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Ecological and Economic Importance with Sustainable Use of DörtEylül Dam Lake in Sivas, Turkey

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Abstract: *Water, besides having a vital importance, is a basic need for the development of countries. Water scarcity is becoming an increasingly common problem and the quality of water is deteriorating rapidly in almost every country. This problem causes many chained problems in ecological and economic terms. DörtEylül Dam Lake is located 10 kilometers northeast of Sivas city center. It was built on the Mısmılırmak Stream for the purpose of supplying drinking water. It is the most important dam lake that provides drinking and utility water needs of Sivas. The total cost of DörtEylül Dam is 65.5 million Turkish Liras. After the completion the drinking water treatment plant in 2007, with the commissioning of the DörtEylül Dam Lake, 50% of the city of Sivas was supplied with treatment water. The water treatment from DörtEylül Dam Lake and supplied to Sivas city water mains systems provides international and national drinking water standards continuously and uninterruptedly. The protection and use of DörtEylül Dam Lake is very important in terms of ensuring sustainable development. All these ecological and economic elements can only be evaluated within the scope of sustainable water management. The developing approach in terms of water management in DörtEylül Dam Lake is to perform resource management on a basin basis and in an integrated manner with other natural resources. Thus, effective and continuous use of the water of DörtEylül Dam Lake will be ensured today, when our usable and drinking water resources are limited.*

Keywords: *DörtEylül Dam Lake, Ecological, Economic, Characters, Sustainable use.*

1. INTRODUCTION

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. Water, which is an important part of ecological life; although it is a food needed by all living things, it is a habitat for some and a tool and source for human life. The purpose and method of using water differs among all living things. Although water, which is a natural resource, gains importance day by day, consumption habits and economic interests harm water resources. Water, which has been used in agriculture and as drinking water since ancient times, has become an indispensable element in domestic consumption and industry with the development of technology. Water has a vital importance in terms of natural balance and continuity of the ecosystem. In addition to artificial consumption, water is home to millions of living things. Water resources, which are of vital importance for the sustainability of ecological and modern life, including human beings, are exposed to pollution day by day. For this reason, the necessity of taking global measures regarding the use of water is very clear [1]. The importance of water in every aspect of human life, agricultural production, economic and social development is undeniable. A holistic approach is needed for the sustainability of water. Sustainable development in urban areas depends on easily accessible, equitable and safe water. However, the sustainability of water resources is associated with various aspects of ecological and economic dimensions. Water resources must be ecologically healthy. Today, most of the water resources are under various threats by man due to changing land uses in the watershed, water pollution due to the use of agricultural fertilizers and interference with the hydrological cycle of streams. For ecological sustainability, the natural network connections of stream systems should be preserved and minimum water flow of streams should be maintained. Erosion of stream banks and beds should be prevented. Organic, physical and chemical loads in water resources should be controlled and monitored. For economic sustainability, water should be managed

according to the principle of protection and use [2]. Also, since climate change affects aquatic ecosystems, it should be addressed in water management plans. In this study, some ecological and economic features of DörtEylül Dam Lake are mentioned. In particular, it is aimed to reveal the problems faced by the DörtEylül Dam Lake and the solutions.

2. MATERIAL AND METHOD

2.1. Location and Technical Specifications of the Study Area

The study was carried out in DörtEylül Dam Lake. DörtEylül Dam Lake is located approximately 10 km northeast of Sivas city center, at 390 82' 93" latitude and 370 06' 27" longitude. It is 1349 m above sea level. The Dam Lake was named "DörtEylül" in order to draw attention to the importance of the Sivas Congress held on September 4, 1919. The dam was built on the Mısmılırmak Stream between 1996 and 2002 for the purpose of supplying drinking water. The body volume of DörtEylül Dam, which is an earth body fill type, is 4200000 m³. Its height from the stream bed is 65.00 m and the lake volume at normal water level is 85.05 hm³. It has a reservoir area of 5.60 km^2 at normal water level. Some hydrological characteristics of DörtEylül Dam Lake are given in Table 1. The planned drinking and utility water capacity of DörtEylül Dam Lake is 33 hm^3/year, and together with the drinking water treatment plant built in addition to the storage facility, it provides drinking and utility water to the city of Sivas in accordance with the relevant standards. The water storage facility was completed in 2004 and the water treatment facility was completed in 2007 by the General Directorate of State Hydraulic Works and transferred to Sivas Municipality [3].

