Status, Challenges, and Prospects of Aquaculture Development in Iraq

Hasan Ali AL-Hilali[1], Lozovsky Alexander Robertovich[2], Naser Alwan Salih Al-Alnjawi[1], Mohammed Salih Qaddoori[1], Muath Abduljabbar Nayeef Al Azawy[1], Ehab Husam Sabre[1].

1Ministry of Agriculture, Directorate of Animal Resources, Iraq.
2Astrakhan State University, Russia.

*Corresponding Author E-mail: hassanalhilaly89@gmail.com

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Abstract

Aquaculture in Iraq has undergone significant development, transforming from rudimentary practices to modern systems that support food security and economic growth. This sector has shown resilience despite facing numerous challenges, including water scarcity, environmental pollution, Political instability, and limited technological resources. Historically, aquaculture production in Iraq has been dominated by carp species, cultivated primarily in earthen ponds and floating cages using deferent agriculture methods. While production has seen periods of growth, such as the adoption of artificial propagation techniques and the rise of private sector involvement, it has also experienced setbacks due to political and economic instability, as well as external environmental factors. Currently, aquaculture contributes nearly 95% of Iraq's total fish production, making it a vital component of the nation's food system. However, constraints like deteriorating water quality, inefficient farming practices, and limited access to advanced technology hinder sustainable growth. This review provides an in-depth analysis of the historical progression, current state, and challenges facing the aquaculture industry in Iraq. Additionally, it explores opportunities for advancing sustainable aquaculture through the adoption of modern technologies, improved resource management, and policy reforms. The findings aim to guide future strategies to enhance aquaculture's contribution to food security, Luxury living, and environmental sustainability in Iraq.

Keywords: Aquaculture, Common Carp, Food Security, Iraq, Semi-Intensive Systems, Sustainable Development, Water Resources Management.

Introduction

Aquaculture offers significant potential to meet the growing demand for freshwater and marine products, as well as animal protein for human consumption (Hua *et al.*, 2019). Food security is a critical component of sustainable development globally (Varzakas and Smaoui, 2024). With the rapid increase in the global population (fig.1),

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changing dietary habits, the expansion of the middle class, and the rising demand for healthy foods, there has been a growing need for fish and seafood (Garlock *et al.*, 2022). Over the past two decades, fisheries have faced a decline due to the depletion of wild fish stocks (Garlock *et al.*, 2022). Consequently, there has been a shift towards aquaculture, which has experienced rapid growth. In fact, aquaculture has become the fastest-growing sector in agriculture, with an average annual growth rate of approximately 6% (Barange, 2018). In the coming decades, the global demand for food derived from aquatic environments is anticipated to increase, as these meals are crucial for helping to meet the demands of an expanding human population (FAO 2022). The world's population is projected to increase by 2.4 billion in 2050, reaching 9.7 billion (FAO 2020). Due to the emergence of a greater proportion of 'middle-class' individuals with greater purchasing power and a propensity to consume more animal protein than those with lower incomes, food demand is anticipated to increase more rapidly than population growth (Dasgupta and Robinson 2022). Aquaculture production in Iraq represents a recent success story, contributing significantly to the food supply for the Iraqi population despite numerous environmental, geographical, and political challenges faced by the country. Aquaculture production in this country has experienced significant fluctuations over the past few decades, influenced by various political, environmental, and socio-economic factors (El-Sayed, 2017).

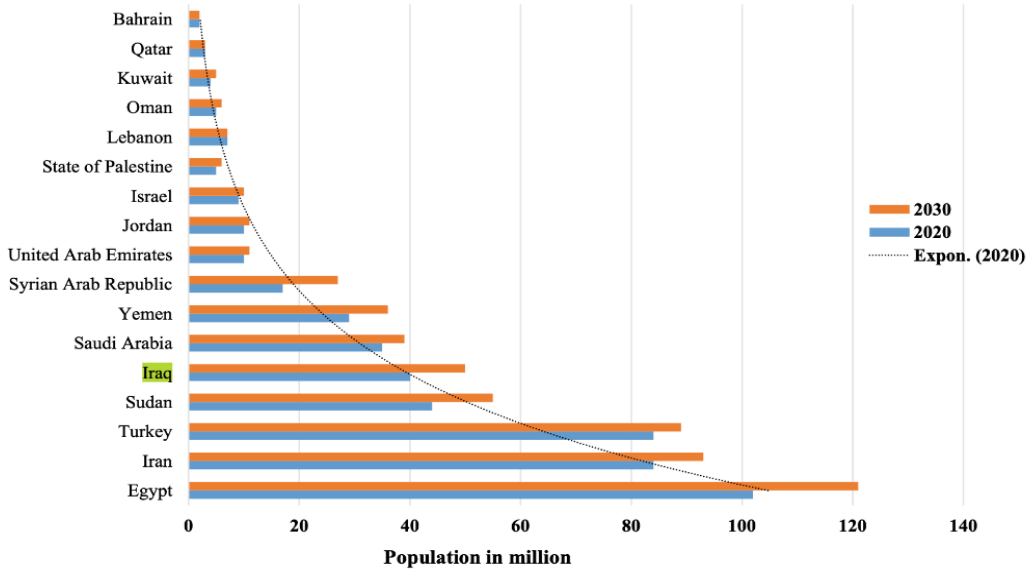


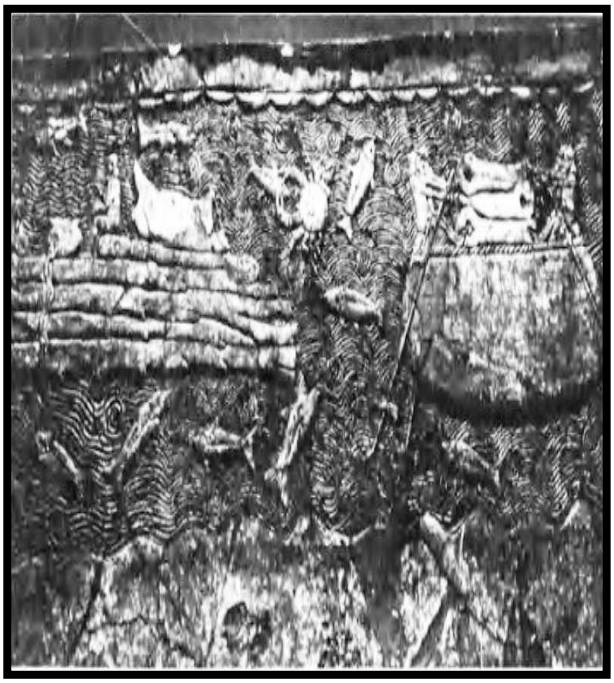
Figure 1. Projected Population Growth in Selected Middle Eastern Countries (2020 vs. 2030)" Compiled by the authors based on data from United Nations world population prospects (2021).

