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Research Article

Analysis of long-term natural streamflow trends in Upper Euphrates River Basin

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Abstract

The Euphrates River Basin system is of vital importance for water, food, energy security in Turkey, Syria, Iraq and under adverse climate change impact. It is therefore this paper mainly focuses on the naturally changing trend in long term streamflow with temperature and precipitation on the Upper Euphrates Basin that lies in Turkey. Because of the complexity of the setting up a basin-wide comprehensive hydrological model in the basin which have several large dams under operation ,we mainly used "run off data" in the statistical regression and time series analyses to predict the long term streamflow trends. We conclude that the annual natural flow has decreased mainly due to natural factors not because of construction dams. Obtained long term precipitation and air temperature trends in study area support the obtained streamflow trends. Results obtained from this study indicate that collaborative approach on transboundary water management between riparian's is an urgent need.

Keywords: Middle East water, Water researches, Flow prediction, Transboundary waters, Multivariate Statistics.

Yukarı Fırat Havzasının Uzun Dönem Akım Eğilimlerinin Analizi

Öz

Fırat Nehri Havzası sistemi, Türkiye, Suriye, Irak'taki su, gıda, enerji güvenliği ve olumsuz iklim değişikliği etkisinden dolayı hayati öneme sahiptir. Bu çalışma, Türkiye'de bulunan Üst Fırat Havzası'nda sıcaklık ve yağış ile birlikte uzun dönemli akarsu akışında doğal olarak değişen eğilime odaklanmaktadır. Havzada, inşası devam etmekte olan büyük barajlarla birlikte, havza çapında kapsamlı bir hidrolojik model oluşturmanın karmaşıklığı nedeniyle, uzun vadeli akış eğilimlerini tahmin etmek amacıyla, regresyon ve zaman serileri analizlerinde akım verisini kullandık. Yıllık doğal akışın esas olarak, baraj inşalarından değilde, doğal faktörlerden dolayı azaldığı sonucuna vardık. Çalışma alanında elde edilen uzun süreli yağış ve hava sıcaklığı eğilimleri, elde edilen akış şiddeti trendlerini desteklemektedir. Bu çalışmadan elde edilen sonuçlar, havzaya komşu olan ülkeler arasındaki sınır ötesi su yönetimi konusundaki işbirlikçi yaklaşımın acil bir ihtiyaç olduğunu göstermektedir.

Anahtar Kelimeler: Ortadoğu suları, Su araştırmaları, Akım Tahmini, Sınırıaşan sular, Çok değişkenli istatistikler

1. Introduction

The Euphrates River system (Figure 1) is a transboundary river system and of crucial significance for water, energy and food safety in Turkey, Syria and Iraq. Therefore, this river system plays a very important role in the architecture of security, peace and stability in the region. Therefore, managing the future sustainability of the river basin system is directly connected to the future of the region. This water management process will first require streamflow's to be defined with reliable data. The main target of this work is to predict the long term trend of the natural streamflow on the Upper Euphrates.

Sadik and Barghouti (Sadik and Barghouti 1994) stressed about the issue of the growing demands for water. Future predictions suggest more shortages(Al-Ansari 2013, Bazzaz and Prognoses 1993) and depletion of groundwater resources (Chenoweth et al. 2011). The current political circumstances is quite complex in Syria and Iraq(Al-Ansari 2013).

Studies concluded that the projected changes in the yearly surface-flows in entire scenarios put forward that the regions in Syria and Turkey are most unguarded to climate change within the basin because Turkey and Syria will see important reduces within yearly surface-flows (Bozkurt and Sen 2013). While many of the past works have examined tendencies in surface climatic factors in Turkey focused on precipitation and temperature models (Türkeş et al. 1995, Türkeş 1996).

Burn and Elnur (Burn and Elnur 2002) showed that there were similarities in the tendencies and models in the meteorologic and hydrologic factors. However, Lettenmaier (Lettenmaier et al. 1994) emphasized that the tendencies within flow are not completely similar to the changes in temperature and precipitation due to a combining of water management and climate impacts.

Kahya and Kalaycı(Kahya and Kalaycı 2004) strongly stressed the significance of a tendencies of hydrologic factors and presented trends computed for the long-term monthly streamflow data in Turkey. They found the way of tendencies is, in commonly, decrease.

Zhang (Zhang et al. 2001) showed that under particular geomorphic circumstances, the character of the river shows the combined basin answer to climatic strength. Peterson (Cayan and Peterson 1989), Dracup and Kahya (Kahya and Dracup 1993) also previously noted this point by identifying connections amongst surface hydro-climatic factors and the big scale atmospheric circulation.

The importance of the trend analysis of hydrologic variables is obvious. In fact, run off data is the most attractive variable to study using trend analyses of streamflow's in a basin that is accepted to not be showed to anthropogenic effects.

Consequently, hydrologic variables are suitable for detecting long-term trends in streamflow and monitoring climate change. Therefore, we try to define the trend in mean annual streamflow with a certain point on natural flow regime features (i.e., annual, monthly flows). The role of transboundary water management has gained vital importance, especially in regions such as Middle East and Central Asia the under the effects of climate change (Yıldız 2016).

The threat of climate change, adaptation measures and the necessity of collaboration might be a driving force to reach improved transboundary water diplomacy in the 21st century.

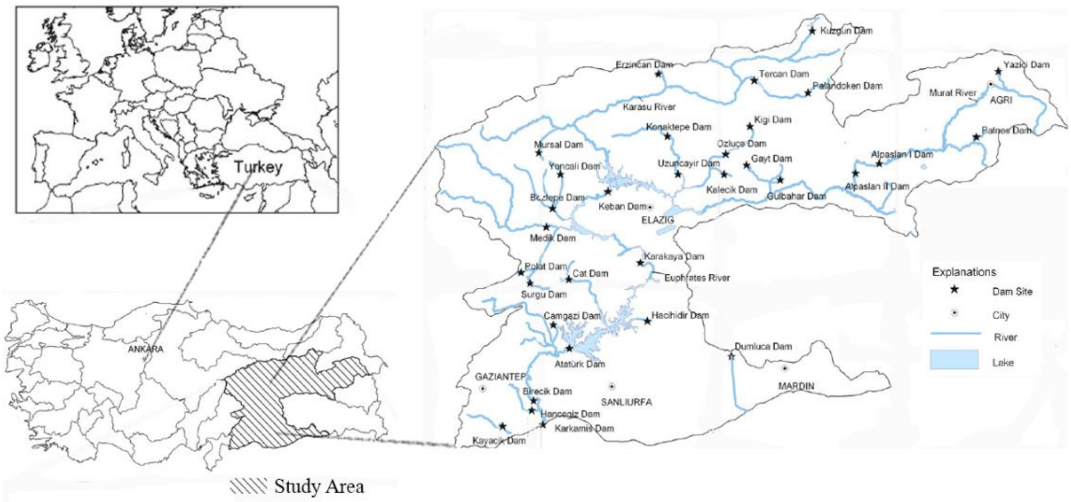

Figure 1. The Euphrates River Basin and completed dams

When we consider the climatic, social and security threats concerning water management, the Middle East needs this new hydro diplomacy more than ever before. The recommendations contained in this article may provide an opportunity to make a new realistic evaluation of the natural hydrological effects on streamflow's in the Euphrates for the future of the region.

