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ORIGINAL PAPER

Detecting seasonal cycle shift on streamflow over Turkey by using multivariate statistical methods

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Abstract Climate change analysis includes the study of several types of variables such as temperature, precipitation, carbon emission, and streamflow. In this study, we focus on basin hydrology and, in particular, on streamflow values. They are geographic and climatologic indicators utilized in the study of basins. We analyze these values to better understand monthly and seasonal change over a 40-year period for all basins in Turkey. Our study differs from others by applying multivariate analysis into the streamflow data implementations rather than on trend, frequency, and/or distribution-based analysis. The characteristics of basins and climate change effects are visualized and examined with monthly data by using cluster analysis, multidimensional scaling, and gCLUTO (graphical Clustering Toolkit). As a result, we classify months as low-flow and high-flow periods. Multidimensional scaling proves that there is a clockwise movement of months from one decade to the next, which is the indicator of seasonal shift. Finally, the gCLUTO tool is utilized in a novel way in the hydrology field by revealing the seasonal change and visualizing the current changing structure of streamflow.

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1 Introduction

There is a serious threat of climate change on a global scale, which will affect all life on Planet Earth. Stern (2007) (which cites Burke et al. (2006)) states that “the fraction of land area in moderate drought at any one time will increase from 25% at present to 50% by the 2090s, and the fraction in extreme drought from 3% to 30%.” Even though there are plenty of critics of the pessimistic report of Stern (2007), underestimating the effects of climate change may be the worst mistake of humankind in history. Moreover, the Intergovernmental Panel on Climate Change (IPCC 1996) stated that the average surface temperature is increasing, and also that both droughts and floods would be increasing globally.

Water stress is the primary concern of global warming. In the Comprehensive Review of the Freshwater Resources of the World (World Meteorological Organization 1997) report of United Nations, it is indicated that the majority of the world’s population would be under stress conditions because of the rise in population and in water use by 2025. Recently, the Paris Agreement unites many countries with a common goal of battling environmental change and adjusting to its effects (The Paris Agreement 2017).

In the study of Arnell (1999a), the implications of climate change for global hydrological regimes and water resources are described with the Comprehensive Assessment (Shiklomanov 1997) for the present water use data. Another study of Arnell (1999b) focuses on hydrological regimes to see the effects of climate change by the 2050s using a macroscale hydrological model describing four different climate change scenarios at the continental scale in Europe, including Turkey. For all scenarios, there are risks for the majority of Turkey. As an example, the percentage change in average annual runoff by the 2050s is mainly −50 to −25% in the UKTR scenario (high-resolution transient climate change experiment) (UK Hadley Centre, Murphy and Mitchell (1995)). This is a prediction depending on the simulations with macroscale hydrological models. It is expected to have some errors, since simulation models are dependent on some assumptions such as the stabilization of CO_2 values at a certain amount. However, this may not be the case in reality. The moral of the study is that all scenarios indicate a potential decrease in average annual runoff for the area including Turkey in the report.

This study will be a piece of a puzzle (climate change) including the streamflow in the amount of rainfall in Turkey, which is estimated to be one of the countries affected from gradual climate change. Turkey is an urbanizing country (the urban population was 73% in 2014). Urbanization brings harmful sides effects such as pollution in water resources and decreasing forestry areas. The annual precipitation is decreasing in the main part of the Mediterranean area, including Turkey. Also, Turkey has a wide variety of climate regimes. It is in the middle of subtropical and mid-latitude temperature climate zones with high and diverse topography (Iyigun et al. 2013). Mid-latitude and some subtropical regions have a decrease in precipitation and increase in temperature (Hulme et al. 1999).

There are several types of studies about the climate and climate change in Turkey. Iyigun et al. (2013) focus on temperature, precipitation, and humidity to determine the climate regions of Turkey by using hierarchical cluster analysis. Their study differs from previous reports (Türkeş 1996; Unal et al. 2003) which used a reduced number of stations from the database of the Turkish State Meteorological Service (TSMS). The reduction in the former investigations was due to missing observations and homogeneity problems. They use the expectation maximization–Markov chain Monte Carlo (EM-MCMC) method to impute missing values for the stations in which less than 50% of observations are missing, especially for precipitation series. We emphasize, however, that imputation may lead to biased estimations, and it reduces variability. There is also a conflict on the type of missing values since the data set of TSMS includes zeros for both missing values and for precipitation amounts which are 0.1 mm or less. The comprehensive definitions of the climatology of Turkey—depending on the monthly rainfall values of 91 stations from 1930 to 1993—are found in Türkeş (1996).

The hydrological movement of river basins has been importantly affected by seasonal cycle shift and climate change (besides others) and also by hydrological variables, such as precipitation and streamflow. Also, these variables can be easily affected by deforestation or afforestation and agricultural management measures. Therefore, studies concentrating on the impacts of climate change on streamflow over a river basin have become an important field of research in hydrology and water resources (Zuo et al. 2014).

Deniz et al. (2011) use continental, oceanite, and aridity indices in Turkey to describe climatic conditions. They use the same database from TSMS to implement a different method of understanding the climate system of Turkey. Their study indicates a potential increase in aridity that would affect central and southeastern Anatolia.

In this study, we prefer to use the database of the General Directorate of State Hydraulic Works (DSI), which includes a larger number of stations (577). The streamflow in the amount of rainfall is used as a single variable in this study. The reason why the streamflow measures are used is that the variables affecting the streamflow are always dynamic. They include environmental factors such as forest fire or flora in addition to precipitation and humidity. For a specific time period in a particular geographical area, the precipitation amount may be higher than previous years. However, if the flora, humidity, or any other variable causes evapotranspiration (ET), the streamflow may not be that high for that topographical territory. Also, even with precipitation increase, there is a potential increase in evaporation, and this situation leads to a potential decrease in runoff (Arnell 1999a).

Similar to the previous work of Unal et al. (2003) and Iyigun et al. (2013), this study includes cluster analysis. Unal et al. (2003) and Iyigun et al. (2013) used precipitation (mm) and temperature (°C) variables. In contrast, we use the streamflow (m^3/s) data of DSI from 1970 to 2010 for multidimensional scaling (MDS) and cluster analysis. Since there are several types of studies defining the climate regions of Turkey (which are mentioned above), we try another perspective, namely, clustering months and scaling them multidimensionally to check the behaviors of climates.

Several hydrology studies include trend analysis, such as Birsan's (2015) study about streamflow in Romania. They demonstrate the streamflow regime changes using the non-parametric Mann–Kendall test. Kahya and Kalaycı (2004) work on the monthly streamflow data from 26 basins over Turkey with a different approach. They focus on trend analysis for monthly data over a 31-year period using non-parametric trend tests. They discovered no trend for the basins located in Eastern Turkey and a downward trend for the basins located in Western Turkey. Other studies (Kadioğlu 1997; Tayanç et al. 1997; Türkeş et al. 1995) regarding trends in climate for Turkey use temperature and precipitation patterns, not streamflow values. Additionally, we include as much basins as possible to better understand the variability throughout months.

We organize the rest of the paper as follows. The second part includes detailed information about basins. The third part includes the analysis methods, including cluster analysis, MDS, and gCLUTO (graphical Clustering Toolkit). gCLUTO is mainly used in the document-clustering area, but we endeavor to utilize this method in the field of hydrology for revealing the seasonal change and visualizing the current changing structure of streamflow. The applications of these methods, and the results of the analysis, are located in the fourth and fifth parts. Additionally, we provide a streamflow map for Turkey, depending on the MDS results in the sixth part. General results and comments are found in the seventh part of this study.

2 Basin stations

The data used in this study is gathered from 25 basins and 577 measurement stations from the Turkish General Director of State Hydraulic Works (DSI). Figure 1 shows the basin stations on the map of Turkey.

The number of stations and average flow values are located in Table 1, and monthly streamflow mean values of all stations are located in Table 2. Basin names and station numbers are located in Table 5.

Figure 2 is the hydrograph of 10-year periods from 1961 to 2000, with monthly average streamflow of all stations. The difference between the first 10-year period (1961–1970) and the last 10-year period is obvious in the early rainy period (October–April). This difference may be the result of the increase in water-storage capacity of the Atatürk Dam (finalized in 1993), which doubled the water-storage capacity of Turkey. This increase in the storage capacity leads to a decrease in streamflow during the rainy period between 1991 and 2000, which is obvious in Fig. 2.

Additionally, Fig. 2 shows that the streamflow (m^3/s) decreases and shifts forward from 1961 to 2000. The reason of decreasing and shifting movements may be the outcome of seasonal shift, in addition to an increase in water storage capacity.

Figure 3 shows the seasonal average streamflow values (m^3/s) for 10-year periods. The increase in the dam storage capacity is obvious between 1961 and 2000. The Keban Dam and the Atatürk Dam reservoirs started to be filled in 1974 and 1991, respectively. This storage effect is more obvious during the rainy period.

Figure 4 shows the long-term flow trends for July, March, August, and September. The decreasing trend from 1970 to 2000 is obvious, especially for March.

Descriptive statistics and trend graphs help us to have a general sense of understanding about the basins of Turkey and their behaviors over time. The next section includes the brief introduction to two complementary multivariate analyses, which are used to state periodic differences of basins.

