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FROM MODEST GROWTH TO MARKET LEADERSHIP:

TRANSFORMING INDIA'S SHRIMP SECTOR

PART B: WHITE PAPER

Presented By:
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White Paper 1

From Modest Growth to Market Leadership: Transforming India's Shrimp Sector

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Table of Contents

Table of Figures 1
Overview 2
Opportunities in Shrimp Industry 4
Shrimp as a Protein Source and Food Staple 5
Expanding Export Markets and Global Dominance 5
Diversification into Value-Added and Premium Products 6
Employment Generation and Rural Development 7
Regional and Species Diversification 7
Integration with Allied Sectors and Circular Economy 9
Technological Interventions 9
Site Selection 10
Enhancing Productivity 11
Marine Spatial Planning 13
Policy Interventions 14
Capacity and Capability Building 16
Challenges 17
Conclusion 18
References 18

Table of Figures

Figure 1: Percent share of the factors responsible for the growth of the shrimp industry [5] 3
Figure 2 Percent share of the factors responsible for the growth of the shrimp industry [7] 4
Figure 3: Comparison of shrimp, egg and meat* on their cholesterol, saturated fatty acids and atherogenic index [8] 5
Figure 4: List of major shrimp-exporting & Importing countries [7] 6
Figure 5: LAST 5 years L. vannamei production (Left) & P. monodon production (Right) (Values in Metric Tons) [19] ... 8
Figure 6: India is the second-largest producer of Whiteleg Shrimp (Litopenaeus vannamei) [20] 8
Figure 7: Biological processes in biofloc cultivation [24] 10
Figure 8: The logical framework of the application of new digital technology in marine aquaculture. [25] 10

Figure 9: (a) APY Tool user entering values to the application corresponding to the table (b) and the app predicting the growth status of the organism, and expected biomass yield from the farm, and total production based on farm area (c) Growth Rate Curve" feature to track weekly growth rate (g/week) variations over time. 12
Figure 10: The graph shows the variation in shrimp biomass as influenced by temperature and stocking density, incorporating the impact of varying survival rates. (Image part of MRC publication and not to be reproduced).....13
Figure 11: FDA's Shrimp Refusal due to Banned Antibiotics comes from 13 countries but 88% are from 3 countries- China, India & Vietnam [43].....17

Overview

India continues to play a pivotal and increasingly influential role in the global fisheries and aquaculture landscape. As the world's second-largest fish producer, the country contributes significantly to global food security, accounting for approximately 8% of total global fish production as of 2025 [1]. This achievement reflects not only India's rich aquatic biodiversity and extensive coastline but also the result of sustained policy attention, technological innovation, and inclusive development strategies pursued over the past two decades.

During the fiscal year 2023–24, India recorded an all-time high fish production of 184.02 lakh tonnes (18.4 million tonnes), a remarkable rise from 95.79 lakh tonnes in 2013–14 and 63.99 lakh tonnes in 2003–04. This reflects an impressive net increase of 88.23 lakh tonnes over the past decade (2014–24), compared to an increase of 31.80 lakh tonnes during the preceding decade (2004–14) [1]. Particularly noteworthy is the dramatic growth in inland and aquaculture-based production, which surged by 77.71 lakh tonnes between 2014 and 2024—almost tripling the increase observed from 2004 to 2014, which stood at 26.78 lakh tonnes. Similarly, marine fish production witnessed a near doubling, rising from 5.02 lakh tonnes during 2004–14 to 10.52 lakh tonnes during 2014–24, highlighting the sector's strategic importance to coastal livelihoods and food systems.

The fisheries sector has emerged as a key pillar of India's national economy, contributing approximately 1% to the country's overall Gross Domestic Product (GDP) and over 5% to the agricultural GDP [2]. This robust performance is further reflected in India's seafood export achievements. During the review period, exports reached a historic peak of 17,81,602 metric tonnes, generating a substantial foreign exchange inflow of ₹60,523.89 crore (approximately USD 7.38 billion), reaffirming India's position as a reliable and competitive player in international seafood markets [1].

States such as Andhra Pradesh have played an instrumental role in driving this growth. With a strategic focus on infrastructure, innovation, and stakeholder capacity-building, Andhra Pradesh alone accounts for 22% of national fish production, setting an example for effective state-led intervention in the fisheries sector [3].

A major engine behind this progress has been the rapid advancement of shrimp aquaculture. Once a traditional and subsistence-based activity, shrimp farming has evolved into a sophisticated industry that now significantly contributes to both the national economy and global seafood supply chains. The roots of shrimp farming date back centuries, particularly in Southeast Asia, where primitive systems involved the use of natural water bodies and tidal enclosures. These early models were low-intensity and dependent on natural productivity. However, transformative shifts began to occur in the mid-20th century, driven by breakthroughs in hatchery technologies, breeding, and feed formulations.

In today's context, shrimp aquaculture has gained undeniable global importance. Shrimp, with their distinct flavor and culinary appeal, have become a staple in both traditional cuisines and modern food markets across the world. As the Indian shrimp sector matures, it finds itself at a critical inflection point—ready to transition from a phase of moderate growth to one characterized by strategic expansion, global competitiveness, and sustainable development.

Valued at USD 9.2 billion in 2024, the Indian shrimp market is poised for substantial growth, projected to reach USD 22.7 billion by 2033, reflecting a strong compound annual growth rate (CAGR) of 10.1% [4]. This trajectory is underpinned by a confluence of favorable factors, including rising consumer demand for protein-rich seafood, both within India and globally; the increasing culinary popularity of shrimp; and ongoing advancements in aquaculture management, disease control, and breeding science.

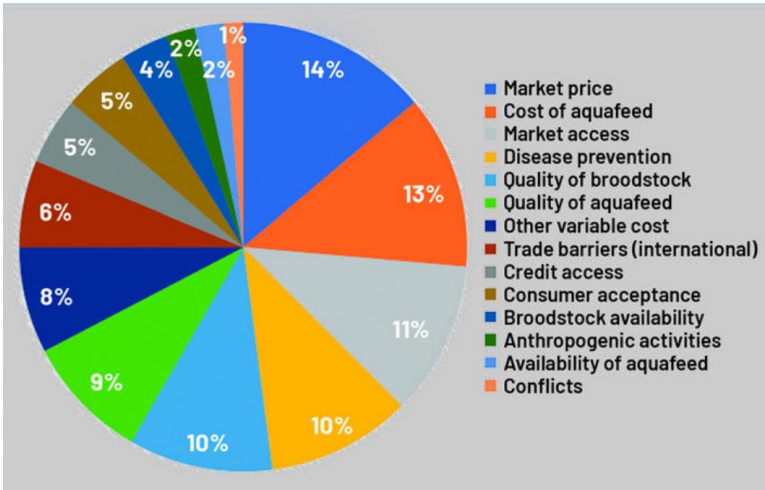

Figure 1: Percent share of the factors responsible for the growth of the shrimp industry [5]

India’s growing prominence in the global shrimp trade is a testament to the nation's strategic investments and the resilience of its shrimp farming industry. A key aspect of this success is the country's expanding export reach to major international markets, including the United States and China. This upward trajectory in global trade is not only indicative of the increasing demand for Indian shrimp but also highlights India’s competitive edge in a highly dynamic global marketplace.

Several external factors have further reinforced this positive momentum. The resurgence of global demand for high-quality seafood, particularly shrimp, has played a central role in driving growth for Indian exporters. The increasing preference for shrimp in international markets, combined with shifting consumption patterns toward protein-rich seafood, has created a favorable environment for Indian shrimp to capture a larger share of the global market.

