Turkish Journal of Agriculture - Food Science and Technology, 12(12): 2457-2463, 2024
DOI: https://doi.org/10.24925/turjaf.v12i12.2457-2463.6817

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Spatial Evaluation of Carp Production by Using Geography Information Systems (GIS) in the Anatolian Region of Türkiye

İlknur Uçak[1,a,*], M. Cüneyt Bağdatlı[2,b], Maliha Afreen[1,c]

[1]*Niğde Ömer Halisdemir University, Faculty of Agricultural Sciences and Technologies, Department of Animal Production and Technologies, Niğde, Türkiye*
[2]*Niğde Ömer Halisdemir University, Faculty of Architecture, Department of City and Regional Planning, Niğde, Türkiye*
[*]*Corresponding author*

ARTICLE INFO

Research Article

Received : 17.04.2024
Accepted : 31.10.2024

Keywords:
Carp Production
GIS Mapping
Spatial Analysis
Anatolian Region
Türkiye

ABSTRACT

Fish industry has significant importance all over the world because red meat is not enough to complete the protein requirements of growing population. Therefore, focus is now on those fish species production rate which are more suitable. In this study we focused on common carp which has important commercial value due to its size and tasty meat. Common carp is a fresh water fish and mostly found in rivers, ponds, dams and lakes. It is special due to its ability of adjustment in any aquatic habitat and sometimes beneficial also for other aquatic animals by releasing nutrients in habitat. Türkiye is a rich country in terms of rivers, dams and lakes. In this research, we described famous water reservoirs in Türkiye and in which regions higher amount of carp fish produced. It was focused on Central Anatolian Region of Türkiye which has large amount of water reservoirs. Geography Information System (GIS) based mapping and spatial analysis was used in this study to check the production rate of carp in Central Anatolian Region of Türkiye for long period from year 2000 to 2019. It was concluded from this study that highest average production rate of carp is obtained in Konya province (total: 11919,2 tons/2000-2019; average: 596 tons/20 year) which is west part of Anatolian region and lowest average production rate is found in the Niğde province (total: 163,5 tons/2000-2019; average: 8,2 tons/20 year) which is south part of the Central Anatolian Region.

[a] *ilknurrucak@gmail.com* *https://orcid.org/0000-0002-9701-0824*
[b] *cuneytbagdatli@gmail.com* *https://orcid.org/0000-0003-0276-4437*
[c] *malihaafreen120@gmail.com* *https://orcid.org/0000-0001-7542-1318*

Introduction

Fishing remains a considerable source of income for humans since ancient times. Countries concerned of balanced nutrition have focused on optimum utilization of water reservoires and to expand their animal protein bases. For this purpose many new projects have been developed. Major production is through fishing from natural habitats. Although, the participation of aquaculture in fisheries is increasing gradually. Türkiye has also affected by this global revolution because aquaculture sector has considerably increased also in Türkiye (Akova, 2015).

Even though there are many modifications in countries, 16.7% of animal protein sources are provided by fishery foods. This includes as 59% in Taiwan, 3% in Austria, 55% in Japan and 7.1% in Germany. Fifty percent population in developing countries fulfill 40% of their animal protein requrement from fish. All over the world, in 1960 average amount of fish consumed by people was 9.9 kg per capita, while in 2009 it increased to 18.4 kg and in 2012 increased to 19.2 kg. Average amounts of fish consumed in Europe, North America, Oceania, Asia, and Africa was 22 kg, 24.1 kg, 24.6 kg, 20.7 kg, and 9.1 kg per capita respectively (Akova, 2015). Fish yields have been decreasing over the year due to quickly increase in world population. Fish reservoirs also in threat due to many adversarial environmental aspects inpite of using many advance techniques in fishing. Earth population is more than seven billion. Fish farming make an important contribution to fulfill the nutritional requirements of this growing population, providing raw material for the fish industry and increasing facilitation for employment (Yılmaz et al., 2008). In general, the worldwide yield of fishery captured reached from 13.13 million tones in 1990 to 66.6 million tons in 2012. The produced income was 144.4 billion US dollars (Akova, 2015).