The fluctuations in Iraq's fish production are driven by water scarcity, quality degradation, unsustainable fishing, weak management, habitat destruction, and illegal practices (Harlıoğlu *et al.*, 2023). Outdated aquaculture methods and instability further exacerbate these issues (Corner *et al*, 2020). Despite challenges, efforts to revitalize the

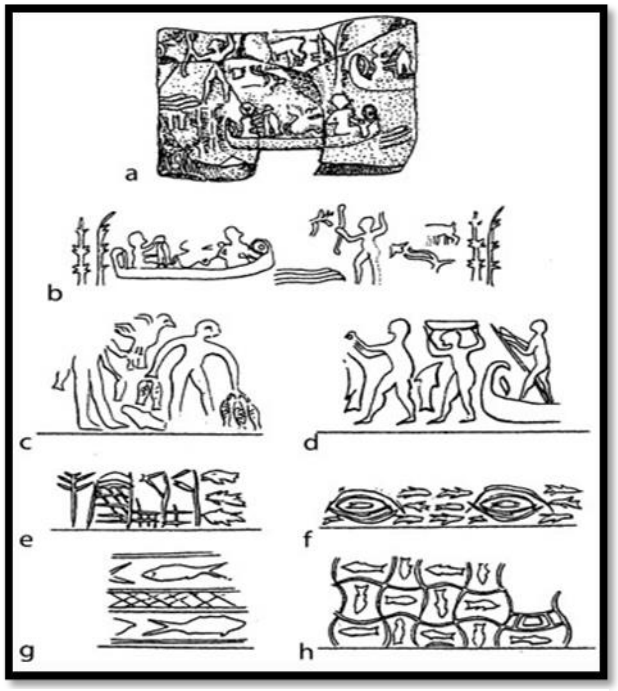
sector include sustainable practices, improved water management, and modern techniques (Mohamed and Abood, 2024; Shafaq, 2023). The industry, dominated by small- and medium-scale private farms, accounts for 95% of fish production (Directorate of Animal Resources, 2024). Common carp, grass carp, and silver carp are the main cultivated species, with semi-intensive earthen pond systems being the most prevalent (Jawad, 2021 a). Recently, intensive systems like floating cage farming along the Tigris and Euphrates Rivers have grown rapidly (Salman and Khalil, 2021; Aliwi *et al*., 2023). While this growth enhances food security, livelihoods, and poverty reduction, it also raises environmental and sustainability concerns.

History of Fish Farming in Iraq

Fish farming in Iraq dates back over 4000 years, with ancient practices along the Tigris and Euphrates rivers (Jawad, 2021 b). Sumerian tomb carvings depict fish and man-made ponds, indicating early aquaculture (Rogers, 2024). The Sumerians built the first fish ponds in temples, and private ponds became common in settlements, as seen in tomb scenes and documents. Fishing tools included reed boats, woven nets, and willow-branch baskets (Potts, 2012). Records from 422 BC mention fishpond taxation by merchants (Nash and Geffen, 2012; Yoder, 2015).



pic 1: Iraqi fish as documented in the Babylonian clay tablets.



pic 2: Iraqi fish as documented in the Sumerian clay tablets

Ancient Mesopotamians identified and documented marine and freshwater fish on clay tablets (Landsberger and Kilmer, 1962). Systematic fish classification began in the 19th century when Heckel (1843) described 17 freshwater species from the Tigris near Mosul (Jawad, 2012). The Tigris and Euphrates originate in Turkey, flow through Iraq,

and converge in Basra to form the Shatt al-Arab, emptying into the Arabian Gulf (Pournelle, 2003). The Mesopotamian Marshes, including the Hammar Marsh, are vast wetlands rich in aquatic life (Richardson and Hussain, 2006). A notable Babylonian clay tablet from the first millennium BCE depicts river scenes with wooden rafts, traditional boats, and realistic illustrations of fish (Rzóska, 2012), pic (1, 2) As above.

Modern Aquaculture Development in Iraq

Modern aquaculture in Iraq began in the 1950s with support from the Food and Agriculture Organization (FAO), leading to research centers, pilot farms, and successful carp farming trials (Poynton and Lovatelli, 2006). In 1954, Iraq's first fish farm was established in Al-Zaafaraniya, spanning 8 dunams with hatcheries for fingerling research (Salman and Saleh, 2021 b). Soon after, the Latifiyah fish farm was developed, covering 166 dunams, with 126 dedicated to water surfaces. Japanese and Indonesian carp species were introduced, but progress was limited due to a lack of trained personnel (Ministry of Planning, 1990). The general fish company was formed in 1970, later renamed the general fish corporation. During the 1970s, fish farming was under state control, but inefficiencies led to privatization in the 1980s.

The real growth began with the adoption of artificial propagation and cage culture (Schnenf, 2004).In 1982, a cage farming project with 56 cages started on Lake Habbaniyah's southern shore (Mohsen, 1988). By 1985, Iraq partnered with a Hungarian company to build the Central Al-Suwaira Hatchery in Wasit Province, covering 336 dunams and focusing on breeding common, silver, and grass carp (Ministry of Agriculture, 2009). The number of fish farms grew rapidly, reaching about 1000 by the late 1980s, driven by the dissolution of the general marine fisheries company in 1986. This expansion relied on traditional monoculture systems (Al-Nasiri, 1988). In 1989, privatization accelerated as water bodies and farms were leased to the private sector. However, unregulated fishing and water body drying led to alarming declines in fish stocks, falling to 3–5 kg per dunam (Harlıoğlu *et al.*, 2023).

Revitalization of the Aquaculture Sector in Iraq

The general authority for the development of fish resources was reactivated in 2005, initiating numerous projects across various provinces utilizing modern techniques (Directorate of Animal Resources, 2024), Key achievements included the rehabilitation of the central Al-Suwaira Ffish Hhatchery in wasit province, the establishment of a laboratory for artificial propagation, and the creation of a laboratory for diagnosing and treating fish diseases, Additionally, several government hatcheries were established in collaboration with the Food and Agriculture Organization (FAO) to breed fish in cities such as Anbar, Nineveh, Basra, Maysan, and Salahuddin.

The authority also set up multiple advisory centers for fish farmers, including a center in Al-Faw, Basra, and another in Sadda Al-Hindiya, Babylon (Directorate of Animal Resources, 2024). In 2008, a new fish farming system was introduced in Iraq—floating cage aquaculture ,This system quickly gained popularity, and by 2011, fish farmers

across most Iraqi provinces had adopted it. The government facilitated this transition by issuing permits to the private sector for installing floating cages in rivers and water bodies (Abbood *et al*., 2017).

Adoption of Modern Aquaculture Technologies in Iraq

In response to the ongoing water scarcity in Iraq, modern fish farming techniques suitable for the country's new aquatic environment were introduced,In 2009, Iraq contracted with a German company to establish a closed recirculating aquaculture system at the Central Al-Suwaira fish hatchery. This government project began experimental operations in 2011, focusing on raising Cyprinus Carpio weighing 50 grams or more. Subsequently, licenses for private projects using this system were granted in various provinces in 2014 (Salman and Saleh, 2021 b) In 2013, the Radwaniyah lakes were designated as a sanctuary for indigenous Iraqi fish species to protect them from extinction and promote their propagation (Dyck, 2017).

The Ministry of Agriculture oversaw this effort by establishing a specialized hatchery for breeding these fish. That same year, the General Authority for Fisheries was merged with the General Company for Animal Resource Services, forming the Directorate of Animal Resources, with fish farming becoming one of its divisions (Ministry of Agriculture, 2013).

Expansion of the Current Aquaculture System in Iraq

The modern aquaculture system in Iraq began to expand significantly from the 1960s to the 1970s, with the establishment of a scientific foundation for aquaculture development (FAO, 2010). In the late 1970s, a comprehensive plan was proposed to enhance aquaculture development. By the end of this plan in the mid-1980s, annual aquaculture production had surged 5000 tons until the mid-1980s, aquaculture activities in Iraq were concentrated in specific regions, primarily in central and southern parts of the country, fish production was achieved through extensive or semi-intensive pond systems using freshwater and slightly brackish water.

Private-sector-owned traditional aquaculture farms, which predominantly produced carp species and tilapia, operated large shallow ponds, typically covering up to 25 hectares, Production in these systems ranged between 250–400 kg/ha, relying mainly on enhancing natural productivity through the addition of organic fertilizers (manure) and limited use of artificial feed, typically rice bran (FAO. 2024).

