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Assessment of Water Occupancy Rates of the Çamlıgöze Dam Lake between 2010-2021 from Sivas Province in Turkey

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ABSTRACT

With the increasing world population, the importance of dam lakes is increasing within the framework of more effective and efficient use of water resources. This study focuses on the water occupancy rates of Çamlıgöze Dam Lake, located in Turkey, between the years 2010-2021. The annual average water occupancy rate of Çamlıgöze Dam Lake between 2010-2021 was calculated as 69.55 percent. This shows that approximately seventy percent of Çamlıgöze Dam Lake was full between 2010-2021. According to these values, it was determined that the water occupancy rates of Çamlıgöze Dam Lake did not face a serious decrease between 2010-2021. As a result, there is no short term problem in terms of water occupancy rates in Çamlıgöze Dam Lake, but this does not mean that it will not be a problem in the long term. For this reason, it should not be abandoned to use the water of Çamlıgöze Dam Lake effectively, economically and consciously.

Keywords: Climate change; Çamlıgöze dam lake; Water; Occupancy; Rates; Turkey.

1. Introduction

Climate is the long-term average weather conditions in a geographic area. Temperature, precipitation, relative humidity, sunshine duration, sunshine intensity, pressure, wind direction, wind speed, evaporation are the factors affecting the climate. Turkey is located between the temperate zone and the subtropical zone. Different climate types are seen among the geographical regions of Turkey. The reason for this difference is that it is surrounded by the sea on three sides, the extension of the mountains and the landforms. The landforms of a place are closely related to the climate of that region.

As the landforms affect the climate formation, the climate and land structure also affect the economic activities of that region. Turkey generally has a mountainous terrain. Animal husbandry in the mountainous regions, forestry in the humid regions and agricultural activities in many regions are carried out. The difference in latitude, the distance of the inner regions to the sea and the difference in altitude affect the temperature. The temperature difference is felt more in the interior than in the coastal areas [1]. The location of Çamlıgöze Lake, chosen as the research area, is located on the transition line between the temperate climate of the Black Sea Region of Turkey and the continental climate of the Central Anatolia Region.

Turkey is a bridge between east and west. The 3% of Turkey's surface area is located in the European Continent (Thrace) and the rest is in the Asian Continent (Anatolia). The surface area of Turkey is 783.562 km^2. The 11.4% of this area consists of lakes and swamps, 28.8% is forest land, 35.8% is arable land, 19% is grassland, and 5% is residential and other areas. In addition, Turkey's population reached 84.34 million as of 2020 and it is estimated that the population will be 104.8 million in 2050. Turkey has 112 billion m^3 of consumable surface and underground water potential. Of this, 94 billion m^3 is surface water and 18 billion m^3 is groundwater. The annual amount of water per person is 1,403 m^3. The 40 billion m^3 of 112 billion m^3 of water is used for irrigation, 7 billion m^3 is used as

drinking water and 7 billion m^3 of water is used in industry. The 72.2% of the consumed water is obtained from surface waters and 28.8% from groundwater [2]. The flow rates/regimes of the rivers, the amount of water they carry and their erosional power vary throughout the year due to the fact that the precipitation in Turkey is variable according to the regions and seasons and the bed slopes of the rivers vary. Due to the high bed slopes of the streams, there are potentials such as hydroelectric power generation, agricultural irrigation and drinking water supply from the rivers.

The 82% of the electrical energy consumed in the world is from fossil-based sources and nuclear sources; the remaining 18% is supplied from hydraulic and renewable energy sources (wind, solar, geothermal) [3]. The largest share in greenhouse gas emissions, which are considered to cause climate change, belongs to energy production and conversion processes. In recent years, energy has become a problematic area both in the world and in Turkey. Fossil fuels such as coal, oil and natural gas are generally used in the supply of electrical energy.

In addition to the supply security problem in the field of energy, the fact that the use of fossil fuels is the main cause of climate change, as well as the emission of pollutants such as sulfur dioxide and particulate matter, creates a new limiting factor. In this regard, attempts to reduce greenhouse gas emissions, especially carbon dioxide, will be an important factor that will affect policies in the energy sector. In addition, the energy sector is also affected by the possible consequences of climate change. Dam lakes built in various regions are basically built for purposes such as collecting the water potential around them and preserving the water, such as energy, drinking water, agricultural irrigation. Çamlıgöze Dam Lake, built in the Suşehri district of Sivas province, has started to hold water since 1998. In the study, the water occupancy rates of Çamlıgöze Dam Lake between 2010-2021 were investigated in Sivas province of Turkey.