Fish farming through aquaculture is diveded into two ways as freshwater aquaculture and marine aquaculture. Freshwater aquaculture globally has great contribution in provision of fish protein (Belton et al., 2018; Belton and

Bush, 2014; Bayhan et al., 2017). Freshwater aquaculture comprise a large variety of systems throughout economic and physical scales, species, value chains, ownership and infrastructure configurations. It mostly contains household organized ponds and commercial businesses at medium and small levels which yields many species of carp fish and some other fish in polyculture schemes for consumption of local people (Hernandez et al., 2018). Freshwater aquaculture is mostly known for the production of striped catfish and tilapia that are mainly produced in mud ponds for usage at national and international level. A key factor of freshwater aquaculture production throughout the past twenty years has been the propagation of value food chains inside and outside of country situated in South and Southeast Asia (Belton et al., 2017; Hernandez, et al., 2018; Belton and Filipski, 2019; Belton and Little, 2008; Loc et al., 2010). China is the largest provider of freshwater fish at domestic level and also at international level (Fluet-Chouinard et al., 2018). In 2003, approximate 400.000 tons of common carp, grass carp, chub and crucian carp were produced in China for commercial use in the native market. Asia is the major producer of aquaculture, as in 2017 comprising 92% of the aquatic animals and seaweeds (FAO, 2019). Türkiye gained the 36th position in the global fishing yield in 2005, and 23rd position in the global aquaculture fish farming yield. Freshwater fishery production was the greatest in East Anatolian region from 1998 to 2008. The mostly farmed species in Türkiye are trout, sea bass and sea bream. Fishery products in Türkiye produced from freshwater is 52.7%, while production from marine water is 47.3%. Rainbow trout which is most dominant farmed specie, accounts 56% of the whole production. In previous nine years trout farming increased three times (from 2004 to 2013). According to location Türkiye has opulent water reservoirs, and due to rich reservoirs of water and suitable climate, it is actually best state for aquaculture (TUIK, 2014).

Inland waters of Türkiye comprised 236 fish species and 26 subspecies of fish families. The Cyprinidae fish family has 166 species which is 49% of the whole fish yield. Common carp fish, is the most common specie of cyprinid family that makes a significant portion of inlandwater (stream, lake and dam lake,) fish production in many areas of Türkiye (Çetinkaya, 2006; Balık et al., 2006). Inland waters always had a great potential of fish production in terms of variety due to sufficient freshwater reservoires that comprised about 175 km of rivers, 1 million hactar of natural lakes, 170.000 hactar of reservoirs, 70.000 hactar of lagoons and 700 small reservoirs. Many species including carp, mullet, wells and eel are major produced species in these freshwater reservoires (Rad, 2000). Additionally, as marine fish storage in the marine adjoining Türkiye are slowly decreasing, inland water reservoires gives a major choice for establishment of freshwater fish harvest and fish farming (Celebi, 2010; Karabas et al., 2018).

Common carp linked to the Cypriniformes order and the Cyprinidae family, which is known the biggest family of freshwater fish. It mostly produced and lived in freshwater habitates specifically in rivers, lakes and ponds and very rarely found in salty water (Barus et al., 2001). It is generally found in almost whole countries of the world though is very famous in Asia and in European countries (Weber and Brown, 2011; Kloskowski, 2011a; Parkos and Wahl, 2014). Globally Common carp is the third major cultured and commercially significant freshwater fish specie (FAO, 2013). It is known as commercially important fish specie because of its excellent adaptive ability to both food and ecosystem (Soltani et al., 2010; Manjappa et al., 2011; Rahman, 2015; Erguven and Aydin, 2019). Over than 80% of whole fish yield comes from common carp in few European countries (Woynarovich et al., 2010; Anton-Pardo et al., 2014). Common carp is mostly known as 'ecological engineer' due to its ability of create modification in properties of aquatic ecosystems (Matsuzaki et al., 2009; Bajer and Sorensen 2015; Rahman, 2015).

Globally the production of common carp is about 4 million tons. According to global production of finfish aquaculture in 2010, grass carp categorized as first, silver carp categorized as second and common carp categorized as third. Only China produced 77% of the worldwide aquaculture production of common carp fish in 2009 (FAO, 2012). The most produced six finfish species in china including grass carp, silver carp, common carp, bighead carp, crucian carp and tilapia (FAO, 2013). Common carp (*Cyprinus carpio*) has an important place in Türkiye's fishing industry and it is mostly found in our freshwater reservoires such as rivers, streams, ponds, lakes and dam lakes. It is commonly found in calm-flowing bottom areas of big rivers in reigon of Anatolian but not in very cold mountain lakes (Geldiay and Balık, 1988). In 2006 Carp fish contained 27.5% of whole freshwater captured fish production in Türkiye (Anonymous, 2007).

