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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Assessment of Drought Hazard of Yapıaltın Dam Lake (Sivas-Türkiye) According to the Water Occupancy Rates of the Last Thirteen Years

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Abstract: Global problems affect all living things. Global warming and the resulting global climate change affect the natural balance in the systems and processes of the hydrobiological cycle. The number one factor necessary for the continuation of life on earth is water. But the world has been in danger of drought for a very long time. Drought danger is a serious problem that can lead to a decrease in biodiversity, drying of vegetation, soil erosion, decrease in agricultural production, decrease in water resources and water scarcity. Yapıaltın Dam Lake was established between 1975-1977 for agricultural irrigation and flood protection. This research focused on the assessment of drought hazard in Yapıaltın Dam Lake according to the water occupancy rates of the last thirteen years. For this reason, the data of the water occupancy rates in Yapıaltın Dam Lake for the years 2010-2022 were presented and evaluated in this research. As a result, the average water fill rate of Yapıaltın Dam Lake, which has fallen below 20 percent compared to the last thirteen years, carries a potential risk for agricultural irrigation. For this reason, the waters of the Yapıaltın Dam Lake should be used more consciously than ever before and classical irrigation methods should be abandoned.

Keywords: Climate change, drought, global warming, water occupancy rates, yapıaltın dam lake.

Yapıaltın Baraj Gölü (Sivas-Türkiye)'nün Son On Üç Yıllık Su Doluluk Oranlarına Göre Kuraklık Tehlikesinin Değerlendirilmesi

***Sorumlu yazar:**
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Öz: Küresel sorunlar tüm canlıları etkilemektedir. Küresel ısınma ve bunun sonucunda oluşan küresel iklim değişikliği, hidrobiyolojik döngünün sistemleri ve süreçlerindeki doğal dengeyi etkilemektedir. Yeryüzünde yaşamın devamı için gerekli olan bir numaralı faktör sudur. Ancak dünya çok uzun zamandır kuraklık tehlikesiyle karşı karşıyadır. Kuraklık tehlikesi biyolojik çeşitliliğin azalmasına, bitki örtüsünün kurumasına, toprak erozyonuna, tarımsal üretimin azalmasına, su kaynaklarının azalmasına ve su kıtlığına yol açabilecek ciddi bir sorundur. Yapıaltın Baraj Gölü, 1975-1977 yılları arasında tarımsal sulama ve taşkınlardan korunma amacıyla kurulmuştur. Bu araştırma Yapıaltın Baraj Gölü'ndeki kuraklık tehlikesinin son on üç yıllık su doluluk oranlarına göre değerlendirilmesine odaklanmıştır. Bu nedenle, bu araştırmada Yapıaltın Baraj Gölü'nün 2010-2022 yıllarına ait su doluluk oranlarına ilişkin veriler sunulmuş ve değerlendirilmiştir. Sonuç olarak son on üç yıla göre yüzde 20'nin altına düşen Yapıaltın Baraj Gölü'nün ortalama su doluluk oranı tarımsal sulama açısından potansiyel risk taşımaktadır. Bu nedenle, Yapıaltın Baraj Gölü'nün suları her zamankinden daha bilinçli kullanılmalı ve klasik sulama yöntemlerinden vazgeçilmelidir.

Anahtar kelimeler: İklim değişikliği, kuraklık, küresel ısınma, su doluluk oranları, yapıaltın baraj gölü.

INTRODUCTION

Using water consciously and making it sustainable should be an important duty of every individual. Water, which is the main element of water resources development studies, can affect our lives in many ways. Controlling or regulating these effects and using them for our benefit is the subject and purpose of water resources development studies. According to the changing conditions of the rapidly developing world, demands for the use of water resources for numerous goals have also increased. On the other hand, the world public has started to act more sensitively to the problems related to water, which is one of the basic elements of the natural environment. This sensitivity has led to a systematic review of all activities directly and indirectly related to the development of water resources and efforts and approaches to improve them have gained great importance in recent years (Keskin & Demir, 2018). In recent years, water scarcity is experienced in many countries and regions. Although the reason for this scarcity stems from natural hydrological conditions, the main reason is the increase, diversification, pollution and climate change in water uses. In response to the increase in food demand due to the world population, climate change stands out as the biggest threat to agricultural food production (Kadioglu et al., 2017). It is estimated that climate change will affect ecosystems, societies and economies, increasing the pressure on all livelihoods and food sources, including the agriculture and fisheries sectors. We are all experiencing the effects of climate change, which sets the agenda all over the world, with droughts occurring one after another or irregularities in the precipitation regime that cause excessive precipitation and floods. In addition, global climate change increases the duration and negative effects of drought by causing excessive increases in temperature and decrease in precipitation throughout the world (Akbas, 2014).

