THE STUDY OF THE EXISTENCE OF TREND IN ANNUAL AND SEASONAL RAINFALL OF ZAYANDEHROOD BASIN IN IRAN

PEZHMAM ALLAHBAKSHIAN FARSANI¹, AFSHIN HONARBAKHSH² & PAYAM EBRAHIMI³

¹Graduate Student of Watershed Management Engineering, Department of Watershed Management Engineering, Sari Agricultural Sciences and Natural Resources University, Sari, Iran

²Assistant Professor, Department of Watershed Management Engineering, Shahrekord University, Shahrekord, Iran

³M.Sc Student, Watershed Management Engineering, Department of Watershed Management, Sari Agricultural Sciences and Natural Resources University, Sari, Iran

ABSTRACT

Rainfall is one of the most variable parameters in each climate that its long-term deficiency can cause severe droughts and its severe fall can cause flood. This study is conducted to investigate the existence of trend in rainfall in Zayandehrood basin for long-term management of water resources in the region. In this study, seasonal and annual rainfall data from 20 rain gauge stations in Zayandehrood basin with appropriate distribution of data for a time span of 33 years, from 1976-2009, is used. Using the nonparametric Mann-Kendall and Sen’s Estimator of Slope, the existence of trend in annual and seasonal rainfall of the stations is studied. According to the results, none of the stations under the study showed a significant trend at the level of 95 and 99 percent in precipitation on an annual scale. Also, the rainfall trend in fall season in the stations at the level of 95 and 99 percent was not significant. In winter, only Jafarabad stations had a negative trend at the level of 95% and other stations had no significant trend. In spring, Zayandehrood and Eskandari stations had a significant ascending trend at the level of 95% while in summer. In addition to Zayandehrood and Eskandar stations, Tiran and Jafarabad stations had a significant ascending trend at 95% level and other stations had no significant trend. The results of this study can be used in forecasting and zoning the future droughts and also planning and managing water resources of the region.

KEYWORDS: Nonparametric Methods, Rainfall, Trend Analysis, Zayandehrood

INTRODUCTION

One of the consequences of global warming is climate change which can affect environment, water sources and human industrial and agricultural activities (Shi and Xu, 2008). Global warming is occurred because of the human activities and greenhouse gases production and then lead to intensify hydrological cycle of earth(Allen and Ingram, 2002; Allen et al, 2003; Arnell, 1999). Besides, intensification of the hydrological cycle causes to change temporal and local patterns of precipitation. As result, maximum precipitation fall is occurred and consequently this can lead to increase natural disturbances such as flood and drought in most of the world (Qiu, 2010; Mirza, 2002; Allan and Soden, 2008; Houghton et al,2001; Easterling et al, 2000).

Based on the report of International Panel on Climate Change (IPCC) concerning precipitation fall variations from 1900 to 2005 it is concluded that the climate in northeast and south of America, North of Europe, North and center of Asia was humid, while the climate in southern coast of Africa, Mediterranean and south of Asia was dry (Trenberth, 2007).

Among vital sources, water is the most important source to develop and secure economics of ecosystem and
biodiversity. In spite of this, the critical status of water sources across the world. Thus, to schedule and sustainable manage of water sources, it is necessary to determine temporal and local change of sources and evaluate the effects of climate and human activities on this source. It is required to have sufficient data about hydrology, flow pattern, quantity and quality of water source of river basins (Oyebande, 2001).

In recent years the worries about extreme disturbances on climate and weather have increased due to its destructive effects on human community and nature (Karl and Esterling 1999; Easterling et al, 2000). Climate variation along with the effects of human activities on production of greenhouse gases causes to increase global temperature (Zhang et al, 2005) and evapotranspiration rate in atmosphere. Finally, hydrology cycle of the world is intensified (Menzel and Bürger, 2002).

The patterns of atmosphere cycle in large scale determined the temporal and local distribution of temperature and precipitation in the earth. The regional change in hydrology cycle and consequently variations in quality and quantity of stream regime are results of climate change. The water has important role in society and nature. So it’s understood is necessary. The global warming causes to change hydrology and runoff cycle in global scale. Therefore, the accessibility to water sources is changed from a region to another region due to climate change (Xu and Singh, 2004; Labat et al, 2004).

