Aquaculture Reimagined: Modern Approaches to Sustainable Fish Farming
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Chapter_22

Aquaculture's Role in Global Food Security

Beemalla Samatha[1], Shivaji Argade[1*] and Amin Binth Basheer[2]

[1]*Fisheries Economics, Extension and Statistics Division,* [2]*Fisheries Resource Harvest and Post Harvest Management Division, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra (400 061), India*

Abstract

Aquaculture is essential for meeting the demand of food and nutrition nationwide. This chapter outlines the significant importance of aquaculture and its role in food security. In addition to this it also identified the challenges and opportunities in the global perspective. We have presented the current trends in the sector, like production and human consumption, majorly in developing countries. The sector has a positive impact on households, employment and fostered economic growth in both rural and coastal areas. In 2022, aquatic animal foods production reached 185 million tonnes globally, with Asia being the highest consumption region. These foods provide high-quality proteins, nutrients, minerals and vitamins, which are important for human nutrition. However, there are significant challenges faced by this sector, including the impact of climate change and environmental degradation, which are severe threats to biodiversity and local ecosystems and the imbalance between fish supply and demand, which results in an increase in prices. Challenges in production facilities, including feed supply and usage of antibiotics in inland aquaculture, are also major threats. However, aquaculture also has many opportunities to enhance food security worldwide. So, adopting sustainable practices and implementing eco-friendly technologies are necessary for the growth of aquaculture, maintenance of ecosystem health and to improve food security. Encouraging small-scale and community-based aquaculture, providing accessibility to training and technology and encouraging regional collaboration and knowledge sharing are crucial for the development of the sector.

Keywords Aquaculture, Consumption, Food Security, Sustainability

1. Introduction

Aquaculture is the sun-rising sector in the world. It covers different species from aquaculture and capture fisheries, including finfish, shellfish, aquatic plants and other aquatic animals. It provides potential benefits to meet growing food demand and address nutritional deficiencies (Golden *et al.*,

[*]***Corresponding author's e-mail***: beemalla.fexpb201@cife.edu.in, shivaji@cife.edu.in

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2021; Filipski and Belton, 2018; Smith *et al.*, 2010). The world's population is estimated to reach 8.5 billion by 2030, with almost 600 million people remaining chronically undernourished. There is an essential need for food security, mostly in developing countries where a majority of household expenditure goes for food. Aquaculture had a positive effect on households' income and consumption (Ahmed and Lorica, 2002). It plays a significant role in achieving food security and production is maximum in developing countries, which is up to 90%, contributes directly and indirectly to food security. The global consumption of aquatic animal foods (*i.e.,* excluding algae) was estimated162 million tonnes in 2021. There are 62 million people who are engaged as full-time, part-time, occasional, or unspecified workers in the sector of fisheries and aquaculture in 2022 (FAO, 2024). The availability of fish and other seafood has increased due to the rise in this sector. With this, people in rural and urban areas can have easy access to it. Hence, this chapter explores aquaculture's role in global food security and the challenges and opportunities involved in promoting sustainable food systems.

2. Addressing Food Security: Aquaculture's Contribution

Food security means everyone should have access to enough food (FAO, 2000). It can be said to exist when people have access to it in all ways, like physical, social and economic ways to meet their needs for a healthy life. Achieving food security involves availability, affordability, utilization and firmness. Food security is very important for the country to grow economically at the community level. If there is sufficient provision of food by countries to their populations, then we can say they are food self-sufficient nationally, but there is no guarantee of food security at the household/ individual level. If we see some countries with food self-sufficient but they have a large population suffering from food insecurity, other countries may not have self-sufficiency, but they have little food insecurity due to higher imports.

Fisheries play a vital role in uplifting the people who depend heavily on this sector for their livelihood and income. It plays a vital role in the world's food economy and contributes a large part to regulate the food security problem. About 200 million people depend on ocean fishing for their livelihoods (Gareth, 2001). This sector has experienced rapid growth in the last few decades, exceeding other meat production units and is expected to increase as an agro-science industry. According to the Global Panel on Agriculture and Food Systems for Nutrition (2021), the aquaculture sector has the potential for economic growth, providing employment opportunities, improving food security and delivering good source of nutrition to people, which is environmentally sustainable, mostly in countries with low and middle-level income. Developing countries will contribute 79% of fish production in 2020 (Delgado *et al.*, 2002). In 2022, aquatic animal production reached 185 million tonnes at the global level, contributing 70 million tonnes from inland and 115 million tonnes from marine sectors. In addition, 37.8 million tonnes (wet weight) of algae was produced, making a total of 223.2 million tonnes of fisheries and aquaculture production. About 164.6 million tonnes