3 Methods

3.1 Cluster analysis and multidimensional scaling

Cluster analysis brings similar objects into a cluster depending on their characteristic properties. We evaluate basin areas with graphical methods by using Euclidean distances (Borg et al. 2013), which describe changes in clusters, and by obtaining optimally scaled data matrices

Fig. 1 Location of open 577 streamflow (m^3/s) stations on Turkey map

Table 1 All basins with the number of stations, units, and streamflow means (m^3/s) in Turkey

Basin names	SN	N	Mean		Basin names	SN	N	Mean	
			Statistics	Std. Error				Statistic	Std. Error
Akarçay	9	233	4.01	0.2667	Kizilirmak	76	1737	5.46	0.4300
Antalya	19	408	14.73	0.7900	Konya Kapali	45	995	8.26	0.3416
Aras	24	474	13.02	1.3766	K. Menderes	7	124	3.43	0.4771
Asi	12	240	25.25	4.0319	Kuzey Ege	20	404	6.18	0.6295
Bati Akdeniz	30	658	14.95	1.1158	Marmara	16	443	6.81	0.3099
B. Karadeniz	20	393	18.96	1.4982	Meric	14	338	37.06	6.4530
Burdur	7	167	2.41	0.2684	D. Akdeniz	14	309	31.47	2.4115
B. Menderes	29	724	27.37	2.1035	Sakarya	35	700	7.20	0.4047
Ceyhan	28	602	18.31	2.4402	Seyhan	15	220	13.79	1.6485
Coruh	14	290	36.75	5.7711	Susurluk	21	549	7.39	0.3613
D. Karadeniz	29	569	27.00	0.9082	Van G. Kapali	5	104	15.67	1.0005
Firat Dicle	49	1049	10.17	0.3601	Yeşilirmak	25	584	4.03	0.2047
Gediz	14	289	16.87	2.2203	*Total*	*577*	*12.603*		

SN number of stations (belonging to a particular basin), *N* number of units (belonging to a particular basin), *Mean* the average annual flow, *Std. Error* standard deviation of the sample mean

in MDS. It is a useful way to combine the results of these analyses on a single diagram when the MDS is two-dimensional (which is the most common situation). In these combined diagrams, the locations of the dots are obtained with MDS, while the lines connecting these dots are obtained with cluster analyses.

Cluster analysis was used by Tryon (1939) for the first time. The book of Sneath and Sokal (1963) named *Principles of Numerical Taxonomy* is a crucial base source in this field (Anderberg 1973). The main objective of the cluster analysis is to obtain maximum differences between clusters and similarities within clusters.

The study of Young and Householder (1938) is counted as one of the preliminary studies about multidimensional scaling (MDS). They show how to display distances on a two-dimensional coordinate system by keeping distances

Table 2 Monthly descriptive statistics of streamflow (m^3/s) values in Turkey

Months	N	Mean		Std. Deviation	Range	Coefficient of variation
		Statistics	Std. Error			
October	11,186	6.1283	0.16595	17.55167	352	286.4036
November	11,191	7.8888	0.20307	21.48207	362	272.3110
December	11,224	12.1885	0.33640	35.63937	806	292.4016
January	11,241	14.4738	0.45363	48.09525	1121	332.2918
February	11,259	15.1756	0.45054	47.80647	1001	315.0219
March	11,262	21.2442	0.54448	57.78153	1209	271.9873
April	11,263	28.4319	0.72506	76.94897	1631	270.6431
May	11,264	24.1123	0.71317	75.68987	2148.77	313.9056
June	11,266	13.1910	0.42162	44.75177	1628.6	339.2599
July	11,263	7.6964	0.22811	24.20871	984.1	314.5459
August	11,263	5.8804	0.16786	17.81460	658	302.9488
September	11,261	4.9052	0.16202	17.19276	1054	350.5007

N number of units (belonging to a certain month), *Mean* the average annual flow, *Std. Error* standard deviation of the sample mean, *Std. Deviation* a measure that is used to quantify the amount of variation, *Coefficient of variation* standardized measure of dispersion of a probability distribution or frequency distribution, *Range* difference between minimum and maximum value (belonging to a particular month)

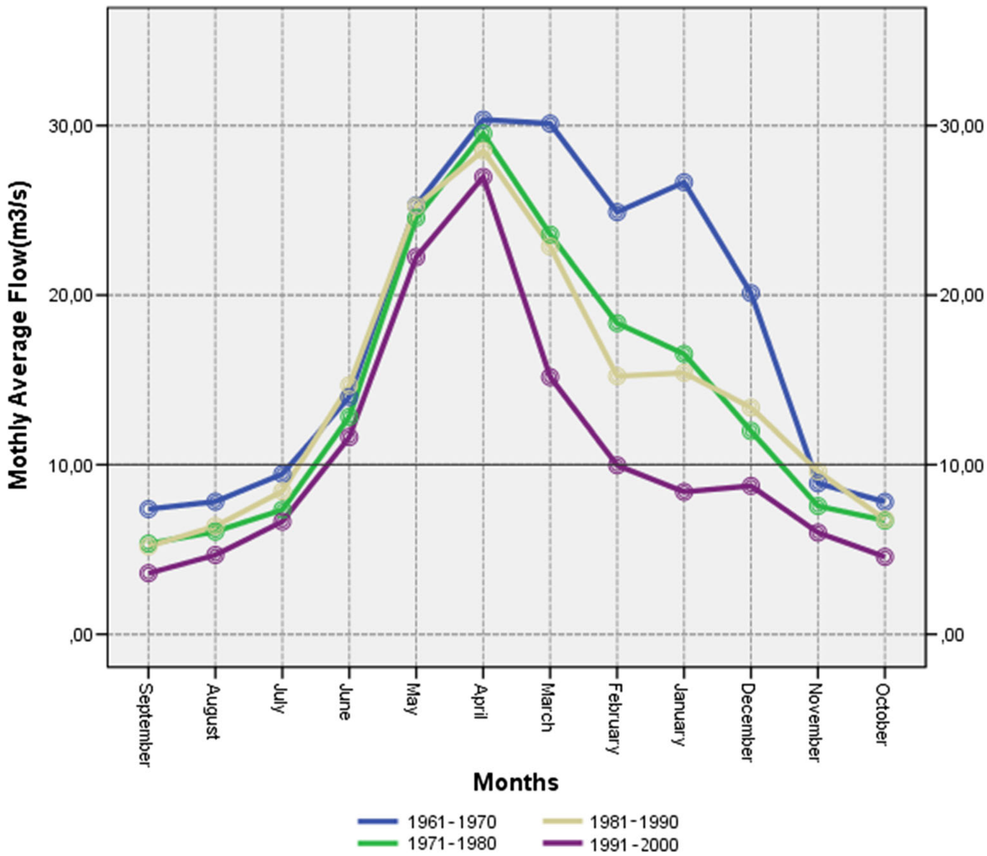

Fig. 2 Monthly average streamflow (m^3/s) values for all stations, 10-year periods in Turkey (Monthly Hydrograph)

in a Euclidean distance matrix. There are two main approaches to improve MDS. The first one is a matrix approach that is also known as the "Princeton" or "Torgerson" approach. The foundations of the classical MDS were laid by the Psychometric Group, which included Torgerson (1952) in Princeton University. The second approach was derived in the Beil Telephone Laboratory (Shepard 1962a, b), and it is called non-metric MDS. It is also known as the "Kruskal–Shepard" approach.

The data can be interval- or proportional-scaled in metric MDS (Malhotra 2010). It is assumed that distances in a distance matrix are proportionally scaled or at least equally spaced-scaled. The difference when using the metric MDS from principal component analysis (PCA) is that it includes negative eigenvalues which are not present in PCA (Tatlıdil 1996). Detailed information about clustering and multidimensional scaling is found in Kruskal (1964) and Kruskal (1976).

Metric MDS is used to obtain a graphical coordinating by using proportional scaled distances. In a classical metric MDS, a distance matrix with $n(n-1)/2$ number of distances is used as inputs and it creates two- or three-dimensional output maps. The differences between the input and output matrix are aimed to be minimum. The distances between less similar objects are greater than the distances between more similar objects (Härdle and Simar 2007).

Most of the optimization methods used in metric MDS try to minimize the stress value, which is described as the representation of the coherence between distances and configured distances. Stress is described as

$$\text{stress} = (\text{scale factor})^{-1} \sum_{i=1}^{n-1} \sum_{i+1}^{n} \left(d_{ij} - f\left(\delta_{ij}\right)\right)^2 \quad (1)$$

Even though the *scale factor* is described with several formats, the scale factor proposed by Kruskal (1964) is used most of the time (Martinez et al. 2011).

3.2 Cluto clustering

The gCLUTO (graphical Clustering Toolkit) is a statistical tool to visualize clusters by using the first or the second vector views of instances. SenseCluster is a clustering toolkit and it provides impeccable interface with gCLUTO (Karypis et al. 2002). Also, this visual method contains various processes such as repeated bisections, direct, nearest neighbor, agglomerative, and biased

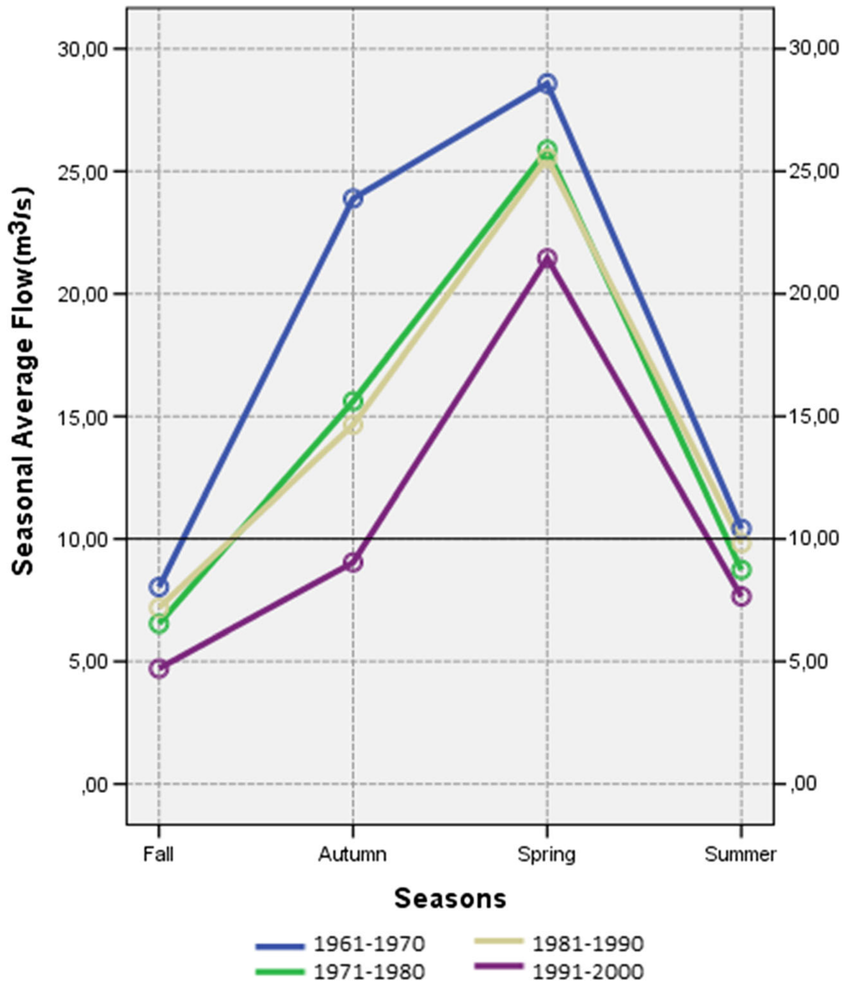

Fig. 3 Seasonal average streamflow (m^3/s) values for all stations, 10-year periods in Turkey (seasonal hydrograph)

agglomerative. SenseCluster provides support for a number of similarity measures, such as simple matching, the cosine, the Jaccard coefficient, and the Dice coefficient. In this study, we use the cosine similarity measure and *I*2 criterion function. The cosine similarity measure is defined as

$$\cos(c_1, c_2) = (c_1 \times c_2)/\|c_1\|\|c_2\|, \tag{2}$$

where c_1 and c_2 are m-dimensional vectors over the term set. The *I*2 maximization criterion function is

$$\sum_{r=1}^{k} \sum_{x_i \epsilon S_r} \cos(x_i, C_r), \tag{3}$$

where C_r is the centroid of the cluster where the units are assigned.