In previous mid-century, according to population pressure and climate change the worries about accessibility to sweet water with high quality has been converted to a public concern (Gleick, 1993, 2000; Shiklomanov and Rodda, 2003; Vörösmarty et al, 2000; Milliman et al, 2008). Water consumption increased rapidly because of the population expansion, enhancement of standard level in human life and economic development. This status has other problems such as water pollution which lead to negative effects on sustainable socio-economic development of human society. These problems are occurred because of natural reasons such as lack of temporal and local distribution of precipitation fall and lack of knowledge about water sources problems.

Recently, many researchers have been conducted about climate change especially concerning determination of trend. Kampala et al. (2008) analyzed the long term precipitation data for 5 precipitation gage stations in Zambezy river basin, Zambia to determine the temporal series, similar regime. The Man-Kendal test was used to determine this trend.

Each 5 stations showed a decreasing trend but this trend was not significant. Sanjio et al. (2009) in India investigated the flow trend in 131 stations with 50 years data. The flow trend in annual and seasonal scale and under flow condition of minimum, moderate and maximum was determined using Man-Kendal test.

xu et al (2010) investigated the precipitation fall and runoff trend using Man-Kendal test in large streams of China from 1951 to 2000. Of 160 studied stations, 4 to 11 percent of them showed increasing trend. Moreover, the data of 22 hydrology stations investigated in 5 large stream of China. The runoff increased 10 percent in xigiang stream in south of china, while the runoff variation of Yang-Tese was less. In northern regions, the flow in Zard, Lio and Sagva streams decreased 80, 50 and 14 percent, respectively.

zhang et al. (2011) investigated the variations of precipitation and flow in China. They evaluated the variations of precipitation and flow in 590 precipitation gage stations and 382 hydrology stations in 1960-2000. Results indicated that the precipitation fall has decreased in northeast of China and the precipitation is rarely observed in spring and autumn. It seems that the winter be moist because the variation of the Mosemi activities in south east of Asia causes to change local patterns of precipitation fall. Variation in flow is occurred due to variation in precipitation fall. Moreover, irrigation has main effects on variations and accessibility to water sources.
xu et al (2010) assessed the temperature variation and extremely precipitation fall during two recent decades in China. They used daily minimum and maximum temperature and daily precipitation fall of 532 climate stations in periods of 1960-1986 and 1990-2007. Results indicated that annual maximum precipitation fall and annual maximum and daily maximum were increased 9, 10 and 12 mm, respectively. The frequency of the occurrence of warm and cold night in annual scale was achieved from data of daily minimum temperature which was varying about 38% and 28%, respectively.

Tabari and Hossein Zadeh Talaei (2011) determined the annual and seasonal precipitation fall trend using Man-Kendal test, Shib-man estimations and linear regression in 41 stations of Iran for statistical period of 1966-2005. Results showed that the annual precipitation fall decreased in 60% of stations. The significant decrease trend was recorded for 7 stations at probability level of 95% and 99%. Local distribution of annual precipitation fall with negative trend was occurred in northwest of Iran. In seasonal scale the precipitation fall trend was often negative in spring and winter. Many stations have significant trend in winter, while there wasn’t significant trend in autumn.

In Iran during the previous year's several researches was conducted to investigate the variations trend of some hydrological and weather parameters. Sohrabi et al (2009) in a study assessed the annual precipitation fall of 23 stations in Hamedan province from 1982 to 2006 using Man-Kendal test. Results showed that the increasing significant trend was recorded in stations of Aghajamblaghi, Toyserkan and Ghavand (at probability level of 5%) and for others it was static. In some cases in spite of the significant trend, there was increasing and decreasing trend.

Hejam et al. (2008) with use of nonparametric method investigated the variations trend of seasonal and annual precipitation fall in the several selected stations in central river basin of Iran. Results showed that the Man-Kendal method and age estimation method are similar to each other in analysis of seasonal and annual precipitation fall. The capability of age estimation method in observation studies which have many zero data is better than that of Man-Kendal method. Results of this study showed the reducing significant trend for both of two methods in some temporal series, but no significant increasing trend was verified by these methods. They found that the number of series with significant trend was less than series without significant trend, there for it is not possible to consider an especial trend for seasonal and annual precipitation fall.

