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The Influence of Dams on Surrounding Climate: The Case of Keban Dam

Barajların Çevre İklime Etkisi: Keban Barajı Örneği

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Abstract

Dams are subject to study not only with their benefits but also with their effects to environment. However, sometimes the advantages can outweigh its advantages due to environmental effects. Dams which are built for both irrigation and energy production have significant effects on the environment and climate. The environmental effects of dams reflect as erosion and siltation while climatical effects reflect as local differences in climate parameters as a result of creation of greenhouse gases and large water surface by incorrect engineering planning of dams .While projects of dams on the Euphrates River which date as far back as 1930's, their construction was started after 1970. One of these dams, Keban, is highly important investments for which Turkey's electricity production and irrigation. In this study, it was analyzed whether Keban Dam created differences in climatic parameters as spatial and temporal in their environment. For this purpose, two non-parametric methods (Mann-Kendall rank correlation test and Sen's slope estimate) were used to detect the meteorological variables' trends. Data stations in which are located close to dam and relatively distant from the dam were used. As a result, while temporal differences were determined in average temperature, temporal and spatial differences were determined in humidity values.

Key words: Dam's effect, Keban Dam, climate change, humidity, temperature, precipitation.

Özet

Barajlar son yıllarda sadece sağladıkları faydalarla değil, çevreye etkileri ile de inceleme konusu olmaktadırlar. Hatta bazen çevreye etki bakımından dezavantajları avantajlarına ağır basabilmektedir. Gerek sulama gerekse de enerji üretimi amaçlı inşa edilen barajların çevre ve iklimsel etkileri yıllardır tartışılan konulardandır. Barajların çevresel etkisi erozyon, ekosisteme etkisi ve siltasyon olarak yansırken, iklimsel etkisi ise barajın mühendislik açıdan yanlış planlanmasına dayalı olan sera gazı üretimi ve büyük su kütlesi yüzeyi oluşturması nedeniyle iklim parametrelerinde yarattığı yerel değişimler şeklinde özetlenebilir. Fırat nehri üzerinde yer alan barajların projeleri 1930'lara kadar dayanmakla birlikte, bu barajların inşaları 1970'lerden sonra başlamıştır. Bu barajlardan Keban Türkiye elektrik üretiminde ve sulamada oldukça önem arz eden yatırımlardır. Çalışmada Keban barajının bulunduğu çevrede zamansal ve alansal olarak iklimsel bir farklılık oluşturup oluşturmadığı analiz edilmiştir. Bu amaçla, meteorolojik verilerin eğilimlerini belirlemek için non-parametrik iki method (Mann-Kendall sıra korelasyon testi ve Sen'in eğilim tahmini) kullanılmıştır. Baraj yakınındaki ve baraja nispeten uzak istasyonlara ait meteorolojik veriler kullanılmış ve sonuçta sıcaklıklarda zamansal; bağıl nem değerlerinde ise zamansal ve alansal değişimler tespit edilmiştir.

Anahtar kelimeler: Baraj etkisi, Keban Barajı, iklim değişikliği, nemlilik, sıcaklık, yağış.

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Introduction

Dams substantially affect their places and close vicinity from economic, sociocultural and ecological aspects. Impacts of dams can be positive or negative. Especially, big dams with grade level above 15 m and storing more than 3 million m^3 water have even bigger environmental effects (Degu, et al., 2011: 1). In areas where large dams are constructed, the amount of irrigated agricultural areas rapidly increases, which in turn provides raw materials for the industry. Besides, energy shortage problem is solved thanks to the hydroelectric power, floods-overflows are mitigated and thus densely populated areas emerge around dams. As a result, dams become a key to economic development for many regions. Due to brilliant economic benefits of dams for surrounding regions, often political concerns come to the forefront and potential environmental impacts are overlooked during planning and construction stages (Boakye, 2001: 17). As a matter of fact, negative ecological impacts of many large dams overweigh their economic contributions due to their short economic life cycle (70-100 years) (Strahler and Strahler, 2006: 557). As an example, there are many dams in Turkey that have already completed their economic life or are facing the threat of siltation (Ertek and et al., 2004: 51; Sönmez, 2012: 222).

