



# A Data-Driven Analysis of Romania's Freshwater Fisheries Production

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**Abstract:** Fishing has been an important activity since ancient times, providing people with a vital source of food. However, this practice was limited to specific periods when certain fish species were most accessible, usually during migration or spawning seasons. To overcome these limitations and secure a steady supply of fish, people began breeding various species in controlled environments such as lakes and ponds. This led to the development of aquaculture, which focuses on the controlled breeding, and the qualitative and quantitative improvement of fish resources through selective breeding and proper feeding. In Romania, the earliest documented evidence of fish farming originates from the southern, south-eastern, and central regions, where pond-based systems were established. The country covers a total area of 238,400 km<sup>2</sup>, of which approximately 4% consists of freshwater bodies; notably, more than one-quarter of this area is represented by the Danube River and the Danube Delta. The present study investigates the spatial distribution of freshwater fish farms across Romania and provides an analysis of the predominant farmed species together with their production volumes.

**Key words:** Aquaculture, Fish farms, Cyprinids, Salmonids

## Introduction

Since the earliest times, humans have sought accessible sources of food, with fishing being one of the earliest and most important means of sustenance (Sahrhage 2008, Bridault et al. 2022). Initially, fishing was limited to specific periods of the year when certain fish species were available, primarily during their migration or natural breeding seasons (Bartosiewicz & Bonsall 2000). Over time, people developed methods to ensure a constant supply of fish by breeding various species in controlled environments such as small lakes and ponds (Beveridge et al. 2002, Colin 2011, Svanberg & Cios 2014). This led to the

beginning of aquaculture, which focuses on the controlled production of aquatic organisms, aiming to increase yield and enhance quality through selective breeding and optimized nutrition. According to the FAO report published in 2022, global consumption of farmed fish has, for the first time, surpassed that of wild-caught fish captured for human consumption. The highest production coming from Cyprinids, followed by Tilapias and Salmonids (FAO 2022). In Romania, evidence of wild fish capture as a significant food source dates back to the Mesolithic and Early Neolithic periods, in communities settled near large water bodies. Archaeological findings highlight the importance of fish in the diet of these early set-

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lements (Bartosiewicz et al. 2001, Dinu 2010). By the early modern period, commercial trade in wild-caught fish was well-established, especially along the Danube River (Giurescu 1964). Historical records from the 18th century describe traditional fishing methods and the extensive trade of salted fish, particularly sturgeon, which was harvested in large quantities, preserved, and exported to various European capitals (Marsigli 1726, Giurescu 1964). A detailed overview of Romanian fishing and fisheries was conducted in the early 20th century by Grigore Antipa, who documented fish species and the state of fisheries in Romania (Curcă 2017, Antipa 1909, Antipa 1916). Due to the constant decline in fish catches from commercial fishing, mainly caused by human-induced alterations in water basins, land drainage, and excessive pollution throughout the 20th century, greater attention has been given to controlled fish farming to help meet market demand while reducing pressure on wild fish populations (Schiemer et al. 2005, Oțel 2007). For example, a major concern arose regarding the decline of sturgeon populations in the lower Danube River, leading to a ban on fishing for all Danube sturgeon species (Manea 1966, Manea 1980, Oțel 2007, Hont et al. 2021). As a result, fish farms were established to compensate for the loss of wild populations, and studies were conducted to support the development of aquaculture and improve the efficiency of fish farms, particularly for high-value fish species (Smederevac-Lalic et al. 2011, Nenciu et al. 2022). Romania's aquaculture has been based on extensive fish farming in lakes and ponds, focusing on both native and acclimatized species. Cyprinid species dominate production, followed by trout, sturgeon, common pike, pike perch, and catfish (Neculita & Moga 2015, Eurofish Last modified 2023). Similar development trends have been observed in neighboring Bulgaria, where freshwater aquaculture has also evolved from traditional carp-based systems toward greater diversification and increased economic efficiency (Hadjinikolova et al. 2010; Uzunova et al. 2023). These regional parallels emphasize the shared trajectory of aquaculture modernization in Eastern Europe and the growing importance of adaptive strategies to enhance production and market competitiveness.

Comparable patterns are visible across other Eastern European countries. In Serbia, aquaculture has gradually diversified beyond carp-based pond systems, with increasing technological modernization and interest in high-value species (Marković et al. 2011). Hungary, traditionally one of the most established aquaculture producers in Central Europe, has strengthened sustainability and competitiveness

through EU-funded modernization programs, while maintaining carp as a key production species (Varadi et al. 2015). Ukraine has also followed a similar trajectory, with carp dominating pond aquaculture and sturgeon culture expanding in recent years despite major geopolitical and economic disruptions (Movchan 2015, Dyudyayeva 2023).