(89%) from aquatic animal production are destined for human consumption, which is equivalent to an estimated 20.7 kg capita^{-1} (FAO, 2024). Fish is relatively affordable for low-income populations, ensuring their access to nutritious foods and the dependence is usually higher in coastal areas. The total world fish production in both capture and aquaculture during the year 2022 was 91.0 tons and 94.4 tons (Table 1). Under the utilization, 20.8 million tonnes are used for non-food purposes, like preparing fish meal, fish oil, glue, gelatin, leather, pharmaceutical use, *etc.* Growth in aquaculture production has been unevenly distributed. Developing countries dominate global production as they have participated in the blue revolution much more than the developed world (Garlock *et al.*, 2020).

Countries in Asia are in the top position in aquatic animal production with

Table 1: Fisheries and aquaculture production and utilization (million tons) in the latest FAO 2024 report

Sl. No.	Category	Production of fish (million tons) (2022)
Capture		
1	Inland	11.3
2	Marine	79.7
	Total capture	91.0
Aquaculture		
1	Inland	59.1
2	Marine	35.3
	Total aquaculture	94.4
	Total	185.4
Utilization		
1	Human consumption	164.6
2	Non-food uses	20.8
3	Per capita apparent consumption (kg)	20.7

70%, followed by countries in Europe and Latin America with 9% each, Africa with 7%, North America with 3% and Oceania with 1%. The major producer is China with 36%, followed by India with 8%, Indonesia with 7%, Vietnam with 5% and Peru with 3%. Aquatic animal production is estimated to reach 205 million tonnes in 2032, with contributions from aquaculture is 111 million tonnes and from capture fisheries is 94 million tonnes, increasing by 17% and 13%, respectively (FAO, 2024). Aquaculture can be seen as an essential sector for improving food and nutritional security and other needed welfare.

2.1. Consumption of Fish

There was a positive relation between aquaculture production and aquatic food consumption at the national level, where a 1% increase in production

is associated with a 0.9% increase in per capita consumption (Garlock *et al.*, 2022). Fish consumption will have a substantial impact on the food security, nutrition, diets and income of the poor. Aquaculture consolidated its contribution to food for human consumption, supplying more than 50% of aquatic animal foods. Global apparent consumption of aquatic animal foods has increased significantly, at a higher annual growth rate. The continents and other countries with the highest consumption of aquatic food (Figure 1) and per capita consumption increased from 9.1 kg year^{-1} in 1961 to 20.6 kg year^{-1} in 2021.

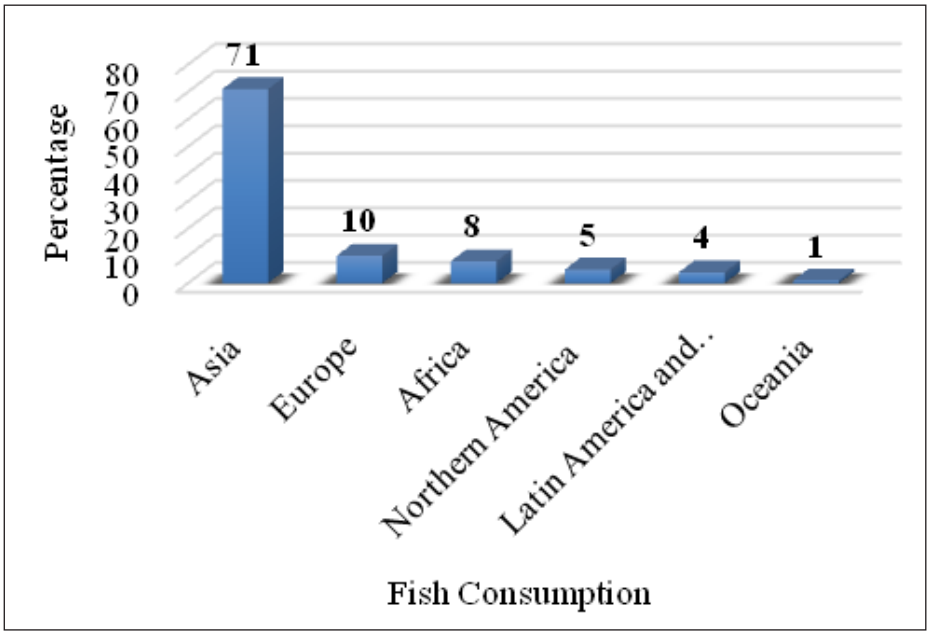

Figure 1: Aquatic food consumption during 2021 (FAO, 2024)