Recent studies about positive and negative impacts of dams on the environment often deal with impacts of dams on both local and regional climate. In most of the studies carried out in various countries and climatic zones (Tonbul, 1986; Boakye, 2001; Miller, Jin and Tsang, 2005; Correia, Da Silva Dias and Da Sılva Aragao, 2006; Yılmaz, 2006; Degu, et al., 2011; Kellogg and Zhou, 2014), it was found out that dams often affect the climate at local level. These studies show that humidity rates increases in close surrounding of especially large dams and annual temperature differences decreases; however, precipitation values did not vary significantly. The amount of change in the rate of mentioned climatic elements was found to become smaller as distance from dams increased. Contrasting results in these studies can be explained with research method, study data and climate zones selected for the study at a considerable extent. For example, one of these studies was written by Degu et al., (2011) reports the highest extent of influence of large dams on local climate in Mediterranean and semi-arid climates, while such influence is reported at minimum level in humid climates.

In order to find out impacts of dams on surrounding climatic conditions, pre and post data collected from areas which were established 25 or 30 years ago with a certain scale of lake surface need to be studied. Keban Dam is one of the most important examples in Turkey to be considered in this context. The Keban Dam, which is situated on the Euphrates, was started to be planned in 1930s, but its construction was completed after 1970s. Keban Dam is a considerable investment project for both electricity generation and irrigation in Turkey. It seems to be a suitable sample for investigating climatic impacts of dams due to the years passing after completion of its construction in 1970s. Another reason for selecting Keban Dam is the fact that it has a relatively large lake space. Though there are studies investigating the relationship between dams and climate in Turkey (Tonbul, 1986), visible changes were not noted for Keban Dam since it was too early to draw conclusions then. In a study examining the relationship between dams-climate (Kadıoğlu, 1994) by using the Keban, Ağın and Akçapınar stations, considerable differences were not reported in comparison with pre-construction period. In another study carried out on Keban Dam by using the climatic data for the last 60 years (Şengün, 2007), no significant climatic differences were found after 1975 except for a slight tendency to mildness due to changing maximum and minimum temperature during winter. In his study investigating the impact of Keban Dam on climate, (Özkan, 1996) found out that temperature increased in winter while decreasing in summer as a result of the dam construction. Also it was noted that humidity values increased in summer while precipitation values increased in autumn. (Yeşilnacar and Gülşen, 1999) in their study about impact of Atatürk Dam on climatic conditions of Şanlıurfa found no significant changes in temperature or precipitation rates; however, humidity values increased by 25 % especially between April and October. Yeşilata and et al. (2004) researched climatic impact of Atatürk Dam Lake on its region by using the last 30 years' meteorological data for Şanlıurfa and Adıyaman provinces. It was found out that both temperature and humidity values increased in both provinces throughout most of the year due to the construction of the dam (Yeşilata, Bulut and Yeşilnacar, 2004). In another study about impact of Keban, Karakaya and Atatürk Dams on temperature and precipitation, indicators were noted to have a tendency to increase or decrease depending in different periods (Uysal, 2011). In most of the studies, urban central stations were used, which is thought to be an improper selection for demonstrating dams' impact because it is susceptible to external factors. Therefore, in this study, Keban, Çemişgezek and Arapgir stations located in close vicinity of the Keban Dam Lake with low density of population were selected. Data collected from these stations were discussed for two different periods. The first period was between 1964 and 1980, when the dam was built and water was held. During the second period covering the years between 1980 and 2012 following completion of the construction, the dam lake was completely full. Looking at this, effects of Keban Dam Lake on the climate in its surrounding could be indicated more clearly.