Fish Species in Iraq’s Aquatic Environment

In the 1950s, carp species were introduced to Iraq for research, paving the way for freshwater aquaculture. The focus has been on Cyprinidae species, including common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*), Common carp were first imported in 1955–56 from Indonesia and the Netherlands and successfully reared at Zafarania fish farm, becoming Iraq’s primary species due to their resilience and rapid growth (Al-Hamed, 1960; FAO,

1989).Grass carp were introduced in 1968, and silver carp followed in the 1980s (Salman *et al* ,2021 b). Attempts to cultivate bighead carp (*Aristichthys nobilis*) in 1986 failed due to unsuccessful spawning. Efforts to domesticate local species, such as Bunni (*Barbus sharpeyi*) and Gattan (*Barbus xanthopterus*), faced challenges like slow growth and high costs, though artificial spawning of Bunni succeeded in 2005 with 250,000 fingerlings released into marshes (Al-Noor *et al.*, 2012).

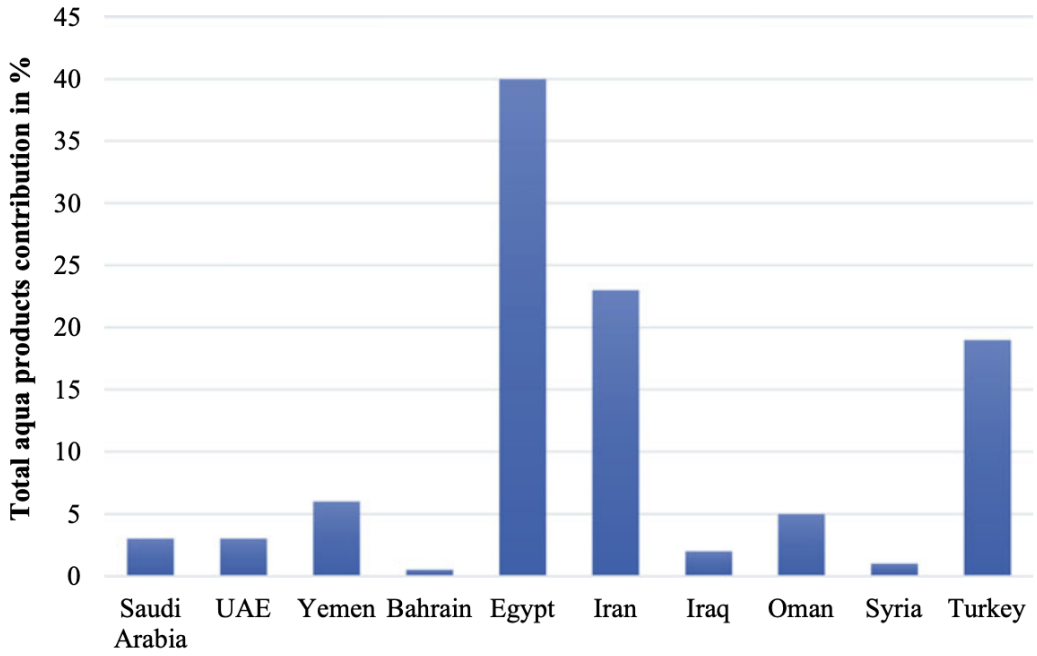


Figure 4. Percentage Contributions of aquaculture products by country in the region.

Marine aquaculture experiments include Zubaidy (Pampus argenteus) and more recently, species like Shanak (*Acanthopagrus latus*), Biah (*Liza klunzingeri*), and Subaity seabream (*Sparidentex hasta*), adapted for increasing salinity in southern waters (Mohamed *et al.*, 2000). In northern Iraq, rainbow trout (*Oncorhynchus mykiss*) have been cultivated in concrete ponds using the region's cooler waters (Abdulrahman *et al.*, 2017). Catalogs of Iraq's fish species highlight both freshwater and marine diversity, including Cobitis linea in the Al-Huwaiza Marsh (Hussain and Ahmed, 2014) and 18 species from six families in Radwaniyah Lake near Baghdad (Dyia *et al.*, 2023). Tabe 1 Timeline and Development of Fish Species in Iraq.

A total of 53 fish species, including 51 bony and 2 cartilaginous species, were recorded in the Shatt al-Basra Canal, southern Iraq. In Al-Huwaiza Marsh, 13 species from six families Cyprinidae, Mugilidae, Siluridae, Heteropneustidae, Mastacembelidae, and Bagridae were identified (Abdullah *et al.*, 2020). Lake Dokan documented 27 species from five families: Cyprinidae, Mugilidae, Heteropneustidae, Sisoridae, and Mastacembelidae (Dyia *et al.*, 2023). The Euphrates River near Sadda Al-Hindiya recorded 20 species from six families, with Planiliza abu, Carassius auratus, and

Carasobarbus luteus being the most abundant (Al-Helli, 2019). Carp species, particularly *Cyprinus carpio*, dominate aquaculture in Iraq due to their adaptability and economic importance (Al-Hilali *et al*., 2024).

Carp Farming: The Dominant Aquaculture Practice in Iraq

Carp farming, encompassing various carp species, is the most prevalent aquaculture practice in Iraq, accounting for 95% of total aquaculture production, indicating a narrow production spectrum, (Basin,2014). The popularity of carp farming stems from strong consumer demand for this product (Ahmed *et al*., 2020). However, the rising salinity levels in Iraqi water bodies have prompted efforts by the Iraqi government to explore new fish species capable of tolerating higher salinity, broadening the scope of aquaculture in the country (Salman, 2011).

Distribution, Characteristics, Economics, and Environmental Issues of Aquaculture Systems in Iraq

Aquaculture in Iraq is composed of extensive, semi-intensive, and intensive systems, predominantly located in central and southern regions. Below is an overview of the primary aquaculture systems and their features (El-Sayed, 2017):

1. Traditional Extensive Aquaculture

The most common aquaculture practice since the 1950s involves earthen ponds. Farmers build ponds and rely on gravity-fed water from nearby rivers.

- **Production:** Low productivity, around 250–750 kg/ha.
- **Management:** Minimal intervention with limited feeding, fertilization, and low capital investment. Basic management practices dominate (Rasool, 2018 ;Taher and Dubakel, 2020).
- **Efficiency:** Producing 1 kg of fish requires about 12 m^2 of land and 25 m^3 of water.
- **Economic Viability:** Due to the increasing value of natural resources (water and land), this system has limitations in productivity. To address these challenges, a shift towards more efficient semi-intensive systems is encouraged (Abdulrahman *et al*., 2019) fig.3

2. Semi-Intensive Aquaculture in Earthen Ponds

Semi-intensive aquaculture in earthen ponds is the primary fish farming system in Iraq, contributing about 90% of aquaculture production. Both freshwater and brackish water are used.

- **Infrastructure:** Ponds range in size from 0.5 to 12 hectares, often located in low-lying irrigated or saline lands.
- **Farming Systems:** Mixed aquaculture is common, though monoculture of carp is practiced in some areas.
- **Inputs:** Fish stocking, organic fertilizers, and low-quality feeds.
- **Annual Yield:** Ranges between 5–25 metric tons per hectare, depending on management and resources.

• **Economics:**
- Labor costs in southern provinces: ~$200 per hectare per cycle (8–10 months), including salaries and seasonal expenses (El-Sayed, 2017).
- Input costs remain moderate, making the system cost-effective for small-scale farmers (Jawad and Abdulsamad, 2021).