In Türkiye carp specie was initially examined by Numann (1958). He observed many ecological and biological properties of carp fish population living in Beyşehir, Akşehir, İznik, Eğirdir, Süleymaniye, Manyas and Apolyont Lakes. Actual biological properties of Common carp (*Cyprinus carpio*) were identified in Mogan Lake, in Hirfanlı Dam Lake, in Eymir Lake, in Hafik Lake (Sivas), Akşehir Lake (Konya), Bafra Balık Lakes (Samsun), in Çıldır Lake, Gölhisar Lake (Burdur), in Kaz Lake (Tokat), İznik Lake (Bursa) (Tanyolaç and Karabatak, 1974; Karabatak, 1977; Tanyolaç, 1979; Cengizler, 1987; Çetinkaya, 1992; Demirkalp, 1992; Yerli, 1997; Alp and Balık, 2000; Karataş, 2000; Özeren, 2008). The commercial value of common carp is increasing day by day by increasing the growth rate, higher weight and length, high yield of meat, adjustable in any habitat and good taste (Demirkalp, 1992). Common carp fish is a very famous benthivorous fish that has bottom–up effects. The bottom–up effects of common carp msostly rely on the integration of nutrients which are derived from benthos and nutrients which are excrete from bottom sediment through feeding on benthos.

Common carp increases productivity of phytoplankton by excreting nutrients such as soluble phosphorus from the sediment. These all chracteristics of common carp are important elements for resuspension of sediment. (Rahman et al., 2008a; Rahman, 2015). This influences positively on those fish production, which directly or indirectly rely on natural food. For example, rohu fish is a planktivorous fish, which produced better in those ponds where common carp also exist nither in a monoculture (Rahman et al., 2006). Common carp also increases the oxygen accessbility in the

bottom soil through sediment resuspension. However, resuspension of the bottom soil through common carp increases the depth and limit of oxygen penetration into the bottom soil. Enough oxygen availability enhances the aerobic breakdown of organic matter which also increases the amount of minerals in the bottom soil (Rahman et al., 2009; Yathavamoorthi et al. 2010). Common carp also excrete enough amount of phosphorus and nitrogen which transfers from the bottom sediment to the water column (Morgan and Hicks, 2013).

The most important benefit of GIS analysis is that it gives the desired map as the end result by considering the distribution maps formed by including many factors within a specific database (Xu et al., 2001; Akdeniz et al., 2011; Arslan, 2008; Erguven and Sener, 2019). GIS consists of four major parameters: collection of data and installation of data, second is data base of area geography, third is analysis of data and modeling of data, then fourth is data imagining and presentation. The purpose of spatial analysis is creating the relationship between parameters of water quality by making an estimation from the point values of sample.

This data which is obtained through spatial analysis is used to check the involvement of each parameter of water quality throughout the lake on a GIS spatial distribution map. GIS has been used for sectorial, regional and national studies of aquaculture (Nath et al., 2000; Salam et al., 2003).

In this study we focused on evaluation of carp production with GIS-based mapping and spatial analysis in Central Anatolian Region of Türkiye for long periods from 2000 to 2019. Geography Information System (GIS) analysis is a broadly used technique specifically for management of water quality in previous years.

Material And Method

This study was conducted in Anatolian Reigon of Türkiye. According to geography, total area of Central Anatolian Region is 163.057 km^2 while its total population is 12.896.55. Central Anatolian region is located in the middle of Türkiye. There are 13 provinces in total. The location of research area is presented in Figure 1.

In this research, carp production included from the year of 2000-2019 years. All this production rate information data got from TÜİK reports (TÜİK, 2019). In order to determine the distribution of carp production by provinces and the relationship between the carp production, the linear regression method was analyzed. In additon to the standard deviations of the total 20 years production amounts of the provinces of the Central Anatolian Region between the years 2000-2019 were determined (Schneider et al., 2010). In the study, the carp production amount of the provinces of the Central Anatolian Region was analyzed spatially by using Arc GIS 10.3.1 one of the geography information system software (Anonymous, 2010). All this data was analysed by using GIS-based mapping and spatial analysis. In the research, distribution maps were created by using spline interpolation method for spatial evaluation of carp production amounts in Anatolian region's provinces (Hou and Andrews, 1978; Hummel, 1983; Lee, 1983).