2. Materials and Methods

The study area is Çamlıgöze Dam Lake; It is located within the borders of Suşehri district of Sivas province in the Central Anatolian Region of Turkey. Çamlıgöze Dam Lake is located on the Kelkit Stream, one of the most important branches of the Yeşilırmak River, approximately 10 km from the Suşehri district of Sivas province. Some technical features of Çamlıgöze Dam Lake are shown in Table 1. Çamlıgöze Dam Lake was built between 1987-1998 in order to generate energy. It is built of clay core rock fill body type. The height of the dam lake from the creek bed is 38.00 m. At the normal water level of the Çamlıgöze Dam, the lake volume and lake area are 59,000,000 m^3 and 4.70 km^2, respectively. The maximum depth of Çamlıgöze Dam Lake is 30 m. The installed power of Çamlıgöze Hydroelectric Power Plant is 33.00 MW and produces 102.00 GW of energy annually (Table 1). Flow is observed throughout the year in Kelkit Stream feeding Çamlıgöze Dam Lake.

Suşehri district of Sivas province, where Çamlıgöze Dam Lake is located, is located in the northeastern part of Turkey, at the intersection of 38.04 east longitude and 40.08 north latitude. The climate of the district is on the transition line between the temperate climate of the Black Sea Region and the continental climate of the Central Anatolia Region. For this reason, summers are dry and winters are warm compared to Central Anatolia. In winter, precipitation is usually in the form of snow. The most abundant rain falls in the spring, while the autumn is short-lived. The fact that the climate affecting the district is open to many different factors has also diversified the

vegetation. Tatar and Karacaören regions in the south of the district are covered with forests. The areas outside the forest areas are partly covered with bushes and heaths, partly with meadows and pastures [4]. The main livelihood of the district is agriculture, animal husbandry and aquaculture.

Table 1. Some technical features of Çamlıgöze Dam Lake

S.No.	Property	Value
1	Province	Sivas
2	District	Suşehri
3	Date of Construction Start	28.08.1987
4	Date of Construction End	16.05.1998
5	Purpose of the Dam	Energy
6	Stream	Kelkit Stream
7	Body Fill Type	Clay Core Rock Fill
8	Height	38 m
9	Lake Volume	59.000.000 m^3
10	Lake Area	4.70 km^2
11	Maximum Depth	30 m
12	Installed Power	33.00 MW
13	Annual Production	102.00 GWh

In this study, water occupancy rate data between 2010 and 2021 obtained from the General Directorate of State Hydraulic Works in Turkey for Çamlıgöze Dam Lake were used. The occupancy rate includes the data of the monitored dams (with an active water volume of 3 million m^3 and above). With these data obtained, the changes in the water occupancy rates of Çamlıgöze Dam Lake were investigated between 2010 and 2021. The changes in the water occupancy rates of Çamlıgöze Dam Lake were analyzed and synthesized in accordance with the purpose of the study. Occupancy rate of Çamlıgöze Dam Lake was calculated as the ratio of active dam volume to total active dam volume. The occupancy rate of Çamlıgöze Dam Lake is expressed in %.

3. Results and Discussion

Changes in the annual average water occupancy rates of Çamlıgöze Dam Lake between 2010 and 2021 are presented in Figure 1. According to the data of the General Directorate of State Hydraulic Works in Turkey, the water occupancy rate in Çamlıgöze Dam Lake was 63.41% in 2010, 61.90% in 2011, 70.90% in 2012, 64.30% in 2013, 67.80% in 2014, 55.00% in 2015, 57.10% in 2016, 71.60% in 2017, 86.00% in 2018, 55.00% in 2019, 86.00% in 2020 and 95.60% in 2021. While the highest water occupancy rate was determined as 95.60% in 2021,

the lowest water occupancy rate was determined as 55.00% in 2015 and 2019 years (Figure 1). The average annual water occupancy rates of Çamlıgöze Dam Lake were calculated as 69.55 and the standard deviation was ±13.25 for the period between 2010-2021. Accordingly, the water occupancy rates of the Çamlıgöze Dam Lake are in good condition.

In this study, it has been determined that approximately 70 percent of Çamlıgöze Dam Lake is full, according to the water occupancy rates between 2010-2021. The slope line in Figure 1 is also upwards. This indicates that the occupancy rates of the waters of the Çamlıgöze Dam Lake are at a good level. Therefore, water levels in Çamlıgöze Dam Lake are quite normal for energy and for rainbow trout production in cages. Currently, there is no short-term risk for Çamlıgöze Dam Lake in the production of rainbow trout in energy and cages.