The *I*2 criterion function is used by the popular vector-space variant of the *K*-means algorithm with the cosine similarity measure (Dhillon and Modha 2001; Steinbach et al. 2000). Each cluster is showed by its centroid vector to maximize the similarity measure of the cluster that is assigned to a certain cluster.

The gCLUTO clustering method provides excellent visualization for cluster analysis and hierarchical trees. We call them matrix and mountain visualization, respectively. The detailed explanation of two visual tools is found in the multidimension scaling results section of this study.

3.3 *K*-mean clustering with repeated bisections method

Bisecting *K*-means produces relatively uniform size clusters, while regular *K*-means methods produce widely different size clusters. That is why we use the repeated bisection method instead of the regular *K*-means method in this study. Smaller clusters are often of higher quality, but this does not contribute to the overall quality measure, since the quality measures weigh each cluster's quality contribution with the cluster size (Steinbach et al. 2000).

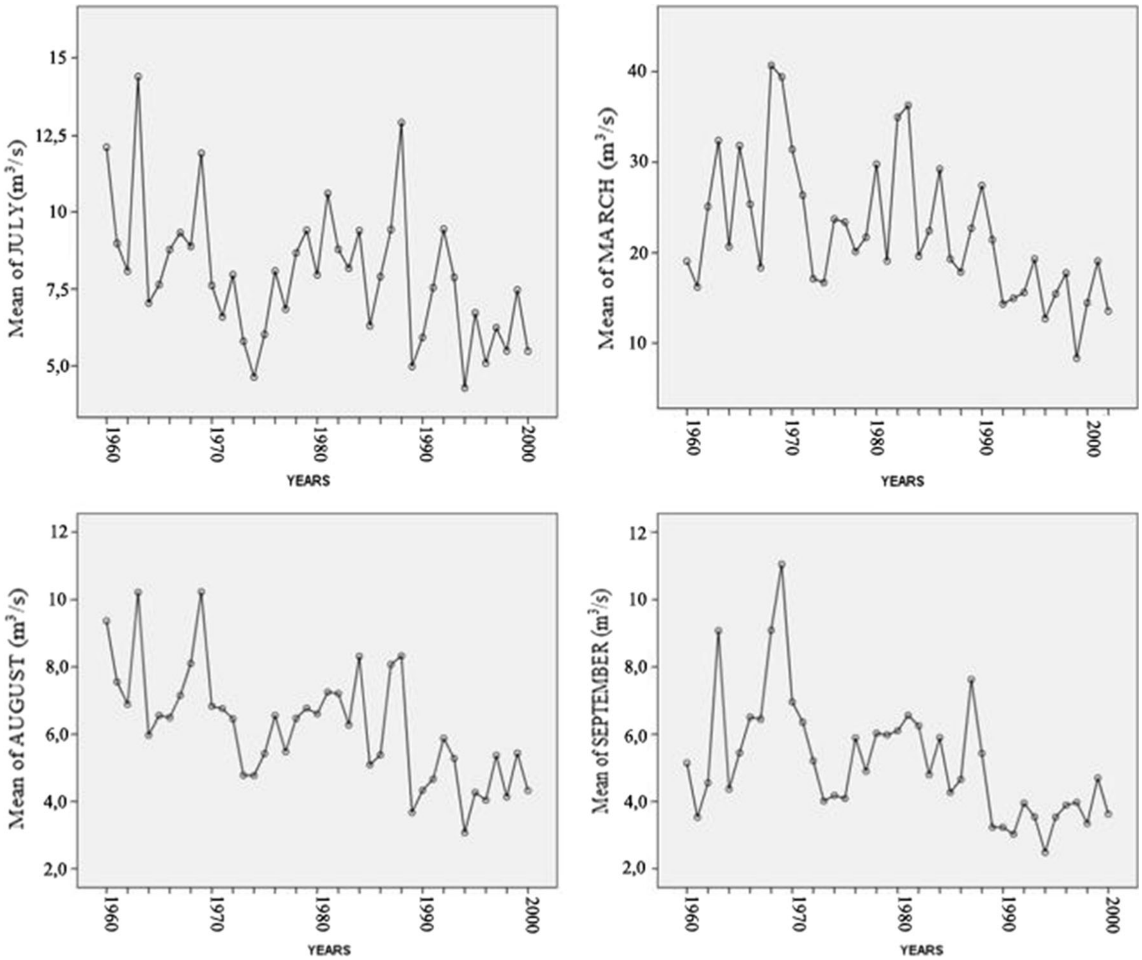

Fig. 4 Long-term streamflow (m^3/s) trends in certain months for all basin regions of Turkey

Clustering solutions are produced with the criterion functions and the overall solution is obtained with a sequence of cluster bisections (RB). In this approach, a k-way solution is obtained by the first bisection of the entire collection. Then, one of the two clusters is selected, and it is further bisected to lead a total of three clusters. This level of choosing and bisecting is performed $(k - 1)$ times, to gather the desired k-way clustering solution. Each of these bisections is performed so that the resulting bisection optimizes a particular criterion function (Zhao and Karypis 2004).

4 Cluster analysis results

Cluster analysis is implemented to see the similar features of flows depending on the monthly average data for 40 years in Turkey (Yildiz 2015, Technical Report for Yildiz Technical University, Scientific Research Projects, named "Modeling, forecasting and estimation of social, economic and hydrological effects of water supply and demand in Turkey on the Basin Level"). The basin regions on the map are found in Fig. 5.

Investigating four different geographic region basins in terms of their climate and geographic features, Bati Karadeniz and Antalya are two basins for which the seasonal effects of flow regimes do not change. In other words, the cluster features of months have seasonal effects for these two regions. The natural trend in the Buyuk Menderes Basin is affected by flow and climate irregularities stemming from irregular precipitation. On the other hand, the Firat Dicle Basin reflects the characteristics of the continental climate.

Figure 6 shows that there are two main clusters for each basin, but the average monthly values for clusters are obviously different from each other. Analyzing these four basins shows that flow regimes are different in terms of seasonal effects for Bati Karadeniz and Antalya. In other words, the cluster characteristics of months for these two basins have season effects. The dendrogram properties of these four basins are as follows:

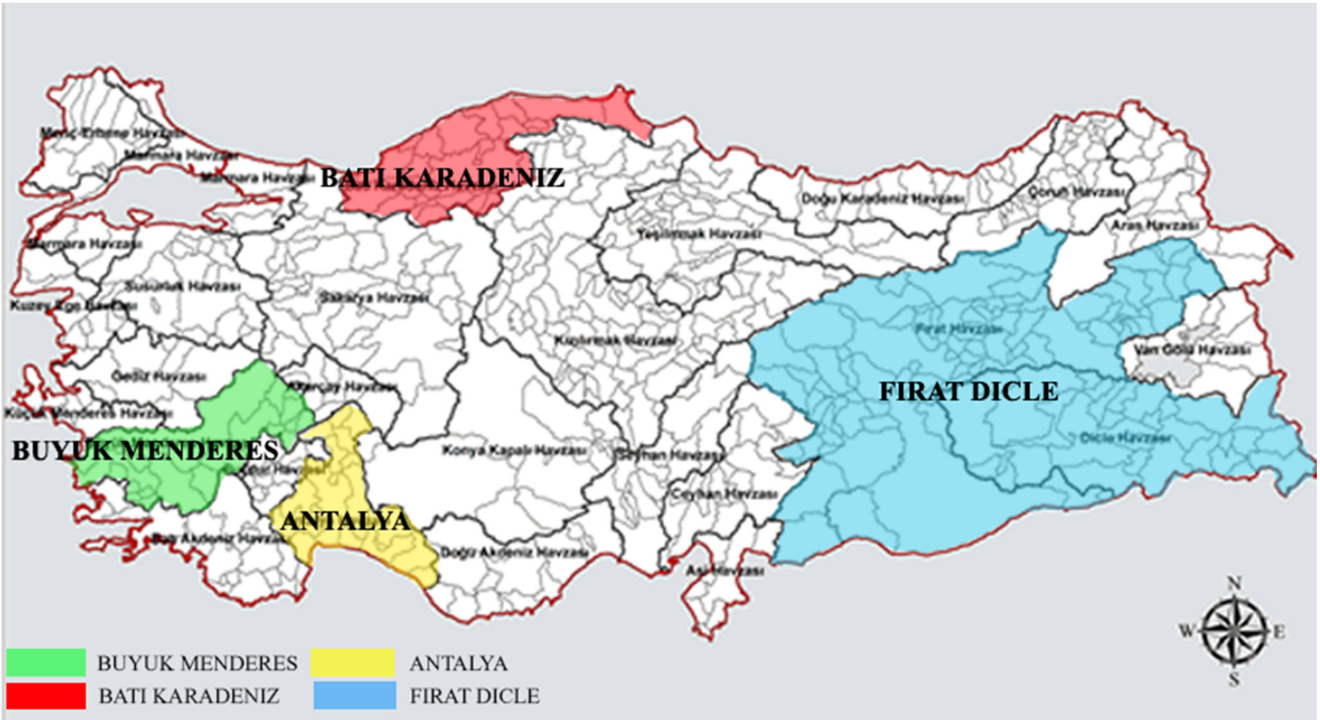

Fig. 5 Four basin regions of Turkey (source: *aris.ormansu.gov.tr*)

Buyuk (Big) Menderes Basin The dendrogram at the upper-left of Fig. 6 shows that flow regimes in January, February, and March are similar. These levels determine the first cluster with the highest flow. All other months are in the second cluster, including December, which has some partial differences. We may say that seasonal variations exist in the West Coast, and flow levels of seasonal differences are highly irregular in this area.