Underground and surface water resources, whose current balance has changed due to climate change, will change significantly in terms of both quantity and quality until they find their new balance. Increasing temperatures and changing precipitation regimes will cause changes in the periodicity, size and spatial distribution of excessive events such as floods and droughts (Vörösmarty et al., 2000). Another effect of climate change in terms of water resources is the changes it will create on water use. In particular, the water needs of the agricultural sector, which benefits from approximately 70 percent of the surface waters, will increase, causing the problems experienced with the energy, industry and drinking water sectors, which are already in competition, to grow even more. The rapidly increasing population and the increase in the energy and water needs of the developing industry will also fuel this competition (Alcamo et al., 2007). One of the most major consequences of global climate change is the danger of drought. It is undoubtedly very important to combat the danger of drought both individually and socially in order to leave a more habitable world to the next generations. There is no research conducted so far examining the water occupancy rates of Yapıaltın Dam Lake. This research was conducted to examine the drought hazard in Yapıaltın Dam Lake from Türkiye according to the water occupancy rates of the last thirteen years. This research is the first and pioneering study on the water occupancy rates of Yapıaltın Dam Lake. According to the data of 2010-2022, the change in water occupancy rates of Yapıaltın Dam Lake was investigated. The findings obtained in the light of the data used in this research will make significant contributions to the sustainability of Yapıaltın Dam Lake.

MATERIAL AND METHOD

The entire research area is inside of the frontiers of Sivas province in the Central Anatolian geographical part of Türkiye (Figure 1). Yapıaltın Dam Lake, which was chosen as the research area, is approximately 80 kilometers away from Sivas city center, to which it is connected. However, the distance between Yapıaltın Dam Lake and Şarkışla district center of Sivas province is 6 kilometers.

Figure 1. Location map of the research area.

Some structural hallmarks of Yapıaltın Dam Lake are given in Table 1. Yapıaltın Dam was built on Çaylak Creek. Yapıaltın Dam was constructed between 1975-1977 for irrigation and flood protection purposes. The height of the dam is 37.00 meters from the creek bed. At normal water elevation, the lake capacity is 14600000 cubic meters and the dam lake area is 1.42 square kilometers. Approximately 1880 hectares of land are irrigated by Yapıaltın Dam Lake (Table 1). The water of Yapıaltın Dam Lake is mostly used for irrigation, flood protection and recreation purposes. Since it is close to Şarkışla district, Yapıaltın Dam Lake and its surroundings are used as a recreation and picnic area. Yapıaltın Dam Lake and its surroundings attract great attention by the people of Şarkışla district, especially in the summer months.

Table 1. Some structural hallmarks of Yapıaltın Dam Lake (SPEP, 2023).

N	Hallmarks of the Dam Lake	Values
1	Province Name	Sivas
2	Built Date	1975-1977
3	Aim	Irrigation and Flood Protection
4	Creek	Çaylak Creek
5	Trunk Fill Type	Soil
6	Height	37.00 m
7	Lake Capacity	14.60 hm^3
8	Lake Area	1.42 km^2
9	Net Irrigation Area	1880 ha