The southeastern region of Romania, supported by numerous water bodies supplied by the Danube River and streams flowing from the mountainous center of the country, has become an important area for aquaculture due to its abundant water resources (Tenciu et al. 2020). In the mountainous regions of central and northern Romania, where numerous streams carry clean, well-oxygenated cold waters, trout farms are predominant. After 1989, trout farming experienced constant growth, with production increasing from 300 metric tons (t) in 1989 to 3,000 metric tons in 2014 (Stoicescu & Pal 2014) and reaching 3,527 metric tons in 2023. This growth was driven by European funding and rising demand from tourism (Bogan & Iamandei 2016). However, despite the increase in fish production, domestic aquaculture cannot meet Romania's growing fish consumption, necessitating significant imports (Roșca & Ignat 2014). This study analyzes the evolution of Romania's aquaculture production between 2015 and 2023, focusing on production levels, the distribution of fish farms, and the most commonly farmed species. The analysis highlights key trends observed during this period, providing insights into the sector's development. While not offering an in-depth forecast, the study discusses implications for sustainability and the economic role of aquaculture in Romania, contributing to a clearer understanding of its recent dynamics and potential.

## Materials and Methods

The information used for publishing this article is based on data released by the National Agency for Fisheries and Aquaculture (NAFA) in Romania. The aquaculture farm authorization issued by NAFA generally covers multiple fish species that can be cultivated in polyculture (ANPA 2024). For mapping purposes, the dominant or primary species listed in the authorization has been selected for representation on the map. The data of fish farms used to create maps, figures, and tables was filtered by removing farms without a valid license, keeping only those farms officially registered as active and holding a valid fish farming license. The processed data was uploaded into Q-GIS software, which was used to generate the map. The analysis of farm distribution

was conducted based on Romania's administrative-territorial organization, which consists of 41 administrative regions (counties) with areas ranging from 1,583 km<sup>2</sup> (Ifov County) to 8,697 km<sup>2</sup> (Timiș County), as well as the capital city, Bucharest, which covers 228 km<sup>2</sup>. Statistical analysis of the catch data, as well as the graphical representation of catches, was performed using Microsoft Excel.

## Results

Most fish farms in Romania produce more than one fish species within the same farm or even in the same ponds, a practice known as polyculture. There are also farms that focused on breeding a single species, most of which are dedicated to salmo-

nid farming (*Salmo trutta*, *Oncorhynchus mykiss*, *Salvelinus fontinalis*). These farms are located in the mountainous regions of central, western, and northern Romania, where rivers provide clean, cold, and well-oxygenated waters (Fig. 1). Farms that are breeding cyprinid species, like native species (*Cyprinus carpio*, *Carassius gibelio*) and Asian species (*Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis*) (Table 1), are distributed throughout the country, particularly in lowland areas of southern and south-eastern Romania (Fig.1).

The distribution of fish farms in Romania highlights significant differences between administrative areas in terms of the number of farms, total surface area, and average farm size (Fig. 2). Călărași County