Bati (West) Karadeniz Basin The dendrogram at the lower-left of Fig. 6 shows that March and April are in a different cluster. It is worth noting that the total cluster number is 3, with December-January-February, July-August-September, and October for this basin different than others. The seasonal effect is low in this part of the country.

Antalya Basin There are two main periods obvious in this basin. December, January, February, March, April, and May with high and regular flow is the first period. June, July, August, September, and October constitute the second period with high increase in flow that is observed from the dendrogram at the upper-right of Fig. 6.

Fırat Dicle Basin Two different periods are obviously different at Firat Dicle Basin, which is the highest region of Turkey in terms of its flow level. The dendrogram located in the lower-right of Fig. 6 shows that April and May appear as the first affective dimension. The rest of the months represent the second period with very low-flow level, and they have homogenous features.

Table 6 shows clustered months for all basins.

5 Multidimensional scaling (MDS) analysis results

MDS gives an easier understanding on the structure of the data by displaying essential information in the data rather than just an array of numbers (Borg and Groenen 2005). MDS searches for a low dimensional space and transforms Euclidean distances into a set of point coordinates (Young and Householder 1938).

The reliability and validity tests of MDS are implemented with R^2 and stress values. R^2 shows how likely the MDS represents the input data; it is expected to be more than 0.60. Stress values show the quality of MDS, and Table 3 shows the goodness of fit of the stress values.

MDS is implemented with monthly flow data for 577 stations and for 10-year periods in this part of the study. The graphs of MDS with Euclidean distance model for two seasons and for each 10-year period are located in Fig. 7.

It is inferred from the first graph in Fig. 7 that there are three different homogenous groups depending on the Euclidean distance model of monthly flow values (m^3/s) from 1961 to 1970. The flow levels in March, April, and May are high and they constitute a cluster according to the distances from the origin. Distances closer to the origin with low level flows are observed in July, August, September, October, and

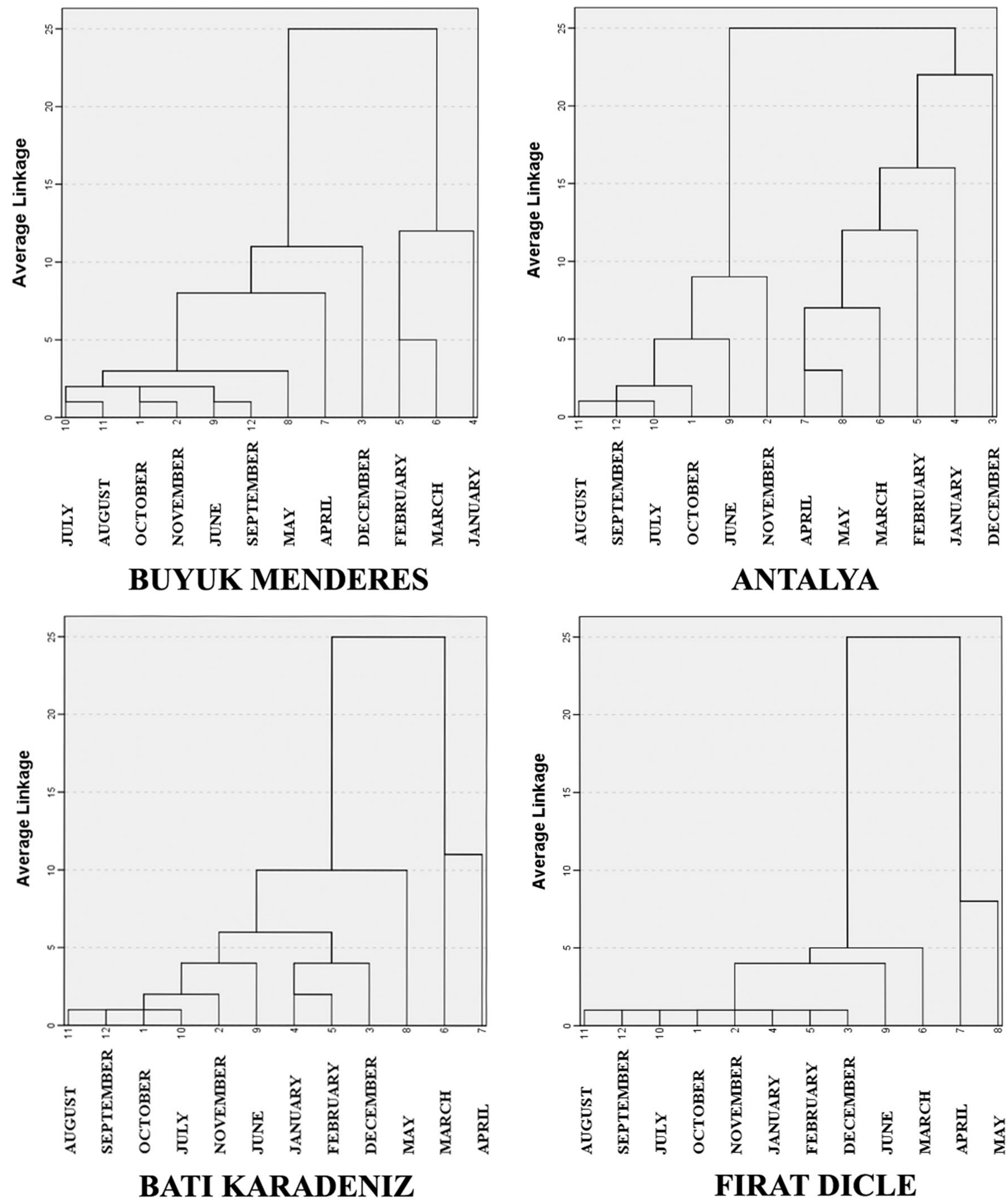

Fig. 6 Cluster analysis dendograms of four basin regions of Turkey

November. The dissimilarity matrix of months constituting Fig. 7 for the 1961–1970 period using Euclidean distance model is located in Table 8.

For the second 10-year period, the clockwise movements of months in the Euclidean distance model are noteworthy at the second graph in Fig. 7. May and April take each other's placement in this model, and this may be evaluated as the indicator of the seasonal shift. The dissimilarity matrix of months constituting Fig. 7 for the period from 1971 to 1980 is located in Table 9.

Similarly, the clockwise movements are observed in the third graph of Fig. 7 similar to the previous period. For the third 10-year period, holistic movements for all months appeared. The dissimilarity matrix for 1981–1990 is located in Table 10.

April and May behave differently than other periods in the last graph in Fig. 7, which represents the fourth 10-year period. The clockwise movement is not as much obvious as in previous periods, but flow level differences are noticeable in these months. There are two potential reasons causing these

Table 3 Stress values interpretation for multidimensional scaling

Stress	Goodness of fit
> 0.20	Poor
0.10	Fair
0.05	Good
0.025	Excellent
0.00	Perfect

Source: Wickelmaier 2003

differences. The first one may be the great increase in average flow values (m^3/s) in April and May, while the second one may be the great decrease in other months. In this manner, we may say that the last 10-year period states the seasonal deformation more obviously than the previous periods. See Table 11 for the dissimilarity matrix.

Following 10-year period interpretations, the gCLUTO is conducted to visualize the current structure of flow values. Figure 8 depicts the matrix and mountain visualization from gCLUTO for 10-year intervals for all basins in Turkey. The colors of the mountain visuals on the right column of Fig. 8 are used to represent the values of the matrix on the left column of Fig. 8. For instance, dark red represents the large positive values, while lighter shades are used for values near zero. In Fig. 8, the rows of the matrix represent the years and the columns represent the months. Years are divided into three clusters according to the repeated bisection (RB) algorithm (with *I*2 and $k = 3$). The dark red region shows the massive effect on February, March, and April.

In Fig. 8, each mountain represents a cluster, where position, height, width, and slope depend on cluster characteristics such as year groups. The objects of the same cluster have their rows placed consecutively, and black horizontal lines separate rows belonging to different clusters. This display allows us to inspect the data for patterns visually.

In Fig. 8, the streamflow density in March and April is obviously decreasing from 1971 to 1980. As a consequence, the structure with two clusters in the mountain graph is more appropriate for this period. This structure underlines the monthly changes in streamflow.

The matrix visualization in Fig. 8 shows a decrease in monthly streamflow and in the streamflow density in March, April, and May.

For the last 10-year period, streamflow is dense for March and April according to the matrix visualization. This can be interpreted as the signal of a seasonal shift and the increase in seasonal differences.

Evaluating all four of the 10-year periods together demonstrate that streamflow density is moving to April direction systematically from both sides in time, which is seen in the matrix visualization. Mountain graphs show that color changes are decreasing for the first three periods, and the irregularity in streamflow regimes is getting obvious for the last period.

Streamflow distributions from 1961 to 2000 are shown in Fig. 9. The order of magnitude in months in terms of changes in streamflow is April, May, and March. This result endorses MDS and gCLUTO results for 10-year periods.

Generally speaking, MDS graphs of these 10-year periods show that the seasonal transitivity periods are stretching out and the sharp precipitation and temperature differences do not exist anymore. The effect of this situation on the flow of precipitation regime is observed in Fig. 3, too.

Twelve months are split into two clusters after implementing cluster analysis, and they are mainly seen in basin dendrograms in Fig. 6 for the four basins. The total flow values of these two group months for each basin are used to create MDS dimensions. The month groups for each basin and their dimension coordinates are found in Tables 6 and 7, respectively.