Asia constituted 71% of this apparent consumption, the biggest proportion globally, as the contributions of China, Indonesia and India increased from 17% to 51% during the same period, with China alone accounting for 36% of this total. Household income and expenditure surveys (HIES) and socio-economic surveys (SES) to estimate existing patterns of fish consumption in the Pacific region and found that the consumption was high in many areas of the region where rural communities depended heavily on fish compared to urban areas (Bell *et al.*, 2009)

2.2. Protein Supply

Fish and other aquatic food from marine and freshwater environments are nutrient-dense animal source food. These foods provide high-quality proteins, i.e., 15% of animal proteins and 6% of total proteins worldwide and other

important nutrients, including omega-3 fatty acids, minerals and vitamins, are important for human nutrition. The local communities can get easy access to protein derived from fish, which is affordable too. As a protein-rich food, it provides a vital option for kids suffering from malnutrition in many regions of the world. The World Health Organisation (WHO) recommended that protein intake should be 0.7 g kg^{-1} body weight day^{-1} for good nutrition. Moreover, omega-3 fatty acids play a significant role in protecting against coronary heart diseases (FAO and WHO, 2010). Thus, aquaculture plays a major role in addressing hunger by providing rich protein and other nutrients that support nutritional security.

2.3. Employment and Economic Development

From farming and processing sectors to distribution and retail, aquaculture has created various jobs across the value chain. It is crucial for people living in rural and coastal areas where limited employment opportunities are offered. This economic boost contributes to food security by enhancing household income, which increases the power and access to a wide range of foods. Aquaculture contributed significantly to national economies by generating foreign exchange derived *via* international trade. Exports of aquatic animals increased from USD 7.9 billion in 1976 to 192 billion in 2022 at an average growth rate of 7.2% in nominal terms and 4% in real terms annually, facilitated by the liberalization of trade policies, reduced transportation costs and improved technology, logistics and storage (FAO, 2024).

2.4. Poverty Alleviation

Food security is the key component of poverty. Aquaculture contributes both directly and indirectly to food security. Directly through the fish supply and indirectly by providing income generated from production, processing and marketing activities, which can be used to purchase different foods. People from poor households who engage in small-scale fishing activities occasionally, seasonally, or full-time contribute to individual/household food security. In 2021, FAO launched its Blue Transformation vision (FAO, 2022), which aimed at increasing the opportunities through aquatic food systems to enhance food security, improve nutrition, reduce poverty and support the achievement of the 2030 Agenda for Sustainable Development.

3. Challenges and Opportunities: A Global Perspective

3.1. Challenges in Aquaculture Sector

There are several challenges and opportunities in the aquaculture sector. Developing countries often lack the resources and, with the growing population, require an adequate amount of food supply to meet food security and safety requirements (Pradeepkiran, 2019). If we look at the different regions in the world in the year 2023, Africa is top in food insecurity among all countries with 58% which is nearly double the global average, whereas, in the Caribbean (28.2%), Oceania (26.8%) and Asia, Latin America (24.8%)

are closer and slightly below the worldwide estimate (FAO, IFAD, UNICEF, WFP and WHO, 2024). Food insecurity is moderate to high in certain continents, mainly in Africa, but it has not changed even over the years. Figure 2 represents the food insecurity in the world from 2019 to 2023, which is severe, moderate and unchanging over the time period (FAO, 2024, FAOSTAT). This chapter highlights the need for continued and targeted interventions to address these critical issues. Several strategies for leveraging aquaculture to help reduce food insecurity in these areas through the promotion of small-scale and community-based aquaculture, accessibility to training and technology and encouraging regional collaboration and sharing knowledge *etc.*