Depending on the planetary factors, the summer season in Türkiye is generally dry, whereas the spring, autumn and winter seasons are rainy. However, the changes in this general table under the influence of local conditions cause some differences in terms of seasonal precipitation (Olgen, 2010). Türkiye is climatically divided into two Mediterranean climate regions and non-Mediterranean climate (Oceanic and Continental climate) regions. The research area enters the Mediterranean climate regions. The Mediterranean climate is a non-tropical climate whose photoperiodism is diurnal and seasonal, with precipitation collected into cold or relatively cold seasons, the dry season being summer and this summer drought matching a maximum summer temperature. In the Upper Kızılırmak Basin, where Yapıaltın Dam Lake is located, the annual average total precipitation in the 1971-2020 period is 435.74 mm, the annual average air temperature is 9.33 °C and the annual average total potential evapotranspiration is 624.00 mm (KBDMP, 2022). In terms of vegetation, the most striking feature of this climate is the presence of a more or less pronounced but always present dry season and the very small amount of summer precipitation associated with high temperatures during this period. This dry season is an extremely important factor for natural Mediterranean vegetation. There is steppe, forest, meadow and rock vegetation in the research area. Almost all of the area is dominated by brown soils and non-calcareous brown soils. As a tree, *Pyrus eleagnifolia* and *Amygdalus orientalis* species are found in places. In addition, species forming the gallery forests such as *Rosa canina*, *Elaeagnus angustifolia*, *Myricaria germanica*, *Salix alba* and *Populus alba*, which are among the species that form the gallery forests in narrow wetlands and in small creek beds where snow waters flow in the spring but dry in the summer, are also seen, although not continuously (Ozturk, 2007). In this research, the last thirteen-year water occupancy rate data for Yapıaltın Dam Lake between the years 2010-2022 obtained from the General Directorate of State Hydraulic Works of the Republic of Türkiye were used (URL, 2024). With these data, the changes in the water occupancy rates of the Yapıaltın Dam Lake in the last thirteen years were analyzed and synthesized in accordance with the purpose of the research. The water occupancy rate of Yapıaltın Dam Lake was calculated as the ratio of the active dam capacity to the total active dam capacity. The occupancy rate of Yapıaltın Dam Lake is expressed in percent (%).

RESULTS AND DISCUSSION

A fluctuation trend was observed in the water occupancy rates of Yapıaltın Dam Lake from 2010 to 2022 (Figure 2). The occupancy rate for 2010 was determined as 16.20 percent. In 2011, the occupancy rate increased to 21.46 percent. In 2012, the lowest water occupancy rate was observed in Yapıaltın Dam Lake with 2.50 percent. In 2013, the occupancy rate increased to 19.20 percent. In 2014, the occupancy rate decreased to 9.00 percent. In 2015 and 2016, the occupancy rate increased to 20.10 percent and 20.60 percent, respectively. The water occupancy rate decreased to 2.80 percent in 2017. In 2018, the occupancy rate increased to 22.90 percent. In 2019, the highest water occupancy rate was found in Yapıaltın Dam Lake with 40.20 percent. In 2020, 2021 and 2022, the occupancy rate decreased to 34.60 percent, 28.60 percent, and 12.4 percent, respectively (Figure 2). The lowest occupancy rate values of Yapıaltın Dam Lake were found as 2.50 percent in 2012, the highest 40.20 percent in 2019 and the average was calculated as 19.27±11.16. This indicates that the water level in Yapıaltın Dam Lake has decreased significantly due to the effect of drought for the last thirteen years. The decrease in water levels of Yapıaltın Dam Lake also poses a serious problem for urban and rural areas trying to meet food and agricultural water needs. Correspondingly, the average water occupancy rate of Yapıaltın Dam Lake, which falls below 20 percent compared to the last thirteen years' water occupancy rates, will pose a potential risk for agricultural irrigation.

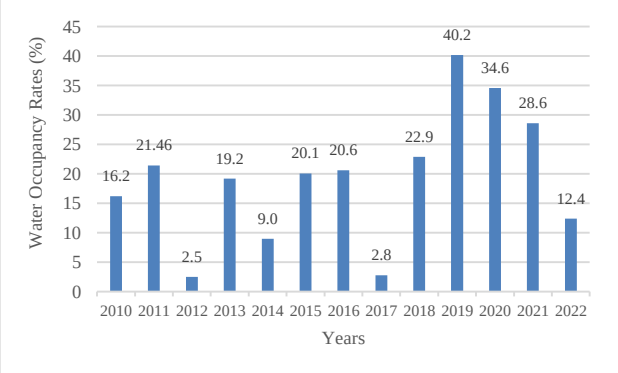

Figure 2. Water occupancy rates of Yapıaltın Dam Lake for the last thirteen years (URL, 2024).