Results And Discussion

According to GIS-based mapping and spatial analysis we found the following maps and graphs in which the carp production amounts are given according to the cities in the map, and a comparison of these production amounts is given in the graphs. Each graphs shows the detail of five year data of carp production.

In Figure 2 it can be seen in 2000 Aksaray carp production is 80 tons, Ankara production is 422 tons, Eskişehir production is 296 tons, Karaman production is 72 tons, Kayseri production is 421 tons, Kırıkkkale production is 70 tons, Kırşehir production is 432 tons, Yozgat production is 170 tons, *Çankırı* production is 305 tons, Sivas production is 186 tons and *Niğde* carp production is 20 tons. The Nevşehir production is 18 tons with the lowest value and highest carp production was reported in Konya with a highest value of 683 tons. In maps we see the blue places where the carp production is mostly conducted, which means that carp production is highly conducted around the west part of the research area as spatial, while the production is getting lower near the south part of the research area as spatial.

Figure 1. The location of research area

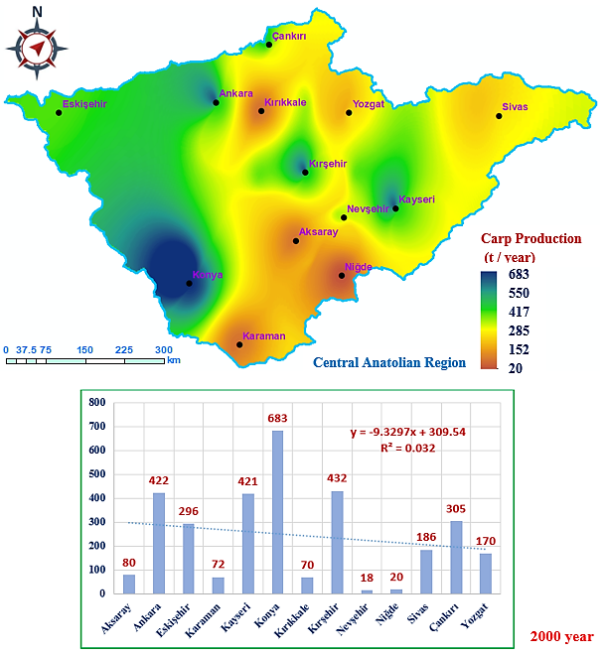

Figure 2. Spatial analysis of carp production in 2000

As seen in the Figure 3, in 2005 Aksaray carp production is 91 tons, Ankara production is 574 tons, Eskişehir production is 351 tons, Karaman production is 86 tons, Kayseri production is 274 tons, Kırıkkale production is 74 tons, Kırşehir production is 433 tons, Yozgat production is 135 tons, *Çankırı* production is 283 tons, Sivas production is 185 tons and Nevşehir carp production is 36 tons. The *Niğde* poduction is 7 tons with the lowest value and highest carp production was reported in Konya with a highest value of 869 tons. In spatial maps we see the blue places where the carp production is mostly conducted, which means that carp production is highly conducted around the west part of the research area as spatial, while the production is getting lower near the south part of the research area as spatial.

Figure 4 shows that in 2010 Aksaray carp production is 79 tons, Ankara production is 557 tons, Eskişehir production is 336 tons, Karaman production is 82 tons, Kayseri production is 237 tons, Kırıkkale production is 87 tons, Kırşehir production is 241 tons, Yozgat production is 123 tons, *Çankırı* production is 131 tons, Sivas production is 184 tons, Nevşehir carp production is 17 tons. The *Niğde* poduction is 2 tons with the lowest value and highest carp production was reported in Konya with a highest value of 897 tons. In spatial maps it can be seen that the green places where the carp production is mostly conducted, which means that carp production is highly conducted around the west part of the research area as spatial, while the production is getting lower near the south part of the research area as spatial.