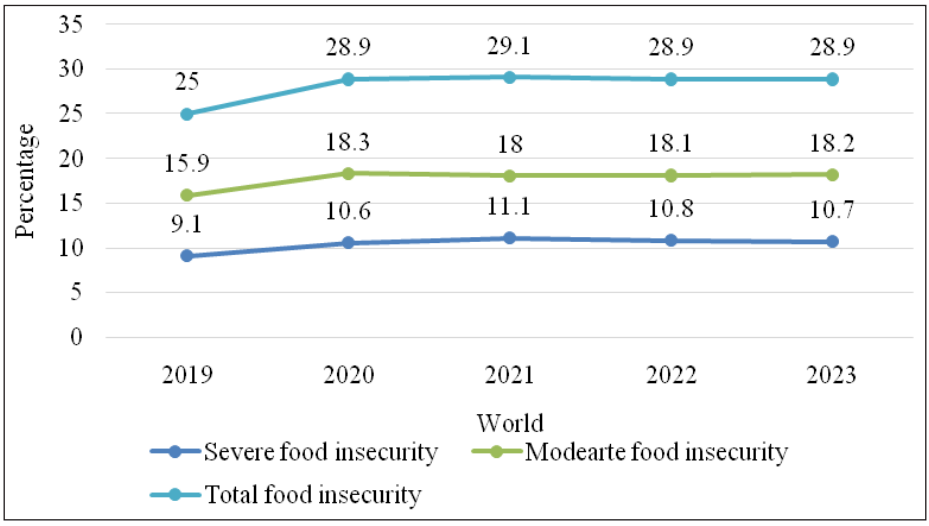

Figure 2: Food security levels (FAO, 2024, FAOSTAT)

There are many unsustainable practices in aquaculture that lead to the pollution of water and other resources, destruction of habitats, climate change, creating imbalances in the ecosystem and overall threat to biodiversity. So, there is a need to provide sustainable solutions to global consumption needs. By focusing only on the direct contribution of fish to food security, a reduction in fish and fish product imports and greater exports will lead to the lesser availability of fish for local consumption (FAO, 2005). Another dimension of the fish-food security issue is an imbalance between fish supply and demand, which results in an increase in prices. Aquatic food production is stagnant and distributional shifts in fish stocks resulting from climate change will reduce the capacity for fisheries to contribute to future aquatic food security in tropical, low-income nations (Lotze *et al.*, 2019). Other challenges in production facilities include feed supply and usage of antibiotics, which need to be overcome for further development of aquaculture (Belton *et al.*, 2020). Hence, it is high time to adopt sustainable practices, which are crucial to address the environmental, economic and social factors,

eventually reducing harmful impacts on the ecosystem and ensuring its long-term viability. Specifically, eco-friendly farming techniques need to be implemented and the usage of chemicals and antibiotics should be reduced.

3.2. Opportunities in Aquaculture Sector

Many studies show that aquaculture has good opportunities to enhance food security worldwide. Advancing aquaculture in regions such as sub-Saharan Africa, where there highest rate of malnutrition and food insecurity, is very crucial for maintaining and improving access to aquatic food (Koehn *et al.*, 2021; Chan *et al.*, 2019; Golden *et al.*, 2016). Aquaculture has diversified protein sources beyond traditional agriculture, so the food system resilience can be improved through this. There are many aquaculture systems, like integrated multi-trophic aquaculture, are designed in such a way to be more sustainable and reduce waste. Others include aquaponics, where fish farming with hydroponic plant cultivation creates a closed-loop system and can be productive in different environments, including urban areas. Aquaculture is crucial in the global scenario for shifting toward more environmentally sustainable diets and simultaneously achieving food security goals (Garlock *et al.*, 2022). It is very important for advancing food security at the global level by providing a sustainable source of nutrition, supporting livelihoods and enhancing resilience in food systems. Through this, food security can be increased and the needs of the people can be addressed. Small-scale and subsistence-oriented farmers can be targeted for improving food security in all developing countries.

4. Conclusion

This chapter explained aquaculture's role in global food security. Particularly in underdeveloped nations, aquaculture contributes significantly to global food security by generating income, supporting livelihoods and providing nutrition. The increasing food industry is making a substantial contribution to meet the rapidly growing population's demands and preventing undernourishment. Additionally, it discusses food insecurity in various regions of the world and how to improve it. However, this industry faces a number of difficulties, including unsustainable practices and their effects on the environment. These types of obstacles should be addressed by adhering to inclusive policies and sustainable practices to ensure that aquaculture is enhancing food security without affecting the health of the ecosystem. In addition, a variety of policies are required in which social and economic actions react to consumer demand, access, supply and nutrition. Sustainable practices and innovation should receive more attention since they guarantee aquaculture's ability to meet global food security goals, economic advancement and ecological resilience.

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