Study Area

The study was carried out on Keban Dam, which is located in Upper Euphrates Basin of Eastern Anatolia Region. The dam was built on the deep and narrow valley of Ehrates River around Keban Town of Elazığ province (Figure 1). The dam is situated in 45 km northwest of Elazığ and 75 km northeast of Malatya. Karasu and Murat River reaches flow into the dam lake. Base elevation of the dam is 685 m and subbasement is 845 m. Its depth is around 160 m. On normal water elevation, the lake volume is 31 000 hm^3 and lake area is 675 km^2 (Çolak, 1981). Receiving rainfall and snowfall, the river's flow rate reaches maximum level around the dam due to snow melting between April and June. Keban Dam Lake is the largest artificial lake in Turkey following Atatürk Dam Lake in Turkey. Length of the dam lake is 125 km along the Murat River Valley, and its width varies.

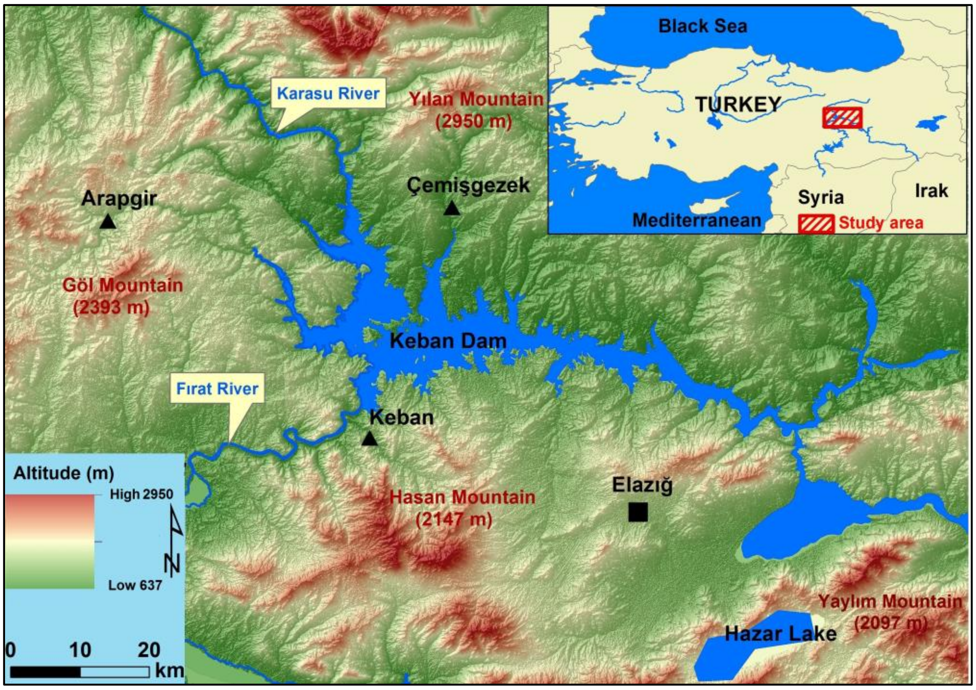

Figure 1. Location map of the study area.

As Keban Dam is within borders of the Upper Euphrates Basin of Eastern Anatolia, it is located on converging point of Tunceli, Malatya and Elazığ provinces. The dam is bordered by the Göl Mountain (2393 m) in the east, the Munzur Mountains (Yılan Mountain 2950 m) in the north and the Hasan Mountain ranging from east to west (2147 m), the Yaylım Mountain (2097 m) and the tectonic Lake of Hazar in the south. Keban Dam is situated on a narrow and deep valley where Permo-carboniferous aged calcschist and marbles contact. There are water leakages in this area of karstification. Upon holding of water in the dam, the leakages became active and much was spent in order to prevent these so that such expenditures doubled the total cost of the dam (Özdemir and Özgen: 67).