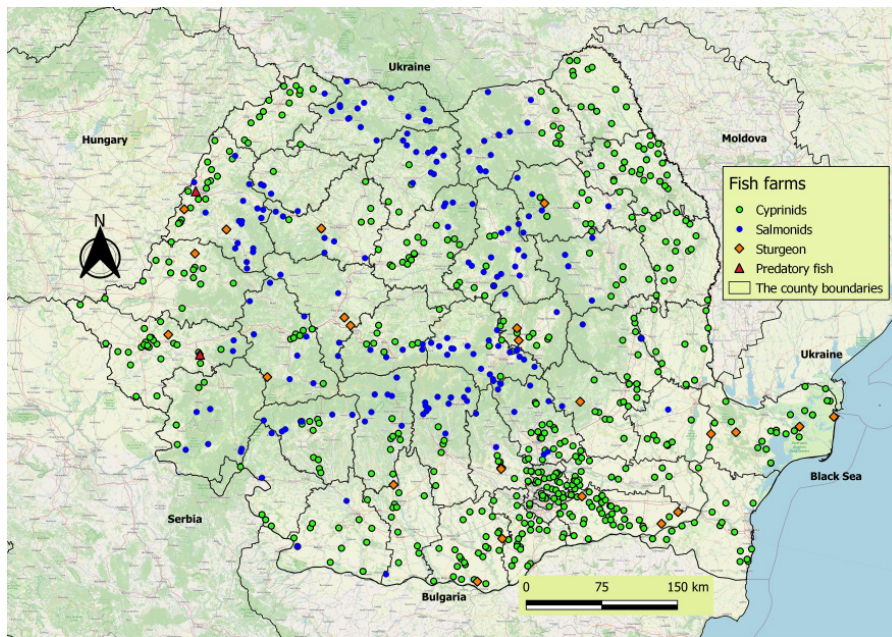


Fig. 1. Map of fish farms for various species in Romania

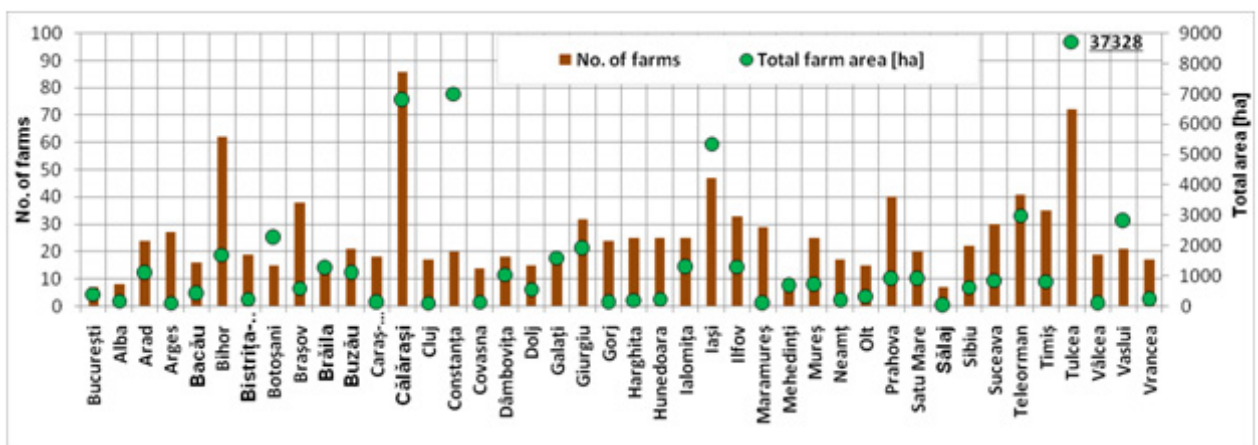
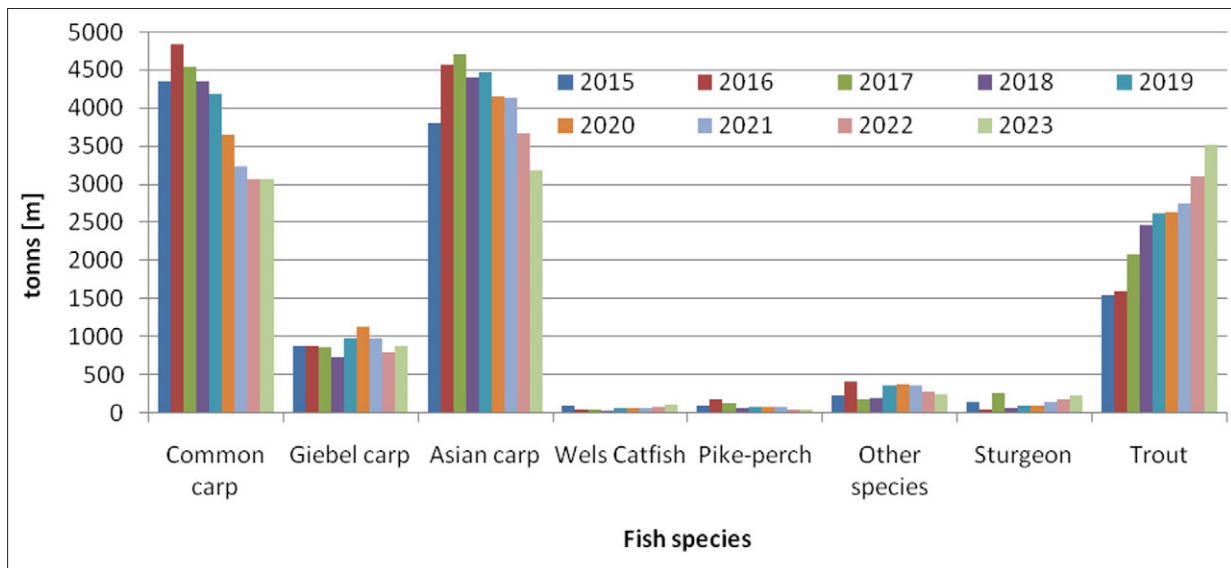