In addition to demand dynamics, India’s competitiveness has been significantly bolstered by easing competition from other major shrimp-exporting countries, such as Ecuador. As some shrimp-producing nations face challenges related to disease outbreaks, rising production costs, and environmental regulations, India has been able to capitalize on these gaps by maintaining high-quality standards and cost-effective production practices.

Furthermore, reductions in essential input costs, such as feed and fuel, have provided Indian shrimp producers with a crucial advantage. The cost savings from these factors have enabled Indian producers to maintain their price competitiveness, even amidst global fluctuations in market conditions. This has further enhanced the profitability and sustainability of shrimp farming in India, creating a virtuous cycle of growth, investment, and market access.

In total, India exported an impressive 1.78 million metric tons of seafood in 2024–2025, underscoring the sector’s pivotal role in the nation’s economic and trade dynamics [6]. Of this, frozen shrimp accounted for nearly two-thirds of all seafood exports, illustrating the dominant role of shrimp in India’s seafood export portfolio. This strong performance in the global marketplace is not only a

testament to India’s robust shrimp farming infrastructure but also highlights the sector's contribution to the nation’s economic growth, employment generation, and foreign exchange earnings.

United States imports of shrimp
January–September (1 000 tonnes)

	2022	2023	2024
Imports			
India	232.27	215.46	213.52
Ecuador	154.26	154.40	142.70
Indonesia	128.47	107.08	94.34
Other countries	130.98	98.40	99.61
Total imports	**645.98**	**575.33**	**550.16**

China imports and exports of shrimp
January–September, 2022–2024 (1 000 tonnes)

	2022	2023	2024
Imports			
Ecuador	394.13	541.48	501.84
India	105.82	105.36	104.37
Canada	21.73	23.92	19.17
Other countries	142.04	151.32	104.45
Total imports	**663.71**	**822.08**	**729.83**

Figure 2 Percent share of the factors responsible for the growth of the shrimp industry [7]

Despite the positive growth trends observed in India’s shrimp sector, several persistent challenges remain that threaten both its long-term sustainability and its competitive positioning in global markets. The industry is continually impacted by disease outbreaks, which have the potential to disrupt production cycles and erode confidence within both domestic and international markets. Fluctuating export volumes, coupled with regulatory hurdles, present further barriers, while the imposition of trade duties in key markets underscores the sector’s vulnerability to external economic and political pressures. These challenges underscore the need for a more resilient and adaptable shrimp aquaculture industry that can weather market uncertainties and safeguard its future growth.

In addition to these operational concerns, the industry must also confront increasing pressures related to environmental sustainability. Issues such as water management, habitat degradation, and the environmental footprint of feed production demand immediate attention. There is a growing imperative for the sector to adopt responsible sourcing practices and integrate sustainability principles into every facet of its operations. Furthermore, innovation in farming techniques, including advancements in breeding, disease prevention, and feed practices, will be critical in ensuring the sector’s ability to meet both domestic and international demand in a sustainable and environmentally responsible manner.

International markets are evolving rapidly, with consumers and buyers placing greater emphasis on ethical sourcing, environmental stewardship, and the quality of the products they purchase. In particular, there is a rising demand for antibiotic-free, certified, and value-added shrimp products, which is reshaping production and export strategies. As global consumers become more conscious of the sustainability of their food choices, India’s shrimp industry must adapt by aligning with these shifting preferences, ensuring that the products it offers meet international standards for quality and sustainability. Concurrently, domestic consumption is also on the rise, driven by increasing disposable incomes and changing dietary habits, providing an additional avenue for growth and market expansion.

To transform India’s shrimp sector from a phase of modest growth into one of market leadership, a strategic shift is essential. This transformation will not only require scaling up production and enhancing export competitiveness but also necessitate a deeper commitment to sustainable aquaculture practices. Strengthening disease management systems and improving biosecurity will be crucial in mitigating risks and stabilizing production outputs. Furthermore, fostering continuous innovation across the value chain—from hatcheries and feed formulation to processing and value addition—will be vital to maintaining a competitive edge in an increasingly globalized market.

Opportunities in Shrimp Industry

India’s shrimp sector has emerged as a key driver of economic progress, rural livelihood enhancement, and global trade integration. Its transformation from a modest source of protein to a

thriving, multi-billion-dollar export industry highlights the complex yet promising synergy between rising domestic consumption, global market dynamics, and the country's inherent competitive strengths. As the world's second-largest producer and exporter of shrimp, India now stands on the threshold of a new phase of accelerated growth. This remarkable growth trajectory is underpinned by a constellation of economic opportunities that extend well beyond the plate.

Shrimp as a Protein Source and Food Staple

Shrimp continues to play a fundamental role as a high-quality protein source for millions across India. With rising incomes and increasing urbanization, dietary preferences are evolving—leading to greater demand for seafood, particularly shrimp, valued for its low fat content, rich nutrient composition, and culinary adaptability. Additionally, shrimp is a low-glycaemic index (GI) food and a notable source of essential vitamins and minerals, in the context of heart health and diabetes management.

Non-vegetarian food	SFA[@] (g/100 g)	Cholesterol[#] (mg/100 g)	Atherogenic index[$]
Shrimp	0.25	173	0.36
Egg	4.0	400	0.40
Chicken	6.0	100	0.50
Mutton	7.0	65	1.00
Beef	8.0	70	0.70
Pork	13.0	90	0.67
Health significance	Lowest in shrimp; good for health	Moderate in shrimp; but not harmful due to low SFA	Lowest in shrimp; good for health

*Dietary guidelines[24,25,30]. [@]Higher saturated fatty acids consumption increases blood cholesterol. [#]Cholesterol consumption should not be more than 300 mg (USA) per day. [$]Lower atherogenic index is good for a healthy heart.

Figure 3: Comparison of shrimp, egg and meat on their cholesterol, saturated fatty acids and atherogenic index [8]*

As a key component of nutritional security, shrimp not only addresses health needs but also supports expanding demand across retail, foodservice, and home consumption segments. The growing appetite for processed and value-added shrimp products is fostering new domestic revenue streams, reducing the sector's historical dependence on exports. This diversification is also driving the growth of essential infrastructure, including cold chains, logistics, and modern retail networks—collectively reinforcing the broader economic framework that supports India's aquaculture sector.

Expanding Export Markets and Global Dominance

India's shrimp industry continues to be a cornerstone of the global seafood trade, contributing significantly to foreign exchange earnings and supporting the livelihoods of millions. The United States stands out as India's largest shrimp importer, accounting for over 34% of total export value, with frozen shrimp making up more than 91% of exports to that market [9]. In January 2025 alone, India exported 49,058 metric tons of shrimp, generating $355 million in revenue—a 9% increase in value compared to the previous year, despite a modest 3% decline in volume [10]. This performance underscores the industry's adaptability and resilience in responding to shifting global market dynamics.