Climate

It is milder in the stations than their surrounding because they are located within a valley channel. Steppe climate is dominant in overall area. Situated far from warming effect of seas and having little unevenness elevation due to the surrounding mountains, this area receives little precipitation, and semi-arid climate is seen. As a consequence of continentality, the radiation intensity difference is high between seasons (Koçman, 1993: 79). Annual temperature averages are recorded as 11.9 ºC in Arapgir, 14.9 ºC in Keban, and 13.5 ºC in Çemişgezek (Figure 2). In January, temperature average decreases to -2 and 1.5 ºC (Arapgir -1.8 ºC, Keban 1.3 ºC, Çemişgezek 0 ºC). Despite high thermic values in summer, temperature average in July remains even below 30 ºC (Arapgir 25.2 ºC, Keban 29.1 ºC, Çemişgezek 27.2 ºC).

In general, due to the movement of polar air above Turkey towards east throughout the year, maximum precipitation is seen in winter and spring in this area. In end-summer, when polar air is completely replaced by tropical air mass, drought is seen across the study area. Total precipitation values vary among stations. For example, high elevation around Arapgir and Çemişgezek stations induces more precipitation than the precipitation level in Keban (Arapgir 756 mm., Keban 385.9 mm., Çemişgezek 568.8 mm.) (Figure 3).

Humidity values are not high in this area due to elevation and continentality factors (Arapgir and Keban 52 %, Çemişgezek 53 %) (Figure 4). Also seasonal distribution of relative humidity value ranges. Lastly, humidity values reach minimum levels since temperature increases in all of the three stations during summer.

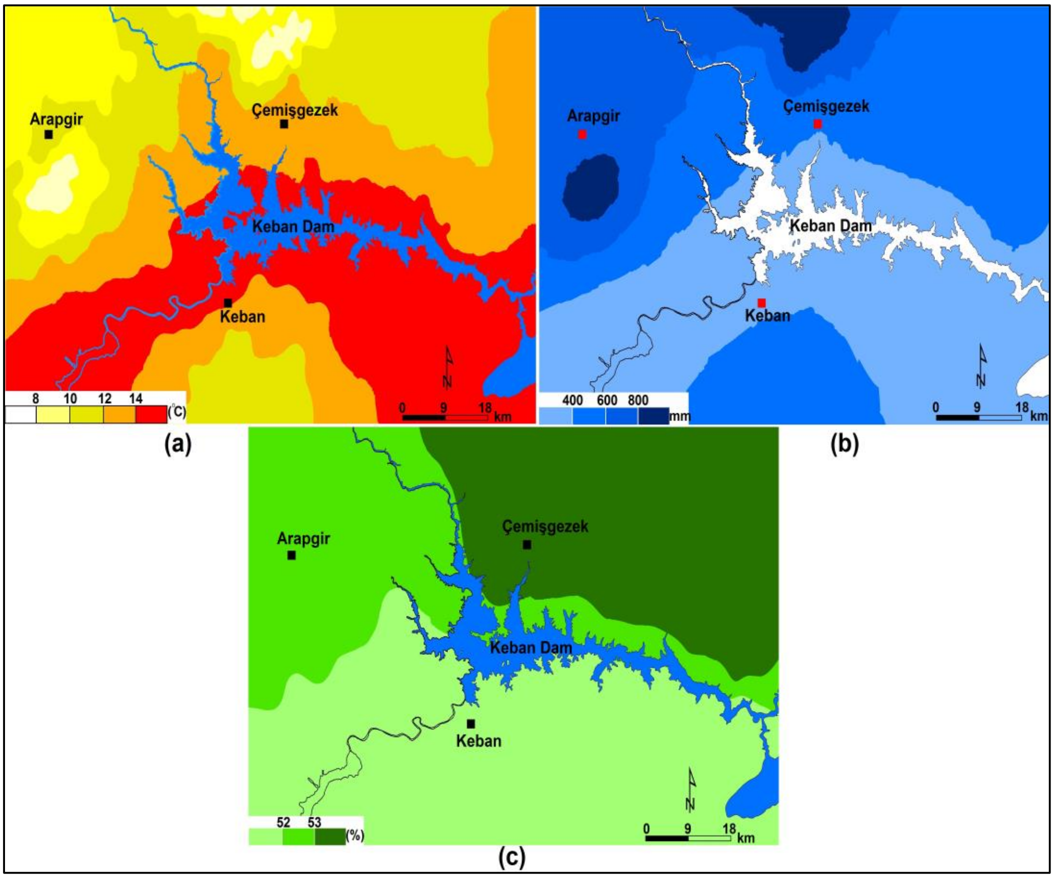

Figure 2. (a) Distribution of average temperature of the study area. (b) Distribution of precipitation of the study area. (c) Distribution of relative humidity of the study area.