2. Streamflow-Precipitation-Temperature Relationship

Many researches have used experimental rainfall runoff models to work the effects of climate change on hydrological events. The relationship between mean-annual precipitations, temperature, and runoff improved by Langbein (Langbein 1949), based on 22 drainage basins in the connected United States, were used by Stockton and Boggess (Stockton and Boggess 1979) to predict changes in the average-annual runoff of 18 designed areas throughout the United States for assorted climate scenarios.

Revelle and Waggoner (Revelle and Waggoner 1983) used the identical model as the base for researching the impacts of climate change on runoff in the Western United States (Leavesley 1994). Mirza (Mirza 1997) also used the Langbein model for a similar work on the Ganges River Basin. Nevertheless, application of these experimental relationships to climate and basin circumstances different from those used in the original development of these purposes are contestable (Leavesley 1994).

In some studies (Fu et al. 2007, Fu et al. 2009) the streamflow–precipitation–temperature relationship clearly indicates that annual streamflow is related to precipitation in positive way and related to temperature in negative way.

As shown in Fig 2. this creates much greater streamflow sensitivity to precipitation than to temperature (Cai and Cowan 2008, Yu et al. 2010).

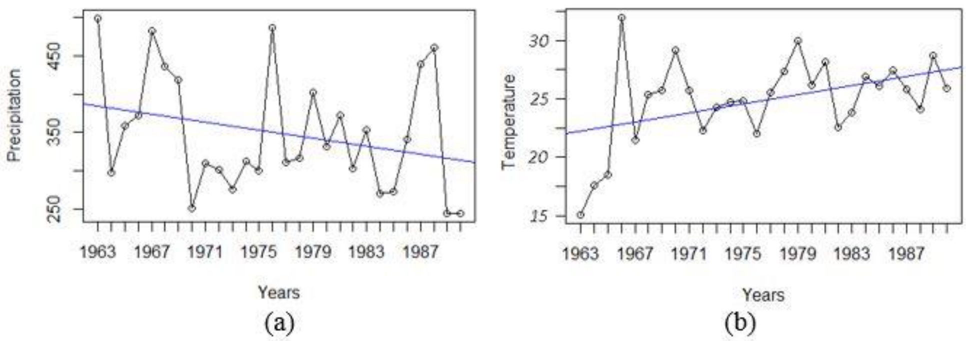

Figure 2. (a, b) (a) Long term annual precipitation trend (mm). (b) Long term annual temperature trend(0C).

Figure 2 shows general tendencies for precipitation and temperature belongs to Turkey. This figures guides to general structure of Turkey and how differ from Upper Euphrates River Basin. Runoff generation is controlled by precipitation. Higher temperatures can be taken as a second order effect. It is usually leading to increased evaporation and transpiration (McCarthy et al. 2001). Because of that, changes in precipitation characteristics naturally reduce catchment efficiency.

It results in large changes in streamflow. In fact the increase of temperature may not result in a change in hydrological processes directly. It could potentially lead to changes in precipitation characteristics that modify hydrological processes and streamflow generation. In this study we aim to predict the Long Term Natural Trend in streamflow on the Upper Euphrates using flow measurement data and compare the major factors long term trend influencing the streamflow.

Precipitation and temperature(Fig 2) trends over the Upper Euphrates Basin is obtained as parallel trends with long term streamflow trend in the same basin. In the literature survey we found some studies (BASIN 2013) on influence of climate change effects on the neighbouring river basin (Zeeb and Waste Management 2010).

The ultimate aim of this study is, therefore, to investigate the changes in the natural streamflow of the Upper Euphrates River for the 40-year period between 1960 to 2000. An attempt is also made to identify the climatical changes, precipitation behind a downward trend in the annual streamflow's.

3. Study Area & Data Description

3.1. Study Area

The Upper Euphrates River has its headwaters in Turkey and flows through Syrian territory before entering Iraq. Turkey occupies the upper portion of the river basin, as seen in Figure 3. The river basin extends over six countries: Iraq, Turkey, Syria, Saudi Arabia, Kuwait and Jordan. Turkey contains 28% of the Euphrates basin, while seventeen percent in Syria, fourty percent for Iraq, fifteen percent for the S.Arabia. Euphrates is approximately 2800 km long, and Turkey contains 1,263 km. Turkey contains 62% of the catchment area of the river, while Syria contains 38%. 89% of the annual flow originates from Turkey while Syria, has 11% of the annual flow of the river (Naff and Matson 1984); the remaining areas contribute very little water. The total water potential of Euphrates River is in the order of 37 km3 /yr, when 4 km3/yr contributed by Syria and 1 km3 /yr from Iraq is added (Öziş et al. 2002).

The climate zone which Euphrates River originates can be characterized by hot, dry summers and cold, wet winters. In the mountainous headwater areas, precipitation predominates in autumn, winter and spring with a mixture of rain- and snowfall in winter (Bozkurt and Sen 2013).

In this study, approximately 40 years of flow measurement data that represent the natural flow regime in the upper Euphrates River to the extent possible. We searched sub-basins with finite water-regulation in the runoff generating field. The Karasu sub-basin, Murat sub-basin and Tohma sub-basin have been selected to use prediction model. A detailed investigation has been made to find if there has been any water storage, regulation and water use development works in the period over which the flow measurement data were gathered (Figure 3).

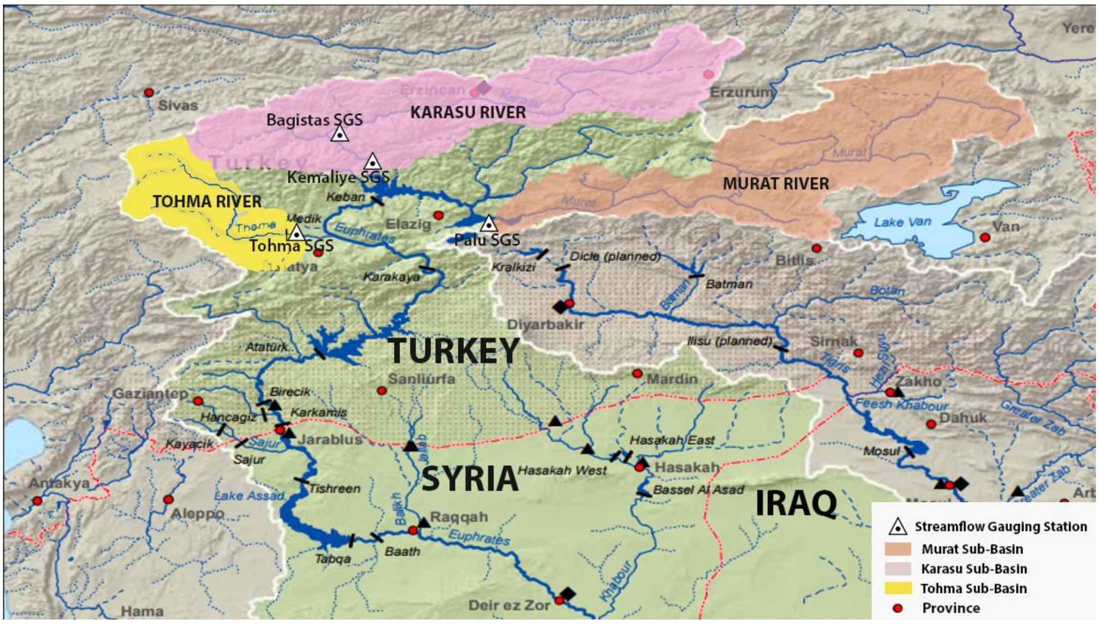

Figure 3. The Upper Euphrates River's main tributaries

3.2. Study Area

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There has been no significant water use development has been observed these three sub-basins.

