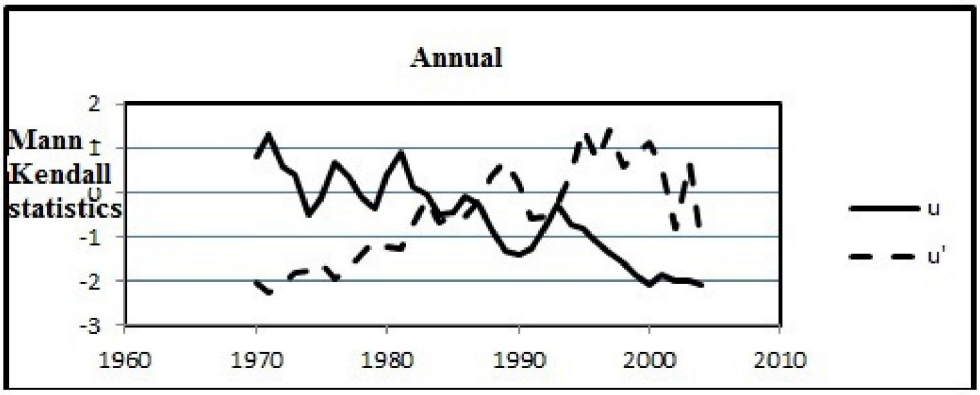

Figure 2 - Example of graphical Mann - Kendall Station of Tabriz

In Table 3, for more detailed analysis of changes occurring during the entire period of study is divided into four 10-year periods to be determined by the way the synchronization of changes in the stations. This table shows that: In the first and fourth periods studied will not see any change in precipitation in the spring, and all changes to the second and third period, the rate of change in each period is 50 percent. More than 80% of summer and winter precipitation changes in the third period and the second period were done. In the first and fourth periods like spring change is not observed. Fall about 62 percent since the start of the third period and a 38% change in the first period. Overall, a total of 65 percent since the start of the third period and the change order is allocated first to the second period. Beginning in the fourth period, no change is found.

Table 3: Frequency of occurrence of seasonal and annual precipitation changes during the studied stations

Period	Intervals	Spring		Summer		Fall		Winter		Annual		Total Period	
		No.	percent	No.	percent	No.	percent	No.	percent	No.	percent	No.	percent
I	1970-1999	0	0	0	0	3	37.5	2	33.3	0	0	5	13.1
II	1980-1989	4	50	1	12.5	0	0	2	33.3	1	12.5	8	21.1
III	1990-1999	4	50	7	87.5	5	62.5	22	33.3	7	87.5	25	65.8
IV	2000-2009	0	0	0	0	0	0	0	0	0	0	0	0
Total		8	100%	8	100%	8	100%	6	100%	8	100%	38	100%

Conclusions:

Series of annual rainfall at all stations with a decreasing trend in spring and autumn and winter rainfall series in about 60% of stations have a decreasing trend. Summer rainfall at all stations show an increasing trend, but the trend is not significant in any of the stations. The periodic review of the data indicated that most changes occurred in the second and third periods. So that, the sum total of 65 percent since the start of the third period and the change during the second and first, respectively, were assigned. There was also no change in the fourth

period began.

Regarding the distribution of stations in the basin, one can conclude that the processes occurring in the basin is not subject to any particular order. Also, since the number of significant trends in the series without trend is much less than the series can not be a pattern of seasonal and annual precipitation in the basin others. In this study, precipitation was considered the changes that are proposed for closer scrutiny of climate change in the area of climate other elements should be used.

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5/10/2014