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Research Article

# CAGE AQUACULTURE IN ÇAMLIGÖZE DAM LAKE (SİVAS-TURKEY): CHALLENGES AND OPPORTUNITIES

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**ABSTRACT.** This research tries to explore the challenges and opportunities of aquaculture in cages in Çamlıgöze Dam Lake. Aquaculture in Çamlıgöze Dam Lake has been carried out by using cage systems since 2008, and it has made significant progress until today. In Çamlıgöze Dam Lake, 5 large-capacity enterprises started to operate. The water of Çamlıgöze Dam Lake, due to its coldness, dissolved oxygen amount and flow rate, allows the raising of extremely high quality and delicious rainbow trout. This situation makes significant contributions to the development and progress of aquaculture in Çamlıgöze Dam Lake. According to the data of 2021 in Çamlıgöze Dam Lake, approximately 4000 tons/year of aquaculture production is carried out in 155 cages. While the trout raised in the cages established in Çamlıgöze Dam Lake provide job opportunities to the people of the region, they are in high demand from Turkey and abroad. Although aquaculture production in Çamlıgöze Dam Lake is affected by the Covid-19 pandemic, it still continues. In order to benefit effectively from aquaculture in the future, it is necessary to focus on measures to ensure the protection and sustainable use of Çamlıgöze Dam Lake.

**Keywords:** *Aquaculture, Cage, Çamlıgöze Dam Lake, Turkey*

## INTRODUCTION

Water resources, one of the basic elements of human life, are one of the most important elements of economic activities. Water resources, which enable the distribution of the population and the diversification of economic activities, are of vital importance for every society. Fisheries activities in sea, lake and river sources are also one of the oldest forms of human use of water resources. For the future of humans, aquaculture plays a critical role in meeting animal protein needs. Aquaculture is a sector that continues to grow in the world. The amount of aquaculture produced increased from 7.4 million tons in 1980 to 16.8 million tons in 1990, 40 million tons in 2002 and 85.4 million tons in 2019 [1, 2]. Aquaculture production has increased approximately 12 times in the last 30 years, with an annual average increase of 8.8% throughout the World [3]. Aquaculture is one of the fastest growing and constantly progressing sectors among all food sectors [4]. There is a similar situation in Turkey. While Turkey's fisheries production shows a fluctuating change over the years, aquaculture production tends to increase continuously.

The production share of trout has increased strongly in the world in recent years [5]. Rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) farming is an important agricultural activity in the world and in Turkey. Rainbow trout farming in Turkey started in the 1970s and increased rapidly in the following years. Until the 1990s, traditional trout farming was practiced in concrete and earthen ponds on land. In recent years, in addition to pond farming, rainbow trout farming in net cages in dam lakes has become increasingly common [6]. In Turkey, mostly rainbow trout farming is done in inland waters and dam

lakes also create an important potential for aquaculture. In Turkey, the amount of rainbow trout produced with aquaculture in inland waters reached 990 tons in 1986, 56026 tons in 2006 and 126101 tons in 2020 [2, 7]. One of the main reasons for this development in Turkey is the intensive trout production in cages applied in dam lakes.

Rainbow trout farming in dam lakes, especially in cages, is increasing day by day. Advantages such as low capital requirement, easy fish harvesting and feeding, and simple application make trout farming activities in cages widespread. Strong investments that join the aquaculture sector with each passing day cause the sector to develop [8, 9]. Aquaculture is carried out in dam lakes in 34 provinces and approximately 250 enterprises in Turkey [10]. Çamlıgöze Dam Lake is one of the dam lakes where rainbow trout farming is done intensively in cages. This research was carried out to determine the challenges and opportunities of aquaculture in cages in Çamlıgöze Dam Lake.