We also conducted the same analysis for the whole 40-year period. The derived stimulus configuration map (visual output from multidimensional scaling) for the 40-year period is located in Fig. 10.

As we mentioned before, MDS is implemented with the total flow values for month groups located in Table 7 for each basin. Figure 10 is drawn with these values. The first dimension includes the months with higher flow values, while the second dimension includes the lower ones. For the rest of the study, the first dimension is called the high-flow dimension and the second dimension is called the low-flow dimension.

The more the basin is far from the origin, the more heterogeneous the basin is in Fig. 10. Heterogeneous means that the flow value differences between two dimensions for that particular basin is high. The basins closer to the origin have similar values for both dimensions. For example, Büyük Menderes, Dogu Karadeniz, Meric, and Kuzey Ege Basins are heterogeneous in terms of their flow values, while Asi, Aras, and Gediz are homogenous basins. Before finalizing this part, we want to emphasize that it is a natural cycle that climate change causes water cycle changes (Nan et al. 2011); therefore, water cycles are needed to be observed and reported periodically.

6 Streamflow map of Turkey

As a final step in the analysis part, we drew a map to see the general picture of streamflow levels in Turkey. The principal component analysis (PCA) was implemented with dimension values to see their variance explanation ratios to determine the dimension that was used for this map.

Table 4 shows that the first component explains 84% of total variation, and we use the first dimension to create the flow value regional map. Depending on their flow values, the basins are sorted from very low to very high, and they are colored in Fig. 11.

The streamflow (m^3/s) in the east side of Turkey is 46% of the whole streamflow of the country. However, only 23% of the total population lives in this part of Turkey (depending on

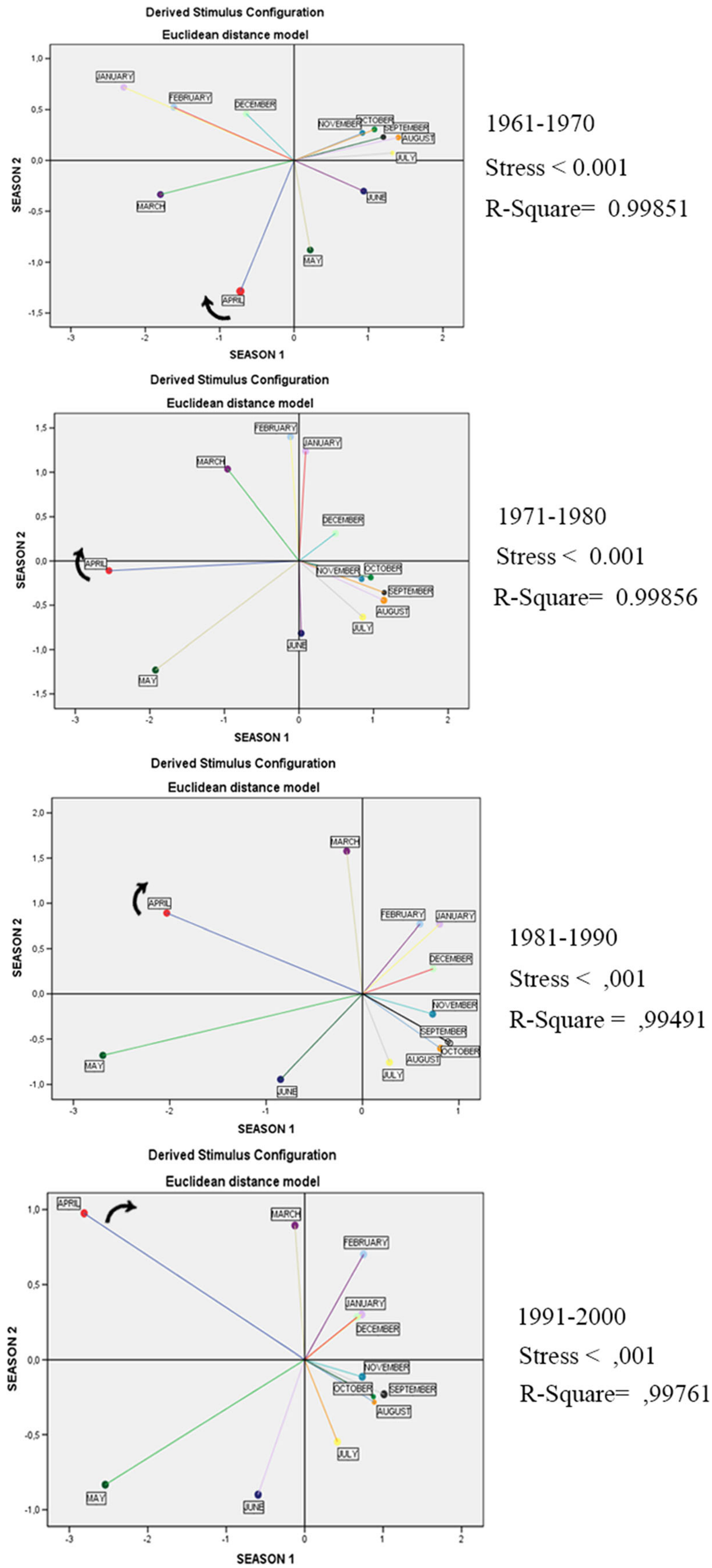

Fig. 7 MDS coordinates according to month movements with 10-year intervals for all basins of Turkey

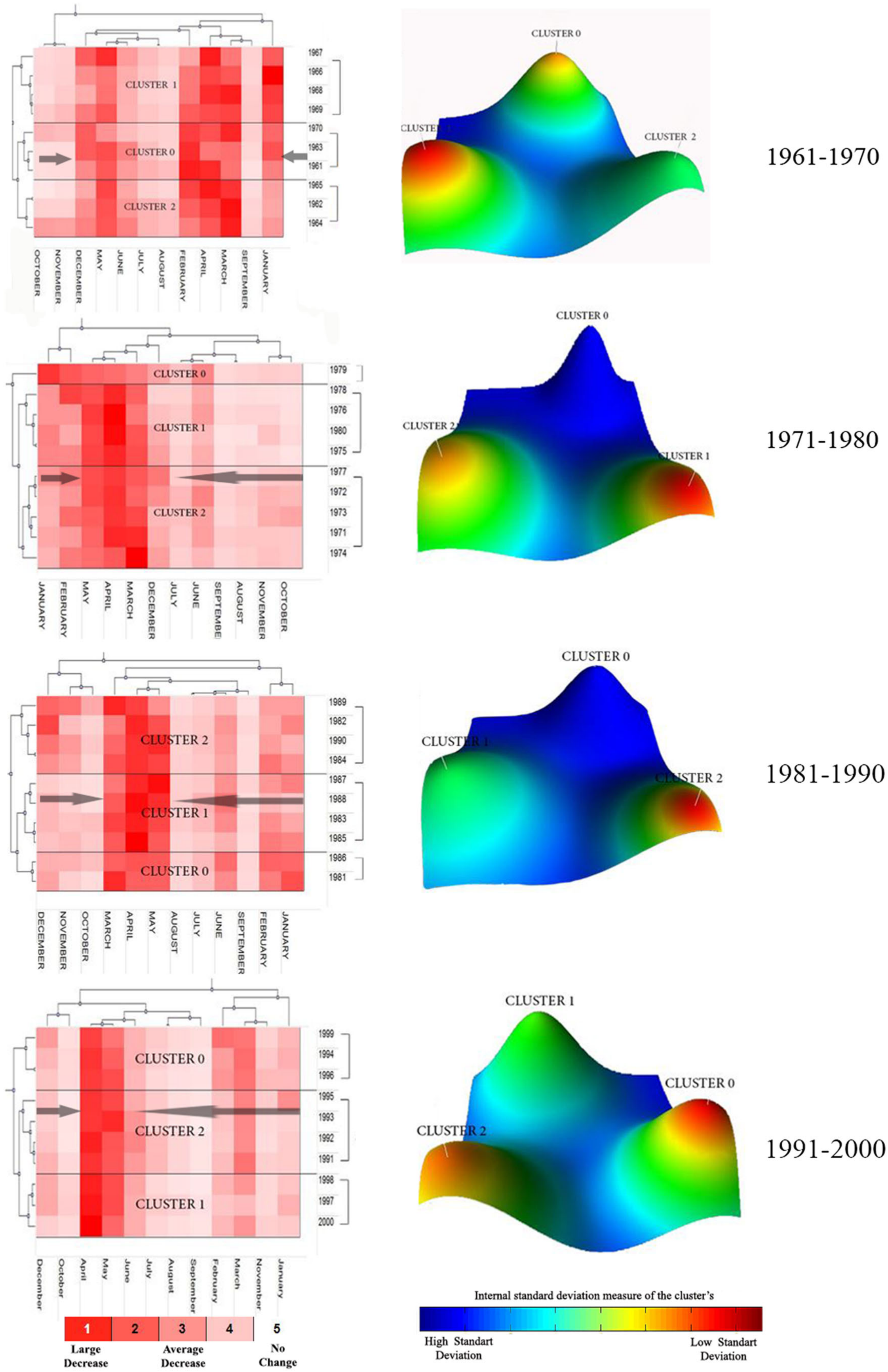

Fig. 8 Matrix and mountain visualization outputs from gCLUTO for 10-year intervals for all basins of Turkey