Bagistas SGS (Stream Gauging Station): The drainage area of the Karasu tributary is 15562 km2 at the Bagistas flow measurement station, numbered EIE 2156. It is based at an elevation of 865 m (asl: above sea level) and near Erzincan City and Bagistas town.

Kemaliye SGS: The drainage area of the Karasu tributary is 20687 km2 at the Kemaliye Stream Gauging Station, numbered EIE 2109. It is based at an elevation of 810 m (asl) and near the town of Kemaliye, Erzincan City.

Palu SGS: The drainage area of the Murat tributary is 25515 km2 at the Palu flow measurement station, numbered EIE 2102. It is based at an elevation of 859 m (asl) and near Erzincan City and Palu town (EIE 2000).

Tohma SGS: The drainage area of the Tohma tributary is 5822 km 2 at the Palu flow measurement station, numbered EIE 2145. It is based at an elevation of 935 m (asl) and near the town of Darende, Malatya City.

The flow measurement data used in this study are gathered from 46 stream gauging stations in the Euphrates Basin operated by Turkish General Directorate of State Hydraulic Works (DSI). In Table 1, one can see the descriptive statistics and coefficients for variation for each month in the Euphrates Basin. Results of a standardization process on the four stations is given in Figure 4.In all analysis, this study used for main tributary (with flow, temperature and precipitation data if available) and each tributary has different number of measurement stations belongs to itself. Table 1 shows which main station has how many stations in there. From Table 1, coefficient of variation shows us Bagistas has smaller change when we compare with other stations. Tohma has minimum value of mean and standard deviation as well as small range. Upper Euphrates Basin has nearly 50 flow stations according to State Hydraulic Works (DSI) and those station names given in Appendix A. Descriptive statistics will help us to make an assemble of Upper Euphrates River Basin flow structure.

Statistical normalization is a method used in the fields of statistical data processing, such as data mining. The aim of the method is to address data on one scale in case there is a variety of data. Another usage of the method is to compare the data on different scales with each other. The aim here is to transfer the data in different systems to a common system and make them comparable to each other using mathematical functions.

Table 1. Descriptive statistics of stations

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Coefficient of Variation
Kemaliye	38	190,34	115,98	306,32	194,0163	45,19030	0,23292
Bagıstas	37	109,00	104,00	213,00	148,7838	28,60666	0,19227
Palu	49	345,31	126,73	472,04	249,6533	82,23005	0,32937
Tohma	43	31,66	15,00	46,66	23,1380	6,94298	0,30006

* N: Number of Units (Belong to Certain Station), Mean: The Average Annual Flow, Range: Difference Between Minimum and Maximum Value

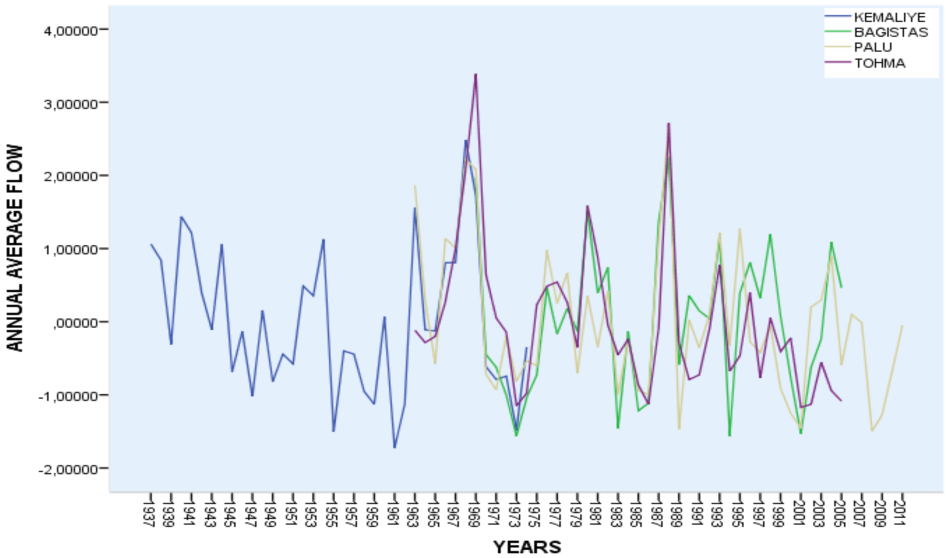

Figure 4. Comparison of the annual average flows (m3/year) measured by the Kemaliye, Palu, Tohma and Bagistas SGS after standardization

Standard Score: In the case of the existence of known parameters in the population, the standard score is used in order to normalize the error. The standard score is based on the normal distribution and run successfully with the population fitting with this distribution. It is simply obtained from the differences between each value and the mean using the standard deviation rate.As shown in Figure 4, the annual average flow variation is very similar among the Palu, Tohma and Kemaliye and Bağıştaş SGS catchment areas.The flows of the sub-rivers Palu, Bagıstas and Tohma, considered as continuations of the main tributary, Kemaliye, strengthens the prediction, as seen in the graph. The question as to whether the sub-rivers can represent the main tributary is investigated by means of regression and time analysis models.

3.3. Data Description

This work mainly focuses on meanly streamflow, precipitation, temperature and their relationships on Upper Euphrates River basin and impacts on transboundary waters. We used those variables for determine hydrological and climatological characteristic of the Upper Euphrates River basin.

The Upper Euphrates River basin has 48 stream gauging station (SGS) whose data are available from both General Directorate of State Hydraulic Works (DSI) and General Directorate of Electrical Power Resources Survey and Development Administration (EIE) between the year of 1961 and 2000. We filter the data for location, length, and quality, four gauging stations remain to be used for analysis. All these stations have 24-year continuous daily measurements between 1972 and 2006.Due to lack of streamflow data in many stream gauging station, Bagistas, Tohma, Palu and Kemaliye stream gauging stations have been found more suitable for depict Upper Euphrates River basin with strong data structure(Fig 3).