World top exporters of shrimp
January–September (1 000 tonnes)

	2022	2023	2024	% change 2024/23
Ecuador	805.30	916.86	918.13	0
India	535.47	537.02	530.86	-1
Viet Nam	248.11	215.70	241.71	12
Indonesia	180.09	163.89	165.55	1
China	104.48	105.34	123.72	17
Argentina	99.35	104.03	119.07	14
Thailand	112.21	101.84	100.51	-1
Others	605.35	596.26	556.27	-7
Global	2,690.36	2,740.93	2,755.81	1

World top importers of shrimp
January–September (1 000 tonnes)

	2022	2023	2024	% change 2024/23
China	663.71	822.08	729.83	-11
United States of America	645.98	575.33	550.16	-4
Japan	160.53	140.57	150.07	7
Spain	125.93	118.36	128.42	8
France	94.89	93.53	91.92	-2
Republic of Korea	78.00	68.76	75.25	9
Denmark	83.24	73.59	70.57	-4
Others	857.52	857.52	857.52	0
Global	2,709.80	2,749.74	2,653.73	-3

Figure 4: List of major shrimp-exporting & Importing countries [7]

With the global shrimp market projected to surpass USD 102 billion by 2033 [11], India is exceptionally well-positioned to expand its market share, benefiting from a confluence of favorable conditions. Declining input costs-particularly for feed and fuel-are improving margins for Indian producers, while tightening inventories in major import markets are driving up demand and prices. The recent slowdown in Ecuador's shrimp production [12], following industry consolidation and the rollback of government subsidies, has further opened up space for Indian exporters to fill the supply gap in global markets.

India's competitive pricing, efficient supply chains, and consistent compliance with international quality and food safety standards have enabled it to maintain and grow its presence in these established markets, even as global competition intensifies. This export momentum is not only fueling India's national economic growth but also sustaining a vast network of stakeholders. The sector supports millions of livelihoods, including shrimp farmers, processors, logistics providers, and allied industries, and is a major contributor to India's foreign exchange earnings. Looking ahead, India's shrimp industry is poised to capitalize on global market dynamics.

Diversification into Value-Added and Premium Products

A key economic opportunity shaping the future of India's shrimp industry lies in the strategic shift toward value addition and product diversification. Indian producers are increasingly expanding their offerings beyond conventional raw, frozen shrimp to include breaded, cooked, peeled, and ready-to-eat (RTE) products tailored to evolving consumer preferences in both domestic and international markets. Industry projections suggest that by 2030, India's RTE and ready-to-cook (RTC) food production could reach approximately INR 9,600 crore, or 4.6 lakh metric tons. This growth is largely driven by younger consumers—particularly millennials—who represent roughly 34% of the country's population and play a central role in shaping demand for convenient, high-quality seafood options. [13]

The trend toward premiumization is reshaping the shrimp industry, creating significant opportunities for both Indian and global producers. As consumers become more health-conscious and environmentally aware, there is a marked increase in demand for shrimp that is antibiotic-free, certified, organic, and sustainably sourced. Producers who align their operations with these expectations are able to access premium markets, where products command higher price points and enjoy greater brand loyalty. This not only enhances profitability but also strengthens the sector's long-term resilience by meeting evolving regulatory and consumer standards.

The robust growth of India's shrimp feed market is playing a pivotal role in the transformation and modernization of the country's shrimp aquaculture sector. Valued at USD 2.0 billion in 2024, the shrimp feed market is projected to expand at a compound annual growth rate (CAGR) of 15.7%, reaching USD 7.4 billion by 2033 [14]. This rapid growth is fueled by the rising preference for shrimp among consumers, the widespread adoption of advanced and sustainable farming practices, and increased investment in aquaculture technologies. A key driver of this expansion is

the development and adoption of high-quality, nutrient-rich, and environmentally sustainable feed formulations. Modern shrimp feeds are carefully balanced to include proteins, carbohydrates, vitamins, and minerals, ensuring optimal growth, health, and disease resistance for farmed shrimp. The focus on improved water stability, nutritional density, and the use of hygienic raw materials not only boosts productivity but also minimizes environmental impact, supporting the sector's shift toward more sustainable and specialized, higher-value product offerings.

Employment Generation and Rural Development

The Pradhan Mantri Matsya Sampada Yojana (PMMSY) reflects the Government of India's strong commitment to inclusive growth and rural transformation through sustainable fisheries development. As part of this visionary program, the Department of Fisheries has set a highly ambitious yet impactful target—to generate 5.5 million (55 lakh) jobs in the fisheries sector by 2024–25, with shrimp aquaculture positioned as a key driver of this employment revolution [15].

This initiative embraces the principle of "Sabka Saath, Sabka Vikas," ensuring that economic opportunities are extended across all segments of society. The employment landscape within the shrimp sector spans the entire value chain—from pond preparation, seed stocking, water quality monitoring, and harvesting to post-harvest handling and sophisticated value-added processing. These opportunities range from informal and smallholder-led operations to organized, export-oriented enterprises, making the sector both inclusive and economically dynamic.

The impact of these efforts is particularly visible in states like Andhra Pradesh, Gujarat, and West Bengal, where enabling policies, favorable agro-climatic conditions, and proactive governance have helped develop thriving shrimp farming clusters. Andhra Pradesh, a standout example, has emerged as a national leader in shrimp processing, where the number of processing units has grown from just over 20 to more than 90 over the past decade. Each unit typically involves an average capital infusion of around USD 5 million, with total investments in shrimp processing now exceeding USD 400 million [16]. These investments have catalyzed industrial growth while simultaneously uplifting rural communities.

The social dimensions of this growth are equally significant. Across India, an estimated 12 million (1.2 crore) women are actively engaged in the shrimp and seafood sector, underscoring its potential as a vehicle for women's empowerment and gender equity [17]. In Andhra Pradesh, the sector has not only enhanced household incomes but also enabled many women to invest in their children's education and gain financial autonomy. Many modern shrimp processing facilities now offer improved working conditions—including transportation, accommodation, and workplace safety—signaling a shift toward more inclusive, dignified, and sustainable employment models.

Furthermore, the ripple effects of shrimp aquaculture are felt across a wide array of allied industries, such as hatcheries, feed mills, cold chain logistics, packaging, transportation, and equipment manufacturing. This integrated ecosystem generates employment across both skilled and semi-skilled categories, offering rural youth viable alternatives to traditional agriculture and contributing meaningfully to poverty reduction and economic resilience in underserved areas.

In the broader context of India's development diplomacy and economic diplomacy, the shrimp sector presents a compelling model of how targeted policy interventions, private sector participation, and community engagement can converge to foster rural development, create meaningful livelihoods, and drive inclusive economic progress. Continued support and cooperation—both domestically and through international partnerships—will be key to scaling these successes and ensuring long-term sustainability and prosperity for India's rural communities.

Regional and Species Diversification

India's shrimp aquaculture industry has made strategic strides in both regional and species diversification, strengthening its adaptability and expanding its global market presence. The Pacific

white shrimp (*Litopenaeus vannamei*) continues to be the primary cultivated species, favored for its high productivity and resilience to disease. In 2022–23, production of *L. vannamei* reached an impressive 1,097,481 metric tons—representing a 51% increase from 711,674 metric tons in 2019–20. Although a slight decrease of 1.87% was observed in 2023–24 (to 1,076,970 metric tons) [18], the overall growth trajectory remains robust, supported by sustained investment and technological advancements in key farming states such as Andhra Pradesh, Tamil Nadu, and Gujarat.