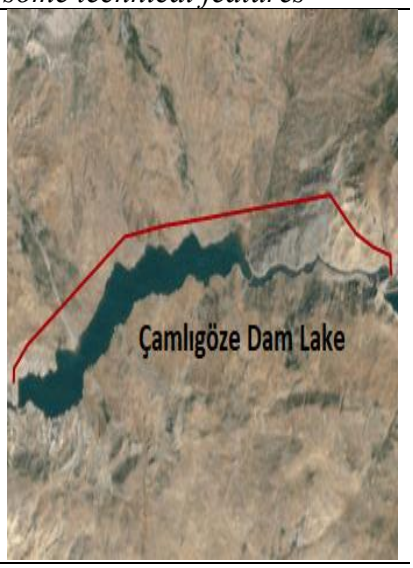
## MATERIALS AND METHODS

### *Research Area*

Çamlıgöze Dam Lake, chosen as the research area, is located on the Kelkit Stream, one of the most important branches of the Yeşilırmak River, approximately 10 kilometers from the Suşehri district of Sivas province of Turkey. The construction of Çamlıgöze Dam was started in 1987 at the downstream of Kılıçkaya Dam for the purpose of energy, irrigation and flood protection and was completed in 1998. Çamlıgöze Dam is a 38 meters high rockfill power plant. The maximum depth of Çamlıgöze Dam Lake is around 30 meters. The annual average energy production of Çamlıgöze Hydroelectric Power Plant is 102 GWh/year [11]. Some technical features and Çamlıgöze Dam Lake are shown in Table 1.

***Table 1.*** *Çamlıgöze Dam Lake and some technical features*

| | |
|---|---|
| Basin Name | Yeşilırmak |
| District | Suşehri |
| Province | Sivas |
| Country | Turkey |
| Stream | Kelkit |
| Construction Start Year | 1987 |
| Construction Finish Year | 1998 |
| Body Fill Type | Rock |
| Body Volume | 2.2 $hm^3$ |
| Dam Storage Volume | 59 $hm^3$ |
| Crest Code | 755 m |
| Height | 38 m |
| Maximum Depth | 30 m |
| Power | 33 MW |
| Annual Production | 102 GWh |




Çamlıgöze Dam Lake, which is located on Kelkit Stream, one of the most important branches of Yeşilırmak, which is the third largest river flowing into the Black Sea after Kızılırmak and Sakarya Rivers in Turkey, is in the “Mesotrophic Lake” class [12]. According to the inland water quality standards of the water pollution control regulation

in Turkey, the waters of Çamlıgöze Dam Lake were found in class I, that is, high quality water class [13]. It is stated in the water pollution control regulation that the waters included in class I are only suitable for disinfection and drinking water supply, recreational purposes, trout production, animal production, farm needs and other purposes.

### *Data Collection and Evaluation*

In this research, the method of reaching a conclusion was followed by making an analysis from the statistical data of some public institutions, field observations and interviews with the authorities of the said enterprises.

## RESULTS AND DISCUSSION

Four kilometers above Çamlıgöze Dam Lake, Kılıçkaya Dam Lake with a depth of approximately 100 meters is located. Kelkit Stream and its spring waters accumulate in Kılıçkaya Dam Lake, and the rested and clean water from here comes to Çamlıgöze Dam Lake. Generally, there is no change in the level of Çamlıgöze Dam Lake waters during the year. Because the water dropped 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. Çamlıgöze Dam Lake waters are a little colder due to the fact that the waters of Kılıçkaya Dam Lake come from deep and the distance between the two dam lakes is short. Therefore, Çamlıgöze Dam Lake has a stream feature. With these features, Çamlıgöze Dam Lake is one of the rare dams in Turkey. Anyway, trouts likes flowing and cold waters. Due to all these features of Çamlıgöze Dam Lake, the fish grown in an environment such as a stream attracts great attention with its taste. Accordingly, the waters of Çamlıgöze Dam Lake allow trout farming in net cages throughout the year. In Çamlıgöze Dam Lake, rainbow trout farming has been carried out intensively in net cages since 2008. Information on the enterprises that raise rainbow trout in cages in Çamlıgöze Dam Lake is presented in Table 2. In Çamlıgöze Dam Lake, as of 2021, there are 5 enterprises rainbow trout in cages and the total current production capacity of these enterprises is 4250 tons/year. In Çamlıgöze Dam Lake, the owners of these 5 enterprises engaged in aquaculture are close relatives and they work together in coordination. All of these 5 enterprises examined in the dam lake are cultured rainbow trout in net cages on rental method within the determined coordinates, and production continues throughout the twelve months of the year. Rainbow trout raised in Çamlıgöze Dam Lake, which has clean, cool and oxygen-rich waters, are in demand both in the country and abroad with their taste. This is a success of Çamlıgöze Dam Lake.

In Çamlıgöze Dam Lake, as of 2021, when the distribution of rainbow trout farming enterprises in net cages is analyzed according to their capacities, there is 1 enterprise in the 251-500 tons capacity group and 4 enterprises in the 501-1000 tons capacity group. In the dam lake, the minimum capacity of the aquaculture enterprises in net cages varies between 500 tons/year and the maximum capacity varies between 950 tons/year. There are a total of 4 enterprises with a production capacity of 900 tons/year and above in the dam lake (Table 2). All of the enterprises operating in Çamlıgöze Dam Lake are large-capacity enterprises with a production capacity of 500 tons/year and above. For this reason, the adaptation of these large-capacity enterprises in Çamlıgöze Dam Lake to new technology, production and marketing methods is quite easy. In addition, Aser Aquaculture Company has purchased the Procurement Rights Tender for Çamlıgöze Dam

Lake Natural Fishing Area from Sivas Provincial Directorate of Food, Agriculture and Livestock between March 15, 2016 and March 14, 2021.