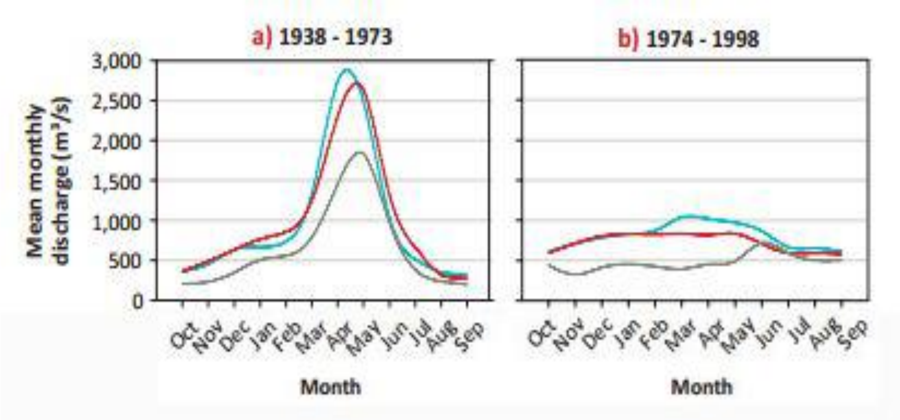

Figure 5. Mean monthly flow regime of the Upper Euphrates River at different gauging stations for different time periods (m3/s)

Source: Compiled by ESCWA-BGR based on data provided by the Ministry of Irrigation in the Syrian Arab Republic, USGS, 2012.

Keban Dam construction (1973) is the most important event on the region which has an impact on streamflow directly. From the previous studies, Euphrates River basin has had natural flow until the construction of Keban Dam in 1973.

Regulated river flow can be seen in Figure 5. This can barely be considered as variables. Regulated streamflow's are oftenly influenced by deliberate human activities (Fig 5) (von Storch and Zwiers 2002).

We also used daily surface temperature data and mean annual rainfall data in the analysis that were obtained from the Turkish State Meteorological Service for seven sites in (or near) the basins that feed the tributaries.In this part, seven precipitation gauging stations given in Table 3 Adiyaman, Elazig, Bingol, Erzincan, Malatya, Palu and Mus. are chosen to determine mean annual rainfall. In addition, air temperature data (0C) from seven meteorological station's namely Adiyaman, Elazig, Bingol, Erzincan, Malatya, Palu, and Mus, are used or the basin study.

It is known that the effect of global climate change on hydrological systems, especially on mountain snow melt and glacier melt, can modify the timing and amount of runoff in mountainous watersheds. Much of the precipitation falls in the highlands of the Euphrates and Tigris Basin as snow falls in winter season (Evans et al. 2004). Thus, any change in precipitation has a strong effect on the amount of snowpack that stores the water. Selected meteorological stations are in convenient locations with the used stream gauging stations. Long term precipitation data is obtained from The Royal Netherlands Meteorological Institute (KNMI) database and air temperature data is obtained from the Turkish General Directorate of Meteorology. Because of the lack of data gathering and organizing in Turkey, this work took some of data from The Royal Netherlands Meteorological Institute (KNMI) such as temperature and precipitation.

Long term reliable rainfall and temperature data between "1960-1990" are obtained from both organizations. Concerning flow measurement data, Kemaliye SGS seem to be a main streamflow gauging station which of it is data extend to 1973.

Kemaliye station is a most critical point of Upper Euphrates due to its own hydrological and climatological location.

4. Methods

The primary target of hydrological and climatological investigations are making estimations for future. Normally, such estimations need a formulation to be found which associates the dependent variable to one or more independent variables. The method in data analysis correspond to multivariate statistical analysis. Regression Analysis is one of the important method in the multivariate statistical analysis. For the support analysis of the results of such techniques, some of visual toolkits exist that shows visualization of hydrological and climatological data.

gCLUTO's (Graphical Clustering Toolkit) main project aims are to give an simple usage software that associates a variation of many clustering algorithms, which are capable of examining different kinds of data and finding clusters with different features.

In this paper, we also used time series techniques as Arima and Holt's Linear methods which are series of data usually interpret at consecutive. Time series techniques includes methods for analysis the data to show significant statistical outputs and to estimate approaching incident(s) with prior conditions to estimate data terms before they measure.

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

4.1. Regression Analysis

4.1.1. Univariate Regression

Simple linear regression is one of the easiest method for the prediction works. Regression equation is Y = c + bX. c shows the constant, b is the regression coefficient. From the regression equation we can do predictions about the model. The predicted parameter is demonstrated by Y (Schneider et al. 2010).

Table 2. The results of univariate regression models

Regression Models	Dependent Variable	Unstandardized Coefficients		Standardiz. Coefficients	t	Sig.	R^2
		B	Std. Er.	Beta			
Model 1	Palu	0,527	0,051	0,956	10,3	**0,000**	0,95
Model 2	Tohma	4,492	1,316	0,733	3,41	**0,007**	0,53
Model 3	Bagistas	1,335	0,190	0,962	7,02	**0,002**	0,92

The parameter Beta represents the regression coefficient. The Beta parameter gives us an information about Y. With continuous Y, the Regression Coefficient shows the changes in the Y per unit of changes in the X (Schneider et al. 2010). Dependent and independent variables are used for three models.

The Kemaliye Stream Gauging Station (SGS) was terminated because of the filling of the reservoir created by the Keban Dam. The station had been in the reservoir of the Keban dam.The Kemaliye SGS has been used as dependent variable in all models because it describes natural streamflow's during a long period of flow without dam regulation and irrigation effects. In order to predict the natural discharge in the main Euphrates River, we should add the most representative sub-basins into the model as of dependent variables.

Multicollinearity effects made the model univariate. Each of the independent variables is able to define to a dependent variable, as seen in above. The regression results are given in Table 2.

All three univariate regression model has same independent variable (Kemaliye SGS natural flow data, as X in regression model). For evaluate differences between that three main tributary belongs to Upper Euphrates River Basin, we use the connection point as independent variable. Three main measurement stations from Upper Euphrates, can be characterize by mainly the natural flow data, respectively Bagistas, Palu and Tohma SGS (as Y in regression model). In addition to support natural flow data, other two essential indicator added improved regression model as temperature and precipitation in multiple regression section.

When we consider each of the three models according to significance level (for the significant model Sig. value has to be smaller than 0.05 at the %95 significance degree), we realize that the characteristics of the Palu model are the highest among them. The Palu model has the highest coefficient of determination (R2) 95, 6%. Therefore, Model 1 can be taken as the most convenient model to describe the Kemaliye (independent variable) SGS. Model 3 (Bagistas) is the second convenient model, with a coefficient of determination of 92,5%. The Tohma model is the least descriptive one. Model 1 also has smaller standard error.

Regression equations can be build from statistics from Table 2. In this point we do not need to make write regression equations because, improved and more reliable regression models will be determine in next section. Figure 6 shows the prediction values of the three models, as well as the natural flow values at the Kemaliye SGS until 1974.

Evaluating the effect of hydrological factors on long-term natural stream flow changes in the region and for the transboundary waters between riparian countries (Turkey and Syria in this case), we need the find and select most suitable station to make future predictions for The Upper Euphrates River Basin. That is why we began use to simple predictions from regression analyses as a preliminary work.

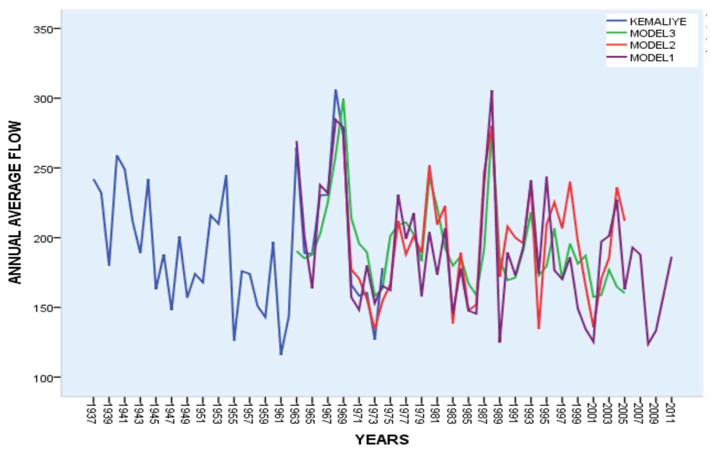

Figure 6. Comparison of regression models used to predict values.