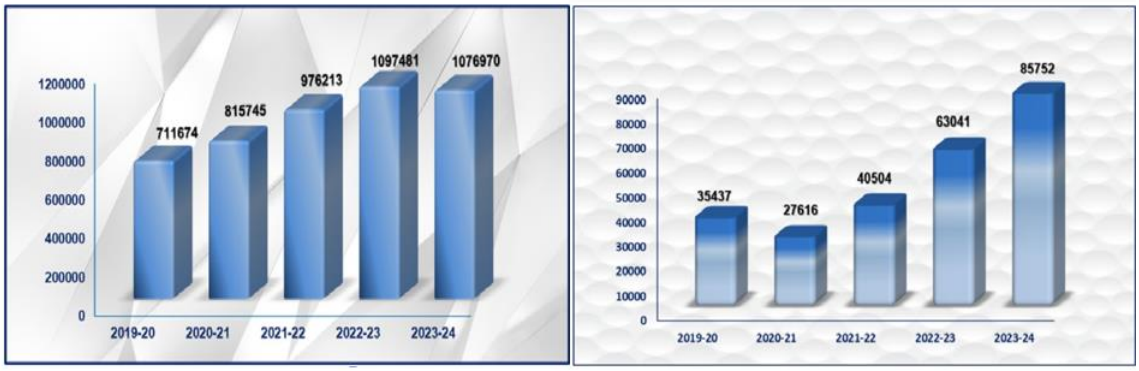

Figure 5: LAST 5 years L. vannamei production (Left) & P. monodon production (Right) (Values in Metric Tons) [19]

At the same time, there is a renewed focus on the cultivation of native species, particularly *Penaeus monodon* (black tiger shrimp) and *Macrobrachium rosenbergii* (giant freshwater prawn). After experiencing a decline—*P. monodon* production dropped to 38,000 metric tons in 2019–20 from over 100,000 metric tons in the early 2010s—black tiger shrimp farming is experiencing a significant revival. From 2021–22 onwards, annual growth rates in *P. monodon* production stood at 46.7%, 55.7%, and 36.1%, reaching 85,752 metric tons in 2023–24. This resurgence reflects growing global demand, higher price realization for premium varieties, and strategic efforts to diversify biological and market risks. Buyers in Europe, Japan, and China are particularly interested in Indian black tiger shrimp due to its reputation for quality.

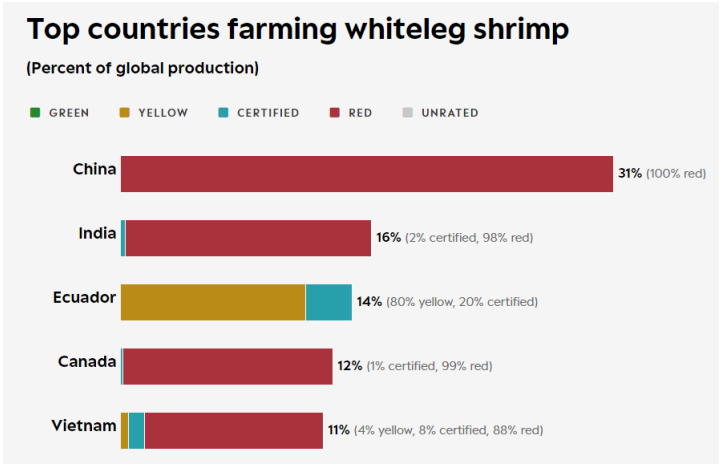

Figure 6: India is the second-largest producer of Whiteleg Shrimp (Litopenaeus vannamei) [20]

Regionally, Andhra Pradesh continues to be a leading hub for shrimp aquaculture. The number of operational shrimp ponds in Central Andhra Pradesh rose from 53,890 in 2020 to 63,184 by May 2024, underscoring its critical role in the sector's expansion. Parallel developments in states like Gujarat—where investments in hatcheries and farms are supporting the cultivation of both *L. vannamei* and *P. monodon*—signal a broader geographical spread of shrimp aquaculture. Today, the industry's footprint spans across all regions of the country, including the North, South, East, West, and Central India, reflecting a balanced and inclusive approach to sectoral development.

This dual diversification—across species and geography—enhances the industry's ecological sustainability and economic resilience. It reduces vulnerability to localized challenges such as

disease outbreaks, market volatility, and climate-related events, while also enabling producers to tap into specialized, premium markets. Ultimately, this approach promotes a more balanced distribution of economic benefits, supporting the livelihoods of diverse coastal and inland communities across the country.

Integration with Allied Sectors and Circular Economy

Shrimp by-products—such as shells and heads—are gaining prominence as valuable inputs for a range of allied industries in India. With annual shrimp production estimated at approximately 800,000 metric tons, processing activities generate nearly 40–50% by weight as by-products, amounting to over 300,000 metric tons each year [21]. These by-products, once seen primarily as waste, are now being harnessed for their potential in creating high-value derivatives.

Innovative uses of shrimp waste include the extraction of **chitin** and its derivative **chitosan**, which have diverse applications across pharmaceuticals, agriculture, and biotechnology [22]. Chitosan, in particular, is widely employed in drug delivery systems and wound care products, with its global market expected to reach US$ 7.06 billion by 2031 from US$ 2.95 billion in 2023; it is expected to record a CAGR of 11.5% during the forecast period [23]. Additionally, shrimp-derived compounds are being incorporated into protein-rich additives, natural preservatives, and health-oriented foods such as omega-3-fortified bread and astaxanthin-enriched yogurt. These functional ingredients are increasingly recognized for their health benefits, including anti-cancer, anti-diabetic, and immune-enhancing properties.

By embedding circular economy principles into its operations, the shrimp sector is not only reducing environmental burdens but also creating new avenues for value addition, resource optimization, and cross-sectoral innovation. This approach supports broader sustainability goals while enhancing the industry's competitiveness and long-term resilience.

Technological Interventions

Technological interventions have fundamentally transformed India’s shrimp industry, driving unprecedented growth, efficiency, and sustainability across the value chain. These advancements have not only propelled India to the forefront of global aquaculture but have also significantly increased productivity and export earnings. shrimp production has increased by over 267%, rising from 0.322 million metric tons in 2013–14 to 1.184 million metric tons in 2022–23. Exports have followed suit, growing from USD 348.84 million to more than USD 5 billion, signaling the sector’s robust global competitiveness [5].

Government initiatives have been instrumental in facilitating this progress. Schemes such as the **Pradhan Mantri Matsya Sampada Yojana (PMMSY)** have played a key role by enhancing infrastructure, improving access to finance, and expanding insurance coverage for aquaculture stakeholders. Complementarily, the **Pradhan Mantri Matsya Kisan Samridhi-Saha Yojana** is helping to address both financial and technological barriers through focused support.

One of the most significant technological breakthroughs has been the adoption of Biofloc Technology (BFT), which utilizes microbial communities to convert organic waste into protein-rich biomass, creating a self-sustaining ecosystem that reduces the need for water exchange and external feed inputs. BFT supports higher stocking densities-up to 350 post-larvae per square meter-and achieves feed conversion ratios (FCR) as low as 1.0 to 1.3, compared to conventional ratios of 1.5 to 2.0. This results in a 15–20% reduction in production costs and a 5–10% increase in yield, while also cutting water usage by up to 90%, significantly reducing the environmental footprint. Trials in Andhra Pradesh’s Nellore district have demonstrated the scalability of biofloc-based systems, especially when combined with high-density polyethylene-lined ponds, making them viable for small and medium-sized farms. Complementing BFT, super-intensive and precision farming systems developed by research institutions like ICAR-CIBA employ advanced

aeration, wastewater management, and controlled environments to achieve yields four to six times higher than traditional methods, with enhanced climate resilience and antibiotic-free production.