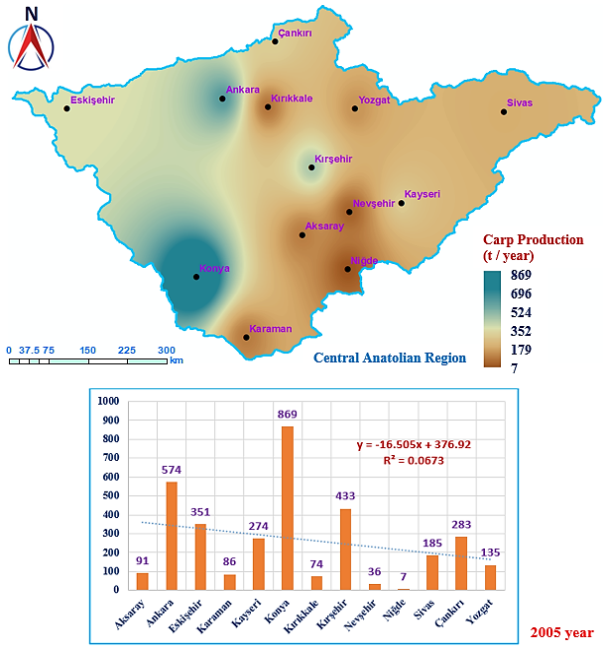

Figure 3. Spatial analysis of carp production in 2005

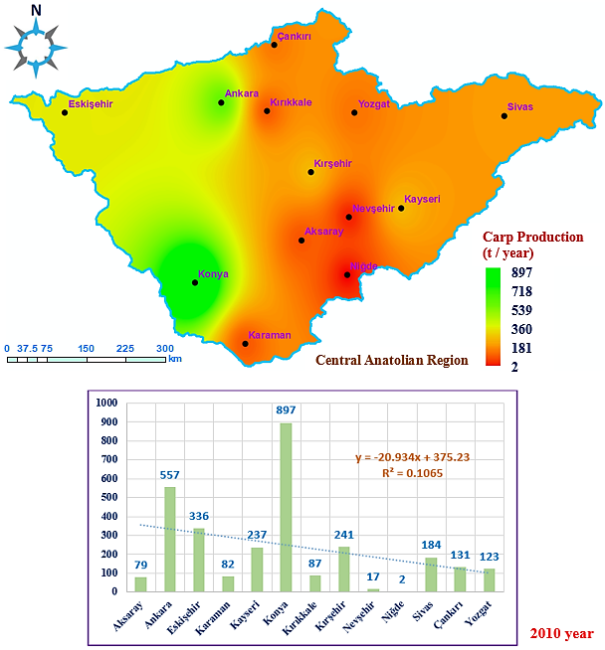

Figure 4. Spatial analysis of carp production in 2010

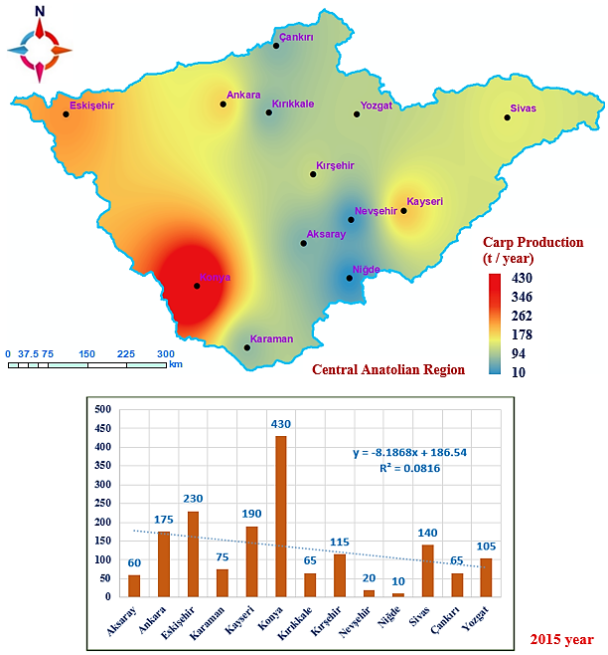

Figure 5. Spatial analysis of carp production in 2015

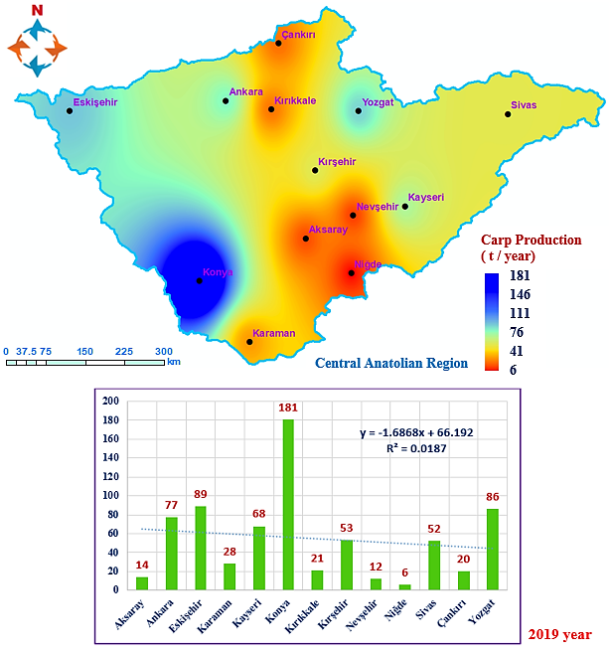

Figure 6. Spatial analysis of carp production in 2019

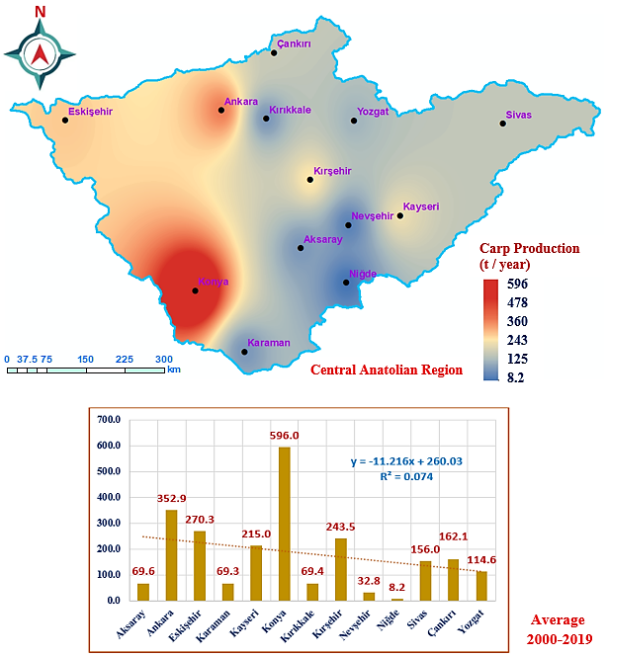

Figure 7. Spatial analysis of carp production in average of long periods (2000-2019)

In 2015 Aksaray, Ankara, Eskişehir, Karaman, Kayseri, Kırıkkale, Kırşehir, Yozgat, Çankırı, Sivas, Nevşehir carp production is 60 tons, 175 tons, 230 tons, 75 tons, 190 tons, 65 tons, 115 tons, 105 tons, 65 tons, 140 tons and 20 tons, respectively. The *Niğde* poduction is 10 tons with the lowest value and highest carp production was reported in Konya with a highest value of 430 tons. In maps we see the red places where the carp production is mostly conducted, which means that carp production is highly conducted around the west part of the research area as spatial, while the production is getting lower near the south part of the research area as spatial.

Aksaray carp production is 14 tons, Ankara production is 77 tons, Eskişehir production is 89 tons, Karaman production is 28 tons, Kayseri production is 68 tons, Kırıkkale production is 21 tons, Kırşehir production is 53 tons, Yozgat production is 86 tons, *Çankırı* production is 20 tons, Sivas production is 52 tons, Nevşehir carp production is 12 tons in 2019 (Figure 6).

The Niğde poduction is 6 tonnes with the lowest value, and the highest carp production was reported in Konya with a highest value of 181 tonnes. In maps we see the blue places where the carp production is mostly conducted, which means that carp production is highly conducted around the west part of the research area as spatial, while the production is getting lower near the south part of the research area as spatial.