As shown in Figure 6, Model 1 is the most suitable one to extend the Kemaliye SGS values. Model 1 is also the most suitable model to obtain long-term annual streamflow trend in the Upper Euphrates with natural streamflow as possible.

4.1.2. Multiple Regression

Multiple regression analysis is one of the substantial statistical method that use the relation between two or more variable and dependent variable could be estimated from the model. Multiple regression analysis is commonly used in the biological sciences, marketing, the social sciences, and many different fields (Neter et al. 1996).

Table 3. (a, b, c)

(a) Upper Euphrates Regression Model Description

Dependent Variable(Y)	Kemaliye (streamflow)
Independent Variables(X) Details	Precipitation, Temperature
Precipitation Data Point(Station names)	*Temperature Data Point(Station names)*
1.Adıyaman(38.80N, 41.50E) 2. Elazig(38.70N, 39.20E) 3. Bingol(36.90N, 40.50E) 4. Erzincan(39.70N, 39.50E) 5. Malatya(38.43N, 38.08E) 6. Palu(38.90N, 40.00E) 7. Mus(38.70N, 41.50E)	1. Adıyaman(38.80N, 41.50E) 2. Elazig(38.70N, 39.20E) 3. Bingol(36.90N, 40.50E) 4. Erzincan(39.70N, 39.50E) 5. Malatya(38.43N, 38.08E) 6. Palu(38.90N, 40.00E) 7. Mus(38.70N, 41.50E)

(b) ANOVA results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	32912,135	2	16456,067	18,046	**0,000**
Residual	10030,636	11	911,876		
Total	42942,770	13			

(c) Upper Euphrates regression model results

		Unstandardized Coef.		Standardized Coef.			
Model		B	Std. Error	Beta	Sig.	R	R^2
1	(Constant)	-101,91	54,078		0,086		
	PRECIPITATION	0,576	0,105	0,801	**0,000**	**0,87**	**0,76**
	TEMPERATURE	1,399	0,573	0,356	**0,033**		

In the multiple regression analysis, within or near Upper Euphrates River basin there are fourteen precipitation and temperature stations are been selected for analyzing relationship between precipitation and temperature on streamflow and generate prediction model from relationships(at the %5 confidence interval).

Table 3(a, b, c) gives us information about multiple regression model. Kemaliye is a dependent variable as we use in univariate regression model trials. Multiple regression assumptions checked for each analyses and none of the assumptions did not violate the analysis such as Multivariate Normality, Multicollinearity, Autocorrelation and Homoscedasticity. Main measurement stations belongs to precipitation and temperature variables are given below. In the model we used mean of these independent variables. Also one can see that stations given with exact map coordinates.

ANOVA (Analysis of Variance) used for testing (Table 3b) if there is relationship between dependent variable and estimator variables. Due to p-value has a confidence interval under 0. 05(%5), so we can say that there is a relation between dependent variable and estimators. On the other hand, regression outputs from Table 3c, one can see that all variables are significant.

Biased and unbiased regression (such as ridge, principal component regression etc.) models are experimented as an alternate regression models.

It was decided that multiple regression technique is the most efficient method among these processes. From the regression results, R2 value is 0.76(%76). This result shows that seventy-six percent of change can computable for independent variables from Table 3c. The most important point obtained here that precipitation and temperature data can be used for the predict stream flow of Kemaliye for 1974 and after.

4.2. gCLUTO Clustering

Main idea of using gCLUTO software is selected streamflow gauging stations in the Upper Euphrates River Basin represent the all area. On the other hand, in our work visualization is the one of the significant part in all paper. Therefore we will support our work with gCLUTO software visualizations. This toolkit is a powerful cluster software which has a great visualization outputs. We change the way of usage of this software from text mining area to hydrological statistic.

In gCLUTO analysis the result is through an order of k-1(k is the input cluster number). The first cluster divided into two cluster. After, one of these cluster is chosen and divided. The dividing process continues until the wanted number of cluster is accomplished (de Andrade Lopes et al. 2005).In the datasets section we concluded that Bagistas, Tohma, Palu and Kemaliye streamflow stations can represent Upper Euphrates River Basin. With this software we will strongly support the idea that those flow stations can be present the region. All Upper Euphrates River streamflow stations (48 FMS or SGS according to Hydraulic State Work) are included in the gCLUTO software solution. Visual results are very significant and clear to understand from Figure 7.

gCLUTO uses the variety of cluster algorithms and uses SenseCluster which is a cluster tool gives to tool perfect interface (Steinbach et al. 2000). In this visual method, we will use correlation similarity and I2 criteria function. The definitions of correlation similarity measure and I2 criterion function are given below.

Correlation coefficient similarity measure:

$$corr(x,y)=\frac{(x-\bar{x},y-\bar{y})}{\left\|x-\bar{x}\right\|\left\|y-\bar{y}\right\|} \tag{1}$$

I2 criterion function:

$$\sum_{r=1}^{k}\sum_{d_i \epsilon S_r}\cos(d_i,C_r)=\sum_{r=1}^{k}\|D_r\| \tag{2}$$

The I2 criteria functions is used by the k-means process with the correlation similarity measure (Steinbach et al. 2000). Using this method, every cluster is shown by its centroid vector, and the purpose is to find the answer that maximize the similarity measure of the cluster that is assigned to a certain cluster.

gCLUTO clustering methods provide excellent visualizations of the cluster analysis and hierarchical trees. We call the visualizations the matrix and mountain visualization, respectively. The detailed explanation of two visual tools will take place in the part of this study.

Figure 7 shows the matrix visualization graph obtained from the data of nearly 50 stream gauging stations over 40 years from different main tributaries. In Figure 7, Kemaliye (SGS No: 2109), Palu (SGS No: 2102), Bagıstas (SGS No: 2156), and Tohma (SGS No: 2145) stream gauging stations are more visible than other stations. This means that these four stream gauging stations represent the main characteristics of the Upper Euphrates Basin better than the other stations. In other words, the other stream gauging stations do not represent the effects of different sub-basins on the entire Euphrates Basin as reliable as the four stations mentioned above.

As shown in figure 7, the Palu Stream Gauging Station (SGS No: 2102) representing the Murat River tributary is the most characterized station in the Upper Euphrates Basin. The Kemaliye SGS, Bagıstas SGS and Tohma SGS are also other descriptive factors in the Upper Euphrates Basin. This case is very informative of the situation in the matrix visualization graph in Figure 7.