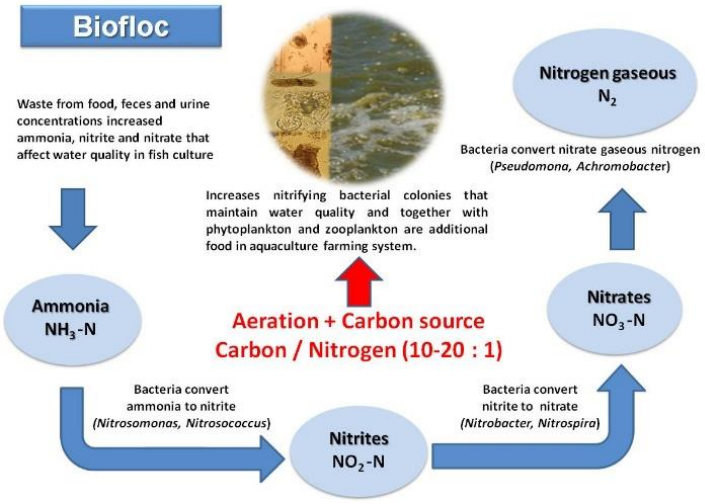

Figure 7: Biological processes in biofloc cultivation [24]

Genetic improvement initiatives, including the establishment of Nucleus Breeding Centres, are enhancing broodstock quality and disease resistance, supporting the long-term sustainability of shrimp farming. Additionally, satellite technology and GIS-based resource mapping aid in site selection, risk management, and environmental monitoring, further strengthening sectoral resilience. The industry is also exploring integrated multi-trophic aquaculture (IMTA) and zero-waste systems to minimize environmental impacts and optimize resource use.

The integration of digital technologies and data analytics facilitates real-time monitoring of key parameters such as water quality, feeding practices, and disease outbreaks. This enhances farm management efficiency while minimizing environmental impact. Additionally, mobile applications—such as the APY Tool—are increasingly being adopted for providing timely advisory support to farmers.

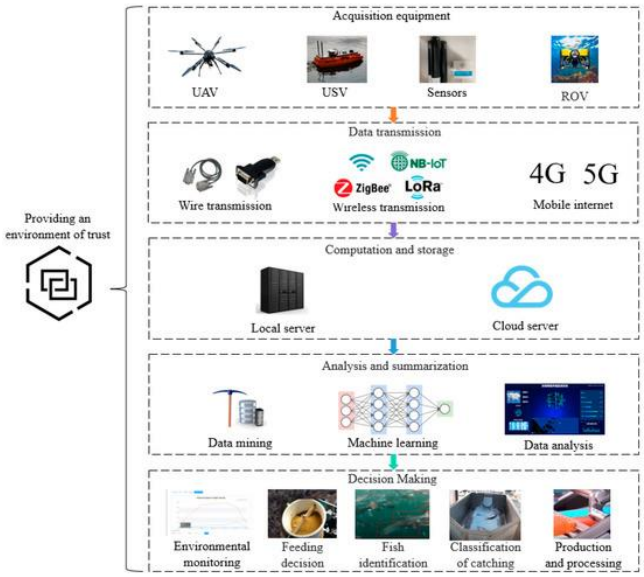

Figure 8: The logical framework of the application of new digital technology in marine aquaculture. [25]

Site Selection

Thoughtful site selection is a cornerstone of sustainable and successful shrimp farming in India. A holistic assessment that integrates environmental, technical, and socio-economic dimensions is essential to ensure long-term viability, optimize productivity, and minimize negative impacts on ecosystems and communities.

A key consideration is the ecological sensitivity of the location. Sites must be chosen with care to avoid environmentally fragile zones—such as intact mangrove forests, erosion-prone coastal areas, and biodiversity hotspots. In particular, mangroves provide critical ecosystem services including shoreline protection and habitat for diverse marine life. Avoiding such areas not only helps safeguard ecological integrity but also aligns with broader conservation goals and international best practices.

Topographical and elevation factors also play a critical role. Ideal sites are slightly elevated—typically between one to three meters above mean sea level or at least one meter above the highest high tide. Such elevation supports natural drainage, mitigates flooding risk, and contributes to efficient pond operations. Sites that are too low are vulnerable to inundation, while higher terrains may incur additional costs for water management.

Soil characteristics are equally important [26]. Preferred soils are those with a pH between 7 and 8, low permeability, and minimal heavy metal content. Acid-sulfate soils (pH < 5) or those with elevated metal concentrations can compromise shrimp health and water quality. Clay-loam or silty-clay loam soils are ideal due to their water retention capacity and ability to foster beneficial microbial communities. Comprehensive soil testing—including parameters such as pH, organic carbon, nitrogen, phosphorus, calcium carbonate, and salinity—is recommended prior to site confirmation.

Water quality and availability are foundational to shrimp farming success. Farms should have access to a consistent and clean water supply, ideally with stable salinity levels (15–30 ppt) and pH (7.5–8.5) [27]. It is important to avoid areas exposed to industrial, agricultural, or urban pollution sources, which can compromise shrimp health and environmental quality. Tidal range is also significant; moderate tidal variations (2–3 meters) are favorable for natural water exchange, whereas sites with extreme or minimal tidal activity may pose logistical and environmental challenges.

Climatic conditions must also be factored in. Regions with evenly distributed rainfall and minimal extreme weather events are preferable. Locations shielded from cyclones, strong winds, and other natural hazards further reduce operational risks and safeguard crop viability.

Infrastructure access enhances both sustainability and operational efficiency. Proximity to roads, electricity, hatcheries, cold chain facilities, and markets facilitates timely access to inputs and expedites product delivery. Availability of trained labor and extension support also contributes to the successful adoption of improved aquaculture practices.

Finally, social and regulatory aspects are crucial. Site selection should avoid areas that could disrupt local livelihoods or trigger social conflict. Transparent engagement with local communities, ensuring legal land use rights, and compliance with regional aquaculture zoning and environmental regulations are essential for long-term success and community acceptance.

In sum, sustainable shrimp farm site selection requires a balanced and context-sensitive approach—taking into account ecological conditions, topography, soil and water parameters, tidal dynamics, climate, infrastructure, and social dynamics. Adhering to these principles can help foster resilient operations, reduce environmental pressures, and strengthen relationships with surrounding communities—paving the way for a robust and inclusive aquaculture sector in India.

Enhancing Productivity

Shrimp farming, like seaweed cultivation, faces dynamic challenges due to shifting environmental conditions and evolving farming practices. To optimize productivity and profitability, **real-time, data-driven decision-making** is critical. The **Area, Production, and Yield (APY) analysis tool**, developed by the Maritime Research Centre (MRC), Pune, offers a transformative approach to shrimp farming by modeling growth patterns, predicting yields, and guiding farmers toward sustainable practices. APY analysis is a data driven modelling and

simulation technique to model the growth of the aquatic organisms, in general, and shrimps and seaweeds, specifically [28].

The APY tool democratizes access to advanced analytics, catering specifically to India's vast network of small and marginal aquafarmers. This inclusive model not only bridges the technology gap but also fosters equitable growth, ensuring that the benefits of digital transformation reach grassroots stakeholders. Furthermore, the tool's iterative learning mechanism—where farmers can input ground-truth data to refine predictions—creates a feedback loop that continuously improves accuracy, a feature lacking in many static, top-down systems employed elsewhere.

