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İKLİM DEĞİŞİKLİĞİNİN SU KAYNAKLARINA ETKİSİ VE GELECEK YAKLAŞIMI

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Özet

Su kaynakları üzerindeki stres nasıl en aza indirilecek ve su kaynakları sürdürülebilir bir şekilde genç nesillere nasıl aktarılacak, mevcut büyüme hızı, değişen su tüketim alışkanlıkları ve artan su talebi ve iklim değişikliğinin su kaynakları üzerindeki olumsuz etkilerine nasıl uyum sağlayacağımız gibi çeşitli tehditler altında, içinde bulunduğumuz yüzyılın en önemli insanlık sorunlarıdır.

İklim değişikliğinin su mevcudiyeti ve hidrolojik riskler üzerindeki etkilerinin yanı sıra, su kalitesi üzerindeki sonuçları henüz araştırılmaya başlanmıştır. Bu çalışmada iklim değişikliğinin su kalitesi üzerindeki etkilerini açıklayan ana faktörler belirlenerek parametre değerlerini (fiziko-kimyasal parametreler, mikro kirleticiler ve biyolojik parametreler) değiştiren kaynakların (nehirler ve göller) su kalitesi üzerindeki etkileri incelenecektir. Ardından, içme suyu üretimi ve tedarik edilen suyun kalitesi üzerindeki beklenen etkiler tartışılacaktır. Çıkarılabilecek temel sonuç, iklim değişikliği bağlamında içme ve kullanma suyu kalitesindeki bir bozulma eğiliminin, potansiyel sağlık etkisine bağlı riskli durumların artışına yol açtığıdır.

Su kaynakları, aşırı nüfus ve mevcudiyetlerini tehlikeye atan aşırı tüketim gibi çeşitli stres faktörlerinden etkilenir. Bu stres faktörlerinin, havzalar ve nehir sistemleri üzerinde doğrudan etki ile dünyanın çoğu bölgesinde iklim değişikliği nedeniyle giderek yoğunlaşması beklenmektedir. Nehir akışının %75 azalmasıyla nehir suyundaki nitrojen ve fosfor konsantrasyonları sırasıyla %500 ve %200 artacağı yapılan çalışmalarla belirlenmiştir. Bu farklılıklar, sürdürülemez uygulamalar ve artan teknolojiye bağımlılıkla işaretlenmiş nüfus artışı ve tarımsal genişleme gibi artan baskıları dikkate alan olay örgülerinde daha belirgindir. Bu çalışmanın sonuçları, gelecekteki olası bir sonucu işaret etmekte ve Kızılırmak Nehri havzasındaki iklim değişikliğinin ve buna karşılık gelen çevresel baskıların etkilerine karşı koymak için su yönetimi politikalarının formülasyonu için etkili kılavuzlar sağlamaktadır.

Anahtar Kelimeler: İklim değişikliği, su kaynakları, kalite, çevre, baskı

IMPACT OF CLIMATE CHANGE ON WATER RESOURCES AND FUTURE APPROACH

Abstract

Under various threats such as how to minimize the stress on water resources and how to transfer water resources to younger generations in a sustainable way, how to adapt to the current growth rate, changing water consumption habits and increasing water demand and the negative effects of climate change on water resources are the most important human problems.

The effects of climate change on water availability and hydrological risks, as well as its consequences on water quality, have just begun to be investigated. In this study, the main factors explaining the effects of climate change on water quality will be determined and the effects of sources (rivers and lakes) that change parameter values (physico-chemical parameters, micro pollutants and biological parameters) on water quality will be examined. Next, the expected effects on drinking water production and the quality of supplied water will be discussed. The main conclusion that can be drawn is that a trend of deterioration in drinking and utility water quality in the context of climate change leads to an increase in risky situations due to potential health effects.

Water resources are affected by various stress factors such as overpopulation and overconsumption that compromise their availability. These stressors are expected to intensify increasingly due to climate change in most regions of the world, with a direct impact on basins and river systems. Studies have shown that with a 75% decrease in river flow, nitrogen and phosphorus concentrations in river water will increase by 500% and 200%, respectively. These differences are more evident in plots that take into account increasing pressures such as population growth and agricultural expansion, marked by unsustainable practices and increased dependence on technology. The results of this study point to a possible future outcome and provide effective guidelines for the formulation of water management policies to counter the effects of climate change and corresponding environmental pressures in the Kızılırmak River basin.

Keywords: climate change, water resources, quality, environment, stress.