Method

This study investigates whether or not climatic changes occur in the area surrounding Keban Dam against temporal and spatial parameters. For this, temperature, humidity and precipitation values were compared in stations close to the dam and distant from it. Trend analysis method was used in this study to distinguish temporal and spatial differences. In this study, two non-parametric methods (Mann-Kendall rank correlation test and Sen's slope estimate) were used to detect the meteorological variables' trends. Nonparametric analysis such as Sen's Slope Estimate, which shows the change more precisely in trend analysis and also allows analysis of missing data, and Mann-Kendall rank correlation test were used. Critical values are identified as 1.96 (at 5 % level) and 2.58 (1 %). As a part of the method, pre- and post-dam data were compared as before and after 1980. Three stations which can be regarded homogenous in climatic sense were used in the study. Of these stations, Keban (Elazığ) is located close to the dam, Çemişgezek (Tunceli) is in a location close enough to be affected from the dam, and Arapgir (Malatya) is taken as the relatively distant station. Spatial distribution of the selected stations in the map is shown in Figure 1. For both climatic parameters, the data for 49 years covering the period between 1964 and 2012 were used in the study.

Findings

Sen’s Slope Estimate, which is applied to climate parameters, and Mann-Kendall rank correlation test were implemented. The results showed that there is the great similarity between the statistical results from the Mann-Kendall and Sen's Slope Estimate statistical methods. In this study, significance levels were determined as 0.001 (99%), 0.005 (95%) and 0.1 (90%).

According to results of the analysis, following changes were observed in climate parameters before 1980 (dam construction and water holding period) and after 1980 (after dam construction and fullness of dam):

Temperature

In the light of the study findings, on the annual time scale, temperature averages increased significantly after 1980 (during the period following 1980). In stations, observable increases were seen in temperature during summer time in post-dam period. The increase of temperature averages in Arapgir is applicable for the cold period as well (Table 1). Nevertheless, temperature increase in Keban and Çemişgezek stations, which are located close to the dam, was not significant during the cold period. Even the trend seemed to have a negative direction at Keban station during some months, though not significant. The magnitude of statistically significant trends on a monthly scale was determined using Sen’s Slope Estimator (Q). A positive Q value represents an increasing trend; a negative value represents a decreasing trend over time. The results show that slopes at all stations were generally positive compared to before 1980. For the post-dam period, the magnitudes of the significant increasing trends in annual average temperature ranged between 0.03 °C/year in Keban and 0.05 °C/year in Arapgir. On the annual time scale, temperatures were statistically significant increasing trends at all stations for the post-dam period. But there were no spatial differences among stations. These significant trends can be explained by natural factors or the different microclimates.

Table 1. Mann-Kendall Rank Correlation Test and Sen's Slope Estimate results in the time series data of average temperature for pre-dam and post dam periods.