Let's carry out an experiment to understand the utility of APY Tool to drive skill training and better practices for the small-scale farmers in the rural areas, to enhance their monetary returns. Consider the following parameters of two contrasting environments:

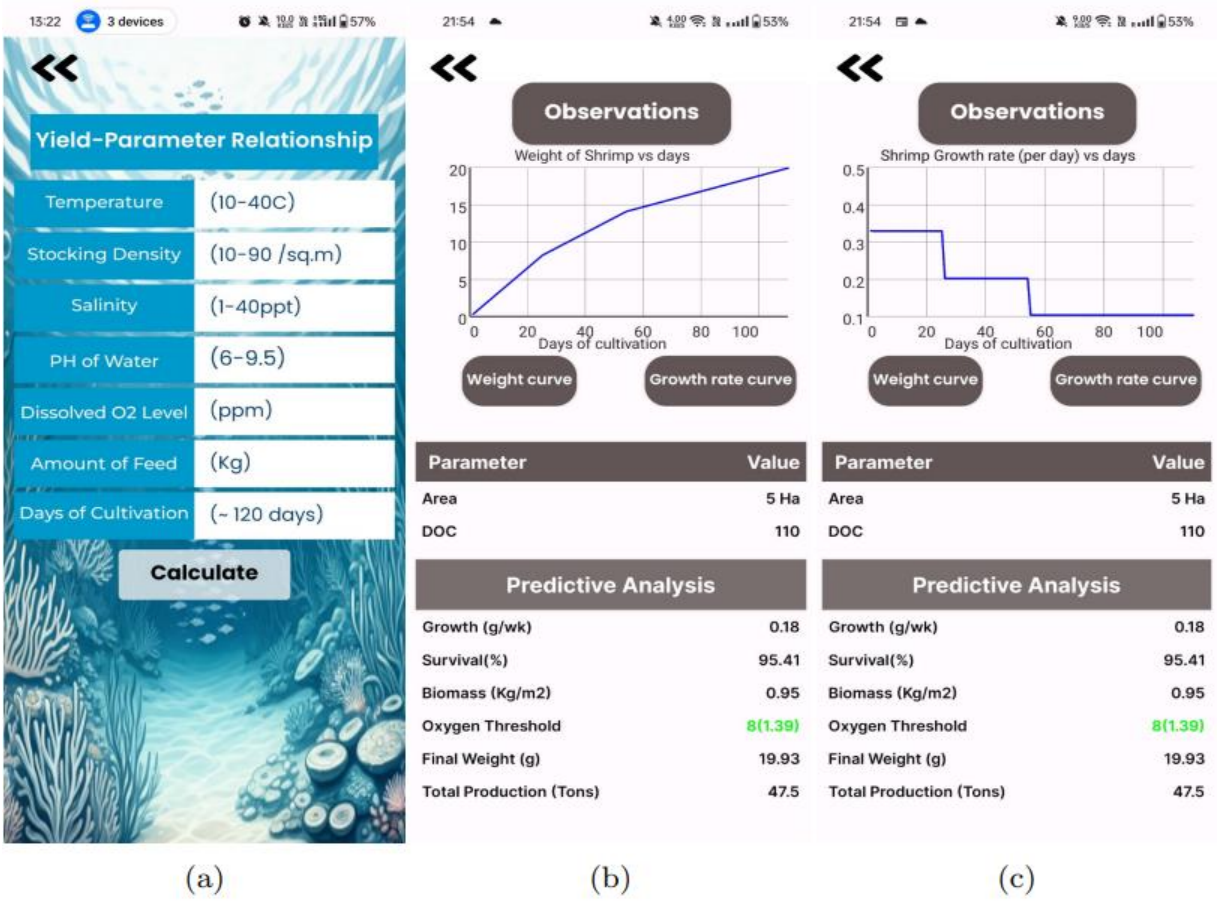

Figure 9: (a) APY Tool user entering values to the application corresponding to the table (b) and the app predicting the growth status of the organism, and expected biomass yield from the farm, and total production based on farm area (c) Growth Rate Curve" feature to track weekly growth rate (g/week) variations over time.

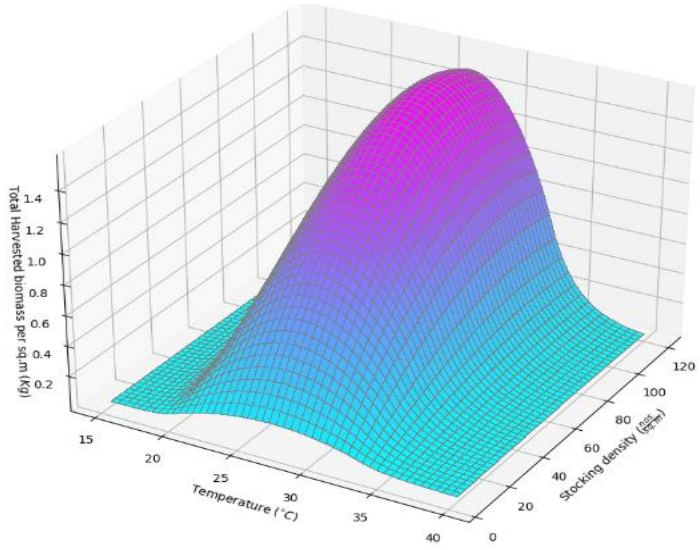

Figure 10: The graph shows the variation in shrimp biomass as influenced by temperature and stocking density, incorporating the impact of varying survival rates. (Image part of MRC publication and not to be reproduced)

As it can be inferred from the tool images above, keeping the variables, days of cultivation, dissolved oxygen level, the sunlight intensity and water depth, constant, just with the **optimization in the temperature and amount of feed clarity has significant dependence on the change of growth of the shrimp**.

While, the APY Tool helps in finding out the unharnessed potential, in terms of the maximum realisable potential that can be extracted by setting all the parameters to their optimum, this may not be feasible to do unless cultivation is done in a very controlled setup. Therefore, APY Tool is not just to maximise it to the maximum potential levels but to help farmers operate their farms in a meaningful enough manner by checking if the farm parameters can be improvised to make farm operations more sustainable.

Marine Spatial Planning

Marine spatial planning (MSP) for shrimp aquaculture is an emerging approach in India aimed at ensuring the sustainable and balanced use of coastal and marine resources. MSP involves the systematic allocation of marine and coastal spaces for various activities, including shrimp farming, to minimize conflicts among stakeholders, protect sensitive ecosystems, and optimize economic benefits [29]. In practice, MSP and aquaculture zoning use advanced tools such as Geographic Information Systems (GIS) and remote sensing to identify suitable sites for shrimp farms based on criteria like water quality, soil characteristics, infrastructure, and proximity to sensitive habitats. For example, GIS-based studies in Gujarat and Karnataka have successfully delineated potential areas for sustainable shrimp farm development, allowing for science-based decision-making and better resource management. In Gujarat, a village-level GIS was developed using high-resolution satellite imagery and cadastral maps to identify and map existing and potential shrimp farming areas [30]. This GIS-based approach allows for the integration of data on soil and water quality, infrastructure, river courses, and other relevant factors to determine the most suitable locations for shrimp aquaculture. Such mapping not only helps in optimizing site selection but also assists in monitoring farm expansion, managing disease outbreaks, and scheduling processing and marketing operations. The Marine Products Export Development Authority (MPEDA) has supported these initiatives, recognizing their role in improving the livelihoods of fishermen and ensuring economic sustainability.