Table1. *Some hydrological properties of the DörtEylül Dam Lake.*

City	Sivas
Construction Date	1996-2002
Age	20
Aim	Drinking Water Supply
Stream	Mısmılırmak
Body Fill Type	Soil
Height	65.00 m
Lake Volume	85.05 hm^3
Lake Area	5.60 km^2

2.2. Method of Study

The material of this study is the DörtEylül Dam Lake ecosystem. In this study, descriptive and explanatory research methods and field research technique were used. In this context, past examples have been used to reveal the researched subject with clear findings with the literature review technique seeking answers to the future. In the research, the information was compiled and interpreted by scanning the written sources in the printed and electronic media. First of all, studies on DörtEylül Dam Lake were used and observations were made. In addition, the data of the General Directorate of State Hydraulic Works, the General Directorate of Meteorology and the Sivas Municipality were used in Turkey. Based on the examination of past examples and the cause-effect relationship between the variables, assumptions were made for the future.

3. RESULTS AND DISCUSSION

The continental climate is observed in Sivas city, where DörtEylül Dam Lake is located. The summer season is very hot, dry and rather short. The winter season is long, cold and snowy. Sivas city is the coldest city of the Central Anatolia Region. Winter months are freezing cold. The average temperature, average number of rainy days and average monthly total rainfall based on the 1930-2021 measurement period of Sivas city, which was created by using the data of the Republic of Turkey Ministry of Environment, Urbanization and Climate Change, General Directorate of Meteorology, are presented in Table 2 [4]. According to Table 2, the average of the coldest month is -3.4 °C and the annual average temperature is 9.0 °C. It has been observed that the temperature in Sivas city drops down to -34.4 °C in winter from time to time. In summer, the temperature is usually above 17 °C. However, it is seen that the temperature exceeds 40 °C in summer. As it can be understood from here, the annual temperature difference shows a big difference of 74.4 °C. The number of days when the temperature values fall below zero °C is 132 days on average. Rainfall in Sivas is observed in winter,

spring and autumn seasons. Summers are generally dry. The annual average rainfall is 430.9 mm (Table 2). The 22% of rainfall falls in autumn, 36% in spring, 32% in winter and 10% in summer. Due to the low temperature in winter, precipitation is usually in the form of snow. In other seasons, precipitation is in the form of rain. Including snowfalls, the number of rainy days is 105. The average number of days with snowfall is 30 days and the snow thickness is around 20 cm. The average pressure around Sivas is 653.2 millibars. The lowest pressure is 634 millibars. Since Sivas is a low pressure center in summer, it is especially open to northerly winds. During the year, 19.3% of the winds blowing in Sivas city blow from the northwest, 16.8% from the northeast, 18.1% from the north and 45.8% from various directions [3].

Table2. *Average temperature, average number of rainy days and average monthly total rainfall in Sivas based on long years (1930-2021).*

Sivas	Average Temperature (^{0}C)	Average Number of Rainy Days	Average Monthly Total Rainfall (mm)
January	-3.4	10.92	43.4
February	-2.1	8.23	39.3
March	2.7	11.69	45.5
April	8.9	8.85	56.5
May	13.5	12.46	60.6
June	17.0	9.92	34.1
July	20.0	1.85	9.3
August	20.2	1.62	6.7
September	16.2	4.62	17.6
October	10.9	7.23	33.2
November	4.7	6.54	40.2
December	-0.7	10.38	44.5
Annually	9.0	94.3	430.9

According to the temperature data for the years 1930-2021 taken from the General Directorate of Meteorology, January is the coldest month in Sivas, while August is the hottest (Table 2). Accordingly, the annual average temperature (9 ^{0}C) in Sivas is below the Turkey average. Similarly, the most precipitation in Sivas is in May (60.6 mm) and April (56.5 mm). However, the annual average precipitation (430.9 mm) in Sivas is below the Turkey average.