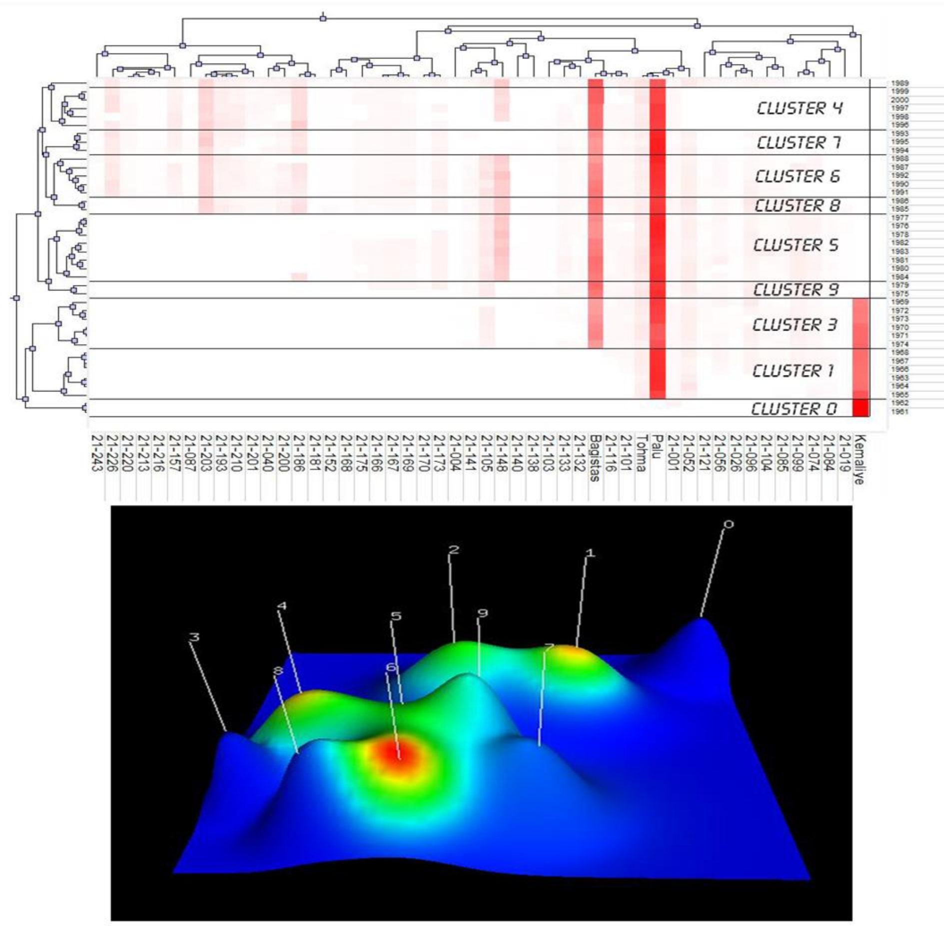

Figure 7. Matrix and mountain visualization graph (gCLUTO outputs)

Table 4. The results of with descriptive statistics of gCLUTO.

Cluster No	Explained Rate of Stations in Clusters					
	Explained Percentage of Stations in Related Cluster					
	1. SGS		2. SGS		3. SGS	
Cluster 0	Kemaliye	98.0%	21-148	0.002	-	
Cluster 7	Palu	76.0%	Bagistas	15.5%	21-203	1.7%
Cluster 3	Bagistas	45.1%	Palu	42.2%	21-148	2.5%

As seen in the mountain visualization above, it is primarily understood that the Palu stream gauging station is the most efficient factor in the Upper Euphrates Basin (Lu et al. 2014). The Kemaliye, Bagistas and Tohma Stations are other stations describe the characteristics of the Upper Euphrates Basin. This case is an expression of the effect in the form of a matrix. As seen in the descriptive values in Fig 7, the mountain number 0 explains the Kemaliye station at the rate of 98%, the mountain number 7 explains Palu station at the rate of 76%, and the mountain number 3 explains the Bagıstas station at the rate of 45,1%. Given the three stations mentioned, Tohma possesses the lowest explainability rate. All the outputs of gCLUTO prove that the stations in the Upper Euphrates on which the analyses are based are sufficient.

4.3. Time Series Models

Time series are a series of datum generally evaluated at consecutive. This method contains technics for analysis the data to give significant statistic results and its own characteristics of datum and to predict oncoming incidents with prior cases to estimate datum periods before they measure. A time series model predicts that observations closer with time are more nearly azimuthal than observations that are also separate. Moreover, the time series data have an innate temporary order. This is the point that time series separates from cross sectional works (Lu et al. 2014).

Arima Model: In statistics and some other sciences such as econometric ARIMA (autoregressive integrated moving average) model is showed by three identification. This identification parameters are p(number of lags), d(degree of differencing) and q(order of the moving average) are non-negative integers. When the Arima result is 0, a unit is not necessary for this method. For the ARIMA model, the equation is given below (McCleary et al. 1980, DeLurgio 1998).

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + ... + \alpha_p Y_{t-p} + \varepsilon_t \quad (3)$$

εt is named white noise, while αi represents the constant.

4.3.1. Holt Linear Model

• Simple Exponential Smoothing

This model is suitable for series if we do not use trend or seasonal effects. Simple exponential smoothing is the most likely to an Arima time series (0.1.1).

• Holt's Linear Trend

Holt's linear model is convenient for sequences. In this method uses linear trend without seasonal effects. Holt's linear method is more widely used than Brown's time series model but can get much longer to calculate for bigger data. Usage of Holt's method is alike to an Arima model (0.1.1).

When two models are compared, with regard to the stationary R-square, Ljung-Box Q and significant criteria, the Holt Linear Method is supposed to be a better model than ARIMA. The graphic output of these models is presented in Figure 8.