The regulatory framework in India is overseen by the Coastal Aquaculture Authority (CAA) [31], which mandates the registration and periodic renewal of shrimp farms, as well as the approval of hatcheries and broodstock imports to ensure environmental compliance and traceability. However, challenges remain, including the encroachment of shrimp farms on ecologically important areas such as mangroves, inadequate field monitoring, and conflicts with artisanal fishers over land and

water use [32]. The recent amendments to coastal aquaculture regulations have sought to regularize unauthorized farms and streamline permitting, but concerns persist about the dilution of environmental safeguards and the impact on traditional livelihoods.

Ultimately, successful marine spatial planning for shrimp aquaculture in India requires integrating scientific site selection, robust regulatory oversight, and stakeholder engagement. This approach can help balance the economic benefits of shrimp farming with the need to protect coastal ecosystems and support the rights and livelihoods of local communities.

Policy Interventions

India's shrimp farming sector has evolved under a well-defined framework of policy interventions aimed at harmonizing economic development with environmental stewardship and social inclusion. A cornerstone of this regulatory landscape is the Coastal Aquaculture Authority Act, 2005, which led to the formation of the Coastal Aquaculture Authority (CAA). The CAA is entrusted with the registration and regulation of shrimp farms, ensuring adherence to environmental norms and the exclusion of ecologically fragile zones such as mangroves and wetlands, in alignment with the Coastal Regulation Zone (CRZ) notifications issued under the Environment (Protection) Act, 1986. These regulatory measures have been further reinforced through recent amendments that not only streamline approval processes but also extend the Authority's mandate to cover all coastal aquaculture activities. These amendments enhance enforcement powers, including the ability to impose penalties for environmental infractions, while simultaneously promoting ease of doing business for small and marginal farmers.

Over the years, fiscal and programmatic support for the sector has witnessed a significant uptick. The Union Budget 2025–26 earmarked ₹2,703.67 crore for the fisheries sector—a 3.3% increase over the previous fiscal—with ₹2,465 crore allocated to the flagship Pradhan Mantri Matsya Sampada Yojana (PMMSY) [33]. This scheme aims to modernize aquaculture, augment shrimp yields from 3 to 5 tonnes per hectare, and double the incomes of fishers [34]. Key policy incentives include notable reductions in customs duties on essential inputs such as shrimp broodstock, fish feed, and fish hydrolysate, thereby lowering production costs and enhancing international competitiveness. The PMMSY also promotes the adoption of advanced aquaculture technologies (e.g., biofloc systems and recirculatory aquaculture systems), encourages the utilization of saline and alkaline land, and facilitates the development of critical fisheries infrastructure through concessional finance [35].

A landmark initiative in 2025 was the introduction of India's first aquaculture insurance program under the Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana (PM-MKSSY), providing financial protection to small and marginal aquafarmers against disease outbreaks, crop failures, and natural disasters. Emphasizing data-driven governance, the Fifth Marine Fisheries Census is being implemented using digital platforms to establish a detailed registry of fisher families and infrastructure, thereby enabling evidence-based policy planning. The 2025–26 budget also outlines a forward-looking vision for the sustainable utilization of India's Exclusive Economic Zone (EEZ), with targeted initiatives in the Andaman & Nicobar and Lakshadweep Islands. These initiatives encompass deep-sea fishing, onboard fish processing, streamlined licensing of vessels, and the development of tuna clusters. Additional focus areas include seaweed farming, ornamental fish culture, and women's empowerment through Self-Help Groups (SHGs).

In a bid to enhance financial inclusion, the Union Budget 2025 raised the Kisan Credit Card (KCC) lending limit from ₹3 lakh to ₹5 lakh, thereby improving credit availability for fishers, farmers, processors, and other stakeholders. This measure is expected to streamline access to working capital across the fisheries value chain. Complementing this, the PMMSY continues to support the establishment of Fish Farmers Producer Organisations (FFPOs) to economically empower stakeholders by strengthening their collective bargaining power. To date, the Department of Fisheries (DoF) has approved the formation of 2,195 FFPOs, with a total investment of ₹544.85

crore. This includes the transformation of 2,000 existing fisheries cooperatives and the creation of 195 new FFPOs. To further support the sector, the extension of the KCC scheme to fisheries in 2018–19 has led to the issuance of 4,50,799 KCCs to date [1].

The DoF is also driving efforts to establish integrated aquaparks under the PMMSY to strengthen the aquaculture value chain. A total of 11 aquaparks have been sanctioned across the country with an investment of ₹682.6 crore [1], aimed at boosting productivity and infrastructure.

In terms of technological integration, the DoF has introduced multiple forward-looking initiatives to modernize India's fisheries sector. These include the nationwide rollout of the Vessel Communication and Support System, supported by Oceansat satellite data and Potential Fishing Zone (PFZ) advisories, underlining the growing role of space technology in fisheries. Geographic Information Systems (GIS) are being deployed to map marine landing centers and fishing zones, improving planning and resource management.

To further institutional capacity, the ICAR-Central Institute of Fisheries Education (CIFE)—established in 1961 and recognized as a Centre of Excellence—continues to serve as a premier hub for fisheries education and research. CIFE has trained more than 4,000 extension professionals who have contributed to sustainable fisheries development. The principles of the National Policy on Marine Fisheries (NPMF), 2017, reinforce this vision by emphasizing ecological sustainability.

Conservation and regulatory measures are also being systematically implemented. These include a standardized 61-day monsoon fishing ban within the EEZ and restrictions on environmentally damaging practices such as pair trawling, bull trawling, and the use of LED lights. Environmentally responsible approaches like sea ranching, artificial reef deployment, and mariculture (e.g., seaweed farming) are actively encouraged. Coastal States and Union Territories have further introduced specific regulations, including gear restrictions, engine capacity limits, enforcement of minimum legal sizes (MLS) for fish species, and spatial zoning—all designed to ensure the long-term sustainability of marine ecosystems.

Spatial planning and technological innovation are becoming central to sustainable aquaculture practices. For instance, Odisha has adopted geospatial tools like the Coastal Aquaculture Information System (COAST) to demarcate suitable farming areas while protecting sensitive ecosystems. Recognizing the potential of non-coastal regions, the government is also promoting inland saline aquaculture in states such as Haryana, Punjab, Rajasthan, and Uttar Pradesh. Although over 58,000 hectares of saline land have been identified, only about 2,600 hectares are currently in use. Proposed policy reforms aim to increase the unit cost ceiling to ₹25 lakh, expand the maximum farm size from 2 to 5 hectares, and offer enhanced subsidies for infrastructure such as pond linings [36], with the goal of converting marginal lands into productive aquaculture zones and generating rural employment.

Maintaining quality and biosecurity is a top priority. In coordination with the CAA [37], the Marine Products Export Development Authority (MPEDA) under the Ministry of Commerce and Industry has enforced bans on specific antibiotics and mandated the use of best practices like probiotics and bacteriophages for disease management. These measures are intended to align India's shrimp exports with international food safety and residue standards. With exports valued at $9.2 billion in 2024, the sector is also working to diversify export markets and focus on premium, high-value products.

Multiple policy instruments continue to support fishermen and small-scale aquafarmers through training, capacity-building, access to credit, and insurance coverage under PMMSY. The promotion of producer organizations and cooperatives aims to enhance collective market engagement and economic resilience.

Nonetheless, challenges such as bureaucratic delays, land-use disputes, and inconsistent regulatory enforcement persist. In response, the government has introduced compensation mechanisms and grievance redressal frameworks to protect community interests and promote participatory governance.