According to the information obtained from the Address Based Population Registration System Results of the Turkish Statistical Institute for the year 2021, 636 thousand 121 people live in Sivas. Annual population growth rate for 2021 in Sivas is 0.4 percent. In the city of Sivas, which has a surface area of 28 thousand 619 km^2, there are 22 people per square kilometer [5]. Drinking water is met from DörtEylül Dam Lake and Tavra Creek in Sivas city, which has an average water requirement of 1.021 liter/second. The water coming from the DörtEylül Dam Lake and Tavra Creek via the transmission lines to the Drinking Water Treatment Plant is sent to the pumping center and water tanks after being treated, and from there it is distributed to the Sivas city water network system [6].

The total cost of the DörtEylül Dam is 65.5 million Turkish Liras [7]. With the commissioning of DörtEylül Dam Lake in 2007 and the completion of the drinking water treatment plant, treated water is supplied to 50% of Sivas city. In addition, DörtEylül Dam Lake, which is one of the most important drinking and utility water resources of Sivas city, is under control 7/24 with newly created security points.

Yıldız and Değirmenci [8] determined the hardness of the water of DörtEylül Dam Lake, which provides the drinking water need of Sivas city, as 16 French Hardness. In addition, due to factors such as possible pollution and global warming, it is recommended to take forward-looking measures to protect this water source.

Yıldız and Değirmenci [9] examined the water quality of the DörtEylül Dam and its branches, which was built to meet the drinking water needs of Sivas city. As a result of the analysis, no heavy metals were found in the water sources. However, it has been determined that there is a bacteriological pollution. The amount of organic matter showed differences in the rainy and dry period samples. According to the hardness parameter, it was observed that the hardness values of the creeks feeding

the dam were higher than the dam lake area [9]. In addition, it has been proposed to keep the waste waters resulting from agricultural activities or any activity in the absolute protection area under control so that the lake area and the creeks feeding the lake area are not polluted.

By Yıldız and Karakuş [10], water samples were taken from 12 different points of DörtEylül Dam Lake, where the drinking water needs of Sivas city are met. Water temperature, conductivity, dissolved oxygen, pH, turbidity, manganese, iron, nitrate and organic matter analyses were made in these samples. According to the results obtained, it was determined that the manganese value increased as the depth increased, while the iron value did not show a significant change. It was determined that while the amount of organic matter was very high on the surface, it did not change much after a certain depth, and the pH value did not change depending on the depth. While measured nitrate values ranged between 0.1-0.3 mg/L, no significant change was observed in dissolved oxygen values. Turbidity has increased considerably towards the bottom of DörtEylül Dam Lake. The conductivity value was measured at higher values at the dam lake edges compared to the middle part.

Table3. *Analysis results of water quality parameters of DörtEylül Dam Lake Treatment Plant Outlet [6]*.