The average water occupancy rate of Maksutlu Dam Lake in Sivas province for the period 2010-2019 was calculated as 16.33 percent by Dirican (2021). Divrik (2022) determined that the average water occupancy rates of Gazibey, 4 Eylül and Pusat-Özen dam lakes in Sivas Province between 2010 and 2019 were 28.58 percent,

31.86 percent and 69.93 percent, respectively. Dirican (2022) determined that the average water occupancy rate of Gölova Dam Lake in Sivas province between 2010 and 2019 was 23.81 percent. The average water occupancy rate of Kılıçkaya Dam Lake in Sivas province for the 2010-2021 period was determined as 38.86 percent by Dirican (2023). Correspondingly, while the average water occupancy rate value calculated for Yapıaltın Dam Lake in this research is higher than the average water occupancy rate value determined in Maksutlu Dam Lake, the average water occupancy rate value determined in Gazibey, 4 Eylül, Pusat-Özen, Gölova and Kılıçkaya dam lakes is lower than the ratio values.

Climate change increases droughts around the world. Countries around the Mediterranean, where the climate is arid and semi-arid, will be most affected by drought. Since drought is a cumulative process, its effects may appear months or years later. In this context, it is not very easy to determine when the drought will begin and when it will end. Drought occurs primarily through meteorology, that is, when rainfall decreases and becomes insufficient. It then progresses as a hydrological, agricultural, social and economic drought (Tatli, 2021). Türkiye's average temperature in 2022 is 14.5 °C, 0.6 °C above the 1991-2020 long-term average of 13.9 °C. There have been positive temperature differences in Türkiye's average temperatures since 2007. However, Türkiye's aerieal average precipitation in 2022 was 503.8 mm, approximately 12.1 percent below the 1991-2020 long-term average of 573.4 mm (CAY, 2023). When at least fifty years of temperature and precipitation data of Sivas province are analyzed, while the general average temperature values increase by 2 ^{o}C, precipitation values decrease in Şarkışla and Ulaş districts of Sivas province (Karakus & Guler, 2022). In Türkiye and Sivas province, water reserves have reached critical levels due to the decrease in average temperature and precipitation in recent years. Drought indicator maps, especially for July, August and September, indicate how widespread and effective the problem is. During the 2010-2022 period, water occupancy rates in Yapıaltın Dam Lake decreased due to increased evaporation and decreased precipitation as a result of increased temperatures due to global warming and climate change. However, the increase in temperatures and decrease in precipitation due to global climate change will affect Yapıaltın Dam Lake with long-term rather than short-term consequences. In this context, every drop of Yapıaltın Dam Lake water should be used wisely and consciously. Measures to reduce evaporation should be taken to reduce water losses due to evaporation by preserving the water quality and water quantity of Yapıaltın Dam Lake.

Drought events are effective in many regions of Türkiye. Water shortage due to drought; It is observed that it affects water resources management at a critical point, including agriculture, energy production, agricultural irrigation, drinking water supply and the activities of other hydrological systems (Turkes, 2012). The research area has both arid and semi-arid sub-very cold and extremely cold bioclimate types. The precipitation regime falls into the second type of the Eastern Mediterranean precipitation regime. This type of rainfall regime is also seen around the province of Sivas. The average annual precipitation in Sivas province is 420 mm and it is classified as semi-arid (Ozturk, 2007). In the last thirteen years, the lowest water occupancy rate of 2.50 percent was observed in 2012 in Yapıaltın Dam Lake (Figure 2). This marks the lowest water level recorded in Yapıaltın Dam Lake in the last thirteen years. Correspondingly, the water occupancy rate of Yapıaltın Dam Lake reached the lowest level in 2012 in Sivas province due to drought. Drought is one of the most harmful and complex natural disasters affecting societies and living organisms in the world. Drought is a recurring phenomenon in Türkiye and is a climatic event frequently observed in Sivas. The effects of drought can vary in both spatial and temporal scales from various economic, environmental and social aspects. Sivas province is among the areas most likely to experience effective drought conditions for short and long periods (Karabulut, 2020).

