

1. A Food-System Perspective on the Development of Fisheries and Aquaculture in India

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1. Introduction

The global population's reliance on aquatic foods for nutrition and livelihood has never been more pronounced. With a staggering rise in demand, particularly for high-quality protein, the twin pillars of fisheries and aquaculture have emerged as cornerstones of the global food architecture. As the world's third-largest fish producer and second-largest aquaculture producer, India occupies a strategic position in this sector. For a nation with a vast coastline and extensive inland water bodies, aquatic foods are more than a commodity; they are a fundamental component of the food basket, a source of income for over 16 million people, and a key driver of rural economic development. Traditional assessments of the fisheries and aquaculture sector often concentrate on

production volume and export value, overlooking the complex web of interactions that define its actual impact. A food-system perspective, however, offers a holistic view, examining the entire value chain from "water to plate." This approach encompasses all elements and activities related to food production, processing, transportation, consumption, and disposal, as well as their environmental, social, and economic impacts. This article applies this integrated framework to analyse India's aquatic food sector. It aims to (1) provide a detailed overview of the sector's current status and its socio-economic contributions; (2) apply the food-system lens to identify key challenges and opportunities across the value chain; and (3) propose strategic policy recommendations for fostering a

sustainable and equitable future for Indian fisheries and aquaculture.

2. Overview of Fisheries and Aquaculture in India

India's aquatic food sector is characterised by its dualistic nature, encompassing a diverse array of practices ranging from small-scale traditional fishing to highly intensive modern aquaculture. The sector has witnessed a remarkable transformation, with total fish production surging from a mere 0.75 million tonnes in 1950–51 to 16.25 million tonnes in 2021–22. This growth has been primarily driven by the rapid expansion of aquaculture, which now accounts for a substantial portion of total production.

2.1 Current Status and Production Statistics

Marine fisheries, historically the dominant sub-sector, continue to contribute substantially to the nation's fish basket. The marine catch is highly diverse, with

significant quantities of Indian mackerel, sardines, and various shrimp species harvested along India's 8,118-kilometre coastline. However, concerns regarding stock depletion and the sustainability of harvesting practices are becoming increasingly prominent.

Inland fisheries, encompassing rivers, lakes, reservoirs, and a vast network of canals, represent a critical, yet often underutilised, resource. This sub-sector supports millions of livelihoods, particularly in rural areas, and is essential for domestic food security.

The most dynamic growth, however, has occurred in aquaculture. India is a global leader in shrimp farming and a significant producer of freshwater fish, including carp (such as rohu, catla, and mrigal). Technological advancements, favourable government policies, and rising domestic and international demand have fuelled the sector's growth.

Table 1.1 Production Volume and Value by Sub-sector (FY 2017–2022). Source: Based on data from the Department of Fisheries, Government of India, and various economic surveys.

Sub-Sector	Production (x1000 tonnes)	Average Annual Growth Rate (%)	Value (₹ Crores)
Marine Fisheries	3,500 - 4,000	1.5–2.0	55,000 - 65,000
Inland Fisheries	2,000 - 2,500	2.5–3.0	30,000 - 38,000
Aquaculture	9,000 - 10,000	7.0–8.5	120,000 - 145,000
Total	14,500 - 16,500	4.5 - 5.5	205,000 - 248,000

2.2 Socio-Economic Significance

The aquatic food sector's contribution to India's economy is multifaceted. It employs approximately 1.2 million fishers directly and supports millions more in related activities such as processing, marketing, and boat building. The sector contributes over 1% to the national GDP and nearly 7% to the agricultural GDP. Beyond economic metrics, fish is an indispensable part of the diet, especially in coastal and northeastern states, providing affordable protein and essential micronutrients like Omega-3 fatty acids, iron, and iodine, which are crucial for addressing malnutrition.

3. Applying the Food-System Lens: Components and Interactions

A food-system analysis reveals that the challenges and opportunities for India's aquatic sector are deeply intertwined and extend far beyond the water.