In Figure 7 we can see graph shows the average carp production amount of each provinces for 20 years from 2000 to 2019 by doing spatial analysis. It shows Aksaray carp production is 69.6 tons, Ankara production is 352.9 tons, Eskişehir production is 270.3 tons, Karaman production is 69.3 tons, Kayseri production is 215 tons, Kırıkkale production is 69.4 tons, Kırşehir production is 243.5 tons, Yozgat production is 114.6 tons, *Çankırı* production is 162.1 tons, Sivas production is 156 tons, Nevşehir carp production is 32.8 tons. The *average* poduction of all these years *Niğde* is 8.2 tons with the lowest value and highest average carp production was reported in Konya with a highest value of 596 tons. In maps we see the red places where the carp production is mostly conducted, which means that carp production is highly conducted around the west part of the research area as spatial, while the production is getting lower near the south part of the research area as spatial. Table 1 shows the total and average values of carp production in 2000-2019 of each city.

It was reported that the carp (*Cyprinus carpio*) has an important place in fishing activities in Türkiye and it is widely distributed in freshwater ecosystems including lake, river, pond and dam lake. There is suitable water conditions and carp mostly captured from fresh waters, however carp farming is quickly decreasing in Türkiye. According to previous literature carp production decreased from year 2003 to 2013, while there was only 146 tons carp cultured in 2013 (TÜİK, 2013). The production of aquaculture carp in Türkiye in 2004, 2008 and 2013 was reported as 683, 629 and 146 tons, respectively (TÜİK, 2013).

On other hand the total amount of captured and aquaculture production of common carp in Türkiye in 2003, 2007 and 2012 was 14363 tons, 12886 tons and 10195 tons/year, respectively. The world total carp population was 3.023.675 (2003), 2.887.591 (2007), 3.877.118 (2012) tons/year, respectively in these years. (FAO-FIGIS, 2014). According to previous study total carp production in the Eastern Anatolian Region is 28.790,8 tons and the highest production is conducted in Elazığ. It records for half of the total production in the East Anatolian Region. After Elazığ, production rate is going to declined in Malatya, Tunceli, Van, Erzincan, Erzurum, Muş, and Bitlis, while Iğdır, Ardahan, Kars, respectively and Bingöl have the lower most production rate (Akova, 2015). Overall production in the Central Anatolian Region is 19.015 tons with trout being the dominant species. Mirror carp is farmed only in Kırşehir and Yozgat as 11.2 tons and 27.2 tons, respectively. Kayseri production comprise more than half of the overall production in the Central Anatolian Region. After Kayseri carp production rate is going to declined in Sivas, Karaman, Kırşehir, Konya, Yozgat, Eskişehir, Ankara, Niğde and Çankırı, respectively. Overall production in the Southeastern Anatolian Region is 10.331,8 tons. Approximately half is cultured in Şanlıurfa. After Şanlıurfa production rate is going to declined in Diyarbakır, Gaziantep, Batman, and Adıyaman. Lower Production values were found in Hakkari, Mardin, Şırnak and Siirt (Akova, 2015).

Conclusions

It is concluded from this article that fisheries have remained an important industry from ancient times to date. As the global population increased captured fish is not enough to complete the requirements of protein in human. Therefore fish farming sector is established all over the world which is called aquaculture. Aquaculture include both farming in fresh water and farming in marine water. In this article we were focused on carp production in Central Anatolian Reigon of Türkiye.

Table 1. The average or total values and standard deviation of carp production in Central Anatolian Region

Provinces	Carp Production (tons/year) in 2000-2019			
	Total	Average	Standard Deviation	R^2
Aksaray	1391.0	69.6	23.661	0.6587
Ankara	7058.9	352.9	192.860	0.6409
Eskişehir	5406.4	270.3	91.697	0.6125
Karaman	1386.0	69.3	21.721	0.3053
Kayseri	4300.9	215.0	84.224	0.7866
Konya	11919.2	596.0	231.013	0.666
Kırıkkale	1387.0	69.4	25.516	0.3421
Kırşehir	4869.0	243.5	148.293	0.9138
Nevşehir	344.7	32.8	7.506	0.1826
Niğde	163.5	8.2	4.705	0.0834
Sivas	3119.1	156.0	48.606	0.584
Çankırı	3241.0	162.1	111.057	0.9463
Yozgat	2291.0	114.6	27.695	0.8116

GIS based-mapping and spatial analysis were used in this study to check the production rate of carp in Central Anatolian Region from year 2000 to 2019. It was concluded from this study that the highest production rate of carp is obtained in Konya province which is the west part of Anatolian region and the lowest production rate is found in the Niğde province which is the south part of the Anatolian region.

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