The purpose of this study was to investigate the existence trend of precipitation fall in seasonal and annual scale for Zayandehrood river basin.
STUDY AREA AND METHODS

Description of the Zayandehrood River Basin

Zayandehrood river basin with an area of 41500 km$^2$ includes in Esfahan and some parts of Chaharmahal and Bakhtiari provinces. The main stream of this river basin with path of west to east is originated from Zardkooh Bakhtiari and then falls into Gavkhooni swamp. This stream in its route provides water sources for regional industries, Esfahan city and agricultural lands.

Investigation Methodology

In hydro climate studies the minimum period duration of 25 years is statistically enough to achieve confidence about results. Therefore, the statistical period duration of current study was determined more than that of minimum period duration of hydro climate studies data. The common temporal base of 33 years in 20 stations was extracted for 37 existence precipitation and evaporation gauging stations in Zayandehrood river basin (figure1). First, in this study the temporal series of annual and monthly precipitation fall was analyzed. Before analysis of data trend, homogeneity test and determination of outlier points in data series was conducted. The run-test method was used to test data homogeneity. Besides, the Groebz-Bak test was applied for determining outlier points.

Man-Kendal Method

This test was introduced by Man and then developed by Kendal (Piki and Jheng, 1989). This method was used to test hypothesis of data sequence random against trend existence. Researchers showed that Man-Kendal test is as effective technique in evaluation of evenness variation of temporal series (Brooks and Carrthers, 1982). Man-Kendal test was used to analysis the trend of hydro climate series because of following reasons: 1- It is nonparametric test and can determine the trend without need to normalize and linearize data (Mann, 1945; Wang and Zhou, 2005). 2- The output of this method is similar to other nonparametric methods of trend determination and has less sensitivity as compared to parametric methods, 3- this method was introduced by international organization of meteorology (Kendall, 1975).

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(x_j - x_k)$$  \hspace{1cm} (1)

Man-Kendal test is based on the difference among precipitation years ($X_i - X_k$) in temporal series ($X_1, ..., X_N$). The $S$ is calculated according to sum of signs Lettenmaier et al. (1994) (always is a number among -1, 0 and 1). In case of $N>10$ the standards $Z$ is calculated using following equation:

$$\text{sgn}(x_j - x_k) = \begin{cases} +1 & \text{if } x_j > x_k \\ 0 & \text{if } x_j = x_k \\ -1 & \text{if } x_j < x_k \end{cases}$$  \hspace{1cm} (2)

Where, $n$ is sample size, if $n>10$ $S$ has approximately normal distribution and the mean and variance are equal to each other.

$$E(S) = 0$$  \hspace{1cm} (3)

$$V(S) = rz(r-1)(2r+5) - \frac{\sum_{i=1}^{n} t_i (i-1)(2i+5)}{18}$$  \hspace{1cm} (4)
Where, \( t \) is the number of nodes with a size of \( I \), \( Z \) for one-range test is describes as follow:

\[
Z = \begin{cases} 
-1 / \sqrt{\text{Var}(S)} & S > 0 \\
0 & S = 0 \\
1 / \sqrt{\text{Var}(S)} & S < 0 
\end{cases}
\]  

(5)

The positive and negative values of \( Z \) show increasing and decreasing trend, respectively. If \( |Z| > 1.960 \) and \( |Z| > 2.576 \) the zero hypothesis of the lack of trend is rejected at probability level of 1 and 5%.

**Sen Test**

There is a quantitative trend to estimate correct gradient (variations in year) and nonparametric test of Sen is often used (Sen, 1998). When it is assumed that the trend can to be linear, this test is used. This means that \( F(t) \) in equation 6 is equal to:

\[
F(t) = Qt + B
\]

(6)

In this equation \( Q \) is slope and \( B \) is constant value. The gradient of all pair values must be calculated to estimate gradient from equation (7):

\[
Q_{j,k} = \frac{(X_j - X_k)/(j-k)}{\sqrt{\text{Var}(s)}} > k
\]

(7)