3. Intensive Cage Aquaculture

Iraq's abundant water resources provide ideal conditions for fish farming in cages at suitable locations (Almasawi *et al.*, 2024). The environmental conditions support sustainable fish growth for up to 10 months a year, encouraging investors and fish farmers to adopt this technique and leverage its advantages (Al-Dabbas, 2024). Although cage culture was initially attempted in Habbaniya Lake during the early 1980s, it faced challenges that hindered its success (Al-Daham, 1990). In the 1980s, fingerlings of common carp (*Cyprinus carpio*), bunni (*Barbus sharpeyi*, also known as *Mesopotamichthys sharpeyi*), and gattan (Barbus xanthopterus, now *Luciobarbus xanthopterus*) were cultivated in cages within Razzaza and Tharthar lakes to assess their growth rates before being released into open waters (IFI, 1982). Efforts to utilize cage culture further expanded, with Saleh and Suliman (1988) experimenting with common carp farming in drainage canals and Salman *et al.* (1997) applying this method in the northern section of the main drainage canal.

Current Status of Cage Fish Culture in Iraq

Since 2017, fish culture in cages has undergone significant expansion, with tens of thousands of cage projects established across various Iraqi provinces, including Babylon, Wasit, Qadisiyah, Northern Baghdad, Salah al-Din, and Anbar (AFP, 2020). This growth was driven by the low construction costs and high financial profitability of cage farming, The resulting surge in production required a substantial volume of feedstuffs, estimated at 900,000 tons, with a large portion dedicated to cage culture. Additionally, approximately 40,000 tons of high-protein feedstuffs were imported to meet the increased demand of the industry (Salman and Saleh, 2021). The feed conversion ratio (FCR), typically below 2.5, has been used as a benchmark for evaluating the biological and economic efficiency of feed in cage culture systems.

Al-Salem (2013) provided a comprehensive analysis of production and economic outcomes for these projects, with data summarized in tables (2 and 3). Cage units were constructed along the upper and lower reaches of rivers and streams, contributing to a significant increase in fish production. This expansion led to reduced wholesale and retail fish prices in Iraqi markets and increased imports of complementary fish products. Prior to the establishment of widespread cage farming, Iraq’s fish production in 2007, derived from an area of 4914000 square meters of fish farms, totaled 14286 tons (Jasim, 2007).

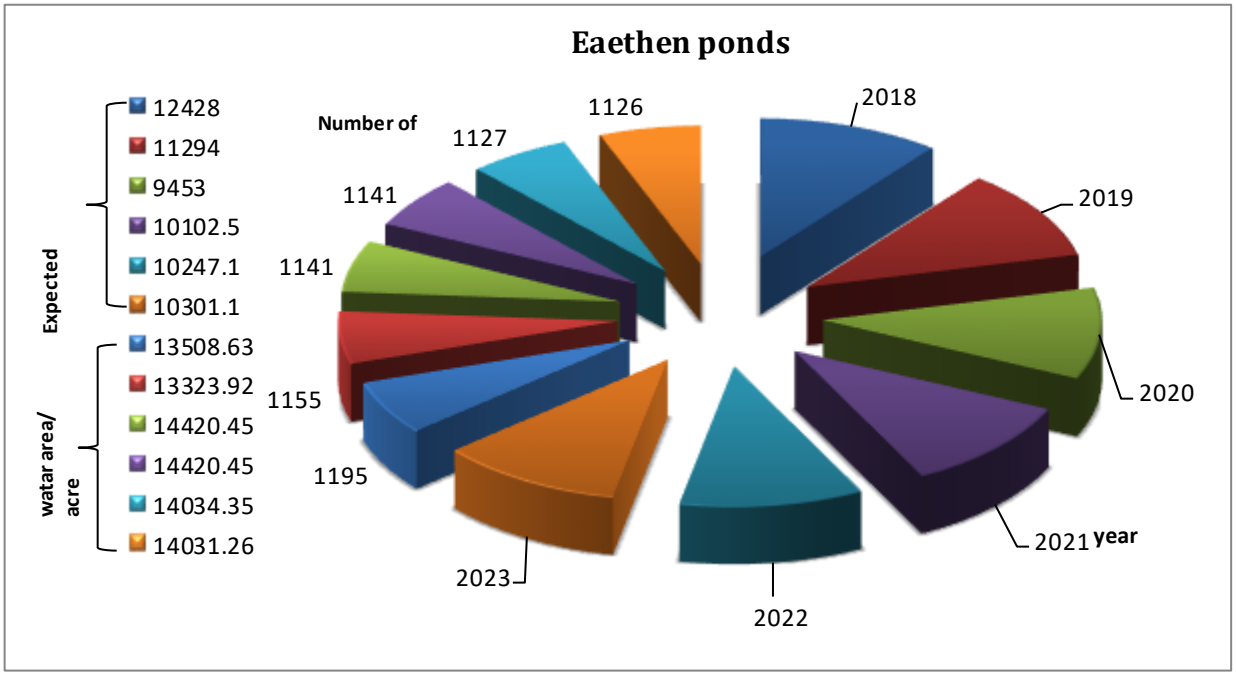


Figure 5. (intensive Cage Aquaculture) Trends in Expected Annual Production and Water Area Usage of Earthen Ponds (2018–2023) (The Directorate of Animal ,2024)

The number of cage projects in Iraq is detailed in Table 1, as recorded by the Ministry of Agriculture (2012). For instance, Al-Salem (2013) reported that Babylon Province alone had 84 projects with 844 cages, many of which operated without legal permits.

This remarkable production increase led to a decrease in fish prices in Iraqi markets, from 6,000 Iraqi dinars per kilogram in 2007 to 3,500 dinars per kilogram in 2017. The sustained growth and reduced prices underscore the success and economic significance. Cage culture gained momentum on a commercial scale in 2009, particularly in Iraq's central and western provinces,This development followed the issuance of legal permissions and the provision of government-backed loans for farmers to establish floating cage projects (Taher, 2014). Cage farming has gained popularity, especially in central and southern Iraq, with semi-intensive and intensive production systems directrion of animal resourse.

• Cage Sizes: Range from small (32 m^3) to large (750 m^3).
• Productivity: 5–35 kg/m^3, depending on management (Salman, 2011).
• Species: Common carp is the primary species, reared using pellet feed with 35–40% CP in early stages, transitioning to 25–30% CP during fattening.
• Cycle Duration: Typically, six months; some farmers stock larger fish to reduce the cycle to four months. Final biomass: ~50 kg/m^3 (Salman, 2013).
• Challenges:

- Environmental pollution in the Tigris and Euphrates rivers from inorganic nitrogen, organic matter, phosphorus, and heavy metals.

- Competing demands for water resources and legislative restrictions limit new projects.
- High salinity in areas like Basra has caused many cage farming projects to halt (Salman *et al.*, 2022).