Fig. 2. The surface area and number of fish farms in each county



**Fig. 3.** The evolution of aquaculture production from 2015 to 2023 for the most important fish species in Romania.

located in the south of the country has the highest number of fish farms (86), with an average farm size of 79 hectares, followed by Tulcea County, which has 72 farms and the largest total surface area (37,328 hectares), with an average farm size of 518 hectares. The Maramureş area, located in the north of the country, has 29 farms with the smallest average farm size (3 hectares), while Constanţa has 20 farms with an average farm size of 350 hectares, and Vaslui has 21 farms with an average farm size of 134 hectares (Fig. 2). Bucharest has seven fish farms, with a total surface area of 395 hectares and an average size of 56 hectares per farm. Some counties, such as Sălaj and Maramureş, have a small number of farms and limited total surface areas, while others, like Călăraşi and Tulcea, have both a high number of farms and larger surface areas (Fig. 2).

The fish production data from 2015 to 2023 reveals notable trends and fluctuations across various species (Fig. 3). Total fish production peaked in 2019 at 12,849 metric tons but has gradually declined in subsequent years, reaching 11,264 metric tons in 2023. The most farmed species remain common carp, trout, and bighead carp, with trout being the only species showing continuous growth. While common carp production peaked in 2016 at 4,841 metric tons, it has steadily declined, reaching its lowest level in 2023 with 3,061 metric tons. Similarly, bighead carp production fluctuated significantly, peaking at 2,870 metric tons in 2019 but decreasing to 1,881 metric tons in 2023. Silver carp followed a similar downward trend, declining from 2,364 metric tons in 2016 to 1,165 metric tons in 2023 (Table 1).

Among other carp species, gibel carp production varied, peaking in 2020 at 1,120 metric tons but stabilizing around 875 metric tons in 2023. Grass carp showed relatively stable production, with its highest value recorded in 2021 at 198 metric tons. In contrast, predatory fish species such as wels catfish and pike-perch demonstrated different trends. Wels catfish production gradually increased, reaching 104 metric tons in 2023, whereas pike-perch declined sharply, dropping from 167 metric tons in 2016 to only 40 metric tons in 2023 (Table 1). Sturgeon production has shown significant fluctuations, decreasing to just 33 metric tons in 2016 before rising to 225 metric tons by 2023 (Table 1). The African Catfish showed an increasing trend until 2021, peaking at 188 metric tons before experiencing a sharp drop in 2022 (Table 1). Other species, such as European perch, common pike, and tench, maintained consistently low production levels. Paddlefish and European eel had minimal recorded production, with sporadic appearances in the dataset (Table 1). While major species like common carp and silver carp are experiencing a decline, all trout species farming is on the rise, more than doubling from 1,542 metric tons in 2015 to 3,527 metric tons in 2023 (Fig. 3).

## Discussion

The analysis of aquaculture in Romania between 2015 and 2023 reveals the evolution of aquaculture production and highlights differences in production levels across the country's regions. While total production remained relatively stable (ranging from

**Table 1.** Aquaculture fish production (tonnes) in the period 2015-2023

Crt. No.	Species	2015 [t]	2016 [t]	2017 [t]	2018 [t]	2019 [t]	2020 [t]	2021 [t]	2022 [t]	2023 [t]
1	Common carp ( <i>Cyprinus carpio</i> )	4349	4841	4539	4357	4191	3647	3231	3062	3061
2	Common bream ( <i>Abramis brama</i> )	38	91	27	25					
3	Gibelio carp ( <i>Carassius gibelio</i> )	873	883	862	730	975	1120	977	786	875
4	Roach ( <i>Rutilus spp</i> )		3	17	15					
5	Grass carp ( <i>Ctenopharyngodon idella</i> )	128	96	89	164	143	178	198	141	146
6	Silver carp ( <i>Hypophthalmichthys molitrix</i> )	1843	2364	1854	1692	1465	1743	1431	1280	1165
7	Bighead carp ( <i>Hypophthalmichthys nobilis</i> )	1840	2121	2771	2548	2870	2237	2509	2253	1881
8	Common pike ( <i>Esox lucius</i> )	42	18	20	17	21	16	19	18	27
9	Wels Catfish ( <i>Silurus glanis</i> )	86	48	46	28	53	62	64	78	104
10	European perch ( <i>Perca fluviatilis</i> )		2	2	1					
11	Pike-perch ( <i>Sander lucioperca</i> )	84	167	124	62	78	70	67	49	40
12	Sturgeons ( <i>Acipenseridae</i> )	144	33	252	51	94	84	137	177	225
13	Brown trout ( <i>Salmo trutta</i> )	27	22	8	11			2536		
14	Rainbow trout ( <i>Oncorhynchus mykiss</i> )	1345	1109	1840	2251	2618	2636	204	3107	3527
15	Brook trout ( <i>Salvelinus fontinalis</i> )	170	464	230	212			7		
16	American paddlefish ( <i>Polyodon spathula</i> )	1	2	-	2	1		1		
17	African Catfish ( <i>Clarias gariepinus</i> )		113			101	128	188	46	71
18	European eel ( <i>Anguilla anguilla</i> )		0.08	-						
19	Tench ( <i>Tinca tinca</i> )		1.03	-						
20	Other species	144	181	114	134	239	229	145	215	140
	TOTAL	11113	12559	12797	12298	12849	12150	11714	11211	11264