	Çemişgezek (Average Temperature)						Arapgir (Average Temperature)					
	Pre-dam			Post-dam			Pre-dam			Post-dam		
Months	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q
1	0,00		0,00	0,57		0,03	0,38		0,05	0,59		0,02
2	1,16		0,23	1,49		0,06	0,57		0,10	1,97	*	0,09
3	-0,25		-0,01	1,91	+	0,07	1,10		0,09	1,69	+	0,09
4	0,80		0,09	1,52		0,04	0,15		0,01	1,26		0,04
5	-0,31		-0,02	1,12		0,04	1,02		0,06	1,41		0,05
6	-0,31		-0,04	3,19	**	0,07	0,68		0,04	3,07	**	0,07
7	0,24		0,04	1,79	+	0,03	1,21		0,09	2,25	*	0,05
8	0,92		0,06	2,75	**	0,07	0,80		0,08	2,74	**	0,08
9	-0,06		-0,01	-0,39		-0,01	1,14		0,08	0,56		0,02
10	-0,18		-0,04	1,52		0,05	-0,27		-0,01	2,00	*	0,05
11	0,18		0,04	1,95	+	0,08	0,61		0,06	2,33	*	0,09
12	0,43		0,09	0,03		0,00	-0,42		-0,01	0,11		0,00
Annual	0,61		0,03	2,94	**	0,04	1,48		0,08	3,86	***	0,05

Keban (Average Temperature)					
Pre-dam			Post-dam		
Test Z	p	Q	Test Z	p	Q
-0,27		-0,05	-0,11		-0,01
0,30		0,08	0,82		0,03
0,91		0,07	1,41		0,05
-0,23		-0,02	0,17		0,00
0,00		0,00	1,32		0,05
0,23		0,02	3,42	***	0,06
0,84		0,07	1,52		0,04
0,04		0,00	2,19	*	0,06
0,61		0,05	-0,06		0,00
0,34		0,03	1,47		0,04
0,38		0,05	1,60		0,06
0,00		0,00	-0,37		-0,02
0,83		0,04	2,29	*	0,03

Z: Mann-Kendall Test, Q: Sen's Slope Estimator, p: Significance,

* Statistically significant trend at 5%significance level

** or *** Statistically significant trend at 1%significance level

+ Statistically significant trend at 10% significance level

Precipitation

In none of the stations, significant changes were seen in direction or magnitude of the trend concerning annual total precipitation. Table 2 shows the spatial variation in the precipitation time series for each month at stations. Despite an increase/decrease in overall amount of precipitation during some months, it was not found significant. Additionally, significant changes were reported by 5 % in Keban in the hot season. While the trend observed in June had a negative direction, it was seen to be positive in August.

Q and Test Z values were consistent with each other. Even though applicable for Çemişgezek also, the trend was not notable there. However, after the dam construction, Sen's slope estimate Q values turned from negative to positive or magnitudes of negative trends decreased compared to before 1980.

Table 2. Mann-Kendall Rank Correlation Test and Sen's Slope Estimate results in the time series data of precipitation for pre-dam and post dam periods

	Çemişgezek (Precipitation)						Arapgir (Precipitation)						Keban (Precipitation)					
	Pre-dam			Post-dam			Pre-dam			Post-dam			Pre-dam			Post-dam		
Months	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q
1	0,24		0,90	1,84	+	0,99	0,78		3,22	1,77	+	1,68	-0,68		-1,12	1,83	+	0,66
2	-0,49		-2,72	-0,14		-0,08	-0,54		-2,50	0,70		0,66	-1,55		-2,00	-0,02		-0,04
3	-0,24		-0,27	-0,45		-0,25	-0,54		-1,58	-0,70		-0,57	-0,45		-0,76	-0,20		-0,10
4	0,61		3,54	0,60		0,52	0,37		0,80	-0,23		-0,25	-0,08		-0,08	1,44		1,03
5	0,24		0,84	-0,34		-0,05	0,62		0,98	-0,02		-0,01	-0,30		-0,81	-0,79		-0,44
6	-0,24		-0,34	-1,49		-0,34	-0,21		-0,23	-0,26		-0,07	-0,98		-0,95	-2,20	*	-0,57
7	-0,58		0,00	1,44		0,02	-0,64		0,00	-0,03		0,00	-0,08		0,00	1,55		0,03
8	-0,35		0,00	1,88	+	0,00	0,86		0,00	-0,29		0,00	-1,21		0,00	2,23	*	0,02
9	-0,18		-0,02	1,23		0,09	-1,48		-0,55	1,50		0,26	-0,76		-0,10	1,10		0,07
10	0,18		0,49	0,42		0,22	0,49		1,43	-0,14		-0,03	-0,45		-1,30	0,15		0,04
11	-0,92		-2,66	-1,24		-1,02	-1,28		-3,69	-1,41		-1,65	-0,76		-0,95	-0,50		-0,27
12	1,04		3,73	0,09		0,01	-0,21		-0,49	0,20		0,20	-0,30		-0,12	0,29		0,10
Annual	-0,18		-0,57	0,51		1,31	-0,45		-4,81	0,11		0,41	-1,14		-0,68	0,48		1,12