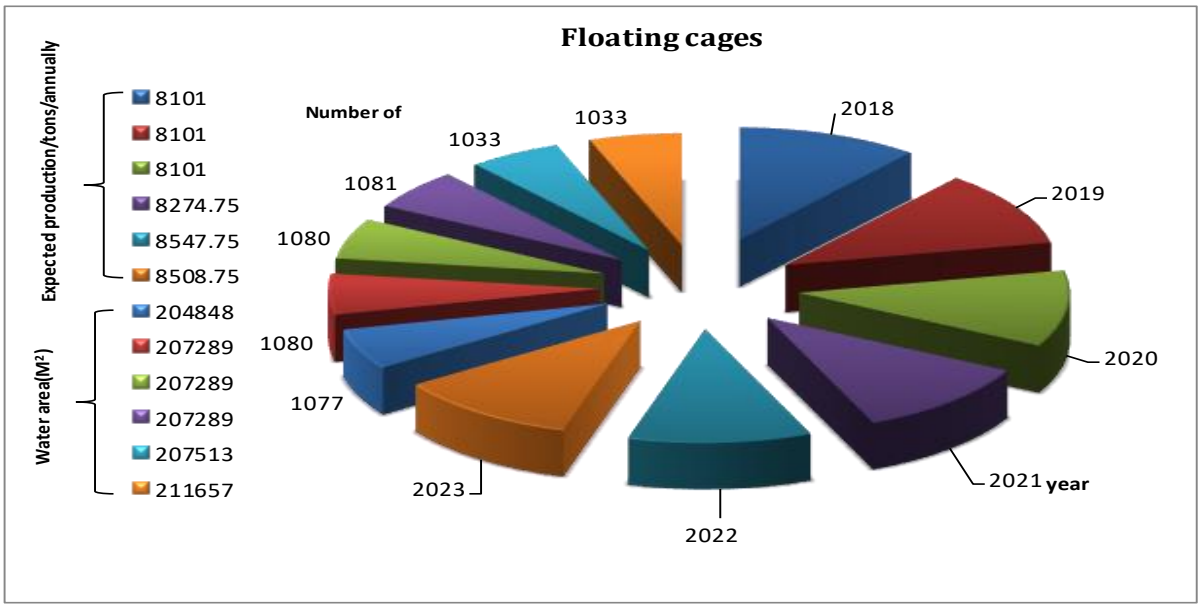


Figure 6. Annual Production and Water Area Utilization in Floating Cages (2018–2023)of cage fish farming in Iraq (Directorate of Animal Resources, 2024).

Environmental and Economic Concerns

- **Environmental Impact:**
  - Extensive and semi-intensive systems have minimal inputs but low productivity.
  - Cage farming faces environmental challenges, including water pollution.
  - Increased salinity in southern Iraq has further restricted aquaculture development (Jawad, 2003).
- **Resource Constraints:**
  - Water availability (freshwater and brackish) is a critical limiting factor.
  - Policies prioritize drinking water and agriculture over aquaculture, hindering sector growth (Salman *et al*, 2021 a).
- **Future Directions:**
  - Improving productivity through intensive and semi-intensive systems.
  - Introducing species tolerant to high salinity.
  - Exploring alternative systems with minimal environmental impact.

Overall, aquaculture in Iraq shows potential for sustainable growth but faces significant environmental and resource challenges. Addressing these through innovative practices and targeted policy measures is essential for long-term development (Jawad, 2021 a; Semenova *et al.*, 2022).

Aquaculture in Iraq's Small Water Bodies

Numerous small water bodies exist in the marshes of Iraq, yet practicing modern intensive aquaculture in these rural water bodies is challenging (Dyck,2017) . Small-scale and large-scale commercial farmers tend to prefer semi-intensive systems, which are increasingly contributing to aquaculture development , In semi-intensive systems, fish stocking densities are typically higher than in extensive systems (Taher and Al-Dubakel, 2020). Farmers often use organic fertilizers and locally available agricultural by-products assupplementary feeds. Experimental ponds with varying stocking densities, representing semi-intensive and extensive systems, have been established to evaluate production outcomes (Salman and Saleh, 2021 b).

Results from these trials showed that:

- **Higher Production:** Semi-intensive ponds significantly outperformed extensive ponds in terms of average fish production.
- **Weight Variations:** While the average final weight of some species differed between the two systems, semi-intensive ponds generally yielded better results. (AlMasawi *et al.*, 2024)

These findings suggest that semi-intensive aquaculture holds substantial potential for improving fish production in Iraq's small water bodies, balancing higher yields with manageable resource inputs (Oddsson, 2020).

Economic and Environmental Considerations in Semi-Intensive Aquaculture

The condition factor of fish varied significantly across treatments for all tested species. Economic analysis revealed increases in variable costs alongside higher net revenues as stocking densities increased. However, the return on capital ratio declined with increased stocking densities, highlighting diminishing returns on investments at higher levels of intensification (Shamsuddin *et al.*, 2022). From an environmental perspective, monitoring water quality is essential to ensure fish survival and product safety for consumers. Many aquaculture sites, especially those employing extensive and semi-intensive systems, are located in areas that receive agricultural wastewater, which may be contaminated with pesticides and other harmful substances. (Yusoff *et al.*, 2024). Proper lake and pond management requires technical and scientific expertise to address these challenges (Doyd and Tucker, 2012) . This knowledge can be provided by experienced staff or supported through public services equipped with the necessary scientific and technical background. Such measures are crucial for ensuring the sustainability and safety of aquaculture practices in Iraq(Jawad and Mutlak, 2021).

Decline in Fish Production in Mesopotamia

The bar chart titled "Global Aquaculture Production for Species (tonnes) illustrates the annual production levels of a specific aquaculture species from 1980 to 2022, During the early period (1980–2000), production was relatively low and inconsistent,

fluctuating between 0 and approximately 10000 tonnes, reflecting the developmental stage of aquaculture practices. From 2000 to 2016, production experienced significant growth, with a steady increase peaking at over 30000 tonnes by 2016, likely due to advancements in technology and rising global demand for aquaculture products. In the most recent period (2017–2022), production stabilized around 30000 tonnes, indicating a mature and consistent industry output. This overall trend highlights the evolution of aquaculture from small-scale operations to industrial-scale production, balancing efficiency with sustainability (fig. 5)(FAO,2024: Cai and Leung ,2022)

The decline in natural fishery production is attributed to several factors:

1. Water Scarcity: Reduced water availability due to regional and environmental changes (Bekheet, 2021).
2. Water Quality Degradation: Pollution from agricultural, industrial, and urban sources (Bekheet, 2021).

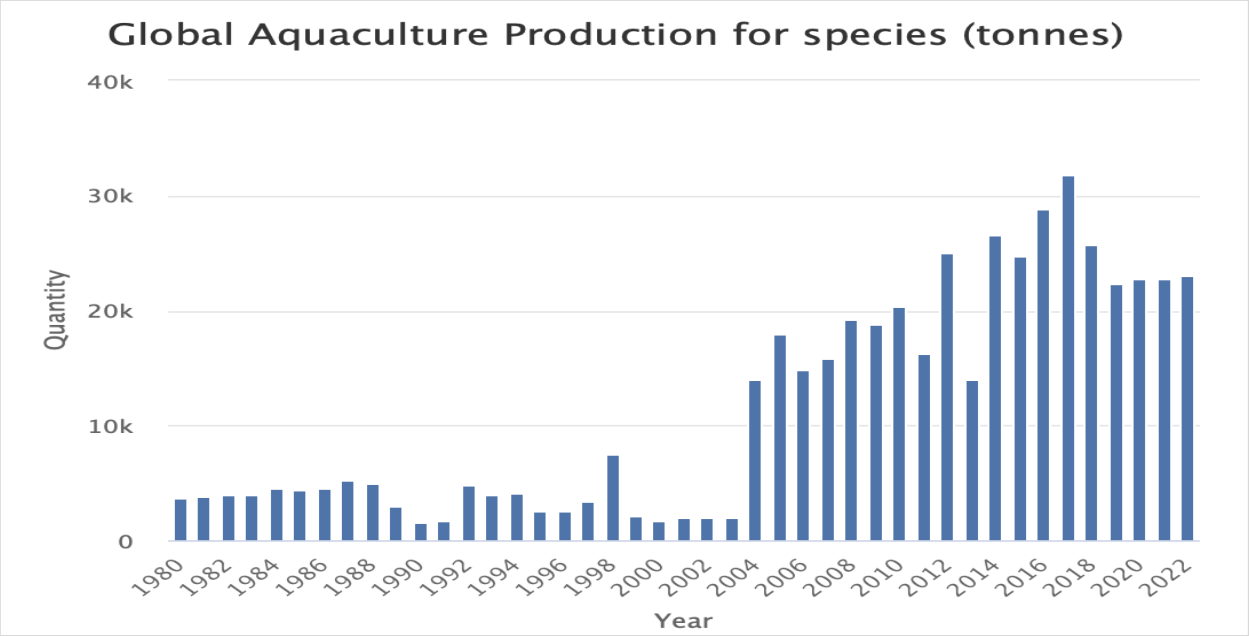


Fig. 5: Trends in Global Aquaculture Production for selected species (1980–2022).