3.1 Production Systems

The production component of the aquatic food system faces distinct challenges in both the marine and aquaculture sub-sectors. Marine fisheries are grappling with the critical issue of overfishing, as evidenced by a consistent decline in catch per unit effort (CPUE) for several commercially important species. This decline not only threatens the sustainability of fish stocks but also jeopardises the

livelihoods of traditional fishing communities, who often find themselves in conflict with large-scale trawlers.

These conflicts exacerbate existing economic and social disparities, as industrial-scale fishing operations tend to dominate access to marine resources, sidelining small-scale fishers and deepening socioeconomic divides. On the other hand, aquaculture's rapid intensification introduces its own set of challenges, including a heavy reliance on imported fish meal for feed. This dependency places additional pressure on already vulnerable wild fish stocks and increases the susceptibility of farmed species to disease outbreaks, primarily due to elevated stocking densities.

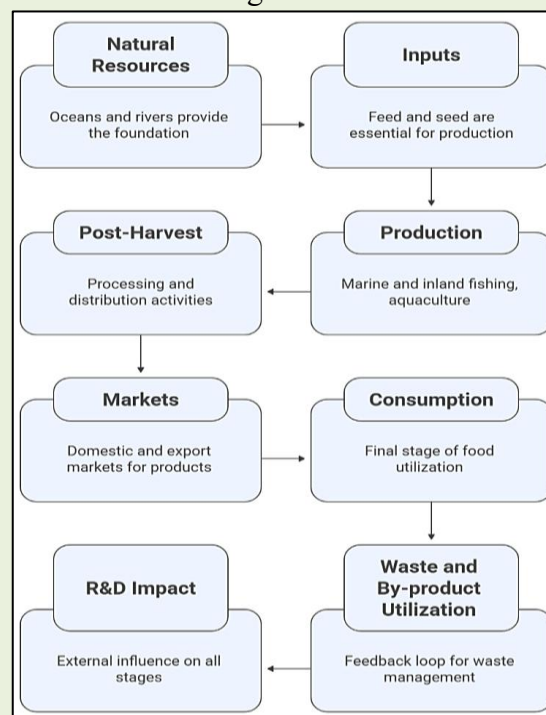


Fig 1.1 The Indian Aquatic Food System Flow

3.2 Processing and Value Addition

A notable weakness within the Indian aquatic food system is the inadequate post-harvest infrastructure, which severely hampers efficiency and profitability. It is estimated that up to 20% of the total catch is lost due to poor handling practices, inadequate cold storage facilities, and fragmented supply chains that lack coherence and coordination. While India boasts modern processing plants designed for export-oriented products, such as shrimp, traditional fishers and small-scale farmers frequently find themselves without access to these technologies. As a result, they are often forced to rely on low-value, sun-dried products, which do not reflect the potential quality and value of the resources harvested. By enhancing value addition through the introduction and adoption of advanced processing technologies, it is possible not only to significantly boost fisheries income but also reduce waste, thereby creating a more sustainable economic structure within the sector.

Table 1.2 Key Export Products and Destinations (FY 2021–22). Source: Marine Products Export Development Authority (MPEDA), India

	Volume (x1000 tonnes)	Value (₹ Crores)	Major Destinations
Frozen Shrimp	750-800	45,000-50,000	USA, China, EU
Frozen Fish	100-120	2,500-3,000	South-East Asia
Dried Fish	40-50	500-600	Bangladesh, Sri Lanka
Fish Meal/Oil	150-180	1,200-1,500	EU, Japan

3.3 Distribution and Marketing

The domestic fish market is characterized by a long and convoluted distribution chain that is often informal and riddled with multiple intermediaries. This complexity drives up consumer prices while simultaneously reducing the proportion of profits that reach fishers and farmers, undermining their economic viability. A critical constraint in this system is the lack of a dependable cold chain network, which serves as a significant bottleneck by compromising product quality and limiting market reach. For export markets, the situation is further complicated by stringent quality standards and traceability requirements. While these demands represent a challenge that must be navigated carefully, they also offer an opportunity to upgrade the supply chain infrastructures and practices, enabling greater efficiency and competitiveness on the global stage.