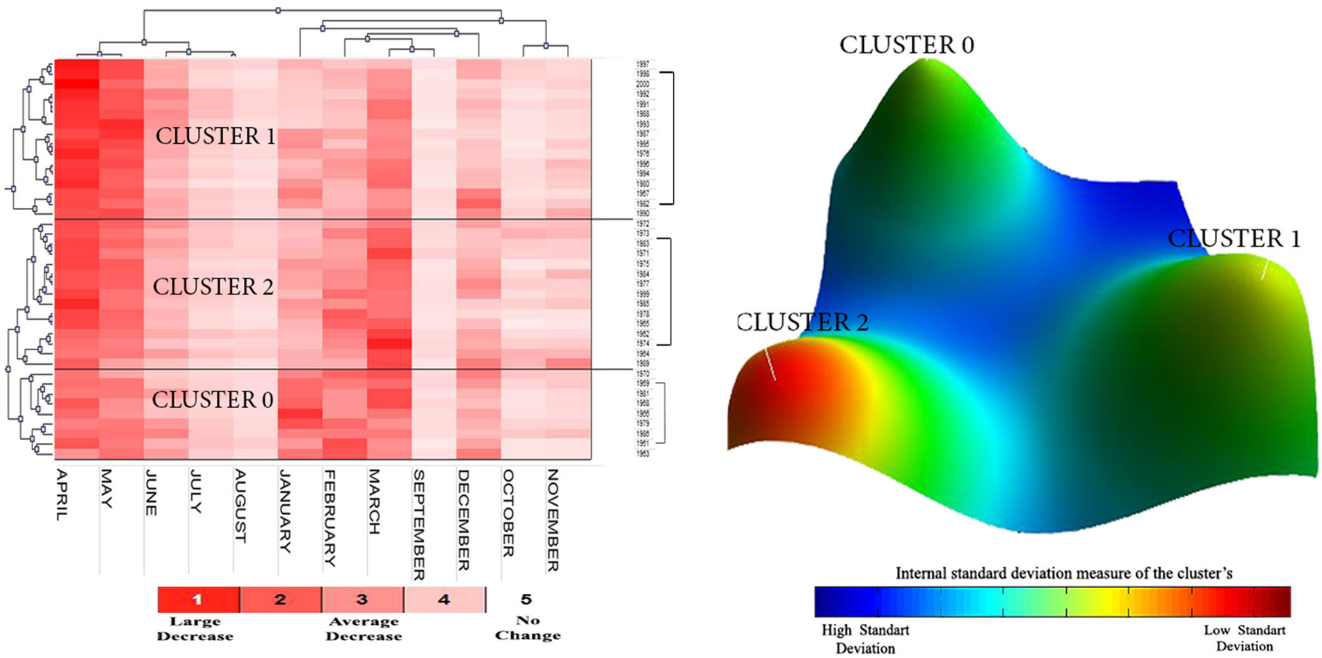

Fig. 9 Matrix visualization and general mountain map of streamflow (m^3/s) with gCLUTO for 1961–2000

the 2014 census). As shown in Fig. 11, the streamflow is weaker in most of the western part basins than those of eastern part. However, immigration from east to west is proceeding gradually. Actually, people are moving from a stronger regional area to a weaker area in terms of its precipitation (mm) regime. This situation shows the importance of regional water development projects (GAP-Southeastern Anatolia Project, DAP-Eastern Anatolia Project, DOKAP-Eastern Black Sea Project) to prevent the regional immigration as well as to increase the development in the east side of Turkey. This map

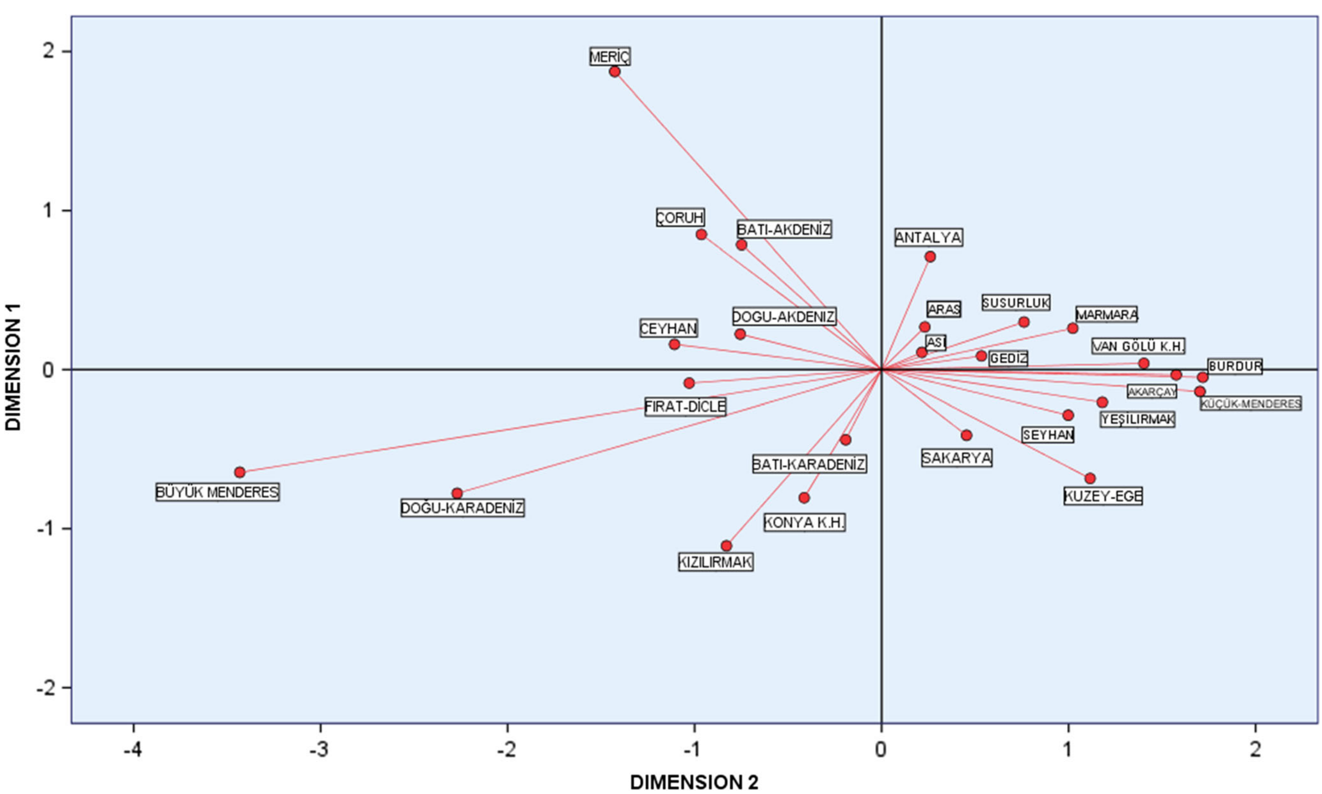

Fig. 10 Derived stimulus configuration map for all river basins of Turkey

Table 4 Principal component analysis results for high- and low-flow dimension

Component	Total variance explained		
	Total	% of variance	Cumulative %
First dimension	1.68	83.92	*83.92*
Second dimension	0.32	16.08	100

also shows which regions should be more careful using their water sources, because if not, they may demand for water transfers from other regions. However, it is well-known that this kind of demands may cause serious regional problems. In summary, the majority of lower flow (m^3/s) basins are located in the west side of Turkey depending on the first dimension of MDS, but this area is densely populated and has higher industrialization.

7 Results

In this paper, we used the monthly Turkish General Director of State Hydraulic Works data recorded in the period between 1961 and 2000. The evaluation of all stations in Turkey indicates that the average flow value in September is the lowest with 4.9 m^3/s, while April is the highest month. The standard deviation is approximately 17 m^3/s for August, September, and October, which is the lowest among all months. The highest standard deviation is approximately 76 m^3/s for April and May. The coefficient of variation for 40-year period of time shows that the flow regime in September is heterogeneous, while the flow regime in April is homogenous. The decrease in seasonal and/or monthly flow values comparing the first 10-year period (1961–1970) and the last 10-year period (1991–2000) can be seen as an important climatological result. This result is supported by long-term monthly flow values, which are gradually decreasing.

Cluster analysis results indicate two main clusters for months for all basins. The month groups acquired from cluster analysis are used to apply MDS for 10-year periods. The MDS results for these 10-year periods contribute to observe the climatological variation more clearly. Two-dimensional MDS graphs demonstrate clockwise movements of months from a decade to the next decade. More importantly, these movements prove the deteriorating climatological variation. Also, these movements in MDS are supported by gCLUTO outputs. Especially for the 1991–2000 period, visuals of MDS and gCLUTO supply enough evidence for the seasonal cycle shift. The gCLUTO provides interactive matrix structure, and this structure makes the interpretation easier. Additionally, the rest of the 10-year period outputs bring similar results on seasonal cycle shift.

In the graph of two-dimensional MDS, the distances of basins to the origin vary considerably. Asi, which is the closest basin to the origin, shows a homogenous structure with a minimum change in two dimensions. Aras, Gediz, Susurluk, Seyhan, Dogu Akdeniz, and Sakarya have similar properties. In contrast, the changes for Menderes, Dogu Karadeniz, Meric, and Kizilirmak are the maximum for two dimensions. This structure appears in the streamflow map of Turkey. The negative relationship of population and water resources between the west and east sides of Turkey is proved in this study.