3. Unsustainable Fishing Practices: Overfishing and inadequate resource management (Jawad, 2021 b).
4. Destruction of Nursery Habitats: Loss of essential breeding and rearing grounds (Jawad, 2021).
5. Illegal Fishing Methods: Practices such as electrofishing and pesticide use have further disrupted fish stocks (Temple *et al.*, 2022).

Addressing these challenges requires comprehensive management strategies, including stricter regulations, sustainable fishing practices, and improved water resource management, to revitalize Iraq's fishery sector (Action, 2020).

Decline in Per Capita Fish Consumption in Iraq

Per capita fish consumption in Iraq has declined significantly over the decades. It dropped from approximately 4 kg annually in 1984 to 1.8–2.0 kg/year during the 1990s and reached as low as 1 kg/year by 1997 (Blasim, 1999). This rate is relatively low compared to the global average of 20 kg/year and even the average of other Arab countries, which was 7 kg/year in 2015 (Salman and Saleh, 2021 b). This declining trend, however, saw a modest recovery between 2011 and 2013, with per capita consumption increasing to 3–4 kg/year. This improvement was largely due to the implementation of a widespread fish import policy(Harlıoğlu *et al*., 2023). While imports helped bridge the gap between domestic production and demand, the reliance on foreign sources underscores the need for sustainable development of Iraq's aquaculture and fisheries sector to meet national consumption needs (Ahmed and Al-Zewar *et al*., 2020).

Despite the growth of cage farming, Salman and Saleh (2021 b) noted the absence of precise records regarding fish production volumes , By the end of 2018, however, the Ministry of Agriculture announced Iraq's self-sufficiency in fish production, halting imports from neighboring countries (Ministry of Agriculture 2018), Given Iraq's population of approximately 40 million and an annual per capita fish consumption of 7 kg, self-sufficiency implies a production volume of at least 280,000 tons per year. Moreover, the Ministry permitted fish exports to Jordan and Gulf states, reflecting Iraq's robust production capacity. The Iraqi Fish Producers Society estimated total production to exceed 350,000 tons, with the majority originating from cage culture.

Current Status of Aquaculture Production in Iraq (2018–2023)

Aquaculture currently represents the largest share of fish production in Iraq. Between 2018 and 2023, the average production from earthen ponds reached 1063762 tons, while the average production from floating cages was 8,272.38 tons.

Trends and Challenges

- **Increase in Production (2018):** There was an initial rise in fish farming projects and production in 2018 (Mahmud, 2021).
- **Decline in 2019–2020:** Production dropped significantly due to water scarcity, project closures, and the outbreak of Koi Herpes Virus (KHV), which caused substantial mortality in common carp stocks (Toffan *et al*.,2024).
- **Shift to Floating Cages (2021–2023):** In response, many fish farmers transitioned to floating cage systems. This period saw an increase in the number of projects and production levels, but output remained insufficient to meet local market demand (Al-Masawi *et al*., 2024).

Government Interventions (2024)

To address the production gap, the Iraqi government permitted the controlled importation of live fish from neighboring countries in 2024. This measure aims to

stabilize the market while supporting local farmers in transitioning to modern aquaculture systems to boost production (Corner *et al.*, 2020).

Future Directions

- Encouraging the adoption of modern aquaculture technologies to enhance production efficiency (Kumar *et al.*, 2018).
- Supporting farmers with financial and technical assistance to transition from traditional to intensive systems (Sanon *et al.*, 2021).
- Developing disease management strategies to prevent outbreaks like KHV. (Bavarsad *et al.*, 2024. b).

These efforts are critical to achieving self-sufficiency in fish production and reducing reliance on imports (Ministry of Agriculture of Iraq, 2024).

Water and Land Use in Aquaculture in Iraq

Iraq faces limited water resources, which significantly affect the quantity and quality of water available for aquaculture (Abd-El-Mooty, 2016). Despite the critical role of aquaculture, the sector is generally not permitted to use irrigation water and instead relies on agricultural drainage water and groundwater (Salman and Saleh, 2021).

Water Quality Challenges

- **Impact on Production:** Poor water quality reduces fish production, increases costs for hatchery operators and fish farmers, and heightens the risk of disease outbreaks. This, in turn, hampers export opportunities for farmed fish (Al-Salihi *et al.*, 2024 b).
- **Environmental and Health Concerns:** Contaminated water pollution impacts the environment and poses risks to the health of workers and consumers (Tahir and Kareem, 2024).
- **Farmers' Preferences:** Many farmers demand access to freshwater, as reused drainage water affects fish quality due to pollutant accumulation and contamination risks (Salman, 2021).

Land Use Restrictions

- **Legal Barriers:** Laws prohibit aquaculture development on agricultural lands (Al-Ansari *et al.*, 2023).
- **Land Ownership and Leasing:**
  - In Iraq, aquaculture is predominantly conducted on privately owned land. As of 2004, there were approximately 1893 licensed fish farms, all operated by the private sector, including both companies and individuals (Kitto and Tabish, 2004).
  - These farms are primarily located near freshwater sources, particularly in areas unsuitable for traditional agriculture. The sizes of these farms vary, ranging from 0.5 hectares to 200 hectares, with most spanning between 5 and 10 hectares.

The total area under aquaculture production was estimated to be around 7,500 hectares (Al-Dabbas, 2024).

Current Practices and Limitations

- **Land Leasing:** Farmers primarily lease land from the government for aquaculture activities.
- **Competition for Water:** With freshwater resources prioritized for agriculture and human consumption, aquaculture often relies on suboptimal water sources, further complicating production quality and sustainability (Ahmed *et al*, 20114).

Future Directions

To overcome these challenges, Iraq must:

1. **Improve Water Management:** Enhance the quality of drainage and groundwater used in aquaculture.
2. **Promote Sustainable Practices:** Develop integrated aquaculture-agriculture systems to optimize water reuse without compromising fish quality.
3. **Reassess Legal Restrictions:** Review laws restricting aquaculture on agricultural land to enable responsible and sustainable expansion.
4. **Support Technological Advancements:** Invest in modern recirculating aquaculture systems (RAS) that reduce water consumption and improve fish production efficiency (Al-Ansari, 2023)

Addressing these issues is crucial for the long-term sustainability of Iraq's aquaculture sector.

Institutional, Political, and Legal Context Governing Aquaculture in Iraq

The Ministry of Agriculture oversees the fisheries and aquaculture sector in Iraq. Policy implementation and management responsibilities were delegated to the General Authority for Fish Resources Development in 2005 as defined by a republican decree that outlined its powers and duties (FAO, 2010).

Institutional Framework

The General Authority for Fish Resources Development, previously under the Ministry of Agriculture, is responsible for all planning and regulatory activities related to fish production. It operates under the authority of the Deputy Minister and is empowered to issue relevant aquaculture and fisheries decisions and regulations (Mac fadyen *et al*., 2011).

Policy Objectives

The overarching policy goals for fisheries and aquaculture include:

1. **Maximizing Returns:** Enhancing fish resource yields through environmentally compatible systems.
2. **Increasing Production:** Achieving an annual fish production target of 1.5 million tons to maintain per capita fish availability by 2017 amidst population growth.

3. **Improving Quality:** Aligning fish products with international standards to ensure competitiveness.
4. **Encouraging Marine Aquaculture:** Supporting marine aquaculture as a sustainable alternative, particularly for species such as grouper, shrimp, sea cucumber, and other shellfish.