***Table 2.*** *Rainbow trout enterprises and capacities in Çamlıgöze Dam Lake*

| N | Province | District | Company Name | Project Capacity |
|---|---|---|---|---|
| 1 | Sivas | Suşehri | Aser Aquaculture Company | 500 tons/year |
| 2 | Sivas | Suşehri | Aser Aquaculture Company | 950 tons/year |
| 3 | Sivas | Suşehri | Falya Aquaculture Company | 900 tons/year |
| 4 | Sivas | Suşehri | Falya Aquaculture Company | 950 tons/year |
| 5 | Sivas | Suşehri | Marsis Aquaculture Company | 950 tons/year |

All of these enterprises in Çamlıgöze Dam Lake have zero juvenile rainbow trout production capacity. There are no hatcheries established in the terrestrial environment belonging to these 5 enterprises by the Çamlıgöze Dam Lake. All of the enterprises meet their fry rainbow trout needs from a business outside the province of Sivas. Fry rainbow trouts are brought to all these enterprises from the hatchery located in Uzunyayla town of Kayseri province, Pınarbaşı district and cultured in net cages in Çamlıgöze Dam Lake. Fry rainbow trouts brought from the hatchery in Kayseri are transferred to the cages in Çamlıgöze Dam Lake and then marketed when they reach sales size after undergoing processes such as grading and grafting. Fry rainbow trouts that are brought to Çamlıgöze Dam Lake with a weight of 3-15 gr reach the market weight of 200-300 gr after about six months. In addition, fry trouts produced in Kayseri are brought to Çamlıgöze Dam Lake and are sent to the Black Sea after being grown to a certain length. After these fish reach a weight of 3-4 kg in the Black Sea, they are exported to Russia, Japan and some European countries.

In all enterprises that cultured rainbow trout in net cages, a separation is made according to lengths during the production phase, and the grading process is done with the help of automatic machines. It has been determined that ready-made pellet feeds are used in trout production in all of the enterprises engaged in trout farming in net cages in Çamlıgöze Dam Lake. Manual feeding method is used in the enterprises in Çamlıgöze Dam Lake. In this method of feeding, fish are carefully fed slowly and with minimal feed loss. The feeds were supplied from outside of Sivas province until 2015. The cost of feed in aquaculture constitutes approximately 60-70% of the production cost. The business owners stated that they established their own feed factory in 2015 and that they met their needs from this feed factory. This factory, which was established by the Çamlıgöze Dam Lake, produces trout feed using fish meal from the Black Sea provinces and fish oil brought from Norway. In particular, fish oil, which is one of the feed raw materials, has foreign dependency. Foreign dependency in aquaculture raw materials plays an impressive role on production costs. Depending on the aquaculture production trends in the world, raw material prices remain high. Decreases or fluctuations in fish oil production can cause prices to rise in a short time and increase production costs. In addition, it is foreseen that this feed factory can meet the needs of the region.

On Çamlıgöze Dam Lake, rainbow trout farming is carried out in approximately 155 net cages with a diameter of 16 meters and a depth of 8-10 meters made of HDPE, that is, high-density polyethylene material. This cages is fixed to each other in groups and to the bottom of Çamlıgöze Dam Lake with ropes by means of anchors and buoyancy systems. The nets of the cages are washed in the washing machine. It has been determined that all of the enterprises producing net cages in Çamlıgöze Dam Lake pay attention to

the cleanliness of the nets in both summer and winter seasons. Access to the net cages is made by motorized boats, and there is a feed warehouse, material warehouse, accommodation for the personnel and building areas for the administration on the side of Çamlıgöze Dam Lake.

According to the findings, when the experiences in farming rainbow trout were examined, it was determined that the owners of the business had an experience of about 30 years. In the research, it has been determined that the owners of trout farming have sufficient knowledge, do not have problems in supplying trout fry and feed. Permanent and temporary workers have about thirteen years of experience. Approximately 100 people work in the aquaculture facilities located on the Çamlıgöze Dam Lake, and they are engaged in trout farming for twelve months of the year. However, in Çamlıgöze Dam Lake, it has been observed that women mostly work in aquaculture with much less numbers. This necessitates the development of female workers' contributions to aquaculture in Çamlıgöze Dam Lake.