3.4 Consumption Patterns

Fish consumption in India is on the rise; however, it remains unevenly distributed across urban and rural areas, as well as among various regions. Addressing this disparity is crucial, and raising awareness about the nutritional benefits of aquatic foods is fundamental in broadening domestic demand. With the advent of

modern retail and e-commerce platforms, new avenues have emerged for reaching consumers with both fresh and processed products. These channels offer a promising opportunity to bypass traditional, often inefficient, market structures, allowing for more direct engagement with consumers and the potential to enhance market penetration.

3.5 Waste and By-Product Utilization

An often-overlooked aspect of the aquatic food system is the potential for utilizing waste and by-products generated during processing. Materials such as fish heads, bones, and trimmings, which are typically discarded, can be repurposed into high-value products like fish meal, fish oil, collagen, and organic fertilizers. This closed-loop approach not only aligns with principles of a circular economy but also helps to reduce environmental pollution by minimizing waste. Additionally, it creates new revenue streams for the sector, supporting both economic growth and improved sustainability practices within the industry. Implementing efficient waste utilization strategies could yield significant benefits, both environmentally and economically, thereby enhancing the overall resilience of the aquatic food system.

4. Challenges and Opportunities within the Food System

The future of India's aquatic food sector hinges on addressing a range of challenges that span environmental, economic, and social domains. The complexity of these interrelated challenges presents both risks and opportunities, necessitating a multifaceted approach to ensure sustainable development.

4.1 Environmental Sustainability

Climate change poses a significant threat, with rising sea temperatures, ocean acidification, and extreme weather events impacting marine ecosystems and fish stocks. These alterations can lead to shifts in species distribution, affecting the productivity of fisheries and the livelihoods that depend on them. Inland water bodies face additional pressures from industrial effluents, agricultural runoff, and plastic pollution, which degrade water quality and threaten aquatic biodiversity. Sustainable resource management practices, including the establishment of marine protected areas and the adoption of eco-friendly agricultural practices, are paramount to ensure the long-term viability and resilience of the sector.

4.2 Economic Viability and Livelihoods

Economic challenges in the aquatic food sector are increasing, characterized by the escalating costs of inputs such as feed for

aquaculture and fuel for marine vessels, which collectively erode profit margins. Small-scale fishers and farmers, who form the backbone of the sector, are particularly vulnerable to market price volatility and often lack access to formal credit and insurance mechanisms. This financial exclusion significantly hinders their ability to invest in innovative technologies and adapt to unforeseen shocks, risking their economic stability and overall resilience. A proactive approach that incorporates tailored financial products and services could significantly enhance the economic viability of these producers.

4.3 Social Equity and Governance

Social equity concerns are pervasive, marked by the lack of clear tenure rights and access to fishing for traditional communities. Such ambiguities create conflicts over resource utilisation and contribute to economic insecurity among these vulnerable populations. While the policy framework governing the aquatic food sector shows signs of improvement, it still requires enhanced integration of stakeholder inputs and more effective implementation to protect marginalised groups and ensure equitable benefit-sharing. Furthermore, the significant contributions of women, primarily involved in post-harvest activities, often go unrecognised and undercompensated,

highlighting the need for gender-inclusive policies and recognition of their critical roles within the sector.

4.4 Technological Gaps and Research Needs

There is a pressing need for technological innovation to address existing gaps in the aquatic food system. This includes the development of sustainable, cost-effective, and locally sourced feeds for aquaculture to reduce reliance on imported fish meal, as well as improved disease diagnostics and management systems that can mitigate health risks among farmed species. Additionally, the adoption of selective fishing gear to minimise bycatch is essential for promoting sustainable fishing practices. Moreover, robust data collection and monitoring systems are critical for generating reliable evidence that informs policy decisions and stock assessments. Investing in research and development in these areas can lead to more sustainable practices and increased productivity within the aquatic food sector, ultimately contributing to food security and economic development.

5. Policy Interventions and Future Directions

Addressing the multifaceted challenges faced by India's aquatic food sector necessitates a holistic and coordinated policy response. The following policy

interventions are essential for promoting sustainable growth and resilience within the sector.