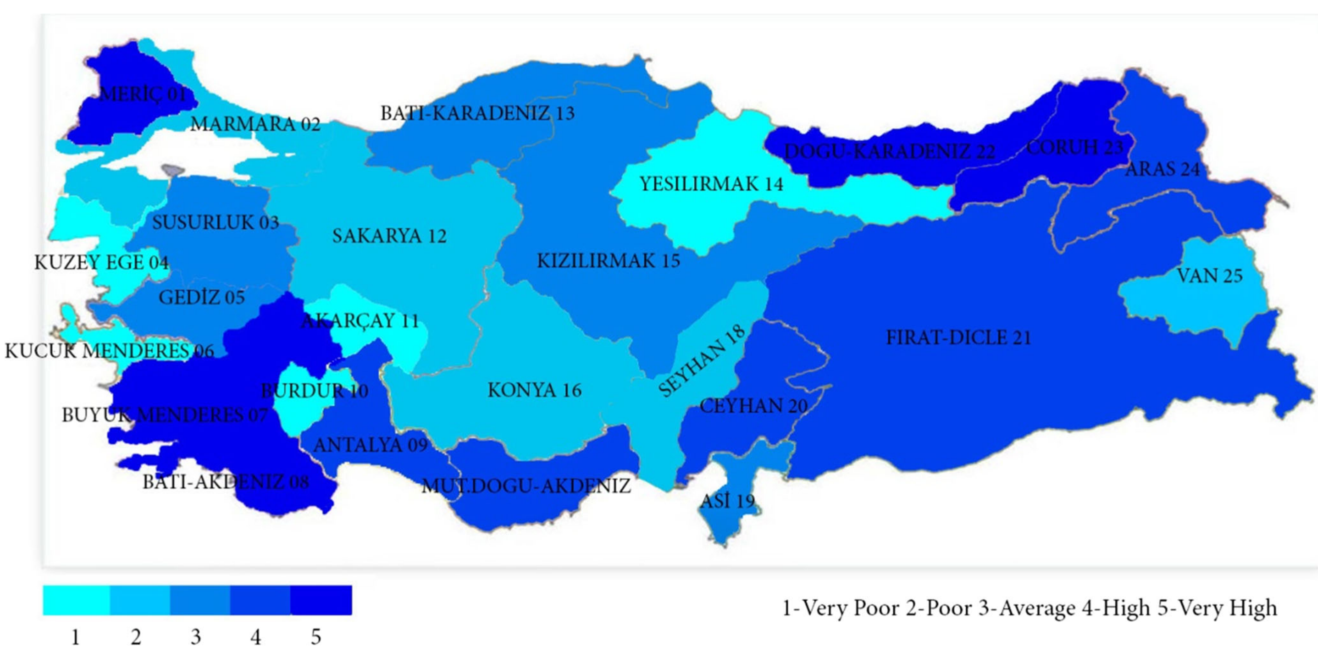

Fig. 11 Regionalization of basin regions depending on streamflow values (m^3/s)

The population is dense and the water resources are low in the west, while the population is low and the water resources are high in the East. This negative relationship emphasizes the importance of an integrated basin management for Turkey.

7.1 Conclusion and comments

Turkey is at risk for global warming and climate change (Sen et al. 2012) and there is a decrease in streamflow values (Gao et al. 2006; Önol and Semazzi 2009). The climate measures should be under projections all the time to make the authorities and the civilian population be aware of global warming's potential risky results such as flood, drought intensity, dry conditions, and social problems. It is worth noting that the effects of climate change are not only a threat on water security but they are also linked to energy, food, and environment security.

Any strategy that focuses on one part of the water-food-energy nexus without considering its interconnections risks serious unintended consequences. As an example, California's drought began more than 2 years ago—a dry stretch that has caused the state to lose a considerable amount of its water supply and allocation dispute between farmers and energy producers. Finally, the state's Department of Water Resources announced that the State Water Project (California's largest canal system) would not deliver any water to customers unless precipitation increases dramatically.

In the United Nations Climate Change Conference (Paris, December 2015), the global climate change is named as a top threat, according to new Pew Research Center Survey measuring perceptions of international challenges (Yildiz 2016). Apart from other parts of the world, the Mediterranean is considered as one of the most risky regions under the climate change threat (Yildiz and Ozguler 2005).

During this study, we realized that the Atatürk and the Keban Dams' reservoirs have slightly affected the regional climate and hydrology of the environment. For instance, meteorological time-series analyses are examined to assess the impact of the Atatürk Dam Lake on selected areas and they showed more monthly, seasonal, and annual fluctuations of rainfall rate on the watershed. It is observed that annual temperature and annual precipitation have slightly increased in Şanlıurfa City region after Atatürk Dam reservoir.

In this study, we observed that the seasonal transitivity periods are stretching and the sharp precipitation and temperature differences are not as obvious as before. The effect of the same situation on flow values is also observed. Key findings from these studies cannot only identify to water security but also food, energy, environment, and national security and their interrelated issues. Decision makers need comprehensive study results to lead the investments and operations effectively. Turkey is in a transition period of establishing a new water management system. Therefore we need to decrease uncertainties as much as possible so as not to lose time and money and set up a sustainable water management system.

As a future work, we aim to enhance our analysis for country comparisons with other hydrological and/or climatological measurements.

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Appendix

Table 5 Basin names and station numbers

Basin	Station numbers
1. Meric	003-008-011-012-013-014-020-031-039-046-052-055-057-058
2. MarMarMarmara	003-004-010-015-028-030-031-038-041-047-057-065-069-070-84-084a
3. Susurluk	004-008-010-013-017-018-020-021-027-028-034-038-046-049-054-064-072-076-084-085-086-087-089-090-095
4. Kuzey Ege	002-005-006-013-014-016-017-019-021-023-024-025-026-028-031-032-034-035-036-037
5. Gediz	007-015-018-021-025-026-028-031-033-034-035-039-041-042
6. Kucuk Menderes	001-006-007-010-011-012-013
7. Buyuk Menderes	003-004-007-008-009-010-014-026-030-032-035-037-039-043-049-052-053-059-061-062-065-071-073-075-081-082-083-087-100
8. Bati Akdeniz	001-009-011-013-018-018-019-028-049-054-055-058-061-065-067-070-072-075-076-079-081-083-085-087-089-091-092-095-096-103-105-108
9. Antalya	002-006-011-013-016-039-042-053-056-065-067-068-070-084-086-088-089-091-100
10. Burdur	002-003-007-010-013-023-027
11. Akarcay	001-002-007-012-013-015-017-020-021
12. Sakarya	

Table 5 (continued)

Basin	Station numbers
	006-017-030-033-034-049-055-063-067-075-087-090-101-120-134-135-138-139-146-152-153-155-156-159-170-172-173-175-181-185-188-189-197
13. Bati Karadeniz	014-015-019-020-021-022-030-031-032-033-036-037-039-040-041-044-045-049-050-053
14. Yesilirmak	011-014-015-020-023-024-026-032-033-042-046-047-062-080-092-093-095-106-108-111-117-119
15. Kizilirmak	010-015-016-017-021-025-026-029-041-043-046-047-048-049-053-054-055-056-057-059-062-066-067-068-069-071-074-078-088-091-092-093-095-098-099-107-108-112-117-126-131-133-134-137-148-152-153-162-163-167-168-169-171-172-177-178-179-180-182-185-186-187-188-190-191-194-201-206-208-211-212-218-236-238
16. Konya	03a-013-015-017-026-028-037-041-048-056a-065-072-078-080-081-083-087-088-088-089-092-094-095-096-098-100-101-104-109-114-115-117-123-126-135-136-137-138-140-141-143-144-145-148
17. Dogu Akdeniz	007-011-012-014-016-017-024-027-029-031-032-033-035-038
18. Seyhan	005-008-012-016-017-018-019-022-023-027-028-031-032
19. Asi	004-006-009-012-014-016-017-018-020-021-022-023
20. Ceyhan	002-004-005-006-007-008-010-013-015-016-017-031-035-036-040-042-043-044-045-046-051-052-053-054-055-058-059-065
21. Firat Dicle	001-004-019-026-040-052-056-074-084-085-087-096-099-101-103-104-105-116-121-132-133-138-138-140-141-148-152-157-166-167-168-169-170-173-175-181-193-200-201-203-210-213-216-220-226-243-008a-028a-040a
22. Dogu Karadeniz	002-006-007-009-013-034-040-044-049-052-055-056-058-059-061-062-063-064-066-067-072-073-074-080-082-085-087-090-092
23. Coruh	001-003-006-007-015-016-024-026-028-029-030-031-032
24. Aras	011-016-018-022-023-025-029-032-040-041-046-048-049-050-052-053-054-058-060-063-065-069-071-073
25. Van	002-012-013-021-024

Table 6 Months with Dimensions

Basins	Cluster 1	Cluster 2
Akarcay	Mar, May, Apr	Jun, Jul, Aug, Sep, Oct, Nov, Feb, Jan, Dec
Antalya	Mar, Apr, May, Dec, Jan, Feb	Jun, Jul, Aug, Sep, Oct, Nov
Aras	Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar
Asi	Jan, Feb, Mar	Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Bati Akdeniz	Dec, Jan, Feb, Mar, Apr	May, Jun, Jul, Aug, Sep, Oct, Nov
Bati Karadeniz	Mar, Apr	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb
Burdur	Jan, Feb, Mar, Apr	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Buyuk Menderes	Jan, Feb, Mar	Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Ceyhan	Mar, Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb
Coruh	Apr, May, Jun	Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar
Dogu Karadeniz	Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar
Firat Dicle	Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar
Gediz	Jan, Feb, Mar, Apr	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Kizilirmak	Apr	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar, May
Konya	Sep, Oct, Nov, Dec, Jan, Feb, Mar	Apr, May, Jun, Jul, Aug
Kuçuk Menderes	Jan	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec, Feb, Mar, Apr
Kuzey Ege	Jan	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec, Feb, Mar, Apr
Marmara	Dec, Jan, Feb, Mar	Apr, May, Jun, Jul, Aug, Sep, Oct, Nov
Meric	Dec, Jan, Feb, Mar, Apr, May	Jun, Jul, Aug, Sep, Oct, Nov
Dogu Akdeniz	Mar, Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb
Sakarya	Mar, Apr	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb
Seyhan	Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar
Susurluk	Jan, Feb, Mar, Apr	May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Van	Apr, May, Jun	JulJul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar
Yesilirmak	Apr, May	Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar

Table 7 Dimensions for MDS

Basin	Dimension 1	Dimension 2
Akarcay	1.5757	−0.0330
Antalya	0.2605	0.7121
Aras	0.2313	0.2685
Asi	0.2155	0.1085
Bati Akdeniz	−0.7487	0.7853
Bati Karadeniz	−0.1920	−0.4399
Burdur	1.7175	−0.0483
Buyuk Menderes	−3.4326	−0.6452
Ceyhan	−1.1078	0.1593
Coruh	−0.9640	0.8496
Dogu Karadeniz	−2.2700	−0.7777
Firat Dicle	−1.0290	−0.0850
Gediz	0.5341	0.0865
Kizilirmak	−0.8300	−1.1084
Konya	−0.4143	−0.8056
Kuçuk Menderes	1.7026	−0.1380
Kuzey Ege	1.1151	−0.6838
Marmara	1.0224	0.2605
Meric	−1.4270	1.8741
Dogu Akdeniz	−0.7560	0.2236
Sakarya	0.4541	−0.4120
Seyhan	0.9981	−0.2855
Susurluk	0.7617	0.2999
Van	1.4027	0.0393
Yeşilirmak	1.1803	−0.2047