Parameters	World Health Organization (WHO)	European Union (EU)	Turkish Ministry of Health Regulation on Water Intended for Human Consumption	DörtEylül Dam Lake Treatment Plant Outlet
Microbiological Parameters, EMS/100 ML				
Escherichia coli	0	0	0/250 ML	0
Enterococcus sp.	0	0	0/250 ML	0
Coliform bacteria	0	0	0/250 ML	0
Physicochemical Parameters, MG/L				
Antimony	0.005	0.005	0.005	<0.002
Arsenic	0.05	0.01	0.01	0
Cadmium	0.005	0.005	0.005	<0.003
Chromium	0.05	0.05	0.05	<0.0005
Copper	-	2	2	0.35
Cyanide	-	-	0.05	0.012
Fluoride	1.5	1.5	1.5	0.14
Lead	0.05	0.01	0.01	<0.0004
Mercury	0.001	0.001	0.001	<0.0004
Nitrate	50	50	50	0.75
Nitrite	0.2	-	0.5	0.003
Selenium	0.01	0.01	0.01	<0.0004
Aluminium	0.2	0.2	0.2	0
Ammonium	1.5	0.5	0.5	0
Chloride	250	250	250	26
Color	15	-	Acceptable by consumers and no abnormal changes	Acceptable by consumers and no abnormal changes
Conductivity (µS/cm)	2500	2500	2500	399
pH	6.5-8.5	6.5-9.5	6.5-9.5	7.87
Iron	-	0.2	0.2	0.01
Manganese	0.5	0.05	0.05	0.027
Odor	-	-	Acceptable by consumers and no abnormal changes	Acceptable by consumers and no abnormal changes
Sulfate	250	250	250	19
Sodium	200	200	200	9.98
Turbidity (NTU)	5	1	Acceptable by consumers and no abnormal changes	0.24
Silver	-	-	-	<0.0004
Beryllium	-	-	-	<0.0004
Phosphate	-	-	-	0.11
Total Dissolved Matter	1000	-	-	192

Zinc	-	-	-	0.05
Total Hardness	-	-	-	190.45
Ca Hardness	-	-	-	138.90
Mg Hardness	-	-	-	51.55
Potassium	-	-	-	1.5
Free Chlorine	5		20.2	0.80

Sivas Drinking Water Treatment Plant has been designed to meet the city's drinking, utility and industrial water needs for the years 2020-2040. In addition to the existing underground water resources for 2020, it is designed to treat the 1.57 cubic meters/second flow rate to be taken from the DörtEylül Dam Lake, which was built 10 km northeast of the city. Sivas Drinking Water Treatment Plant Project consists of two symmetrical stages, each with a capacity of 135.000 cubic meter/day. The facility has been designed to provide a total capacity of 270.000 cubic meter/day for 2040, and the first stage has been built. Necessary fields for the 2nd stage have been left. In the Drinking Water Treatment Plant, daily physical, chemical and microbiological analyses are carried out on the water samples taken from the raw water at the entrance of the facility, from each stage of the facility, from the outlet treated water and from the points representing the entire city water network system. Thus, the water quality is constantly kept under control. For this purpose, a total of 37 parameters are analysed at the Drinking Water Treatment Plant. The analysis results of these parameters are presented in Table 3 [6]. Accordingly, analysis results of some water quality parameters of DörtEylül Dam Lake Treatment Plant Outlet were measured as pH 7.87, turbidity 0.24 NTU, conductivity 399 µS/cm, free chlorine 0.80 mg/L, chloride 26 mg/L, total hardness 190.45 mg/L, Ca hardness 138.90 mg/L, Mg hardness 51.55 mg/L, nitrate 0.75 mg/L, nitrite 0.003 mg/L, ammonium 0 mg/L, iron 0.01 mg/L, manganese 0.027 mg/L, Coliform bacteria 0, Escherichia coli 0, Enterococcus bacteria 0, aluminum 0 mg/L, arsenic 0 mg/L, copper 0.035 mg/L, phosphate 0.11 mg/L, zinc 0.05 mg/L, sulfate 19 mg/L, sodium 9.98 mg/L, cyanide 0.012 mg/L, potassium 1.5 mg/L, fluoride 0.14 mg/L and total dissolved matter 192 mg/L (Table 3).

According to the analysis results in Table 3, the water treatmented and supplied to the Sivas city water network system consistently and uninterruptedly meets the standards of the World Health Organization, the European Union and the Turkey Ministry of Health "Regulation on Water Intended for Human Consumption" [5].

The monthly flow rates of DörtEylül Dam Lake for the year 2020 are presented in Figure 1 [6]. Accordingly, in 2020, the lowest flow rate was observed in January, while the highest was obtained in July. The average flow rate of DörtEylül Dam Lake in 2020 was found to be 852.293 cubic meter/month.