To achieve these goals, the General Authority for Fish Resources Development has implemented a two-pronged strategy:

- **Freshwater Aquaculture:** Increasing productivity in freshwater aquaculture systems.
- **Marine Aquaculture Investment:** Encouraging private and public investment in marine aquaculture, given the limitations of freshwater resources. (Mohamed *et al.*, 2024).

Legal Framework

The Law No. 48 of 1976 governs fishing, aquatic life, and the regulation of fish farms. Administered by the General Authority for Fish Resources Development, this law includes provisions directly applicable to aquaculture (Mohamed, 2014).
Despite its foundation, the legal framework is complex and often struggles to address competing demands for water resources, particularly in light of environmental concerns about water quality and availability (Mohamed and Jawad, 2021 b).

Recent Government Initiatives

Recognizing the need for modernization, the Iraqi government has introduced several national programs to link academic research with practical field applications. These initiatives aim to:

- **Streamline Regulations:** Rewriting laws and regulations to better support investors in the aquaculture sector.
- **Promote Sustainable Practices:** Aligning development policies with environmental concerns and resource limitations.
- **Encourage Marine Aquaculture:** Facilitating the growth of marine aquaculture to complement freshwater systems (Cross, 2022).

By addressing legal, institutional, and environmental challenges, Iraq aims to unlock the full potential of its aquaculture sector and meet both domestic demand and export opportunities.

Environmental Impact Assessment (EIA) and Regulatory Challenges in Iraqi Aquaculture

Fish farmers in Iraq are required to obtain approval from the Iraqi Ministry of Environment after submitting an Environmental Impact Assessment (EIA), in compliance with environmental legislation outlined in the relevant law [specific law reference missing]. Additionally, fish farms must adhere to regulations concerning water discharge (Dyck, 2017).

Potential Future Challenges

As aquaculture expands into open-sea environments, the frequency and importance of conducting EIAs are likely to increase. Marine aquaculture activities, due to their potential environmental impact, will necessitate stricter regulatory oversight and comprehensive environmental assessments.

Recommendations

1. **Streamline Regulations:** Update and harmonize the legal frameworks governing aquaculture to reduce regulatory fragmentation and improve enforcement.
2. **Mandatory EIAs:** Enforce EIA requirements for all aquaculture projects, including both inland and marine environments, to ensure sustainable development.
3. **Capacity Building:** Provide technical support and resources to farmers and regulators to facilitate compliance with environmental standards.
4. **Marine Aquaculture Oversight:** Develop specialized regulations for open-sea aquaculture to preempt potential environmental risks associated with such operations. A robust and transparent regulatory framework, combined with proactive environmental management, is essential for ensuring the long-term sustainability of Iraq's aquaculture sector (Jawad and Mutlak, 2021).

Market and Trade of Aquaculture Products in Iraq

The fish marketing system in Iraq is simple yet effective, dominated by a few key wholesalers who primarily set market prices based on supply and demand dynamics. Fish farmers have the freedom to sell their products either through wholesalers or directly to retailers.

Fish Marketing System

1. **Wholesalers:**
   - Major players in the fish market, operating in formal wholesale markets in major cities.
   - Fish are sold at daily auctions, and wholesalers employ a small number of workers for loading and unloading fish.
   - Wholesalers also provide financial support to many fish farmers, earning a commission of 3–6% on sales, paid by the farmers (Mahmud, 2021).

2. **Retailers:**

Retailers are categorized into two main groups:

- **Informal Street Vendors:**
  - These individual operators purchase fish from wholesalers or markets and sell them from roadside stalls.
- **Formal Retail Stores:**
  - Operate from dedicated shops with storage facilities for unsold fish, allowing them to sell later (Jawad and Abdulsamad *et al.*, 2021 b).

Consumer Perception and Product Labeling

• Aquaculture products are sold alongside wild-caught fish at retail markets.

• While consumers often perceive farmed fish as lower in quality, they generally cannot distinguish between farmed and wild-caught fish of the same species.

• No current regulations require retailers to disclose whether fish are farmed or wild-caught (FAO, 2010).

Imports and Exports

- **Imports:**

Iraq remains a net importer of fish products despite significant growth in domestic aquaculture production.

▪ Import levels fluctuate with the foreign exchange rate.

▪ Fish imports aim to bridge the gap between local production and national demand.

▪ Iraq continues to be a net importer of fish products, despite notable growth in domestic aquaculture. In 2022, the country imported approximately $13.6 million worth of non-fillet frozen fish, primarily from China, Vietnam, India, Burma, and Oman.

▪ OECD Observatory of Economic Complexity

▪ These imports are essential to meet the national demand that surpasses local production capacities.

- **Exports:**

▪ Only a modest quantity of fish is exported, primarily sourced from the Mediterranean.

▪ Iraq does not currently export fish products to the European Union due to non-compliance with EU Directive 91/493/EEC, which specifies sanitary conditions for fish production and marketing.

Iraq's fish exports are minimal. In 2020, the country exported fishery products valued at around $84,300.

- OECD Observatory of Economic Complexity
- Notably, Iraq does not export fish products to the European Union. This is due to non-compliance with EU sanitary standards outlined in Council Directive 91/493/EEC, which specifies health conditions for the production and marketing of fishery products.

Conclusion:

While Iraq has made strides in domestic fish production, imports remain crucial to satisfy national consumption needs. The country's limited export activities, particularly to the EU, highlight the need for enhanced compliance with international sanitary standards to expand market access. Iraq imports a significant quantity of non-fillet

frozen fish, primarily from countries such as Iran, China, Vietnam, Myanmar, and Oman. In 2022, Iraq imported approximately 6700 tons of frozen whole fish, marking a substantial increase from previous years. The average import price for frozen whole fish in Iraq was around $2,023 per ton in 2022. However, prices varied depending on the country of origin; for instance, imports from China averaged $6,743 per ton, while those from Mauritania were about $538 per ton.

Several Iraqi companies specialize in importing and distributing frozen fish:

- AL-SAMAK: Established in 2004, AL-SAMAK offers a variety of frozen fish products, including whole fish, fillets, and marinated options.
- Qafila Al Khair Company: Since 2015, this company has been importing and distributing high-quality frozen meats, chicken, beef, and fish across Iraq, sourcing from reputable international suppliers.
- Khairat Dawd Company: With a long history in the Iraqi market, Khairat Dawd imports a wide range of frozen and chilled products, including various types of fish.

These companies play a crucial role in meeting Iraq's demand for non-fillet frozen fish, ensuring a steady supply to the market.In 2022, Iraq's exports of non-fillet frozen fish were valued at approximately $84300, ranking it 101st among exporting countries for this product. This data highlights that Iraq's non-fillet frozen fish exports are minimal. Specific details about importing countries are not readily available in public data. For precise information, it is recommended to consult Iraq's foreign trade reports or international organizations like the Food and Agriculture Organization (FAO) or the United Nations.

Challenges and Opportunities

1. **Challenges:**
   - Lack of self-sufficiency in fish production.
   - Limited compliance with international export standards, restricting market access to the EU and other regions.
   - Absence of regulations requiring product source identification, affecting consumer trust and transparency.
2. **Opportunities:**
   - Develop infrastructure to comply with international standards for fish exports.
   - Implement policies to enhance the labeling and traceability of fish products.
   - Encourage investment in sustainable aquaculture practices to reduce dependence on imports.

By addressing these challenges and leveraging opportunities, Iraq can strengthen its fish market and trade, supporting both local demand and potential export growth.