It there was \( n \) number of \( X \) value in temporal series, the estimated gradient is obtained according \( N = (n(n - 1))/2 \). The estimated gradient of Sen Test is the median of \( N \) numbers of \( Q \). A mutual confidence interval in limitation of gradient estimation is achieved using nonparametric technique based on normal distribution. In this study confidence interval \( X=0.05 \) and \( X=0.01 \) was calculated in two level. At first the \( C_\alpha \) was calculated using following equation(8):

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

(8)

Where \( Z_{1-\alpha/2} \) is calculated from normal standard distribution. Then, \( M1 = (N - C_\alpha)/2 \) and \( M2 = (N + C_\alpha)/2 \) are calculated. The higher and lower confidence interval is \( Q_{\text{max}} \) and \( Q_{\text{min}} \). \( M_1 \) is the largest and \((M_2+1)\) is larger than that of estimated rowed \( Q \). The differences of \( X_i - Q_t \) are calculated to estimate \( B \) from equation 6. The median of these values gives an estimation of \( B \) for different confidence interval (Sen, 1998). The positive gradient showed increasing trend, while negative gradient shows decreasing trend Xu et al. (2007).

**RESULTS**

In this study the data were initially evaluated as viewpoint of outlier points. Results indicated that there are no outlier points in stations at probability level of 95%. Run-Test was conducted at probability level of 95% to assess the homogeneity of the station's data. Results showed that all data were homogeneity. After mentioned analysis, the existence of trend in different stations and seasonal and annual temporal series were assessed.
Man-Kendal nonparametric test was used to determine the trend of precipitation fall in studied stations. Moreover, Sen-Test was used to determine the magnitude of the gradient of existence trend. Table 1 shows the mean annual precipitation fall and standard deviation of mean annual precipitation fall during 33 years. Kohrang stations and Varzaneh with 1422 mm and 90.8 mm had respectively maximum and minimum precipitation. Besides shows the Z of Man-Kendal test and Q of Sen-Test in annual scale.

No stations showed a significant trend at probability level of 95 and 99% in annual scale of precipitation fall. The results of used tests for seasonal scale of precipitation fall have been illustrated in Table 2.

Table 1: Annual Mean, Standard Deviation of Precipitation Fall and Results of Man-Kendal Test and Age in Annual Scale

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Station Code</th>
<th>Annual Mean (mm)</th>
<th>Standard Deviation</th>
<th>Z</th>
<th>Q</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damaneh</td>
<td>42-004</td>
<td>358.6</td>
<td>109.7</td>
<td>0.75</td>
<td>1.96</td>
<td>-</td>
</tr>
<tr>
<td>Skandari</td>
<td>42-005</td>
<td>387.3</td>
<td>110.8</td>
<td>0.97</td>
<td>2.12</td>
<td>-</td>
</tr>
<tr>
<td>Zayandehrood dam</td>
<td>42-007</td>
<td>224.8</td>
<td>79.7</td>
<td>1.28</td>
<td>2.31</td>
<td>-</td>
</tr>
<tr>
<td>Zaman khan bridge</td>
<td>42-009</td>
<td>357.8</td>
<td>110.9</td>
<td>-0.86</td>
<td>-1.55</td>
<td>-</td>
</tr>
<tr>
<td>Kale bridge</td>
<td>42-011</td>
<td>191.3</td>
<td>69.6</td>
<td>-0.32</td>
<td>-0.41</td>
<td>-</td>
</tr>
<tr>
<td>Tiran</td>
<td>42-014</td>
<td>172.7</td>
<td>55.7</td>
<td>0.41</td>
<td>0.42</td>
<td>-</td>
</tr>
<tr>
<td>Zafreh</td>
<td>42-017</td>
<td>148.6</td>
<td>50.4</td>
<td>0.06</td>
<td>0.08</td>
<td>-</td>
</tr>
<tr>
<td>Esfahan</td>
<td>42-020</td>
<td>120.3</td>
<td>45.7</td>
<td>0.35</td>
<td>0.30</td>
<td>-</td>
</tr>
<tr>
<td>Meimeh</td>
<td>42-022</td>
<td>159.8</td>
<td>62.2</td>
<td>0.13</td>
<td>0.32</td>
<td>-</td>
</tr>
<tr>
<td>Ziar</td>
<td>42-023</td>
<td>107.1</td>
<td>40.6</td>
<td>0.48</td>
<td>0.28</td>
<td>-</td>
</tr>
<tr>
<td>Moorche khoort</td>
<td>42-024</td>
<td>114.7</td>
<td>43.3</td>
<td>0.32</td>
<td>0.29</td>
<td>-</td>
</tr>
<tr>
<td>Varzaneh</td>
<td>42-025</td>
<td>90.8</td>
<td>35.4</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Kohpaieh</td>
<td>42-032</td>
<td>113.8</td>
<td>42</td>
<td>1.93</td>
<td>1.81</td>
<td>-</td>
</tr>
<tr>
<td>Maghsoud beik</td>
<td>42-038</td>
<td>110.8</td>
<td>47.1</td>
<td>0.46</td>
<td>0.39</td>
<td>-</td>
</tr>
<tr>
<td>Mahiar</td>
<td>42-042</td>
<td>154.2</td>
<td>60.1</td>
<td>-0.85</td>
<td>-0.94</td>
<td>-</td>
</tr>
<tr>
<td>Eizad Khast</td>
<td>42-057</td>
<td>154.2</td>
<td>60.1</td>
<td>-0.85</td>
<td>-0.94</td>
<td>-</td>
</tr>
<tr>
<td>Jafar Abad</td>
<td>42-528</td>
<td>166.7</td>
<td>58.8</td>
<td>-1.79</td>
<td>-1.68</td>
<td>-</td>
</tr>
<tr>
<td>Harizeh</td>
<td>42-530</td>
<td>162.2</td>
<td>54.9</td>
<td>0.15</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>Lanjan</td>
<td>42-990</td>
<td>141.7</td>
<td>47.7</td>
<td>-0.49</td>
<td>-0.55</td>
<td>-</td>
</tr>
<tr>
<td>Kohrang</td>
<td>42-001</td>
<td>1422</td>
<td>355.6</td>
<td>-0.16</td>
<td>-0.62</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: Results of Z and Q in Seasonal Scale