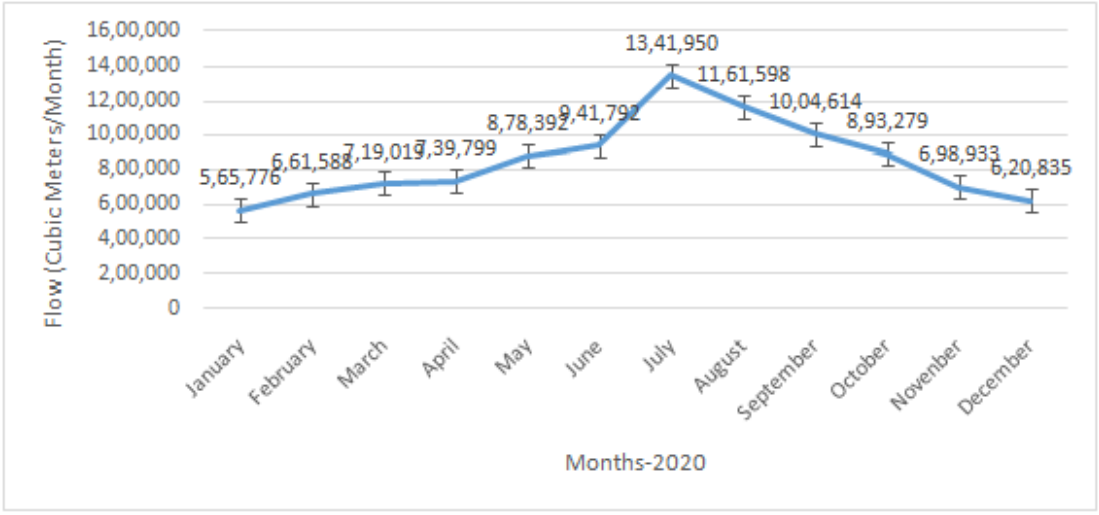

Figure1. *Flow values of DörtEylül Dam Lake by months in 2020.*

Divrik [11] reported the highest water occupancy rate in DörtEylül Dam Lake as 57.10% in 2013, while the lowest water occupancy rate was reported as 8% in 2018. In addition, it has been determined that there is a decreasing trend in the water occupancy rates of DörtEylül Dam Lake. It is suggested that the sources of pollution around the DörtEyül Dam Lake should be determined and controlled strictly and periodically by Divrik [10].

The water level in DörtEylül Dam Lake, which meets the water needs of Sivas city, has decreased to 4 percent [12]. The amount of water in the DörtEylül Dam Lake has fallen below the safety level due to the drought experienced in recent years. The fall in the water level of the DörtEylül Dam caused the mandatory water cuts to be made in Sivas. When work was carried out to transfer the water at the bottom of the DörtEylül Dam Lake to the reservoirs, the water at the bottom of the dam, called the "safety level", had to be used [12]. However, for the drinking water need of Sivas city, it has become necessary to provide new water resources with the decrease in precipitation in recent years. In this context, the investment project of 300 million Turkish Liras related to water replenishment from PusatÖzen Dam Lake to DörtEylül Dam Lake has been included in the 2021 investment program of the Presidency of Turkey.

It was stated by the 19th Regional Directorate of State Hydraulic Works that the water level in the DörtEylül Dam Lake, where most of the drinking water is provided in Sivas, dropped to 6 percent in July 2022 and reached the drying point. On the other hand, it has been stated that the works on the project, which foresees water transfer from PusatÖzen Dam, which is approximately 50 km away, to DörtEylül Dam, will be completed by the end of 2022.

Like all countries in the world, Turkey is rapidly approaching to experience water scarcity. Although Turkey has a rich geographical location in terms of natural resources, this inevitable fact is actually a water insecurity [1]. Although Sivas is a city with underground and aboveground riches, its industry has not developed enough. When viewed sectorally, most of the population in Sivas is engaged in agriculture and animal husbandry [13]. Due to the fact that the agricultural sector dominates the economy of Sivas city, livestock and plant products are the leading products that are subject to trade.