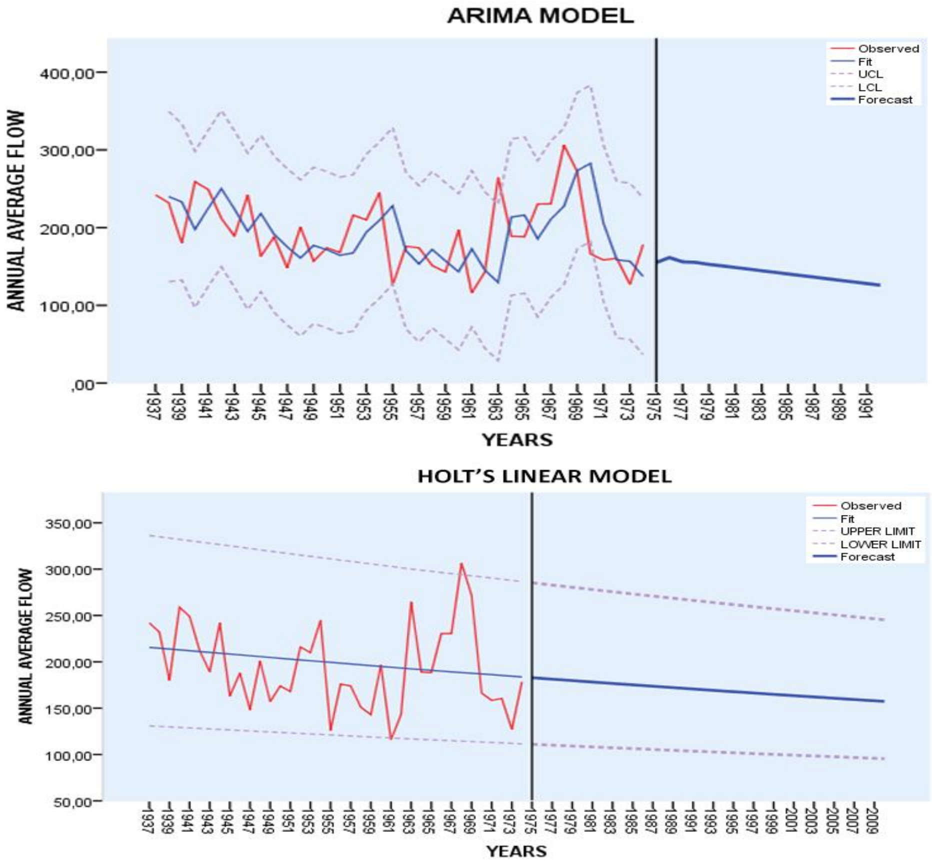

Figure 8. Comparison of ARIMA and Holt's method

With reference to Figure 8, when two models are compared to each other, based on long-term tendencies, Holt's Method is observed to be more suitable than ARIMA. In the study, the model statistics for the Holt Linear and ARIMA Models are given in previous sections.

5. Discussion and Conclusions

Because of eight-year civil war in Syria and emerging political unstability in the region, water networks ,water infrastructures and institutional capacities of water resource management institutional capacities in Iraq and Syria have considerably destroyed and diminished (Michel et al. 2012). Especially, Syrian internal conflict (civil war) and the deterioration of bilateral political relations between any pair of the riparian's constitute disabling political background in the basin.

In one hand this political unstability in the region makes transboundary water collaboration difficult, on the other hand climate change threats on water resources makes this collaboration inevitable.In order to show the climate change threat on the Euphrates River natural flow, it is better to study main Euphrates River through detailed hydrological modelling with a short time step. But several large dams has been built along the main Euphrates River since the late 1970's.

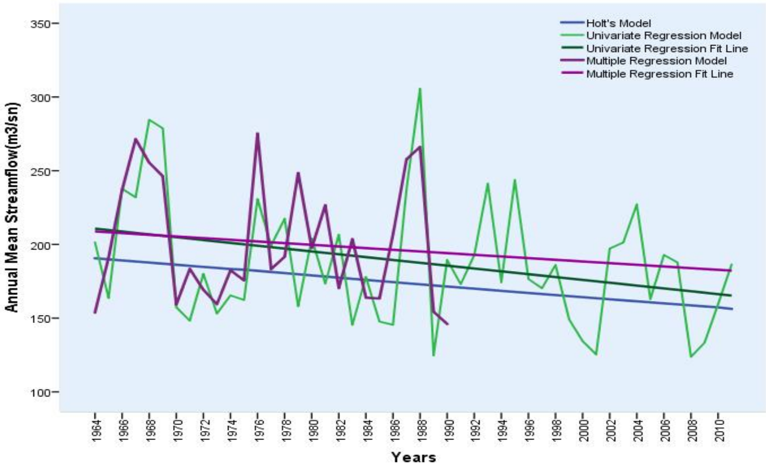

Figure 9. Comparison of all methods

Therefore, some of the main stream gauging stations have been out of operation drawning by reservoirs. Rest of the stream gauging stations data have comprised reservoir's regulation effects. This data need to normalize by accounting dam reservoir operation, released water for energy and agricultural use and reservoir evaporation. Because of the very complex operation system in the main Euphrates River, this efforts would face many uncertainties to get reliable data. For instance; Although Upper Euphrates River is mainly fed by snow melt, due to the lack of long term snow depth data, available rain precipitation data is generally used. But it wouldn't give satisfactory results for comprehensive hydrological model and normalization studies.

It is also known that simulation of the complicated hydrological and land surface physical processes using streamflow–precipitation–temperature relationship based on historical data could be deployed to benchmark outputs of hydrological models, whose exact form is always unknown and validation of such models remains a fundamental challenge (Sankarasubramanian et al. 2001).All these uncertainties mentioned above have made the "normalization of the discharge to use in a comprehensive basin hydrological model" difficult. Considering this current special circumstances in the basin, we decided to use statistical modelling by using run off data obtained from suitable sub basins of the Upper Euphrates River. Data obtained three large sub-basins without reservoir influence and free of other anthropogenic effects investigated in this study. It indicates statistically significant shifts in the annual streamflow's between the compared two consecutive 1961-2000 year periods.

The objective of the study is, therefore, to analyse and evaluate the impact of hydrological factors on long-term natural streamflow changes over Upper Euphrates River Basin. Results obtained from all of the methods used in this study are given in Figure 9. All of these results are free from the dam's reservoir and other anthropogenic effects on the river flow. They clearly show that downward streamflow trend of the Euphrates River mainly due to natural factors and it is prone to continue. Basin wide long-term climate monitoring at low and high level elevations is a key issue to detecting trends in precipitation, snow depth and snowmelt streamflow relations.

Due to emerging climate change effects, predicting change in water resources availability has become more vital in the region. Taking into account this necessity, we study and conclude that the natural flow of the Upper Euphrates River is decreasing mainly due to natural factors.

Addressing the observed and potential future downward trends of the streamflow will require a new urgent collaborative approach among riparian states to avoid emerging water crises in the region. Although the Euphrates River is is completely regulated by dams in the upper part of the basin ,the decreasing trend of natural annual flow may result new water management policies , operational rules and less water release to downstream.

This study clearly indicates that an urgent water collaboration between riparian's are more essential than ever before. Considering decreasing natural trend of streamflow and less available water, it should also be noted that this basin urgently need a benefit sharing approach more than water sharing approach between riparian states.