Table 8 1960–1970 dissimilarity matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	0											
2	0.179	0										
3	1.72	1.57	0									
4	3.39	3.24	1.72	0								
5	2.70	2.54	0.90	0.90	0							
6	2.94	2.75	1.48	1.16	0.90	0						
7	2.4	2.26	1.72	2.54	2.01	1.44	0					
8	1.4	1.34	1.60	2.97	2.30	2.07	0.90	0				
9	0.62	0.62	1.72	3.38	2.68	2.75	1.89	0.90	0			
10	0.44	0.44	2.01	3.66	2.97	3.14	2.45	1.44	0.44	0		
11	0.33	0.48	2.07	3.72	3.04	3.24	2.60	1.60	0.62	0.17	0	
12	0.17	0.28	1.89	3.52	2.83	3.04	2.45	1.44	0.62	0.17	0.17	0

Table 9 1971–1980 dissimilarity matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	0											
2	0.12	0										
3	0.64	0.62	0									
4	1.67	1.62	1.01	0								
5	1.93	1.93	1.20	0.64	0							
6	2.27	2.14	1.61	1.20	1.11	0						
7	3.51	3.38	3.06	2.96	2.86	1.93	0					
8	3.06	2.94	2.86	3.18	3.18	2.51	1.20	0				
9	1.11	1.01	1.20	2.02	2.22	2.14	2.67	1.93	0			
10	0.44	0.44	1.01	2.02	2.24	2.46	3.44	2.84	0.64	0		
11	0.35	0.38	0.99	2.02	2.24	2.51	3.70	3.18	1.11	0.29	0	
12	0.29	0.35	0.93	1.93	2.14	2.51	3.69	3.18	1.11	0.35	0.08	0

Table 10 1981–1990 dissimilarity matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	0											
2	0.25	0										
3	0.64	0.51	0									
4	1.32	1.00	0.64	0								
5	1.32	1.00	0.64	0.34	0							
6	2.35	1.99	1.59	1.32	1.00	0						
7	3.25	2.97	2.83	2.83	2.62	1.99	0					
8	3.58	3.45	3.55	3.78	3.58	3.39	1.74	0				
9	1.74	1.73	1.99	2.38	2.24	2.61	2.18	1.83	0			
10	0.51	0.64	1.13	1.59	1.56	2.38	2.83	2.97	1.00	0		
11	0.25	0.38	1.00	1.37	1.32	2.38	3.21	3.50	1.69	0.34	0	
12	0.34	0.51	1.00	1.32	1.32	2.37	3.25	3.60	1.83	0.64	0.11	0

Table 11 1991–2000 dissimilarity matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	0											
2	0.14	0										
3	0.56	0.40	0									
4	0.56	0.40	0.34	0								
5	0.99	0.93	0.56	0.56	0							
6	1.53	1.31	0.99	0.99	0.93	0						
7	3.88	3.70	3.54	3.60	3.60	2.68	0					
8	3.47	3.35	3.39	3.46	3.60	2.97	1.84	0				
9	1.61	1.54	1.73	1.78	2.09	1.84	2.90	1.95	0			
10	0.56	0.56	0.88	0.88	1.31	1.53	3.57	2.97	0.93	0		
11	0.14	0.34	0.56	0.56	0.99	1.55	3.90	3.47	1.60	0.34	0	
12	0.13	0.30	0.56	0.56	0.99	1.60	4.00	3.60	1.73	0.56	0.13	0

References

Anderberg MR (1973) Cluster analysis for applications. Probability and Mathematical Statistics: A Series of Monographs and Textbooks. Academic Press, New York

Arnell NW (1999a) Climate change and global water resources. Global environmental change 9. Supplement 1:S31–S49

Arnell NW (1999b) The effect of climate change on hydrological regimes in Europe: a continental perspective. Glob Environ Chang 9:5–23

Birsan MV (2015) Trends in monthly natural streamflow in Romania and linkages to atmospheric circulation in the North Atlantic. Water Resour Manag 29:3305-3313

Borg I, Groenen PJF (2005) Modern multidimensional scaling. Springer-Verlag New York, New York

Borg I, Groenen PJ, Mair P (2013) Applied multidimensional scaling. Springer-Verlag, Berlin Heidelberg

Burke EJ, Brown SJ, Christidis N (2006) Modeling the recent evolution of global drought and projections for the twenty-first century with the Hadley Centre Climate Model. J Hydrometeorol 7:1113–1125

Deniz A, Toros H, Incecik S (2011) Spatial variations of climate indices in Turkey. Int J Climatol 31:394–403

Dhillon IS, Modha DS (2001) Concept decompositions for large sparse text data using clustering. Mach Learn 42:143-175

Gao X, Pal JS, Giorgi F (2006) Projected changes in mean and extreme precipitation over the Mediterranean region from a high resolution double nested RCM simulation. Geophysical Research Letters 33:n/a–n/a

Härdle WK, Simar L (2007) Applied multivariate statistical analysis, 2nd edn. Springer-Verlag, Berlin Heidelberg

Hulme M, Mitchell J, Ingram W, Lowe J, Johns T, New M, Viner D (1999) Climate change scenarios for global impacts studies. Global environmental change 9. Supplement 1:S3–S19

IPCC (1996) Climate change 1995. The science of climate change. Cambridge University Press, Cambridge

Iyigun C, Türkeş M, Batmaz İ, Yozgatligil C, Purutçuoğlu V, Koç E, Öztürk M (2013) Clustering current climate regions of Turkey by using a multivariate statistical method. Theor Appl Climatol 114:95–106

Kadioğlu M (1997) Trends in surface air temperature data over Turkey. Int J Climatol 17:511–520

Kahya E, Kalaycı S (2004) Trend analysis of streamflow in Turkey. J Hydrol 289:128–144
Kruskal JB (1964) Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika 29:1–27
Kruskal J (1976) The relationship between multidimensional scaling and clustering. In: Ryzin JV (ed) Classification and Clustering. Proceedings of an Advanced Seminar Conducted by the Mathematics Research Center, The University of Wisconsin-Madison. Academic Press Inc, New York
Malhotra KN (2010) Marketing Research: An Applied Orientation, 6/E, Pearson Education. https://books.google.com.tr/books?id=-_qgAowhVZgC
Martinez WL, Martinez AR, Solka JL (2011) Exploratory data analysis with MATLAB. CRC Press, Boca Raton
Murphy JM, Mitchell JFB (1995) Transient response of the Hadley Centre Coupled Ocean-Atmosphere Model to increasing carbon dioxide. Part II: spatial and temporal structure of response. Journal of Climate 8:57–80
Nan Y, Bao-hui M, Chun-kun L (2011) Impact analysis of climate change on water resources. Procedia Engineering 24:643–648
Önol B, Semazzi FHM (2009) Regionalization of climate change simulations over the eastern Mediterranean. J Clim 22:1944–1961
Paris Agreement (2017) Framework Convention on Climate Change. United Nations. http://unfccc.int/paris_agreement/items/9485.php
Sen B, Topcu S, Türkeş M, Warner J (2012) Projecting climate change, drought conditions and crop productivity in Turkey. Clim Res 52: 175–191
Shepard R (1962a) The analysis of proximities: multidimensional scaling with an unknown distance function. I Psychometrika 27:125–140
Shepard R (1962b) The analysis of proximities: multidimensional scaling with an unknown distance function. II Psychometrika 27:219–246
Shiklomanov IA (1997) Assessment of water resources and water availability of the world. Background report for the comprehensive assessment of the freshwater resources of the world. World Meteorological Organisation, Geneva
Sneath PHA, Sokal RR (1963) Principles of numerical taxonomy. W.H. Freeman, San Fransisco
Steinbach M, Karypis G, Kumar V (2000) A comparison of document clustering techniques. In: KDD Workshop on Text Mining, University of Minnesota
Stern N (2007) The economics of climate change. The Stern Review. Cambridge University Press, Cambridge
Tatlıdil H (1996) Uygulamalı Çok Değişkenli İstatistiksel Analiz. Akademi Mat, Ankara
Tayanç M, Karaca M, Yenigün O (1997) Annual and seasonal air temperature trend patterns of climate change and urbanization effects in relation to air pollutants in Turkey. Journal of Geophysical Research: Atmospheres 102:1909–1919
Torgerson W (1952) Multidimensional scaling: I. Theory and method. Psychometrika 17:401–419
Tryon RC (1939) Cluster analysis. McGraw-Hill, New York
Türkeş M (1996) Spatial and temporal analysis of annual rainfall variations in Turkey. Int J Climatol 16:1057–1076
Türkeş M, Sümer UM, Kiliç G (1995) Variations and trends in annual mean air temperatures in Turkey with respect to climatic variability. Int J Climatol 15:557–569
Unal Y, Kindap T, Karaca M (2003) Redefining the climate zones of Turkey using cluster analysis. Int J Climatol 23:1045–1055
Wickelmaier F (2003) An introduction to MDS, reports from the sound quality research unit (SQRU). Sound Quality Research Unit. Aalborg University, Denmark
World Meteorological Organization (1997) Abridged Final Report with Resolutions and Recommendations. WMO-No. 87, Geneva, Switzerland
Yildiz D (2015) Modeling, Forecasting and Estimation of Social, Economic and Hydrological Effects of Water Supply and Demand in Turkey on the Basin Level. Technical Report for Yildiz Technical University, Scientific Research Projects, İstanbul
Yildiz D (2016) The need of new water politics, from Aral Sea to Dead Sea. LAP Lambert Academic Publishing
Yildiz D, Ozguler H (2005) The water use and climate change impacts in the eastern Mediterranean region-analyses of current situation and future challenges. Mediterranean Conference on Water Resources in Mediterranean Basin, Marrakesh
Young G, Householder AS (1938) Discussion of a set of points in terms of their mutual distances. Psychometrika 3:19–22
Zhao Y, Karypis G (2004) Empirical and theoretical comparisons of selected criterion functions for document clustering. Mach Learn 55: 311–331
Zuo D, Xu Z, Wu W, Zhao J, Zhao F (2014) Identification of streamflow response to climate change and human activities in the Wei River Basin, China. Water Resour Manag 28:833–851