New ecological conditions occur due to dam lakes built on stream systems for purposes such as energy production, drinking water, flood control and irrigation. Changing the natural structure and beds of the stream can affect the biological life cycle and cause the disappearance of some species or their isolation in certain areas over time. In order not to disturb the ecological balance of the DörtEylül Dam Lake, built on the Mısmılırmak Stream, and for the continuation of its living life, water is released into the stream from the bottom weir of the dam. However, there are no fish passages in DörtEylül Dam Lake. For this reason, it is thought that after the construction of the dam lake in the research area, some living creatures and fish that migrated for feeding and reproduction could not reach the upper parts of the Mısmılırmak Stream and the existing individuals decreased or became extinct over time.

Plant products such as wheat, barley, rye are produced around the DörtEylül Dam Lake and animal husbandry is widely practiced. On the hills surrounding the DörtEylül Dam Lake, there are degraded forests, maquis and meadow vegetation from place to place. There are few tree species such as Juniper, Scotch Pine, Poplar, Beech, Hornbeam, Oak and Hawthorn in the environment. Due to the steep coastline of DörtEylül Dam Lake, it was observed that there are very few littoral aquatic plants.

4. CONCLUSION AND RECOMMENDATIONS

Wetlands are ecosystems that are of great importance in terms of maintaining biological diversity and ecological balance. They regulate the water regime of the region where they are located by recharging and discharging groundwater, reducing the destructive effect of floods, balancing the groundwater. In addition, by increasing the humidity of the environment they are in, they have a positive effect on local climate elements, especially precipitation and temperature. They improve water quality by retaining deposits, nutrients and toxic substances. One of the important artificial wetlands in Sivas city is DörtEylül Dam Lake. DörtEylül Dam Lake meets a significant portion of the drinking and utility water needs of Sivas city. Thus, by revealing the economic and ecological values of inland water ecosystems such as DörtEylül Dam Lake, it has been ensured that they contribute significantly to the development of Sivas city and local people.

Water pollution occurs due to many reasons, such as the discharge of domestic and industrial liquid wastes into aquatic ecosystems without treatment, the transport of fertilizers used to increase productivity in agriculture and pesticides used for agricultural control into aquatic environments. DörtEylül Dam Lake and its surroundings are located away from the industrial zone. There are some residential areas around the DörtEylül Dam Lake. The lands where waste water is given in these

settlements should be well controlled and closely monitored in terms of water pollution. Agricultural pollution reaching the aquatic environment of DörtEylül Dam Lake can affect the physicochemical and biological properties of the water. Agriculture and animal husbandry are carried out in the settlement areas around the DörtEylül Dam Lake. Agricultural activities around DörtEylül Dam Lake should be strictly controlled. The mixing of fertilizers and pesticides used in these agricultural areas into DörtEylül Dam Lake should be prevented. It takes a very long time for the water quality of which is deteriorated and polluted to be restored together with its living organisms. Therefore, it is necessary to use and protect the DörtEylül Dam Lake without polluting it.

Agricultural activities carried out around DörtEylül Dam Lake, the destruction of vegetation from place to place, the materials coming from the creeks in the region and the main stream bed in the valley precipitate in the reservoir of the dam lake where the water is collected and accumulate here over time. In this case, it is inevitable for the dam lake, which is exposed to erosion in various ways, to fill up and become a swamp. The filling of half of the volume of a dam lake causes it to not be able to perform its main operation. For this reason, it is necessary to take more stringent measures to prevent erosion, especially around the DörtEylül Dam Lake. In addition, with the increase of the effects of global warming and climate change, a further decrease in the amount of water in DörtEylül Dam Lake is expected. For this reason, efficient and effective management of the waters of DörtEylul Dam Lake is necessary.

With the water stored in DörtEylül Dam Lake, it meets a significant part of the drinking and utility water needs of Sivas city. For this reason, the physicochemical and biological characteristics of DörtEylül Dam Lake should be monitored periodically and necessary precautions should be taken, protected and its continuity should be ensured. Monitoring these features is very important for the conservation of biological diversity and sustainable water resources management. The main thing in sustainable water resources management is to consider the requirements of the natural structure.

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