Z: Mann-Kendall Test, Q: Sen's Slope Estimator, p: Significance,

* Statistically significant trend at 5% significance level

** or *** Statistically significant trend at 1% significance level

+ Statistically significant trend at 10% significance level

Humidity

Humidity factor yielded more precise results than the other climate parameters at selected stations. To make it clear, though magnitude of the trend varies depending on the station before the dam, humidity values were seen to change significantly (Table 3). While decreasing trend in distant Arapgir station was not significant before the construction of the dam, it was seen to change in a negative direction by 1 % after the construction. The level of relative humidity showed a decreasing tendency in Çemişgezek before the dam construction (before 1980); however, the trend entered in an opposite direction after 1980, when the dam lake was completely full. Changes were observed in not only direction but also magnitude of the trend (1 %). Besides, significant increases were not seen at Keban station around the dam. However, strong trends having a negative direction disappeared after settlement of the dam creating more humid climate conditions.

Factors affecting annual temperature difference on the Earth are geographical latitude, distribution of lands and seas, orography and elevation, specific temperature in the region, albedo and humidity (Sezer, 1990). High amount of humidity in a specific region causes decreasing of annual temperature difference (amplitude) in that region. In present study, trends of temperature differences were compared at stations before and after the dam in order to find out the impact of humidity. For this purpose, the difference was found between temperature averages in the hottest (July) and the coldest season (January), and trend analysis was made to demonstrate the period pre and post dam. According to the results of Mann-Kendall trend analysis, Z values in Arapgir were 0.08 before the dam, whereas it increased to 0.5 after the dam. However, the values of 0.53 at Keban remained unchanged after the dam. Similarly, analysis of the amplitude values in Çemişgezek shows that the value changed from 0.48 to 0.5 before and after dam. Thus, it can be suggested that annual temperature difference increased in Arapgir following construction of the dam and changes were not seen at Keban or Çemişgezek stations.

Table 3. Mann-Kendall Rank Correlation Test and Sen's Slope Estimate results in the time series data of relative humidity for pre-dam and post dam periods

	Çemişgezek (Relative Humidity)						Arapgir (Relative Humidity)					
	Pre-dam			Post-dam			Pre-dam			Post-dam		
Months	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q	Test Z	p	Q
1	-1,77	+	-0,96	3,87	***	0,38	0,87		0,54	-1,75	+	-0,31
2	-1,77	+	-0,84	2,91	**	0,40	-0,80		-0,12	-1,29		-0,19
3	-1,16		-0,53	0,67		0,06	-0,91		-0,31	-2,84	**	-0,45
4	-1,04		-0,25	3,07	**	0,44	0,57		0,30	-1,78	+	-0,29
5	0,43		0,17	1,80	+	0,27	-0,72		-0,18	-1,33		-0,28
6	0,06		0,08	1,66	+	0,28	-2,01	*	-0,43	-3,13	**	-0,32
7	-0,31		-0,09	2,06	*	0,32	-1,93	+	-0,71	-2,70	**	-0,30
8	-0,67		-0,13	1,77	+	0,29	-1,63		-0,42	-2,56	*	-0,29
9	-0,79		-0,36	2,96	**	0,54	-0,64		-0,15	-0,22		-0,01
10	-0,79		-0,69	1,50		0,36	0,04		0,01	-0,62		-0,10
11	-2,14	*	-0,81	1,75	+	0,24	0,19		0,03	-2,71	**	-0,44
12	-2,01	*	-0,57	2,49	*	0,34	0,95		0,25	-2,15	*	-0,37
Annual	-1,53		-0,35	2,22	*	0,33	-0,42		-0,06	-3,77	***	-0,29