Together, these comprehensive policy interventions have established India as a global leader in shrimp aquaculture, underpinned by innovation, vertical integration, and sustainability. With sustained investment in technology, capacity-building, and inclusive development, the sector is well-positioned for continued growth and global competitiveness.

Capacity and Capability Building

Capacity and capability building are fundamental to the sustainable advancement and modernization of shrimp farming in India. Recognizing the need to equip farmers, entrepreneurs, and technicians with both technical knowledge and practical skills, a network of institutions and government agencies like MPEDA has established comprehensive training and skill development programs nationwide. MPEDA organizes regular three- to five-day training sessions focused on sustainable shrimp aquaculture and diversification techniques [38], targeting not only established farmers but also newcomers, including members of Scheduled Castes and Scheduled Tribes [39]. These programs cover essential topics such as pond preparation, water quality management, feed strategies, disease prevention, and better management practices, ensuring that participants are well-versed in approaches that boost productivity while safeguarding the environment.

For existing aquaculture practitioners, MPEDA's three-day courses emphasize sustainable farming methods, resource optimization, and risk management, while five-day programs for minor communities are designed to empower individuals to either launch their own shrimp farming ventures or secure employment in the sector. The curriculum also introduces participants to diversified aquaculture, helping them mitigate risks from market fluctuations or disease outbreaks by expanding their range of farmed species. Beyond formal instruction, MPEDA's field offices regularly organize one-day farmers' meets and half-day awareness campaigns at the village level. These forums provide platforms for experience sharing, problem-solving, and the dissemination of new technologies or government schemes, ensuring that knowledge transfer is practical, timely, and tailored to local needs.

The capacity-building ecosystem is further strengthened by research institutes such as the ICAR-Central Marine Fisheries Research Institute (CMFRI) and ICAR-Central Institute of Freshwater Aquaculture (CIFA), which offer specialized training on advanced topics like hatchery technology, genetic improvement, biofloc-based farming, and disease diagnostics. Skill development centers, often established in partnership with universities and private foundations, provide certificate courses in hatchery operation and farm management, enhancing employment prospects for graduates in hatcheries, farms, and processing units. The National Centre for Sustainable Aquaculture (NaCSA) [40], an outreach arm of MPEDA, clusters small-scale farmers into societies and trains them in better management practices and the cluster approach, which fosters resource sharing, cost reduction, and collective disease management, further promoting social and environmental responsibility.

Importantly, these capacity-building initiatives are inclusive, with targeted programs for women, minor communities, and youth, contributing to economic upliftment and inclusive rural development. The cumulative effect of these multi-tiered efforts is a new generation of shrimp farmers and aquaculture professionals equipped with the technical know-how, practical skills, and sustainable mindset necessary to drive the industry forward while ensuring environmental and social well-being.

Challenges

The rapid expansion of shrimp aquaculture, driven largely by increasing global demand, has brought substantial economic benefits but has also exposed a range of environmental and social concerns. Environmentally, the sector has contributed to the degradation of sensitive coastal ecosystems through habitat alteration, pollution, and the spread of disease, all of which threaten biodiversity and ecological stability. Socially, the benefits of this growth have not always been equitably shared, and in some cases, it has led to the displacement of local communities and heightened competition over limited land and water resources.

One of the most significant environmental trade-offs has been the widespread conversion of mangrove forests into shrimp ponds. Mangroves are invaluable for their role in coastal protection, biodiversity conservation, and carbon sequestration. Estimates suggest that 30% to 50% of global mangrove loss is linked to shrimp farming, compromising coastal resilience against storms, erosion, and climate change impacts [41].

Water pollution from nutrient-rich effluents and chemical inputs—such as antibiotics and pesticides—poses additional challenges. These discharges can lead to eutrophication, harmful algal blooms, and the formation of oxygen-depleted zones, affecting both aquatic life and public health. Moreover, overcrowded farming conditions and insufficient biosecurity have increased vulnerability to diseases like White Spot Syndrome Virus (WSSV) [42] and Early Mortality Syndrome (EMS), causing significant economic losses and posing risks to wild populations.

On the social front, the expansion of large-scale commercial shrimp farms has, in some regions, intensified land-use conflicts and social inequality. Reports of land acquisition disputes, reduced access to clean water, and substandard labor conditions have emerged in several producer countries. Particularly concerning are the impacts on marginalized groups, such as smallholder farmers and women, who may face heightened economic and social insecurity.

Health and food safety concerns have also surfaced, particularly around the use of unapproved antibiotics and chemicals. Contaminated shrimp exports have faced increasing scrutiny, especially in markets like the U.S. and EU, with India among the countries most affected by export rejections. These issues highlight the growing importance of traceability, quality control, and compliance with international safety standards.



Figure 11: FDA's Shrimp Refusal due to Banned Antibiotics comes from 13 countries but 88% are from 3 countries- China, India & Vietnam [43]

Climate change further compounds the sector's vulnerabilities. Rising sea levels, ocean acidification, and extreme weather events—such as Cyclone Yaas in 2021—pose serious threats to coastal aquaculture infrastructure and ecosystems. Warmer temperatures can increase disease prevalence and stress aquatic species, while salinization and flooding jeopardize both production and livelihoods.

In light of these interconnected challenges, a balanced and forward-looking approach is essential. Strengthening regulatory frameworks, promoting sustainable farming techniques, enhancing disease surveillance, and ensuring inclusive development can help mitigate adverse impacts. Greater investment in research, climate resilience, and farmer capacity-building will also be key.

With coordinated efforts across stakeholders—governments, industry, local communities, and consumers—India's shrimp sector can continue to thrive in a manner that is both economically viable and environmentally and socially responsible.

Conclusion

India's shrimp sector stands as a testament to the country's ability to transform challenges into opportunities, evolving from a modest industry into a global aquaculture powerhouse. This journey has been marked by resilience, innovation, and the unwavering commitment of countless farmers, entrepreneurs, scientists, and policymakers. As India continues to expand its influence in the global seafood market, it is imperative to adopt a forward-looking and collaborative strategy that embraces both growth and responsibility.

The road ahead calls for deeper and more strategic partnerships—between government agencies, private sector stakeholders, research institutions, and international trade and regulatory bodies. Through diplomatic engagements, India can work to strengthen bilateral and multilateral trade relations, address non-tariff barriers, and ensure that Indian shrimp products continue to meet evolving international standards of quality, safety, and sustainability.

Equally important is the investment in sustainable aquaculture practices that align with global environmental commitments, such as the Sustainable Development Goals (SDGs) and the Paris Agreement. By promoting responsible farming methods, supporting small-scale producers, and encouraging innovations in feed, disease control, and climate-resilient infrastructure, India can position itself as a responsible leader in the blue economy.

Furthermore, India should actively participate in international forums, contribute to shaping fair and science-based trade policies, and advocate for equitable access to global markets—particularly for developing and emerging economies. Capacity-building initiatives and knowledge exchange with partner countries can also strengthen diplomatic ties and promote shared progress in aquaculture.

Ultimately, by aligning its economic ambitions with principles of inclusivity, environmental stewardship, and international cooperation, India can not only sustain its leadership in the global shrimp industry but also emerge as a role model for sustainable aquaculture worldwide. A shared vision, supported by strong diplomacy, innovation, and a commitment to excellence, will ensure that the benefits of this sector reach farmers, industries, consumers, and the global community—contributing to India's broader economic and geopolitical aspirations.

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