Trout sales are made in two ways as retail and wholesale in enterprises producing in net cages. When the product sales point is examined in the enterprises, all of the enterprises sell live and fresh trout in the net cage in the water on the shore of Çamlıgöze Dam Lake. In addition, rainbow trouts of these businesses are also sold to other businesses and restaurants that are engaged in trout farming in the terrestrial environment in Sivas and Suşehri. Since there are no aquaculture processing facilities in Sivas and Suşehri, rainbow trout raised in net cages in Çamlıgöze Dam Lake are also offered for sale after being processed in aquaculture processing facilities owned by private companies in other provinces such as Malatya. Also, rainbow trout produced in net cages in Çamlıgöze Dam Lake are marketed abroad, primarily to Russia, Japan, Netherlands, Germany, Belgium, France and Italy, and also domestically, especially to the provinces of Trabzon, Samsun, Sivas and Ankara. Due to its health benefits, the demand for fish is constantly increasing. This creates an opportunity for trout growers in cages in Çamlıgöze Dam Lake to increase their production and meet both local and international market demands. In addition, the work of business owners to establish a fishery products processing facility in Suşehri district is still continuing.

Keeping the immune system strong against the Covid-19 epidemic is of great importance. For this, it should be fed adequately and balancedly. In this context, trout stands out with its nutritional elements such as vitamins, minerals and omega-3. Despite the difficulties of the Covid-19 epidemic process, trout farming continues uninterruptedly in Çamlıgöze Dam Lake. Due to its taste and quality, especially the trout raised in Çamlıgöze Dam Lake are in high demand.

As in all kinds of farming, the success of aquaculture in net cages in dam lakes depends on site selection [10]. It was determined that Çamlıgöze Dam Lake, which was chosen as the research area, has a very important potential in terms of rainbow trout farming. In terms of evaluating this potential, a total of 5 enterprises engaged in trout farming in net cages have been established in Çamlıgöze Dam Lake. When the situation of the aquaculture enterprises in Sivas province, where Çamlıgöze Dam Lake is located, is examined, there are 45 trout farming enterprises in total according to 2016 data, and the total production capacity of these enterprises has been determined as 5503.5 tons/year [14]. With an annual production of 4250 tons, Çamlıgöze Dam Lake performs 3.37% of Turkey's inland water trout farming and 77.22% of Sivas province trout farming. For this reason, it is seen that Çamlıgöze Dam Lake, situated in the middle Anatolia region of

Turkey and in the northeast of Sivas province, has an important place in rainbow trout farming.

Sivas province, where Çamlıgöze Dam Lake is located, has a very favorable structure in terms of aquaculture. In addition to many natural lakes, aquaculture and fisheries activities carried out in many spring waters feeding the Kızılırmak and Yeşilırmak Rivers, as well as other streams and ponds and dams built on these water resources, have a positive effect on the development of freshwater fisheries in Sivas. The high feed costs and the lack of fish processing facilities in Sivas prevent the development of aquaculture production in Sivas [14]. Karataş et al. [15] obtained data by using the full count method in 14 farms in his study based on a survey with the trout farms in Sivas. According to the data obtained, it was recorded that 14.29% of the 14 trout farms examined produce in the mountain foothills, 35.71% in open land and 50.00% in the valley. Dirican et al. [16] reported that only 3 enterprises engaged in trout farming in net cages operate in the Mursal Dam Lake in the Divriği district of Sivas province, and the total annual production capacity of these enterprises is 84 tons/year. According to these studies, it is seen that trout farming in net cages has not become widespread in Sivas province in 2007 and before. Yüngül et al. [17], in their study based on a survey with Çamlıgöze Dam Lake cage enterprises, determined that the total water surface area rented by these enterprises is 174000 square meters, the average harvest stock density varies between 10.43-12.52 $kg/m^3$, and the average feed conversion ratio is 1.00.

Rainbow trout farming in net cages in Çamlıgöze Dam Lake in Sivas province, where this research was conducted, has shown a very rapid and significant development since 2008. Dirican et al. [16], in their study in Sivas province in 2007, reported that there were 37 rainbow trout aquaculture enterprises and their total production capacity was 770 tons/year. Accordingly, it has been determined that rainbow trout farming in Sivas has increased 7.15 times from 770 tons/year to 5503.5 tons/year in the last thirteen years. It has been observed that the biggest contribution to this rapid growth is provided by trout farming in net cages in Çamlıgöze Dam Lake. This point, which took about thirteen years and a lot of effort in Çamlıgöze Dam Lake, makes a significant contribution to the aquaculture sector. The rapid increase in aquaculture in Çamlıgöze Dam Lake in recent years has brought Sivas and Çamlıgöze Dam Lake to a very important point in trout farming in our country. Trout farming enterprises in Çamlıgöze Dam Lake not only contribute to Turkey of aquaculture sector, but also make a significant contribution to the country's economy by providing employment.