Keban (Relative Humidity)					
Pre-dam			Post-dam		
Test Z	p	Q	Test Z	p	Q
-0,98		-0,40	1,57		0,13
-0,98		-0,43	1,46		0,15
-0,38		-0,32	-1,29		-0,16
0,38		0,16	0,90		0,08
0,42		0,19	-0,57		-0,07
0,30		0,16	-1,67	+	-0,19
1,29		0,38	-0,50		-0,04
1,52		0,60	-0,40		-0,05
0,76		0,32	1,04		0,14
-0,53		-0,19	1,33		0,21
0,23		0,11	-0,71		-0,07
-0,53		-0,15	1,13		0,08
-0,23		-0,05	0,36		0,02

Z: Mann-Kendall Test, Q: Sen’s Slope Estimator, p: significance,

* Statistically significant trend at 5% significance level

** or *** Statistically significant trend at 1% significance level

+ Statistically significant trend at 10% significance level

Conclusion

In this study, temperature, precipitation and humidity parameters around Keban Dam Lake were compared before (1964-1980) and after (1980-2012) building of the dam in order to find out its impacts on the climate in its close vicinity:

Results from both statistical tests, Mann-Kendall and Sen’s Slope Estimate, were consistent with each other. The amount of change in the rate of climatic elements, especially humidity, was found to become smaller as distance from dams increased.

According to the analysis of *temperature averages* at selected stations, average values were observed to increase significantly especially during the hot season after construction of the dam. In Arapgir, which is a distant station, temperature rise was observed also in cold season, while nonsignificant negative trends were reported in the other stations. As change of temperatures did not vary significantly from temporal and spatial aspects, it cannot be said that changes were seen as a consequence of the dam.

Regarding *precipitation* values, though direction of the trend varied from month to month at all stations, observed changes were not significant. In other words, significant changes were not determined in precipitation values dependent or independent on existence of the dam.

In the second period, drastic decrease was observed in the level of *relative humidity* in Arapgir, which is a station distant from the dam lake, while the case was opposite in Çemişgezek. Likewise, humidity values had a tendency to increase at Keban station. Whereas relative humidity was likely to decrease significantly before the dam, it was replaced by nonsignificant decreases after the dam. In other terms, humidity values had a tendency to increase as a result of the dam. It can be suggested that construction of the dam introduced more humid conditions to local climate in the region and it is expected to continue.

Assuming that the increase in humidity might cause decreasing of *temperature difference,* temporal course of annual temperature differences (amplitude) was compared between periods before and after 1980. As a result, changes were not seen in amplitude values at stations close to the dam. On the contrary, in Arapgir, annual temperature differences show a tendency to increase upon construction of the dam.

In this study, generally, while significant trend changing detected for all parameters in the post-dam period, was not significance in pre-dam period. This can be interpreted as the effect of the dam construction. Therefore, it is expected that large dams will create their own local climatic conditions in the future.

As a conclusion, it can be argued that changes were not seen in local climate of the area except for increasing humidity values due to building of the dam. If relative humidity continues to increase in the future, significant changes can be seen in temperature differences, which could reveal differences in microclimate of the region even more clearly.

It seems likely that the studies investigating the interaction between dams and climate can yield misleading results since they collect data at urban stations. Such stations do not seem to be the proper sites for data collection as they are affected by many variables (climate changes, urbanization, etc.). Therefore, it is crucial that data should be collected especially from various locations close to the dam in order to find out effects of dams on the climate. The variability of negative and positive trends at various stations points to the need for more meteorology stations to detect the dams' effects on local climate. Also it can be added that using more sensitive statistical methods could yield more accurate results.

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