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Appendix A

Upper Euphrates River Basin Flow Measurement Stations

21-001 KARASU-KIRKGÖZE	21-121 MAMİKAND.-KAPIKAYA
21-004 MURAT NEHRİ-DİYADİN	21-132 PULUR ÇAYI-SAKALIKESİK
21-019 HACIHIDIR D.-MİLLET BAHÇESİ	21-133 SOFRAZ ÇAYI-ALİŞAR
21-026 KEYSUN ÇAYI-KÖKPINAR	21-138 FINDIKD.-FINDIK
21-040 AKPINAR D.-GİRLEVİK	21-140 CİP SUYU-CİP BARAJ GİRİŞİ
21-052 SERÇEME DERESİ-EĞERTİ	21-141 MANDALIK SUYU-YAPILIKÖY
21-056 ABDULHARAP SUYU-ÇAT	21-148 HATRENK SUYU-AKTUZLA
21-074 GAYIT DERESİ-LEK	21-152 KÖŞK SUYU-KÖŞK
21-084 CUMA ÇAYI-CUMA	21-157 SEYHAN ÇAYI-BETONKÖPRÜ
21-085 LİZ SUYU-CAMİLİ	21-166 HINIS SUYU-HINIS
21-087 KARAHALİT ÇAYI-A.KARAHALİT	21-167 KİSRE ÇAYI-NECMETTİN AĞA KOMU
21-096 SULTANSUYU-HARA	21-168 BÜYÜKÇAY D.-KARAGÖBEK
21-099 MERCAN D.-BİRİK	21-169 AHIRÇİMEN .-HALİL ÇAVUŞ
21-101 AYVALI TOHMA SUYU-ORTAŞUĞUL	21-170 PİSYAN ÇAYI-AŞAĞI ÇAT
21-103 EYMİR SUYU-EYMİR	21-173 MURAT SUYU-TAZEKENT
21-104 YAZICI-ALTINÇAĞIR	21-175 BAŞKÖY DERESİ-KISIKKOMU
21-105 NADİRŞEYH SUYU-KESİKKÖY	21-181 KEKLİK DERESİ-AŞAĞI YENİCE
21-116 LEZGİ ÇAYI-AŞAĞI ÇAT	21-186 GÖKSU N.-SAVRAN
21-193 KOZLUK ÇAYI-AŞAĞI ŞIHLAR	21-216 HANOBA ÇAYI-DÖNERDERE
21-200 KARASU-ILICA	21-220 SOLAN DERESİ-GÖKSU
21-201 GÜZEL DERE-KARABACAK	21-226 TUZLA ÇAY-GÖKÇEŞEYH
21-203 HINIS ÇAYI-KARAÇOBAN	21-243 BEKTAŞ D.-AKÇAKALE
21-210 BÜYÜKÇAY-TAŞKALE	26-008 PAMUKLUK Ç.-DİLAVER KÖPRÜSÜ
21-213 ADADERE-AĞAÇLI	26-028 GÜZELDERE-KUŞÇUKÖYÜ
26-040 MEHMEDİYAN ÇAYI-TEPECİK BARAJI	

References

Al-Ansari, N., 2013. Management of Water Resources in Iraq: Perspectives and Prognoses. Engineering, 5, 667-684.

BASIN, K. A. K. S. R. 2013. Desk Study-Analysis of Trends.

Bazzaz, F. J. W. i. t. A. W. P. and Prognoses, H. U. 1993. Global climatic changes and its consequences for water availability in the Arab World. 243-252.

Bozkurt, D. and Sen, O. L. J. J. o. h. 2013. Climate change impacts in the Euphrates–Tigris Basin based on different model and scenario simulations. 480, 149-161.

Burn, D. H. and Elnur, M. A. H. J. J. o. h. 2002. Detection of hydrologic trends and variability. 255(1-4), 107-122.

Cai, W. and Cowan, T. J. G. r. l. 2008. Evidence of impacts from rising temperature on inflows to the Murray-Darling Basin. 35(7).

Cayan, D. R. and Peterson, D. H. J. G. M. 1989. The influence of North Pacific atmospheric circulation on streamflow in the west. 55, 375-397.

Chenoweth, J., et al. 2011. Impact of climate change on the water resources of the eastern Mediterranean and Middle East region: Modeled 21st century changes and implications. 47(6).

de Andrade Lopes, A., Minghim, R. and Melo, V. 2005. Creating Interactive Document Maps Through Dimensionality Reduction and Visualization Techniques.

DeLurgio, S. A., 1998. Forecasting principles and applications. Irwin Professional Publishing.

Evans, J. P., Smith, R. B. and Oglesby, R. J. J. I. J. o. C. 2004. Middle East climate simulation and dominant precipitation processes. 24(13), 1671-1694.

Fu, G., Charles, S. P. and Chiew, F. H. J. W. R. R. 2007. A two-parameter climate elasticity of streamflow index to assess climate change effects on annual streamflow. 43(11).

Fu, G., Charles, S. P. and Yu, J. J. C. c. 2009. A critical overview of pan evaporation trends over the last 50 years. 97(1-2), 193.

Kahya, E. and Dracup, J. A. J. W. r. r. 1993. US streamflow patterns in relation to the El Niño/Southern Oscillation. 29(8), 2491-2503.

Kahya, E. and Kalaycı, S. J. J. o. H. 2004. Trend analysis of streamflow in Turkey. 289(1-4), 128-144.

Langbein, W. B., 1949. Annual runoff in the United States.

Leavesley, G. H., 1994. Modeling the effects of climate change on water resources—a review. Assessing the Impacts of Climate Change on Natural Resource Systems. Springer, 159-177.

Lettenmaier, D. P., Wood, E. F. and Wallis, J. R. J. J. o. C. 1994. Hydro-climatological trends in the continental United States, 1948-88. 7(4), 586-607.

Lu, W. X., et al. 2014. The analysis of groundwater levels influenced by dual factors in western Jilin Province by using time series analysis method. 4(3), 251-260.

McCarthy, J. J., et al., 2001. Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

McCleary, R., et al., 1980. Applied time series analysis for the social sciences. Sage Publications Beverly Hills, CA.

Michel, D., et al. 2012. Water challenges and cooperative response in the Middle East and North Africa.

Mirza, M. J. J. E. H. 1997. The runoff sensitivity of the Ganges river basin to climate change and its implications. 5, 1-13.

Naff, T. and Matson, R. C. 1984. Water in the Middle East: conflict or cooperation?

Neter, J., et al., 1996. Applied linear statistical models. Irwin Chicago.

Öziş, Ü., et al. 2002. Güneydoğu Anadolu Projesi ve su siyaseti. 422, 35-45.

Revelle, R. R. and Waggoner, P. E. J. M. 1983. Effects of a Carbon Dioxide-Induced Climatic Change on Water Supplies in 7 the Western United States. 419, 432.

Sadik, A.-K. and Barghouti, S. J. W. i. t. A. W., Harvard University Press, Cambridge, Massachusetts 1994. The water problems of the Arab world: Management of scarce water resources. 4-37.

Sankarasubramanian, A., Vogel, R. M. and Limbrunner, J. F. J. W. R. R. 2001. Climate elasticity of streamflow in the United States. 37(6), 1771-1781.

Schneider, A., Hommel, G. and Blettner, M. J. D. Ä. I. 2010. Linear regression analysis: part 14 of a series on evaluation of scientific publications. 107(44), 776.

Steinbach, M., Karypis, G. and Kumar, V., A comparison of document clustering techniques. ed. KDD workshop on text mining, 2000, 525-526.

Stockton, C. W. and Boggess, W. R. 1979. Geohydrological implications of climate change on water resource development.

Türkeş, M., Sümer, U. M. and Kiliç, G. J. I. J. o. C. 1995. Variations and trends in annual mean air temperatures in Turkey with respect to climatic variability. 15(5), 557-569.

Türkeş, M. J. I. j. o. C. 1996. Spatial and temporal analysis of annual rainfall variations in Turkey. 16(9), 1057-1076.

von Storch, H. and Zwiers, F. W., 2002. Statistical analysis in climate research. Citeseer.

Yıldız, D. J. W. S. N. 2016. Natural Diminishing Trend of the Tigris and Euphrates Streamflows is Alarming for the Middle East Future. 47(2), 279-297.

Yu, J., et al. 2010. Impacts of precipitation and temperature changes on annual streamflow in the Murray–Darling Basin. 35(3), 313-323.

Zeeb, S. J. R. B. S. D. f. D., Competence Center Water and Waste Management, p. 2010. Adaptation to climate change in the Kura-Aras River Basin.

Zhang, X., et al. 2001. Trends in Canadian streamflow. 37(4), 987-998.