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Station Code</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Z</td>
<td>Z</td>
<td>Q</td>
<td>Z</td>
</tr>
<tr>
<td>Damaneh</td>
<td>42-004</td>
<td>0.2</td>
<td>-0.23</td>
<td>-0.2</td>
<td>1.95</td>
</tr>
<tr>
<td>Skandari</td>
<td>42-005</td>
<td>-0.12</td>
<td>-0.44</td>
<td>0.67</td>
<td>2.15*</td>
</tr>
<tr>
<td>Zayandehrood dam</td>
<td>42-007</td>
<td>0.35</td>
<td>0.54</td>
<td>0.58</td>
<td>2.35*</td>
</tr>
<tr>
<td>Zaman khan bridge</td>
<td>42-009</td>
<td>-0.80</td>
<td>-0.26</td>
<td>-0.49</td>
<td>0.10</td>
</tr>
<tr>
<td>Kale bridge</td>
<td>42-011</td>
<td>-0.07</td>
<td>-0.43</td>
<td>-0.37</td>
<td>0.01</td>
</tr>
<tr>
<td>Tiran</td>
<td>42-014</td>
<td>-0.60</td>
<td>0.23</td>
<td>0.28</td>
<td>0.94</td>
</tr>
<tr>
<td>Zafreh</td>
<td>42-017</td>
<td>-0.61</td>
<td>0.29</td>
<td>0.28</td>
<td>0.27</td>
</tr>
<tr>
<td>Esfahan</td>
<td>42-020</td>
<td>-1.13</td>
<td>-0.49</td>
<td>-0.01</td>
<td>0.72</td>
</tr>
<tr>
<td>Meimeh</td>
<td>42-022</td>
<td>-0.41</td>
<td>-0.72</td>
<td>-0.50</td>
<td>0.55</td>
</tr>
<tr>
<td>Ziar</td>
<td>42-023</td>
<td>-0.49</td>
<td>0.58</td>
<td>0.23</td>
<td>1.11</td>
</tr>
<tr>
<td>Moorche khoort</td>
<td>42-024</td>
<td>0.29</td>
<td>0.21</td>
<td>0.07</td>
<td>1.10</td>
</tr>
<tr>
<td>Varzaneh</td>
<td>42-025</td>
<td>-0.01</td>
<td>-0.51</td>
<td>-0.21</td>
<td>-0.01</td>
</tr>
<tr>
<td>Kohpaieh</td>
<td>42-032</td>
<td>0.83</td>
<td>0.92</td>
<td>0.42</td>
<td>0.80</td>
</tr>
<tr>
<td>Maghsoud beik</td>
<td>42-038</td>
<td>0.17</td>
<td>1.06</td>
<td>0.51</td>
<td>-0.69</td>
</tr>
<tr>
<td>Mahiar</td>
<td>42-042</td>
<td>0.17</td>
<td>0.35</td>
<td>0.16</td>
<td>0.85</td>
</tr>
<tr>
<td>Eizad Khash</td>
<td>42-057</td>
<td>-0.51</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.13</td>
</tr>
<tr>
<td>Jafar Abad</td>
<td>42-528</td>
<td>-0.13</td>
<td>-2.40*</td>
<td>-1.94</td>
<td>-0.52</td>
</tr>
</tbody>
</table>
The Study of the Existence of Trend in Annual and Seasonal Rainfall of Zayandehrood Basin in Iran