1. INTRODUCTION

It is impossible for living things to continue their lives without water, which is an indispensable natural resource for the continuity of vital activities and whose importance is increasing day by day. The decrease in water resources, which is one of the most important consequences of climate change, reaches dimensions that prevent sustainable life. The effects of climate change directly and indirectly affect water resources, which further increases the importance of water resources. (Yazıcı vd., 2019). Climate change affects not only the quantity but also the quality of water resources. Due to the increase in temperature and the decrease in precipitation and currents, pollution concentrations increase and bring water quality problems. Droughts and heavy rainfall put pressure on water quality. Decreased water levels in streams and lakes during the dry months increase the pollution load, especially from point sources (for example, from a factory), which leads to a decrease in water quality (Yazıcı et al., 2019).

Climate change has significant effects on the hydrological cycle and local-regional-global management and distribution of water resources. These effects are expected to occur very slowly and over many years. There are many changes in river flows throughout the year, river flow regimes change and the frequency of natural disasters such as floods and droughts increases. (Uzmen, 2007). Increasing consumption demands on water resources and having sustainable features that will provide equal benefits to those who benefit from the resources require the river basins to be handled as a whole starting from the source and the current pollutant sources in the basin to be evaluated.

Studies show that climate change will play a restrictive role in water resources in basins. In general, the significant effects of climate change on water resources depend on the regions where the basins are located; decrease or increase in surface water potentials, change in the recharge and discharge of underground aquifers, change in the frequency of extreme currents (floods and drought), change in the seasons and sizes of their occurrence, changing precipitation regime, erosion problems caused by vegetation and land use, flow of rivers fed by snow waters. This is summarized as an increase in agricultural water requirements (Turkes, 1994).

This study aims to determine to what extent the flow changes in stations in the Kızılırmak Basin, one of the important basins of Turkey, are related to climate change and drought index. For this purpose, 3, 6, 9 and 12-month drought values were determined by the Flow Drought Index (SDI) method from the monthly total flow data obtained from the Flow Observation Station D15A026 located in the Kızılırmak Basin.

2. MATERIALS AND METHOD

2.1.General Information About the Kizilirmak Basin

Located in the eastern part of Central Anatolia, Kızılırmak is one of the 26 basins in Turkey. It is the longest river that was born in Turkey and empties into the sea in Turkey. While passing through the provinces of Sivas, Kayseri, Nevsehir, Kırsehir, Kırıkkale, Ankara, Çankırı, Çorum and Samsun, it collects the waters of many streams and streams and reaches the Black Sea from Bafra cape (Köse et al., 2011; Bahardır, 2011; Çakmak, 2002). The map of the Kızılırmak Basin is given in Figure 1.

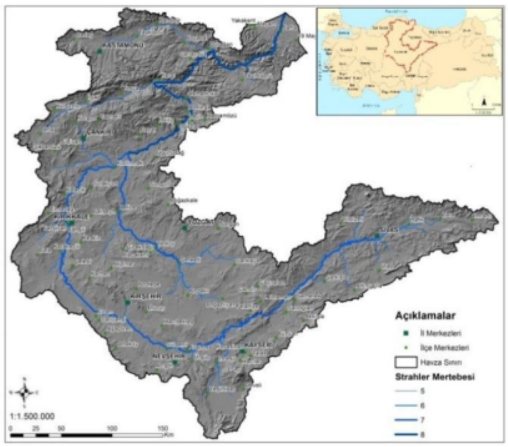

Figure 1. Kızılırmak River Basin

Summers are dry in the basin. Rains fall in the winter and spring periods. The Central Anatolia region is a region where drought is experienced intensely in Turkey. Since this region is surrounded by mountains, it is under the influence of a continental climate with hot and dry summers and cold and snowy winters. The average air temperature is 13.7 °C. Annual rains vary between 300 and 800 mm. After the Euphrates, the Kızılırmak is the largest river in Turkey's water storage area. Kızılırmak constitutes 3.5% of Turkey's water potential with an annual flow volume of 6.48 billion m3. This river, which takes its source from rain and snow waters, has an irregular regime. While the water regime reaches its highest level in April, it flows at the lowest water level between July and February (Çakmak, 2002; Bacanlı et al., 2012).

The Kızılırmak basin, chosen as the study area, has an annual average flow of 5.18 x 109 m^3 (2.09 L/s.km^2) and constitutes ~2.82% of Turkey's surface water potential. The usable part of this is estimated as ~ 2.59 x 109 m^3/year by taking the average usable surface water rate of ~50% (Tubitak MAM, 2010).

2.2. Study Data

In order to analyze the occurrence of drought in the Kızılırmak Basin with the flow drought index (SDI) method, the monthly average flow values of station D15A026 seen in Table 1 were required. For this purpose, the average flow values of the stations in the region for the period of 1991-2015 were obtained from DSI.