Çamlıgöze Dam Lake is a very important water source for rainbow trout farming with its water quality and general ecological structure. The water of Çamlıgöze Dam Lake is of high quality water class, it is suitable for trout farming, the level of the lake water does not change during the year, the cold water dropped from the depths of Kılıçkaya Dam comes to Çamlıgöze Dam Lake and the same amount of water is used in Çamlıgöze Hydroelectric Power Plant to flow back into the stream. The fact that the waters of Çamlıgöze Dam Lake are in a constant state of circulation, is an indication that there is a great potential for the future of trout farming. In addition, although there is a continuous improvement in aquaculture production in the World and Turkey, the areas suitable for aquaculture are decreasing, especially in inland water resources and especially in dams. At the same time, the presence of the energy sector in Çamlıgöze Dam Lake makes it difficult to increase the capacity of existing aquaculture facilities or to establish new facilities.

Changes that cannot be controlled in a short time, such as climate change and global warming, affect aquaculture production. In particular, the decrease in the water levels of Kılıçkaya Dam Lake due to the drought in the region in the last few years negatively affects the waters of Çamlıgöze Dam Lake, especially in summer. For this reason, it is very important to monitor the water level and water quality in Çamlıgöze Dam Lake, especially in summer. In Çamlıgöze Dam Lake, the people working in the aquaculture sector should be informed about the negative effects of climate change and global warming, and necessary training and similar measures should be taken to ensure that precautionary measures are taken and sustainable aquaculture production can be made.

The rapid growth of rainbow trout farming in net cages in Çamlıgöze Dam Lake is a very important development for the aquaculture sector. While this situation reveals the strong potential of Çamlıgöze Dam Lake in terms of rainbow trout farming in net cages, on the other hand, it shows the importance of using this water resource effectively and sustainably. Aquaculture is an extremely important sector in terms of the use of existing natural water resource potential and sustainability. Sustainability is the rational use of natural resources in a certain balance and transferring these resources to future generations safely [18]. The concept of sustainability has three dimensions: economic, environmental and social. In order to achieve sustainability, it is necessary to synthesize these three dimensions. Education, careful management and regulation are essential to ensure sustainability. Sustainable aquaculture, on the other hand, is balancing the use of water resources, protecting the ecosystem that meets human needs, and evaluating the quality of the environment without reducing it [19]. As a result, the sustainability of rainbow trout farming in net cages in Çamlıgöze Dam Lake, which is mesotrophic, can be achieved by protecting the ecosystem, using it in a balanced way and without degrading the quality of the environment. Monitoring and controlling the physical, chemical and biological changes that may occur over time in Çamlıgöze Dam Lake is also extremely important for sustainable trout farming. For the sustainable use of rainbow trout farming in net cages, an appropriate management model should be established with conservation and monitoring studies in Çamlıgöze Dam Lake. In order to ensure the sustainability of Çamlıgöze Dam Lake, where aquaculture enterprises are established in cages, the effects of aquaculture that cause environmental degradation should be minimized along with other negative environmental pressure elements. In order to ensure the sustainability of both Çamlıgöze Dam Lake and aquaculture in cages, proper management should be provided and environmentally friendly techniques should be applied.

## CONCLUSION

With this research, it has been observed that rainbow trout farming practices in cages, which started in 2008 in Çamlıgöze Dam Lake, have taken very important distances today. The trout produced in cages in Çamlıgöze Dam Lake in Sivas's Suşehri district are sent both domestically and abroad. Sustainable and ecological production is very important in trout farming in cages. Trout is a source of quality protein and contributes to food safety. Trout farming in cages in Çamlıgöze Dam Lake is an important initiative that contributes to food security. For this reason, it is important to improve the environment and supports that can encourage the growth of trout farming sector in cages in Çamlıgöze Dam Lake. In order to benefit from aquaculture in cages effectively and efficiently in the future, Çamlıgöze Dam Lake should be operated in a balance between protection and use.

Because aquaculture is a valuable food production source that can meet a significant part of the quality animal protein requirement.

**Conflicts of Interest:** The author declares no conflict of interest.

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