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Table 1. Timeline and Development of Fish Farming in Iraq

Period	Event \ Development t	Key location	Notable Species
Ancient Period (~4,000 years ago)	Evidence of fish farming observed in Sumerian carvings, fish ponds in temples, and written records from Babylonian and Assyrian periods.	Mesopotamia (Tigris and Euphrates rivers, marshes)	Numerous marine and freshwater fish species (e.g., carp); use of reed boats, nets, and fish ponds.
1950s	Modern Aquaculture began with FAO support establishment of research centers and the first farm in al – Zaafaranica	Al-Zaafaraniva	Traditional fish farming techniques , primarily
1970s	General Fish Company was established, later privatized; socialist sector controlled aquaculture activities.	Central and Southern Iraq	Carp and tilapia; limited modern technology.
1980s	Introduction of modern techniques like artificial propagation and cage culture; establishment of the Central Al-Suwaira Hatchery.	Central Al-Suwaira Hatchery, Wasit Province	Common, silver, and grass carp; artificial propagation and cage culture.
1990s	Dissolution of General Fish Corporation; privatization of fish farms; use of prohibited fishing methods increased.	All Iraqi provinces	Traditional monoculture systems; prohibited methods.
2005	Reactivation of General Authority for Fish Resources Development; rehabilitation of hatcheries and establishment of disease diagnostic labs.	Various provinces including Basra, Maysan, Salahuddin	Modern propagation techniques, disease treatment labs.
2008	Introduction of floating cage aquaculture, quickly adopted across provinces.	Most Iraqi provinces	Floating cage aquaculture systems.
2011	Launch of experimental operations for a recirculating aquaculture system at Central Al-Suwaira Hatchery.	Central Al-Suwaira Hatchery	Recirculating aquaculture systems.
2013	Designation of Radwaniyah Lakes as sanctuary for indigenous fish species.	Radwaniyah Lakes	Conservation of indigenous fish species.
2014	Licensing of private aquaculture projects using closed recirculating systems.	Various provinces	Closed recirculating systems.

Table 2. Timeline Fish Species in Iraq's

Time Period	Event/Introduction	Species	Source/Origin	Purpose/Outcome
1950s	Introduction of carp species for scientific research	Common carp (*Cyprinus carpio*)	Indonesia (Runten Carp), Netherlands (Japanese Multi-color Carp)	Acclimation to local environment and experimental cultivation in earthen ponds at Zafarania Fish Farm, Baghdad. Led to successful breeding and restocking.
1955-1956	First introduction of common carp	Common carp (*Cyprinus carpio*)	Indonesia, Netherlands	Foundation of common carp as a primary species in Iraqi inland waters due to rapid growth and consumer preference.
1968	Introduction of grass carp	Grass carp (*Ctenopharyngodon idella*)	Japan	Cultivated in fish farms.
1980s	Introduction of silver carp	Silver carp (*Hypophthalmichthys molitrix*)	Brooders imported in 1985	Used in the Central Governmental Hatchery (Al-Wihda).
1986	Attempt to introduce bighead carp	Bighead carp (*Aristichthys nobilis*)	Alexandria Hatchery	Artificial spawning failed, species disappeared or hybridized with silver carp.
By 2005	Domestication of local cyprinids	Bunni (*Barbus sharpeyi*)	Local species	250,000 fingerlings released into marshes after successful artificial spawning.
1990s	Introduction of marine species in Razzaza salt lake	Shanak (*Acanthopagrus latus*), Biah (*Liza klunzingeri*)	Local waters	Fingerlings released for cultivation.
2000	Documentation of fish species in freshwater ecosystems	Various species	Iraq	Cataloging and grouping based on characteristics.
2017	Introduction of rainbow trout	Rainbow trout (*Oncorhynchus mykiss*)	Iran	Cultivated in northern Iraq in cooler waters using concrete ponds.
2020s	Adaptation of marine species for aquaculture due to salinity increases	Shanak, Biah, Sheam, Subaity seabream	Local waters	Efforts to adapt to increasing salinity in southern Iraq.
Historical	Documentation of fish biodiversity and reviews of freshwater and marine fish	*Cobitis linea*, others	Southern and central Iraq	Documented in regions like Al-Huwaiza Marsh and Radwaniyah Lake.

Table 3. Contribution of Fish to Animal Protein, 201

Country	Protein per capita intake—2019 (g/capita/day)		
	Fish and seafood	Protein animal based	Share of fish %
World	5.5	33.2	16.5
Asia	6.4	29.1	22
Northern Africa	4.2	24.2	17.3
Southern Asia	2.4	17	13.9
Western Asia	1.8	31.3	5.8
Saudi Arabia and selected neighboring countries			
Egypt	6.5	23.7	27.2
Iran	3.3	25	13
Iraq	1	12.5	8
Israel	6.4	76.4	8.3
Jordan	1.4	25.2	5.6
Kuwait	4.1	49.4	8.3
Lebanon	2.3	25.3	9
Oman	7.3	40.9	17.9
Saudi Arabia	2.9	35.7	8.2
Sudan	0.3	19.9	1.6
Turkey	1.3	39.7	3.3
United Arab Emirates	6.7	35.7	18.7
Yemen	1	11	8.7

Source Compiled by the author based on data from FAO (2021)

حالة وتحديات وآفاق تطوير الاستزراع المائي في العراق

حسن علي الهلالي[1]، لوزوفيسكي الكساندر روبيرتوفيتش[2]، ناصر علوان صالح العلنجاوي[1]، محمد صالح قدوري [1]، معاذ عبد الجبار نايف العزاوي[1]، إيهاب حسام صبري[1]

1وزارة الزراعة، دائرة الثروة الحيوانية، بغداد ،العراق.
2 جامعة أستراخان الحكومية، روسيا.

*Corresponding Author E-mail: hassanalhilaly89@gmail.com

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المستخلص

شهد الاستزراع المائي في العراق تطورًا كبيرًا، حيث تحول من ممارسات بدائية إلى أنظمة حديثة تدعم الأمن الغذائي والنمو الاقتصادي. وقد أظهر هذا القطاع مرونة كبيرة على الرغم من مواجهته العديد من التحديات، بما في ذلك شح المياه، والتلوث البيئي، وعدم الاستقرار السياسي، وقلة الموارد التكنولوجية. تاريخيًا. هيمنت أنواع الكارب على إنتاج الاستزراع المائي في العراق، والتي تُربى بشكل رئيسي في البرك الطينية والأقفاص العائمة باستخدام مختلف أساليب الاستزراع، وعلى الرغم من فترات النمو التي شهدها الإنتاج، مثل تبني تقنيات الإكثار الصناعي وزيادة مشاركة القطاع الخاص، فقد تعرض أيضًا لانتكاسات نتيجة لعدم الاستقرار السياسي والاقتصادي، بالإضافة إلى العوامل البيئية الخارجية. حاليًا، يساهم الاستزراع المائي بنحو 95% من إجمالي إنتاج الأسماك في العراق، مما يجعله مكونًا أساسيًا في النظام الغذائي الوطني، ومع ذلك، تعيق عوامل مثل تدهور جودة المياه، والممارسات الزراعية غير الفعالة، ومحدودية الوصول إلى التكنولوجيا المتقدمة النمو المستدام لهذا القطاع. يقدم هذا الاستعراض تحليلًا متعمقًا للتطور التاريخي، والوضع الحالي، والتحديات التي يواجهها قطاع الاستزراع المائي في العراق. بالإضافة إلى ذلك، يستكشف الفرص المتاحة لتطوير الاستزراع المستدام من خلال تبني التقنيات الحديثة، وتحسين إدارة الموارد، والإصلاحات السياسية. تهدف النتائج إلى توجيه الاستراتيجيات المستقبلية لتعزيز مساهمة الاستزراع المائي في الأمن الغذائي، وسبل العيش الرفيه، والاستدامة البيئية في العراق.

الكلمات المفتاحية: الاستزراع المائي، العراق، الكارب الشائع، التنمية المستدامة، الأمن الغذائي، الأنظمة شبه المكثفة، إدارة الموارد المائية.