Table 1. Characteristics of the station located in the Kızılırmak Basin

Station No	Station Name	Years of Observation	Latitude	Longitude	Level (m)	Drainage Area (km^2)
D15A026	Engiz S. Ballıca	1991-2015	36° 4' 3"	41° 29' 11"	15	151,40

2.3. Determination of flow values by Stream Drought Index (SDI) Method

The river drought index, known as the hydrological drought index, is determined according to the relationships given in Nalbantis and Tsakiris (2009). If we define the flow of any month (j) of any hydrological year (i) with Qij, the time series of cumulative stream flows (Vi,k) is obtained from equation 1:

$$V_{i,k} = \sum_{j=1}^{3k} Q_{ij} \qquad i=1,2\ldots,N \qquad j=1,2,\ldots,12 \qquad k=1,2,3,4 \qquad (1)$$

Vi,k gives the cumulative amount of flow for the k-reference period of the hydrological year. N denotes the number of hydrological years. The k-reference period reflects the October-December period when k=1, the October-March period when k=2, the October-June period when k=3 and the October-September period when k=4. Here, the cumulative flows for the October-September period represent annual flows.

SDI values are obtained from equation 2 given below according to cumulative stream flow (Vi,k) four times per hydrological year, depending on each k-reference period.

$$SDI_{i,k} = \frac{V_{i,k} - \overline{V}_k}{S} \qquad i=1,2,\ldots,N \qquad k=1,2,3,4 \qquad (2)$$

$\overline{V}_k$ and S give the mean and standard deviation amounts of the cumulative stream flows for the k-reference period. 5 drought classifications defined as non-arid (0) and extremely arid (4) are given in Table 2.

Table 2. Stream Drought Classes (SDI)

State	Drought Definition	SDI
0	No Drought	$SDI \geq 0.00$
1	Slightly Dry	$-1.0 \leq SDI < 0.0$
2	Moderately Dry	$-1.5 \leq SDI < -1.0$
3	Severe Drought	$-2.0 \leq SDI < -1.5$
4	Extremely dry	$SDI < -2.0$

3. RESULTS AND DISCUSSION

Flow drought index (SDI) results of monthly flow data of the Kizilirmak Basin D15A026 flow observation station between the years 1991-20015 are given below. The graphs of the SDI values obtained for the reference periods of this station for the hydrological year are given in figure 2 for periods of 3-6 months, in figure 3 for periods of 6-12 months, and figure 4 for periods of 9-12 months.

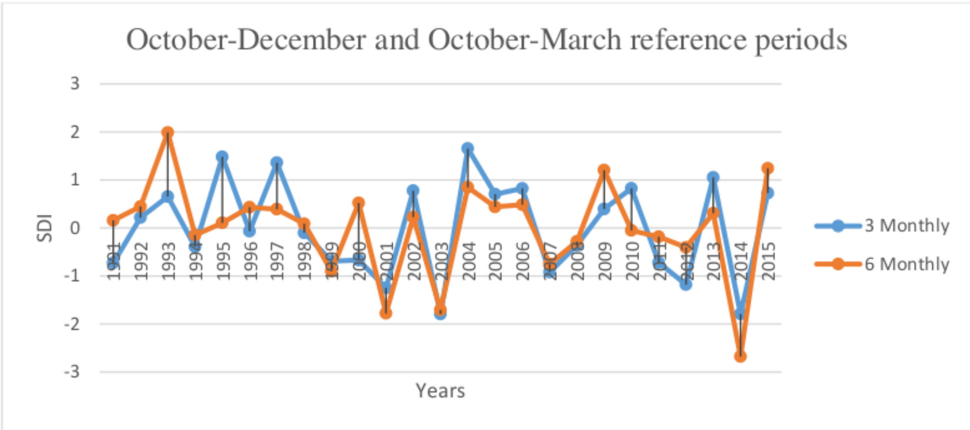

Figure 2. SDI values for the October-December and October-March reference periods

When Figure 2 is examined, 11 wet periods in 3-month periods and 13 wet periods in 6-month periods were determined at this station. Especially between 1998 and 2003, it was observed that drought was experienced in the 3 and 6 month periods. The reason for this is that there is a decrease in the precipitation falling into the basin and with this decrease, the river reservoir does not reach the desired level. It is a fact that as the drought duration increases, the drought severity will increase at a similar rate and the water user will suffer. It was determined that there were wet periods between 2004 and 2007 in only 6-month shifts in the mentioned periods. Dry periods were found in both periods after 2002 when climate change was felt. The drought indicator in river flows will reveal important problems related to the supply and use of water. The most important of these problems is foreseen as domestic water usage needs.