The fact that the average water occupancy rate of the last thirteen years in Yapıaltın Dam Lake has fallen below 20 percent indicates drought. According to the Thornthwaite climate classification system, Sivas province is generally included in the semi-arid, less humid, first degree mesothermal water surplus in winter and close to moderate marine conditions. Rainfall in Sivas is not evenly distributed throughout the year. Precipitation, which is generally dependent on frontal systems for most of the year, occurs as a result of convective processes in summer. For this reason, the amount of precipitation falls under the influence of local geographical conditions as well as global processes. Evapotranspiration maximums are reached in the summer season, while the minimum values are encountered in the winter season. Rainfall maximums occur in April and May, while minimum values occur in July and August. On the other hand, the highest temperatures occur in July, while the minimum values occur in January. Water supply in Sivas province is largely dependent on precipitation. Precipitation is very limited in the summer months (average 49.15 mm in Sivas) and reaches its highest level in the spring (166.55 mm in Sivas) (Karabulut, 2020). Rainfall in winter is more nutritious than precipitation in summer. Yapıaltın Dam Lake is used extensively for agricultural irrigation, especially in summer. An unusual drought was experienced in Yapıaltın

Dam Lake in 2012 and 2017 (Figure 2). In the last thirteen years, drought has been gradually felt in Yapıaltın Dam Lake. This means that there is a shortage of agricultural irrigation water in Yapıaltın Dam Lake. The 100 percent of the bottom water of the Yapıaltın Dam Lake cannot be used. Because there are living things in the Yapıaltın Dam Lake. According to the average of the last thirteen years' water occupancy rate data of Yapıaltın Dam Lake, there is water at an occupancy rate of 19.27 percent. In fact, this indicates that the Yapıaltın Dam Lake has been empty at a level of approximately 80 percent in the last thirteen years.

Precipitation variability in Türkiye is mostly determined by atmospheric circulations affecting the country. However, physical geography features also have an effect on variability and significant differences emerge in this respect. The precipitation variation coefficient in Sivas, where Yapıaltın Dam Lake is situated, is 7.06 percent (Olgen, 2010). As a result of possible climate changes in Sivas province, it is predicted that there will be a temperature increase of 8.5-171 percent and a decrease in precipitation of 0-26 percent in the 2022-2100 period (Selcuk et al., 2022). In Türkiye, which has a continental climate, regulating water in dams to be built on rivers with an irregular flow regime and using it for agricultural irrigation in the summer months is of great importance in terms of increasing agricultural production. (Keskin & Demir, 2018). Agriculture in Türkiye is an important sector both economically and socially. However, aquatic ecosystems and especially the agricultural sector, which is a large open factory, are largely vulnerable to global climate change (Kadioglu et al., 2017). Yapıaltın Dam Lake serves for agricultural irrigation, flood protection and recreation purposes. Irrigated agriculture is practiced in Şarkışla district and its surroundings. The water of Yapıaltın Dam Lake is used especially for irrigation of products such as potatoes and beets. Yapıaltın Dam Lake has a net irrigation area of 1880 hectares (Table 1) and the amount of water withdrawn is 9090000 cubic meters (SPEP, 2023). Agriculture exists at the interface between ecosystems and society. At the same time, agriculture is one of the most vulnerable sectors in terms of drought as a result of climate change (Kadioglu et al., 2017). The average water occupancy rate of Yapıaltın Dam Lake, which has fallen below 20 percent compared to the last thirteen years' water occupancy rates, has undoubtedly adversely affected agricultural production.

CONCLUSION

When the water occupancy rates of the last thirteen years between 2010-2022 are examined, the drought danger faced by Yapıaltın Dam Lake has been revealed with this research. Drought adversely affects the waters of Yapıaltın Dam Lake. It was determined that Yapıaltın Dam Lake was affected extraordinarily by drought, especially in 2012 and 2017, and the water occupancy rate decreased to around 2 percent. Due to the drought, which is expected to show more impact in the summer months, the waters of Yapıaltın Dam Lake need to be used more consciously and sparingly than ever before. Intelligent irrigation systems need to be installed. Classical irrigation methods should be abandoned in the agricultural sector where water is used the most. The agriculture and food sector is based on water. No water means no food. For this reason, classical irrigation methods need to be modernized and revised. Additionally, emphasis should be placed on growing agricultural products that require less water. Farmers who use the waters of Yapıaltın Dam Lake for agricultural irrigation should be made aware of this issue and water use in agricultural lands should be done more carefully.

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