<table>
<thead>
<tr>
<th>Station</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Pearson Correlation</th>
<th>R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harizeh</td>
<td>42-530</td>
<td>-0.23</td>
<td>-0.17</td>
<td>-0.82</td>
<td>0.26</td>
<td>0.15</td>
<td>-0.55</td>
<td>0</td>
</tr>
<tr>
<td>Lenj</td>
<td>42-990</td>
<td>-0.60</td>
<td>-0.33</td>
<td>-0.04</td>
<td>0.74</td>
<td>0.38</td>
<td>0.99</td>
<td>0</td>
</tr>
<tr>
<td>Kohrang</td>
<td>42-001</td>
<td>-0.14</td>
<td>-0.2</td>
<td>-0.16</td>
<td>-0.3</td>
<td>0.16</td>
<td>0.34</td>
<td>0.15</td>
</tr>
</tbody>
</table>

The precipitation fall trend in autumn season in all studied stations was not significant at probability level of 99%. In winter season, Jafar Abad station had only negative trend at probability level of 95% and other stations had not significant trend. In spring, Zayandehrood and Skandari stations had increasing significant trend at probability level of 95% and other existence stations had not significant trend. In summer, the Skandari, Zayandehrood, Tiran and Jafar Abad stations had significant increasing trend at probability level of 95% and other existence stations had not significant trend (figur2).

![Figure 2: Seasonal Trend of Precipitation Variable at 20 Gauging Station in the Zayande Rood River Basin 1978-2010 (Regular Triangle with Red Color Indicates an Increasing Trend at the 5% Significance Level; Inverse Triangle with Red Color Indicates a Decreasing Trend at the 5% Significance Level)](image)

**DISCUSSIONS AND CONCLUSIONS**

The information about climate change and its effects on water sources are necessary to control natural disturbances such as drought and flood as well as reduce damage cost. In recent two decades, the analysis of the existence of trend in precipitation fall data has been considered by researchers as index to investigate the climate change events. According to achieved data from the analysis of trend in station of Zayandehrood river basin didn’t show signs of climate change. There was no significant trend for annual precipitation in studies stations. In seasonal scale, the Skandari, Zayandehrood, Tiran and Jafar Abad stations had significant increasing trend and other existence stations had not significant trend.

Our results were similar to Hejam et al. (2008) findings. Most of the stations hadn’t significant trend in seasonal scale. Moreover, the results of current study were compared to the findings of Kampala et al. (2008) in Zambezy river basin
in Zambia country and it was found similarity. There is no significant trend in annual scale of precipitation fall in Zayandehrood river basin. In Kampala et al. (2008) investigations in Zambezy river basin no stations showed significant trend. It was suggested that the variation trend of other climate parameters such as temperature, relative moisture, wind speed, evapotranspiration potential and etc. are considered to assess the effects of climate change in studied river basin. Moreover, scientists should conduct applicable researches on precipitation fall and other effective parameters on control and utilization of water sources in all of the river basins of country.

REFERENCES


Stockholm, pp. 1-54.