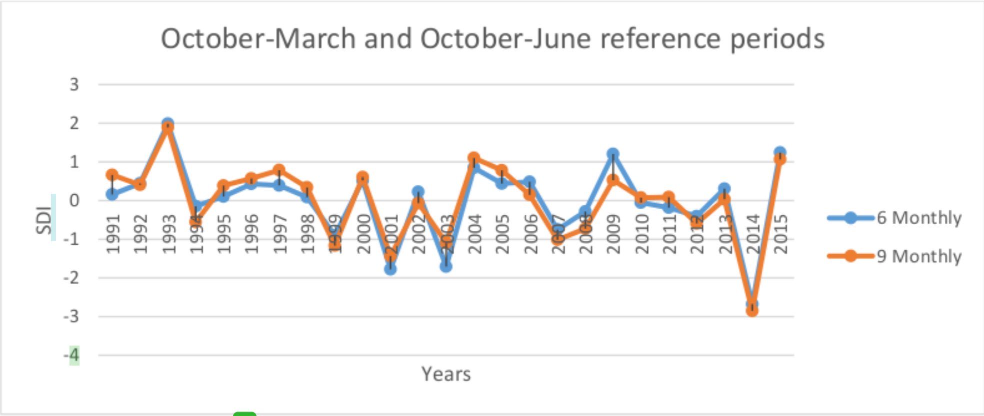

Figure 3. SDI values for the October-March and October-June reference periods

When Figure 3 is examined, no difference was found in terms of drought values (for 6 and 9 months data). This situation shows that the second 6-month periods may be dry in our country, which is located in the Mediterranean Region. A similar result was found by Nalbantis et al. (2009) and Yurekli et al. (2009) as well. The result is that the SDI values show that there is drought in the case of 9-month shift. The change in currents in long-term periods is a phenomenon that triggers drought. In both periods, it is seen that there is drought after 1998-2004 and 2006. Drought values occurring in 9-month periods indicate moderate and severe drought.

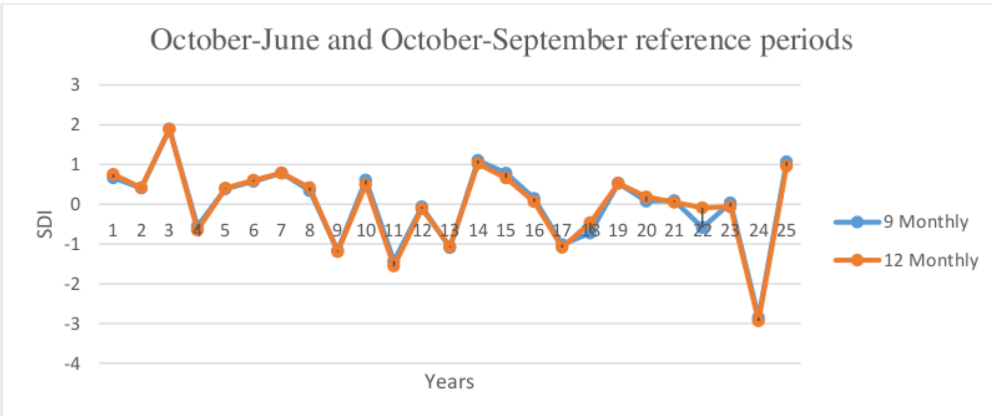

Figure 4. SDI values for the October-June and October-September reference periods

When Figure 4 is examined, it has been determined that there is no difference in terms of drought values (for 6 and 12-month data) compared to the previous 3-month period. 13 wet periods in the 6-month period and 12 wet periods in the 12-month period were determined. Dry periods increased in both periods after 2002 when climate change was felt.

4. CONCLUSION

When the hydrological drought analysis of the basin is made according to the Flow Drought Index (SDI) method, using the monthly average flow values of the observation station for the period 1991-2015; As can be seen from the graphs for the aforementioned periods in the flow observation annuals determined at station D15A026, it has been determined that there is an increase in SDI values as the drought period increases. In other words, as the duration of drought increases, its severity also increases. As a result of the evaluations made for the flow observation station, it was determined that there was a severe dry period between 1999 and 2004, and an extremely dry period between 2013 and 2015.

It is seen that the drought, which is calculated due to the lack of flow, poses a very serious threat in the world and in our country in recent years due to the global climatic differences and changes. For this reason, it is necessary to monitor the drought by a center and to prepare drought action plans for each sector. In addition, it is recommended to consider meteorological drought studies in terms of monitoring water resources, determining their effects and creating management models.

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