5.1 Strengthening Regulatory Frameworks

A robust policy framework is critical for the sustainable management of aquatic resources. This involves implementing stricter regulations regarding fishing gear to minimise environmentally harmful practices and protect non-target species. Additionally, promoting sustainable aquaculture practices through guidelines and incentives will help ensure that farming activities do not hurt surrounding ecosystems. Equally important is the enforcement of environmental protection laws aimed at combating pollution from agricultural runoff and industrial discharges, which threaten water quality and biodiversity. Such regulatory measures must be enforced with adequate training and resources for local authorities to foster compliance and sustain ecological integrity.

5.2 Enhancing Value Chains

Investments in post-harvest infrastructure are vital for reducing losses and maximising the economic potential of the aquatic food sector. This includes expanding cold chain facilities to maintain product freshness from harvest to market, thereby reducing spoilage and enhancing product quality. Establishing modern

processing hubs can facilitate value addition, enabling fishers and farmers to access higher-value markets. Additionally, promoting the use of solar-powered cold boxes not only enhances the sustainability of operations but also empowers remote communities with limited access to electricity to extend the shelf life of their products and improve market access.

5.3 Supporting Small-Scale Fishers and Farmers

Policies must prioritise the welfare of small-scale stakeholders who form the backbone of India's aquatic food sector. This entails providing access to subsidised technologies that enhance productivity and resilience, alongside affordable credit and insurance products that enable them to manage risks effectively. Furthermore, fostering the formation and strengthening of fisher and farmer producer organisations (FPOs) can significantly empower these stakeholders, providing them with greater market leverage, access to information, and collective bargaining power. Enhanced support for these organisations can improve the socio-economic conditions of small-scale fishers and farmers, driving inclusive growth.

5.4 Promoting Research and Development

Collaboration between government bodies and the private sector is essential for

advancing research and development initiatives that address the unique challenges of the aquatic food sector. Focused research should centre on developing indigenous, disease-resistant fish species that can thrive in diverse environments, innovative and sustainable feed formulations that mitigate reliance on overexploited fish meal resources, and the establishment of climate-resilient farming systems that can withstand variable environmental conditions. Such research efforts are crucial for fostering innovation, enhancing productivity, and ensuring the sustainability of the sector in the face of climate change.

5.5 Inter-sectoral Linkages

Integrating the aquatic food sector with other economic sectors can unlock significant synergies and maximize the benefits derived from aquatic resources. For instance, linking aquaculture with agricultural operations can create synergistic systems, such as aquaponics, that optimize resource utilization while promoting sustainable food production practices. Additionally, integrating waste utilization from fisheries and aquaculture with bio-energy production can foster new revenue streams and contribute to rural development. By establishing inter-sectoral linkages, the overall economic resilience of communities reliant on aquatic resources

can be substantially enhanced, paving the way for a more sustainable and productive future.

6. Conclusion

The development of fisheries and aquaculture in India, examined through a food-systems perspective, reveals a multifaceted landscape marked by both significant challenges and opportunities. Existing issues, such as ecological stress from overfishing, substantial post-harvest losses, and socioeconomic inequities, transcend isolated concerns and illustrate systemic gaps that hinder the sector's growth. To address these challenges effectively, an integrated policy approach is essential, one that enhances production efficiency, strengthens value chain infrastructure, builds market linkages, and prioritizes the welfare of all stakeholders. Implementing such a strategy can not only ensure a stable supply of nutritious food for India's expanding population but also contribute to a more resilient and inclusive rural economy.

Furthermore, this holistic approach is vital for securing the long-term sustainability and profitability of India's fisheries and aquaculture sector. By fostering partnerships among government entities, the private sector, and local communities, the sector can harness shared expertise and resources, leading to innovative solutions

that promote sustainable practices. Additionally, addressing gender disparities and enhancing women's participation will contribute to more equitable growth and empowerment within the industry. Ultimately, the commitment to both environmental health and socioeconomic well-being will pave the way for a thriving fisheries and aquaculture sector that benefits future generations.

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