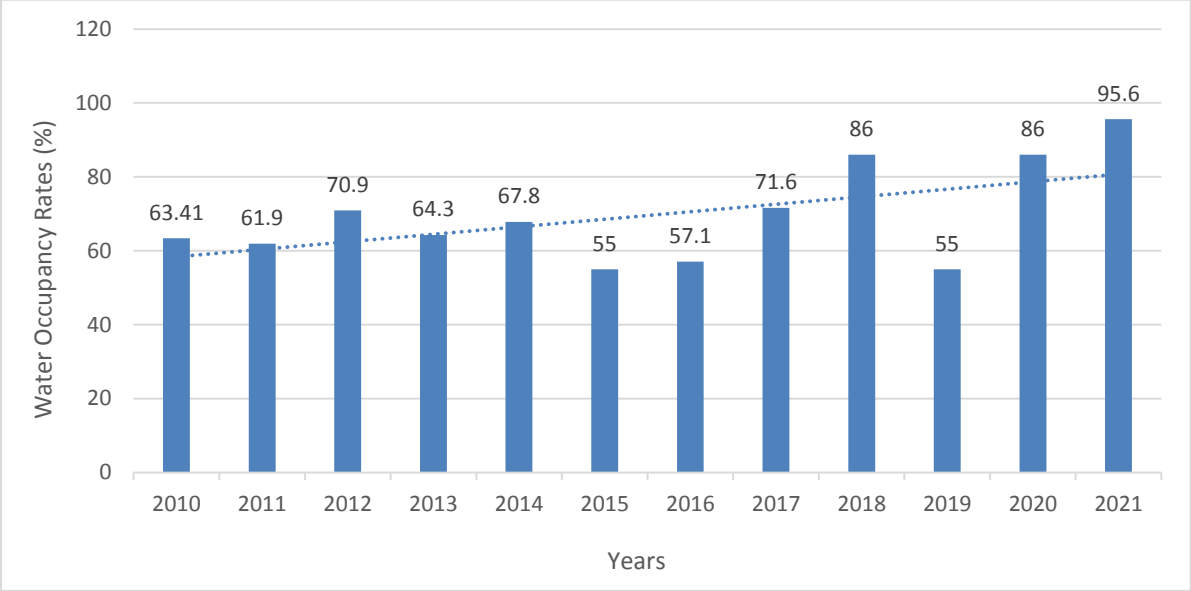

Figure 1. Changes in the water occupancy rates of Çamlıgöze Dam Lake in the period 2010-2021

Four kilometers above Çamlıgöze Dam Lake, Kılıçkaya Dam Lake with a depth of approximately 100 meters is located. Kelkit Stream and other spring waters accumulate in Kılıçkaya Dam Lake, and the rested and clean water from here comes to Çamlıgöze Dam Lake. Çamlıgöze Dam Lake water level almost does not change during the year. Because the water released from Kılıçkaya Dam comes to Çamlıgöze Dam Lake and the same amount of water is used in Çamlıgöze Hydroelectric Power Plant and released back to the stream bed. Therefore, Çamlıgöze Dam Lake has a stream feature. Çamlıgöze Dam Lake waters are slightly colder due to the fact that they come from the depths of Kılıçkaya Dam Lake waters and the distance between the two dam lakes is short [5]. With these features, Çamlıgöze Dam Lake is one of the rare dam lakes in Turkey.

According to the projections of the Turkish Statistical Institute, it is estimated that Turkey's population will reach approximately 93 million in 2030. In this case, the amount of water per capita, which is currently 1,302 m^3/year, will decrease to 1,204 m^3 /year in 2030. It is possible to estimate the pressures on water resources with the effect of factors such as the current growth rate of the country and the change in water consumption habits. In addition, all these estimates can arise if available resources are transferred without destruction by that year. In this sense, contrary to common belief, Turkey is not a water-rich country in terms of water per capita. According to the

Falkenmark index, which classifies countries in terms of water potential per capita, Turkey is a country with "water stress" as it has a water potential of 1,000-1,500 m^3 per capita per year, and the amount of water per capita is below the world average [2]. The nature, culture, history and environmental richness of a country are the elements that provide the integration between the past and the future of that country. All kinds of investment planning should be done without ignoring the fact that societies ensure their continuity by preserving and developing this wealth. Dam lakes are multi-purpose structures. They serve many sectors and are instrumental in economic vitality in the sectors they serve. Çamlıgöze Dam Lake Hydroelectric Power Plant produces 102.00 GW of energy annually (Table 1). The water of Çamlıgöze Dam Lake is mainly used for electricity generation, commercial fishing, aquaculture, irrigation and recreation [6]. Starting to discuss the environmental effects of energy consumption results in reducing the dependence on fossil fuels in energy policies and giving more importance to environmentally friendly energy sources. Renewable energy should also play a major role in reducing poverty through sustainable development so that people can more easily respond to the changes brought about by global warming and climate change. Because renewable energy reduces poverty and reduces the likelihood of conflict over non-renewable energy sources [7]. Catfish, carp and rainbow trout constitute the majority of fish species caught in Çamlıgöze Dam Lake. In addition to economic activities such as energy production and fishing in Çamlıgöze Dam Lake, rainbow trout farming in cages also provides very important contributions to the local economy in Suşehri district and Sivas province.