11,113 to 12,849 metric tons annually), it peaked in 2019 and has slightly declined since then. This downward trend may reflect environmental challenges, regulatory constraints, or shifting consumer demand. A notable shift is observed in species composition. Traditional species such as common carp, silver carp, and bighead carp, once dominant in Romanian aquaculture, have shown a steady decline. In contrast, trout farming has doubled during the period, reaching over 3,500 metric tons in 2023. This growth is likely driven by rising consumer demand, favorable environmental conditions in mountainous regions, and support from aquaculture project funded by European Union (Guillen et al. 2019).

Sturgeon farming has partially recovered, growing from 33 metric tons in 2016 to 225 metric tons in 2023 (Table 1), reflecting increased interest in high-value species this development is primarily linked to the nationwide ban on sturgeon fishing introduced in 2006, which remains in force today. Meanwhile, production of pike-perch and african catfish remains inconsistent, possibly due to specific farming challenges and market uncertainties. Geographically, aquaculture is unevenly distributed. Counties such as Tulcea and Călărași dominate due to their extensive water resources and larger average farm sizes. In contrast, regions like Maramureș and Sălaj host fewer and smaller farms. Trout farms are concen-

trated in mountainous areas, while cyprinids dominate lowland regions. The sector is clearly shifting from traditional polyculture systems toward a more diversified and market-oriented approach. This trend suggests a need for continued investment in technology, improved farming practices, and alignment with changing market preferences. While carp species still play a major role, the future of Romanian aquaculture may rely on premium species and sustainable, specialized production systems that meet evolving consumer expectations and environmental constraints.

## Conclusion

The distribution of fish farms in Romania highlights significant differences between counties in terms of the number of farms, total surface area, and average farm size. These data can be valuable for comparative analyses and for planning the development of the aquaculture sector at the national level. The analysis of fish production from 2015 to 2023 indicates relatively stable outputs, fluctuating within the range of 11,113–12,849 metric tons, with a peak in 2019 (12,849 t) followed by a slight decrease to 11,264 t in 2023. A significant shift in species popularity was observed, as traditional species such as common carp, silver carp, and bighead carp are steadily declining, indicating changes in market demand, production efficiency, or environmental conditions affecting their growth. The trout farming stands out as the only sector experiencing continuous growth, more than doubling from 1,542 metric tons in 2015 to 3,527 metric tons in 2023. This shift suggests a growing focus on trout farming, likely due to its market demand and adaptability. However, certain species such as sturgeon, african catfish, and pike-perch exhibit highly unstable production levels, which may be due to challenges in maintaining consistent output, specific farming requirements, fluctuating demand, or regulatory constraints. The increasing role of high-value species, especially trout and the partial recovery of sturgeon production, highlights a shift toward specialized or premium aquaculture markets rather than the traditional mass production of carp species. This transformation suggests that the Romanian aquaculture sector needs to adapt by diversifying production, investing in modern fish farming techniques, and responding to evolving market trends. With traditional carp farming in decline and high-value species gaining prominence, the sector's long-term sustainability may depend on innovation, improved farming methods, and strategic diversification. The overall fish production in-

dustry remains stable, with annual totals fluctuating between 11,000 and 12,849 metric tons. However, the decline in traditional species and the increase in high-value species like trout and sturgeon indicate potential changes in Romania's aquaculture sector. Future growth opportunities may lie in diversifying production and focusing on species with increasing market demand.

**Acknowledgements:** Sincere appreciation is extended to the National Agency for Fisheries and Aquaculture (NAFA) of Romania for providing the essential data that facilitated the preparation of this article.

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Received: 01.07.2025  
 Accepted: 30.11.2026