Çamlıgöze Dam Lake, located on Kelkit Stream, one of the most important branches of Yeşilırmak River, which is the third largest river flowing into the Black Sea after Kızılırmak and Sakarya Rivers in Turkey, is in the "Mesotrophic Lake" class [8]. Çamlıgöze Dam Lake has first class water quality and the annual average nitrate value is 2.2 mg/L [9]. According to TWPCR [10], the water of Çamlıgöze Dam Lake, which has first class water quality, can be disinfected and used not only for drinking purposes, but also for recreational purposes, rainbow trout farming, animal production and other purposes. Therefore, Çamlıgöze Dam Lake is an important water source for the region and Turkey. The natural structure, water quality and ecological structure of Çamlıgöze Dam Lake is very suitable for rainbow trout farming. The waters of Çamlıgöze Dam Lake are first class, that is, high quality water, and are suitable for rainbow trout farming. The cold water released from the depths of Kılıçkaya Dam Lake comes to Çamlıgöze Dam Lake and the same amount of water is used in Çamlıgöze Hydroelectric Power Plant and released back to the stream bed. Thus, the continuous circulation of the waters of Çamlıgöze Dam Lake creates a great potential for rainbow trout farming. According to the data of 2021 in Çamlıgöze Dam Lake; Approximately 4000 tons/year of rainbow trout is produced in a total of 155 cages [5].

Events within the context of climate change will affect the infrastructure, the areas where cultivation is carried out and the transportation routes. At the same time, many communities living in aquatic ecosystems will be at risk in terms of security. Water scarcity and difficulties in accessing water resources and competition will affect aquaculture in marine and inland waters [11]. Rainbow trout farming in Çamlıgöze Dam Lake is carried out successfully with floating net cage systems. Rainbow trout farming in Çamlıgöze Dam Lake has a great importance in terms of domestic consumption, contribution to export and employment, food security and socio-economic aspects. It is important for the national economy to make the growth in the rainbow trout farming sector sustainable in Çamlıgöze Dam Lake. With the increasing demand from domestic and foreign markets in recent years, rainbow

trout production in net cages in Çamlıgöze Dam Lake has increased to significant levels. Rainbow trout farming in cages is dependent on the waters of Çamlıgöze Dam Lake. Due to rainbow trout farming activities, there may be negative changes in the ecosystem of Çamlıgöze Dam Lake over time. Monitoring and keeping these changes under control is extremely important for sustainable aquaculture.

While it is observed that the water occupancy rate of Çamlıgöze Dam Lake between 2010-2021 is quite good, it has been determined that the water occupancy rate, which was 55 percent in 2019, increased to 86.00 percent in 2020 and to 95.60 percent in 2021. The water occupancy rates of Çamlıgöze Dam Lake increased in 2020 and 2021 compared to previous years. It has been observed that the water occupancy rates of Çamlıgöze Dam Lake are generally in good condition in the short term between 2010-2021 and there are no problems with the water occupancy rates. The biggest threat to life on earth is global warming and climate change.

In recent years, the effects of global warming are observed not only in terrestrial regions, but also in wet areas such as oceans, seas and lakes [12]. Meteorological data are constantly changing, so the situation of water occupancy rates between 2010-2021 in Çamlıgöze Dam Lake is good, but despite everything, using water sparingly and consciously should not be abandoned. Water, an indispensable element for the continuation of life, is a natural and scarce resource that cannot be replaced. Water is important not only for humans, but also for all living creatures and the continuation of the habitable environment on earth. Limited, wasteful and polluted water, the use of which is not given much attention today, will pose a great danger to humanity and cause irreversible results if precautions are not taken. Although water covers a large part of the world, the scarcity of usable water resources needs to be recognized now and it emerges that breakthroughs should be made in that direction. Increasing individual awareness will make significant contributions to the more accurate and efficient use of water.

4. Conclusion

With this study, it was determined that the water occupancy rates of Çamlıgöze Dam Lake did not face a serious decrease between 2010-2021. Water is essential for the continuity of life. However, the amount, sources and quality of water all over the world are under threat due to the negative effects of climate change. Natural disasters such as floods and droughts experienced on a global scale in recent years threaten the ecosystem and water resources, especially human life. Increases are observed in the incidence, impact and duration of these disasters. It is now widely accepted that one of the main reasons that increase the severity of these threats is climate change. Climate change is no longer an environmental problem, but a development problem. Since the living standards of our future generations are directly dependent on our water resources and the effective management of water, precautions should be taken against all hazards on the waters. As a result, decision makers should be forced to combine a rational water management and physical planning, which also takes into account the amount of water, in the planning of human development.

Declarations

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Competing Interests Statement

Author has declared no competing interests.

Consent for Publication

The author declares that he/she consented to the publication of this research work.

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